AAIC 25th Anniversary Meeting

new crops bioenergy biomaterials and sustainability

October 13-16, 2013

Renaissance Hotel

DuPont Circle

Washington D.C.

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PROGRAM AND PROCEEDINGS TABLE OF CONTENTS

Sunday, October 13

Time	Event		Room
9:00 AM	Registration Desk Open	Valerie Teetor, University of AZ, Tucson, AZ	
10:00 AM	Poster Set-Up		New Hampshire
10:30 AM	Tour to Mt. Vernon		
1:00 PM	Oilseed AFRI Meeting	Terry Isbell	Potomac
1:00 PM	Elsevier - Industrial Crops and Prod. Editorial Board Mtg.	Elaine van Ommen-Kloeke	Georgetown
3:00 PM	New Crops, Crop Germplasm Committee	Candice Gardner, USDA-ARS, Ames, IA	Mt. Vernon
4:00 PM	AAIC Board of Directors Meeting	David Dierig, AAIC President, USDA-ARS, National Center for Genetic Resources Preservation, Fort Collins, CO	Dupont
6:00 PM	Welcome Reception and Poster Viewing		New Hampshire Ballroom
7:30 PM	Opening Meeting	David Dierig, AAIC President, USDA-ARS, National Center for Genetic Resources Preservation, Fort Collins, CO	New Hampshire Ballroom
	Dr. Sonny Ramaswamy, Director USDA-NIFA		
	Dr. Caird Rexroad, Acting Administrator, USDA-ARS		

Monday October 14. Plenary Session – New Hampshire Ballroom
Moderator: Bill Goldner, USDA-NIFA

8:00 AM	Welcome and Introductions	
8:15 AM	Under Secretary Dr. Catherine Woteki, USDA, Research, Education and Economics	Broad Perspective on Food, Feed, Fiber, Energy
9:00 AM	U.S. Senator Debbie Stabenow (MI) Chair, Senate Agriculture Committee (invited)	Senate Perspective on the New Farm Bill
9:30 AM	Agriculture and Food Research Initiative Coordinated Agricultural Project (CAP), Brian Stanton, University of Washington, Seattle, WA	Advanced Hardwood Biofuels Northwest - A Multidisciplinary Research Program to Produce Sustainable Biofuels from Woody Biomass.
10:00 AM	**Break**	
10:30 AM	Michael Wolcott, Agriculture and Food Research Initiative Coordinated Agricultural Project (CAP), Washington State University, Pullman, WA	Northwest Advanced Renewables Alliance (NARA): A New Vista for Green Fuels, Chemicals, and Environmentally Preferred Products (EPPs)
11:00 AM	Steve Csonka, Commercial Aviation Alternative Fuels Initiative, CAAFI, Cincinnati, OH	Renewable Jet Fuel: Marketplace Pull And Commercialization Progress
Noon	Buffet Lunch	

Monday Afternoon - Concurrent Sessions
1. Oilseeds for Bioenergy and Biomaterials I - New Hampshire Ballroom
Moderator: Burton Johnson, North Dakota State University, Fargo, ND

1:40 PM	Maria Jesús Pascual Villalobos, Instituto Murciano de Investigación y Desarrollo Agrario y Alimentario (IMIDA), Murcia, Spain	Building a Castor (*Ricinus communis* L., Euphorbiaceae) Germplasm Collection in Spain
2:00 PM	Mark Cruz, USDA-ARS National Center for Genetic Resources Preservation, Fort Collins, CO	Root Phenotyping of New Oilseed Crop Lesquerella Germplasm
2:20 PM	Liv Severino, Embrapa Algodão, Campina Grande, PB, Brazil	Air Temperature Influencing Castor Seed

		Growth
2:40 PM	Travis Witt, Plant and Soil Science Department, Texas Tech University, Lubbock, TX	Performance of Five Castor (*Ricinus communis* L.) Cultivars in Geographically Diverse Environments in North America
3:00 PM	**Break**	
3:20 PM	Mukhlesur Rahman, North Dakota State University, Fargo, ND	High Oil Canola Breeding in North Dakota
3:40 PM	Russ Gesch, USDA-ARS, North Central Soil Conservation Research Laboratory, Morris, MN	Camelina Growth and Yield Response to Planting Rate and Depth
4:00 PM	Burton Johnson, North Dakota State University, Fargo, ND	Winter Canola Adaptation in North Dakota
4:20 PM	Loren Davis, Plant and Soil Science Department, Texas Tech University, Lubbock, TX	Modification of Oil Content in Cottonseed Using Chemical Mutagenesis
4:40 PM	Sujay Mahajan, University Institute of Chemical Technology, North Maharashtra University, Jalgaon (M.S.), India	Low Temperature Hydrogenation of Soybean Oil and Modeling Studies for Selectivity Engineering
	7:00-9:00 Poster presentation	
1	Win Phippen, School of Agriculture, Western Illinois University, Macomb, IL	Seed Oil Characteristics of Wild Field Pennycress (*Thlaspi arvense* L.) Populations and USDA Accessions
2	Steven Cermak, USDA-ARS, National Center for Agricultural Utilization Research, Peoria, IL	Synthesis and Physical Properties of New Estolide Esters
3	Liv Severino, Embrapa Algodão, Campina Grande, PB, Brazil	Salinity of Sodium, Calcium, and Magnesium Affecting the Emergence and Early Growth of Castor, Cotton, and Safflower
4	Duane Johnson, ClearSkies, Inc., Big Fork, MT	Camelina-Based Biolubricant Development in Partnership with Industrial Consumers
5	Roque Evangelista, USDA-ARS, National Center for Agricultural Utilization Research, Peoria, IL	Dehulling of Coriander Fruits before Oil Extraction
6	Joon Hee Lee, USDA-ARS, Northern Great	Modeling Soil Organic

	Plains Research Laboratory, Mandan, ND	Carbon Change in Oilseed Cropping System in North Dakota
7	Tiago Zoz, Department of Agriculture, São Paulo State University, Botucatu, SP, Brazil	Nitrogen and Potassium Application on Crambe (*Crambe abyssinica* Hochst) in Furrow at Planting
8	Tiago Zoz, Department of Agriculture, São Paulo State University, Botucatu, SP, Brazil	Performance of Castor Cultivars Grown at Three Fertility Levels
9	Tiago Zoz, Department of Agriculture, São Paulo State University, Botucatu, SP, Brazil	Impact of Uneven Emergence on Castor Performance
10	Allison Cameron, Department of Plant & Soil Science, Texas Tech University, Lubbock, TX	Cotton Hybridization as a Tool for Developing Interest in Undergraduate Research
11	Erica Tassone, USDA-ARS, U.S Arid Land Agricultural Research Center, Maricopa, AZ	Genetic and Phenotypic Variation for Germplasm Improvement in the Brassicaceae
12	Efi Alexopoulou, Center For Renewable Energy Crops and Saving, Pikermi Attiki, Greece	Comparison of Several Castor Hybrids in Greece
13	Burton Johnson, North Dakota State University, Fargo, ND	Biofuel Oilseeds for the Dakotas
14	Ulysius McGhee, Fort Valley State University, Fort Valley, GA	Effect of Genotypes on *in vitro* Propagation of *Jatropha curcas*
15	Phoenix Mourning-Star, Colorado State University, Fort Collins, CO	Life-Cycle Assessment of Poppystraight Vegetable Oil Fuel Production: A case for Small-Scale, Local Use, and Production

2. Logistics and Conversion Panel - New Hampshire Ballroom, III
Moderator: Bill Goldner, USDA-NIFA

1:30 PM	Bill Goldner, USDA National Institute of Food and Agriculture, Washington, D.C.	Panel Introductions Overview: Challenge and Opportunity - Biomass to Biorefinery Gate and Beyond
2:00 PM	John Sessions, Oregon State University,	Cost-Effective Logistics for

	Corvallis, OR	Forest Harvest Residuals: the Upstream Part of the Sugar Stream
2:20 PM	Andrew Hawkins, Gevo, Englewood, CO	Preprocessing and Converting Forest Residual Sugars into Advanced Biofuels
2:40 PM	Robert Brown, Iowa State University, Ames, IA	The Pyrolysis/Biochar Logistics and Conversion Process for Perennial Grasses
3:00 PM	**Break**	
3:20 PM	Steve Taylor, Auburn University, Auburn, AL	Advances in Feedstock Supply Chain Logistics for Advanced Biofuels in the Southeast
3:40 PM	Daira Aragon Mena, Louisiana State University, Baton Rouge, LA	Conversion of Energy Cane into Biofuels and Chemicals: A Modeling Approach
4:00 PM	Question and Answer Session	
	Posters: Session 7 PM to 9 PM	
16	Eric Gulledge, ArborGen, Bellville, GA	Building Herbicide Resistance for Short Rotation Hardwood Crops
17	Sushil Adhikari, Auburn University, Auburn, AL	The SEED Fellowship: An Innovative Approach to Bioenergy Education
18	Stephen Kelley, North Carolina State University, Raleigh, NC	Thermochemical Conversion: Effect of Biomass Characteristics
19	Oladiran Fasina, Auburn University, Auburn, AL	Impact of Biomass Characteristics On Logistics

3. Sustainability/Decision Tools/LCA - Potomac Room
Moderator: Fen Hunt, USDA-NIFA

1:30 PM	Fen Hunt, USDA National Institute of Food and Agriculture, Washington, D.C. This session will be panel format and will include speakers from land use change, CAPs and policy.	Panel Introductions Session Overview
1:40 PM	John Field, Colorado State University, Fort Collins, CO	Biofuels on the Landscape: Modeling to Balance the Environmental Footprint of Feedstock Production on Marginal Lands

2:00 PM	Amy Landis, Arizona State University, Tempe, AZ	Sustainability Assessments of Biofuels and Related Policies
2:20 PM	Penny Diebel, Oregon State University, Corvallis, OR	Developing a Sustainable Biofuels System in the PNW: Economic, Policy and Commercialization Analysis
2:40 PM	Steve Kelley, North Carolina State University, Raleigh, NC	Recent Progress in Sustainability Metrics for Advanced Biofuels in the Southeast
3:00 PM	**Break**	
3:20 PM	Indroneil Ganguly, University of Washington, Seattle, WA	Environmental Implications of Advanced Biofuels in the Pacific Northwest: An LCA Approach
3:40 PM	Erik Budsberg, University of Washington, Seattle, WA	Life Cycle Assessment for Advanced Biofuel Production from Poplar Feedstock
4:00 PM	Cuizhen (Susan) Wang, University of Missouri, Columbia, MO	Perennial Biomass Crop Establishment and its Environmental Impacts in the Midwestern United States
4:20 PM	Marie-Anne de Graaff, Boise State University, Boise, ID	At the Root of Sustainable Bioenergy: Using Genetic Variation in Root Traits to Maximize Soil Carbon Sequestration and Biomass Yields
4:40PM	Cathy Kling, Iowa State University, Ames, IA	Landscape Scale Water Quality Modeling for Bioenergy Systems.
5:00 PM	Fen Hunt: Question and Answer and wrap-up	5:00 PM
	Posters: Session 7 PM to 9 PM	
20	John Erickson, University of Florida, Gainesville, FL	Direct Effects of Converting Conventional Cropping Systems to Biofuel Cropping Systems on Ecosystem Services for the Southeastern U.S.A.
21	Nithya Rajan,,Texas A&M AgriLife Research and Extension Center, Vernon, TX	Impacts of Biofuel Induced Land Use Change on Energy, Water, Carbon and Greenhouse Gas Balances of the Southwest U.S. Cotton Belt Region
22	Mark Coleman, University of Idaho, Moscow, ID	Impacts of Forest Biomass Removal on Soil Quality and Biodiversity
23	Jason Hill, University of Minnesota, Saint Paul, MN	Full Cost Accounting of Ecosystem Services from

		Biomass Production Landscapes in the Midwest United States
24	Sanjai Parikh, University of California-Davis, Davis, CA	Biochar Impacts on Forest Soil Carbon Stocks
25	Suchada Ukaew, Michigan Technological University, Houghton, MI	Life Cycle Assessment of Rapeseed Hydrotreated Renewable Jet Fuel: Regional Variations in N_2O Emissions

4. Carbon Sequestration and Greenhouse Gas Emissions from Bioenergy Crops - DuPont Room
Moderator: Nancy Cavallaro, USDA-NIFA

1:30 PM	Nancy Cavallaro, USDA National Institute of Food and Agriculture, Washington, D.C.	Introductions and Overview
1:40 PM	Rajesh Chintala, South Dakota State University, Brookings, SD	Partitioning of Macro-Nutrient Anions Depends on Biochar Feedstock
2:00 PM	Joe O. Storlien, Texas A&M Research Foundation, College Station, TX	Assessment of Life Cycle Greenhouse Gas Emissions From Bioenergy Sorghum Production in Central Texas
2:20 PM	John King, North Carolina State University, Raleigh, NC	Loblolly Pine-Switchgrass Intercropping for Sustainable Timber and Biofuels Production in the Southeastern United States
2:40 PM	David Ernest Rothstein, Michigan State University, East Lansing, MI	Carbon Sequestration and Greenhouse Gas Emissions Associated with Short-Rotation Woody Biomass Production in the Upper Great Lakes Region
3:00 PM	**Break**	
3:20 PM	Brian K. Richards, Cornell University, Ithaca, NY	Carbon Sequestration and Gaseous Emissions in Perennial Grass Bioenergy Cropping Systems in the Northeastern U.S.
3:40 PM	Daniel Markewitz, The University of Georgia Research Foundation, Inc., Athens, GA	High Planting Density Southern Pine Feedstock Production: Below Ground Carbon Partitioning and Decomposition
4:00 PM	Caroline Masiello, Rice University, Houston, TX	Measuring the Biochemical Inventory of Cropped Ecosystems Using NMR
4:20 PM	Gail W.T. Wilson, Oklahoma State University, Stillwater, OK	Evaluating Plant-Soil-Microbial Interactions in Low-Input High-Diversity Biofuels: Enhancing Aboveground Ecosystem Services

		Without a Loss in Belowground Services
4:40 PM	Michael Allen Blazier, Louisiana State University Agricultural Center, Baton Rouge, LA	Carbon Sequestration and Greenhouse Gas Emissions Associated with Cellulosic Bioenergy Feedstock Production on Marginal Agricultural Lands in the Lower Mississippi Alluvial Valley
5:00 PM	Nancy Cavallaro, USDA-National Institute of Food and Agriculture, Washington, D.C.	Wrap up and questions
	Poster Session 7 PM to 9 PM	
26	Upendra Sainju, USDA-ARS, Northern Plains Agricultural Research Laboratory, Sidney, MT	Soil Carbon and Nitrogen Affected by Perennial Grass, Cover Crop, and Nitrogen Fertilization
27	David Grantz, University of California, Riverside, CA	Drivers of Soil Respiration in Arid Biofuel Production Systems
28	Roger Koide, Brigham Young University, Provo, UT	Effects of Biochar Soil Amendment on Switchgrass Yield, Soil C Dynamics and Water Availability
29	Zhengrong Gu, Agricultural & Biosystems Engineering, South Dakota State University, Brookings, SD	Bio-Char Based Activated Carbon as a Key Materials for Renewable Energy Production and Storage
30	Jason Wight, Texas A&M Research Foundation, College Station, TX	Management, Productivity and Nutrient Relationships in Biomass Sorghum Systems

5. General Crops – City Center Room I
Moderator: Marisol Berti, North Dakota State University, Fargo, ND

1:30 PM	Efi Alexopoulou, Center For Renewable Energy Crops and Saving, Pikermi Attiki, Greece	Perennial Grasses - Important Biomass Source Feedstock for Bio-Based Products and Bioenergy
2:00 PM	Andrea Monti, University of Bologna, Bologna, Italy	The SweetFuel Project: Sweet Sorghum as Alternative Energy Crop
2:20 PM	Marisol Berti, North Dakota State University, Fargo, ND	Can Forage Sorghum be a Dedicated Bioenergy Crop in the Northern Great Plains?
2:40 PM	Valerie Teetor, School of Plant Sciences, University of Arizona, Tucson, AZ	Evaluation of Sweet Sorghum Germplasm for Maturity in Arizona

3:00 PM	**Break**	
3:20 PM	Dennis Ray, School of Plant Sciences, University of Arizona, Tucson, AZ	Varying Dates of Planting and Harvest to Maximize Productivity of Sweet Sorghum for Ethanol Production in Arizona
3:40 PM	Dick Auld, Plant and Soil Science Department, Texas Tech University, Lubbock, TX	Industrial Crops to Help Mediate Climate Warming in the Southwestern U.S.
4:00 PM	Harbans Bhardwaj, Agricultural Research Station, Virginia State University, Petersburg, VA	Tepary Bean – A Native American Crop For Changing World
4:20 PM	Bralie Hendon, Plant and Soil Science Department, Texas Tech University, Lubbock, TX	Development of Herbicide Resistance in Industrial Crops with Chemical Mutagenesis
4:40 PM	**General Crops and Products Division Meeting** Chair, Marisol Berti, North Dakota State University, Fargo, ND	
	7:00-9:00 Poster presentation	
31	Burton Johnson, North Dakota State University, Fargo, ND	Field Pea Yield Response to Physical Plant Injury
32	Harbans Bhardwaj, Agricultural Research Station, Virginia State University, Petersburg, VA	Introduction and Establishment of Chickpea and Sesame in Virginia (USA)
33	Howard "Sonny" Viator, Louisiana State University, Agricultural Center, Baton Rouge, LA	Sweet Sorghum Production Logistics in Subtropical Regions

6. Fibers and Cellulosic Crops for Bioenergy and Biomaterials - City Center Room II

Moderator: Greg Holt, USDA, ARS, Lubbock, TX

1:30 PM	Gregory Glenn, Western Regional Research Center USDA-ARS, Albany, CA	Optimizing the Value of Ag-Derived Fibers Based on Their Source & Properties
2:00 PM	Hector Ruiz, Autonomous University of Coahuila, Saltillo, Coahuila, México	Integrated Biorefineries Using Hydrothermal Process: A Case Study for Wheat Straw
2:20 PM	Cindy Barrera, Ohio Agricultural Research and Development Center, Food, Agricultural and Biological Engineering, The Ohio State University, Wooster, Ohio,	Effect of Fillers Obtained From Agricultural, Industrial and Food Processing Wastes on

		Natural Rubber Mechanical Properties
2:40 PM	Greg Holt, USDA-ARS, Cotton Production & Processing Research Unit, Lubbock, TX	Evaluation of Acoustic Absorbers Produced from Agricultural Byproducts and Mycelium
3:00 PM	**Break**	
3:20 PM	Dilpreet Bajwa, North Dakota State University, Fargo, ND	Development of Low Density Fiber Boards from Agricultural Fibers
3:40 PM	Efi Alexopoulou, Center For Renewable Energy Crops and Saving, Pikermi Attiki, Greece	Fibre Crops as Biobased Material source for Industrial Products in Europe and China
4:00 PM	Steven Vaughn, USDA-ARS National Center for Agricultural Utilization Research, Peoria, IL	Biobased Absorbents Produced from Seashore Mallow Stem Tissues
4:20 PM	Ana Luisa Fernando, Departamento de Ciências e Tecnologia da Biomassa, Faculdade de Ciências e Tecnologia da Universidade Nova de Lisboa, Caparica, Portugal	How Sustainable is the Production and Use of Kenaf?
4:40 PM	Denise Duclos, Department of Horticulture, New York State Agricultural Experiment Station, Cornell University, Ithaca, NY	Investigating Seed Dormancy in Switchgrass (*Panicum virgatum* L.): Understanding the Effect of Temperature and Plant Hormones on Embryo Dormancy
5:00 PM	**Fibers and Cellulosics Division Meeting** Chair Greg Holt, USDA-ARS, Lubbock, TX	
	7:00-9:00 Poster presentation	
34	Kevin W. Zobrist, Washington State University Extension, Everett, WA	Potential Barriers to Growing Hybrid Poplar as Biofuel Feedstock
35	Haiying Liang, Department of Genetics and Biochemistry, Clemson University, Clemson, SC	Genetic Engineering for Septoria Disease Resistance in Hybrid Poplar
36	Janine Albaugh, Department of Forestry and Environmental Resources, North Carolina State University, Raleigh, NC	Effect of Shading on Switchgrass Physiology, Above- and Belowground Biomass and Light-Use Efficiency
37	Sreekala Bajwa, North Dakota State University, Fargo, ND	Effect of Fiber Treatment on Sorption Characteristics of Plant Fibers

Tuesday October 15 – Plenary Session – New Hampshire Ballroom

Moderator: Daniel Cassidy, USDA-NIFA

8:30 AM	Daniel Cassidy, USDA National Institute of Food and Agriculture, Washington, D.C.	Welcome Remarks
9:00 AM	U.S. Congressman Frank D. Lucas (OK), Chair, House Agriculture Committee (invited)	Congressional Perspective on the New Farm Bill
9:30 AM	Donal Day, Agriculture and Food Research Initiative Coordinated Agricultural Project (CAP), Louisiana State University Agricultural Center, Baton Rouge, LA	A Regional Program for Production of Multiple Agricultural Feedstocks and Processing to Biofuels and Biobased Chemicals
10:00 AM	**Break**	
10:30 AM	Tom Richard, Agriculture and Food Research Initiative Coordinated Agricultural Project (CAP), The Pennsylvania State University, University Park, PA,	NEWBio: Northeast Woody Warm-season Biomass Consortium
11:00 AM	Ron Buckhalt, BioPreferred Program Manager, USDA, Washington, D.C.	Developing New Markets For Biobased Products
Noon	**Lunch on your own**	

Tuesday Afternoon - Concurrent Sessions

1. Rubber and Resin Sources of Biomaterials, Biomass and Bioenergy Feedstocks - New Hampshire Ballroom

Moderator: Lauren Johnson, PanAridus, Carefree, AZ

1:30 PM	Dennis Ray, University of Arizona, Tucson, AZ	Guayule: How Far Have We Come?
2:00 PM	Sarah Smith, Bridgestone Americas, Inc., Eloy, AZ	Overview and Focus of Bridgestone Americas, Inc. Guayule Research Operation
2:20 PM	Byung-guk Kang USDA-ARS, Western Regional Research Center, Albany, CA	Improved Tissue Culture Protocols for Guayule
2:40 PM	Diana Jasso de Rodriguez, Universidad Autónoma Agraria Antonio Narro, Coahuila, Mexico	Guayule from México: Outstanding Shrub's Source for Industrial Development
3:00 PM	**Break**	
3:20 PM	Leif Christoffersen, Yulex Corporation, Phoenix, AZ	Guayule Wetsuit Product Launch and Increasing Guayule Material Supply

3:40 PM	Lauren Slutszky, Department of Horticulture and Crop Science, Department of Food, Agricultural and Biological Engineering, The Ohio State University, Wooster, OH	Formation of Novel Natural Rubber-Plastic Nanofiber Composites via Electrospinning
4:00 PM	Katrina Cornish, Department of Horticulture and Crop Science, Department of Food, Agricultural and Biological Engineering, The Ohio State University, Wooster, OH	Establishing 57 Miles of Buckeye Gold (*Taraxacum kok-saghyz*) in Northeast Ohio
4:20 PM	Brian Iaffaldano, Department of Horticulture and Crop Science, The Ohio State University Ohio Agricultural Research and Development Center, Wooster, OH	Hybridization between *Taraxacum kok-saghyz* and *T. officinale*
4:40 PM	Stephen Kopicky, Department of Horticulture & Crop Science, Ohio Agricultural Research & Development Center, the Ohio State University, The Ohio State University, Wooster, OH	Hydroponic Growth of *Taraxacum kok-saghyz* and the Evaluation of Partial Root Harvest
5:00 PM	**Natural Rubber and Resins Division Meeting** Chair Dr. Lauren Johnson, PanAridus, Carefree, AZ	
	Poster Presentations 7:00-9:00	
38	Lu Zhao Department of Horticulture & Crop Science, Ohio Agricultural Research & Development Center, the Ohio State University, Wooster, OH	Tissue Specific and Inducible Promoter Evaluation in Buckeye Gold
39	Yingxiao Zhang, Department of Horticulture & Crop Science, Ohio Agricultural Research & Development Center, The Ohio State University, Wooster, OH	Chloroplast Genome Sequencing and Plastid Engineering of Kazak Dandelion
40	Wenshuang Xie, Horticulture & Crop Science Dept., Ohio Agricultural Research & Development Center, The Ohio State University, Wooster, OH	Magnesium Affects Rubber Particle Stability and Biosynthesis in *Ficus elastica*, *Hevea brasiliensis* and *Parthenium argentatum*
41	Wenshuang Xie, Horticulture & Crop Science Dept., Ohio Agricultural Research & Development Center, The Ohio State University, Wooster, OH	Studies of the Latex of Brazilian IAC Series Clones from *Hevea brasiliensis*
42	Paul Sanchez, USDA, ARS, U.S. Arid-Land Agricultural Research Center, Maricopa, AZ	Variation in Genome Size and Ploidy Level in Selected *Parthenium* Species and Their Interspecific Hybrids

2. Crop Development, Production, and Protection – DuPont Room
Moderator: Mary Purcell-Miramontes, USDA-NIFA

1:30 PM	Mary Purcell-Miramontes, USDA National Institute of Food and Agriculture, Washington,	Panel Introductions and Overview

	D.C.	
1:40 PM	Pam Ronald, University of California-Davis, Davis, CA	Identification of Genes Controlling Disease Resistance to Mitigate Disease Pressure of Bioenergy Crops
2:00 PM	Bingyu Zhao, Virginia Tech University, Blacksburg, VA	Management of Switchgrass Rust Disease by Deploying Host Resistant Genes and Monitoring Dynamics of Pathogen Populations
2:20 PM	Ted Wilson, Texas A & M University, College Station, TX	Managing Insect Pest in Multi-Use Landscapes of Bioenergy and Conventional Cropping Systems in the Gulf Coast
3:00 PM	**Break**	
3:20 PM	Michael Cunningham, ArborGen, Inc., Tallahassee, FL	Developing Woody Crops as a Feedstock for Advanced Biofuels in the Southeast
3:40 PM	Ken Vogel, USDA-ARS, Lincoln, NE	20 Years of Selection for Increased Biomass Yield in Switchgrass
4:00 PM	Jeff Volenec, Purdue University, West Lafayette, IN	Evaluating Perennial Grasses in Diverse Cropping Systems in the Central United States
4:20 PM	Question and Answer	
	Poster Session 7 PM to 9 PM	
43	Tim Meehan, University of Wisconsin, Madison, WI	Landscape Structure and Natural Pest-Suppression Services in Bioenergy Landscapes: Implications for Regional Food and Fuel Production
44	Gregg Johnson, Department of Agronomy and Plant Genetics, University of Minnesota, St. Paul, MN	The Role of Diversified Bioenergy Cropping Systems in Enhancing Biological Control of the Soybean Aphid
45	Scott Sattler, USDA-ARS Grain, Forage and Bioenergy Unit, Lincoln, NE	The Impacts of Lignin Modifications on Fungal Pathogen and Insect Interactions in Sorghum
46	Brian McCornack, Kansas State University, Manhattan, KS	Impact of Bioenergy Crops on Pests, Natural Enemies and Pollinators

		in Agricultural and Non-crop Landscapes
47	Surinder Chopra, Pennsylvania State University, University Park, PA	Evaluation and Mitigation of Anthracnose Disease Pressure due to the Introduction of Sorghum for Feedstock Production

3. Co-Products from Bioenergy Crops - New Hampshire Ballroom, III
Moderator: Shing Kwok, USDA-NIFA

1:30 PM	Jeff R. Broadbent, Utah State University, Logan, UT	Enhancing the Value of Biofuels Derived from Algae and Perennial Grass Feedstocks through Integration of a Lactic Acid Fermentation
1:55 PM	Claire Vieille, Michigan State University, East Lansing, MI	Engineering Succinate Production by *Actinobacillus succinogenes* on Glycerol
2:20 PM	Matthew J. Morra, University of Idaho, Moscow, ID	Biodiesel Co-Products from Brassicaceae Oilseeds
2:45 PM	Joseph Chappell, University of Kentucky Research Foundation, Lexington, KY	Engineering High Value Oil Production into Biofuel Crops
3:10 PM	**Break**	
3:30 PM	Nicole R. Brown, The Pennsylvania State University, University Park, PA	From Industrial Wastes to a Fuel Briquette
3:55PM	Simo Sarkanen, University of Minnesota, Minneapolis, MN	Cogent Design of Lignin-Based Plastics
4:20 PM	William Tze, University of Minnesota, Minneapolis, MN	Binderless Films as Co-Products of Biomass Saccharification
	Poster Session 7:00-9:00 PM	
48	Kevin Edgar, Professor of Biomaterials, Virginia Tech, Blacksburg, VA	Nanocontrol of Polysaccharide Derivative Structure and Function: Mechanism and Scope of TBAF-Catalyzed Deacylation
49	Mary Rezac, Department of Chemical Engineering, Kansas State University, Manhattan, KS	Catalytic Hollow Fiber Membrane Modules for Use in Three Phase Reactor Systems: Understanding the Influence of Membrane Area on Reaction Rate
50	Ronald Sabo, USDA Forest Service Forest Products Laboratory, Madison, WI	Nanofibrillated Cellulose as a Biofuel Co-Product

51	Zhiliang (Julia) Fan, Department of Biological and Agricultural Engineering, University of California-Davis, Davis, CA	A Self-Excising β-Recombinase/Six Cassette for Repetitive Gene Deletion in *Neurospora crassa* and Homokaryon Purification
52	Mario R. Eden, Department of Chemical Engineering, Auburn University, Auburn, AL	Fuel and Oxygenate Co-Products from Biomass Fractionation and Advanced Catalytic Conversion Processes

4. Education and Extension – Potomac Room
Moderator: Daniel Cassidy, USDA-NIFA

1: 30 PM	Daniel Cassidy, USDA National Institute of Food and Agriculture, Washington, D.C.	Panel Introductions and Overview
1:40 PM	Corinne Johnson Rutzke and Nirav Patel, Cornell University, Ithaca, NY	Bioenergy and Bioproducts Education Partners (BBEP): High School Students' and Educators' Attitudes Toward Renewable Energy Education (REE)
2:00 PM	William G. Hubbard, The University of Georgia, Forest Resources Building, Athens, GA	Education and Outreach Efforts to Accelerate the Deployment of Advanced Biofuels in the Southeast: A Southeastern Partnership for Integrated Biomass Supply Systems (SE-IBSS) Update
2:20 PM	Kevin Zobrist, Washington State University, Pullman, WA	Information, Development, and Transfer to Accelerate Deployment of Advanced Biofuels in the Pacific Northwest
2:40 PM	Sorrel Brown, Iowa State University, Ames, IA	Information Development and Transfer to Accelerate Deployment of Advanced Biofuels in the Central United States
3:00 PM	**Break**	
3:20 PM	Krishnaswamy Nandakumar, Louisiana State University, Baton Rouge, LA	Bioenergy Education and Workforce Development to Serve the Growing Advanced Biofuel Industry in the Gulf States
3:40 PM	Vik Yadama, Washington State University,	NARA's Outreach Efforts

	Pullman, WA	in Promoting Biofuel Infrastructure in the Pacific Northwest
4:00 PM	Hedi Lauffer, University of Wisconsin, Madison, WI	Developing a Community Vision for Teaching and Learning Bioenergy and Sustainability Concepts in a Place-based and Culturally Relevant Context
4:20 PM	Question and Answer	

5. Policy/ Socioeconomics – City Center Room, I
Moderator: Fen Hunt, USDA-NIFA

1:30 PM	Henry Bryant, Texas A&M University, College Station, TX	Effects of Sugar and Bioenergy Policies on Potential Production of Advanced Fuel Alcohols in the Southeastern U.S.
1:40 PM	Jonathan Yoder, Washington State University, Pullman, WA	Effectiveness of a Pacific Northwest Revenue-Neutral Carbon Tax in the Context of Federal Biofuel Policy
1:50 PM	Corey Miller, Mississippi State University, Starkville, MS	Policies to Develop Perennial Grass-Based Advanced Biofuel Supply Chains in the Southeast U.S.
2:00 PM	Christopher Galik, Duke University, Durham, NC	The Effect of Existing and Novel Policy Option on the Sustainable Development of Regional Bioenergy Systems
2:10 PM	Tim Meehan, University of Wisconsin, Madison, WI	Evaluating Policy Incentives for Regional Biofuels Production Systems with a Scenario-Based Decision Support Tool
2:20 PM	Cass Moseley, University of Oregon, Eugene, OR	Regional Bioenergy Policy Effectiveness: Compatibility, Innovation, and Coordination across the Supply Chain

2:30 PM	Darin Saul, University of Idaho, Moscow, ID	Socioeconomic Impacts of Wood-Based Biofuels Development Strategies on Northern Rocky Mountain Communities in the Northwest
2:40 PM	Q & A	
3:00 PM	**Break**	
3:20 PM	Satish Joshi, Michigan State University, East Lansing, MI	Decision Support Systems for Regional Planning and Impact Assessment of Biorefineries
3:30 PM	Burt English, University of Tennessee, Knoxville, TN	Optimal Location of Cellulosic Biofuel Facilities and Their Impact on Employment in the Southeast Region
3:40 PM	Jingxin Wang, West Virginia University, Morgantown, WV	Economic and Environmental Impacts of Woody Biomass Utilization in the Central Appalachian Region
3:50 PM	Pankaj Lal, Montclair State University, Montclair, NJ	Assessing Socioeconomic Impacts of Forest Biomass Based Biofuel Development on Rural Communities in the Southern U.S.
4:00 PM	Peter Brosius, University of Georgia, Athens, GA	Social Acceptability of Bioenergy in the U.S. South
4:10 PM	Haluk Gedikoglu, Lincoln University of Missouri, Jefferson City, MO	Socio-Economic Factors and Adoption of Energy Crops
4:20 PM	Jim Finley, Pennsylvania State University, University Park, PA	Socioeconomic Impacts of Biofuels on Rural Communities
4:30 PM	Q & A	
4:50 PM	Discussion	
5:00 PM	Adjourn	

6. Medicinal and Nutraceutical Plants, City Center Room II
Moderator: Brad Morris, USDA, ARS, Griffin, GA

1:30 PM	Michael Grusak, USDA-ARS, Houston TX	Stable Isotope Technologies to Assess Phytochemical Absorption and

		Metabolism in Humans
2:00 PM	Joe-Ann McCoy, Bent Creek Medicinal Germplasm Repository, Asheville, NC	The NC Arboretum Medicinal Germplasm Repository, Asheville, NC
2:20 PM	Rodolfo Juliani, New Use Agriculture and Natural Plant Products Program. School of Environmental and Biological Sciences (SEBS), Rutgers, New Brunswick, NJ	Quality and Chemistry of New Spices from the Guinea Forest of Liberia
2:40 PM	Dipak Santra, Panhandle Research and Extension Center, University of Nebraska-Lincoln, Scottsbluff, NE	Evaluation of Fenugreek (*Trigonella foenum-graecum* L.) Germplasm for Diosgenin, Galactoamannan, and 4-Hydroxyisoleucine
3:00 PM	**Break**	
3:20 PM	Diana Jasso de Rodriguez, Universidad Autónoma Agraria Antonio Narro; Coahuila, México	Aloe Vera Bagasse Extracts as Potential Control of Postharvest Fungal Diseases
3:40 PM	Robert Imel, Department of Plant and Soil Science, Texas Tech University, Lubbock, TX	Sustainable Production of Guar (*Cyamopsis tetragonoloba* L.) in the Arid Southwest
4:00 PM	**Medicinal and Essential Oils Crop Germplasm Committee (CGC)** Chair – Brad Morris, USDA, ARS, Griffin, GA	
5:00 PM	**Medicinal and Nutraceutical Plants Division Meeting** Chair Brad Morris, USDA, ARS, Griffin, GA	
	Poster Presentations 7:00-9:00	
53	Brad Morris, USDA-ARS, Griffin, GA	Genetic Variability for Phenotype, Seed Production, Oil Content, and Fatty Acid Composition among 17 Roselle (*Hibiscus sabdariffa* L.) Accessions
54	José Ángel Villareal, Universidad Autónoma Agraria Antonio Narro; Coahuila, México	*Jatropha dioica* Antifungal Effect on *Fusarium oxysporum* Control in Tomato
55	Diana Jasso de Rodríguez, Universidad Autónoma Agraria Antonio Narro; Coahuila, México	*Flourensia cernua* Potential Antifungal for *Fusarium oxysporum* Control in Tomato

Wednesday October 16 – Plenary Session New Hampshire Ballroom

Moderator: Dennis Ray, University of Arizona, Tucson, AZ

8:30 AM	Peter Arbuckle, USDA, National Agricultural Library, Washington D.C.	New Digital Commons Database to Deposit Data for Lifecycle Analysis
9:00 AM	Ken Moore, Agriculture and Food Research Initiative Coordinated Agricultural Project (CAP), Iowa State University of Science and Technology, Ames, IA	CenUSA Agro-Ecosystem Approach to Sustainable Biofuels Production via the Pyrolysis-Biochar Platform
9:30 AM	Tim Rials, Agriculture and Food Research Initiative Coordinated Agricultural Project (CAP), University of Tennessee, Knoxville, TN.	The IBSS Partnership: Deploying an Advanced Biofuels Industry in the Southeast
10:00 AM	Break	
10:30 AM	Edgar Spalding, University of Wisconsin, Madison, WI	Machine Vision for Quantifying Dynamic Phenotypes in Mutant and Naturally Varying Populations
11:00 AM	Louise Comas, USDA-ARS, Fort Collins, CO	Root Traits Contributing to Plant Productivity Under Drought
Noon	**Lunch on your own**	

1. Oilseeds for Bioenergy and Bio-materials II - New Hampshire Ballroom, III

Moderator: Liv Severino, EMBRAPA, Brazil

1:30 PM	Terry Isbell, USDA-ARS, Peoria, IL	Overview of session
1:40 PM	Matt Jenks, USDA-ARS, Maricopa, AZ	Genetic and Phenotypic Variation for Germplasm Improvement in the Brassicaceae
2:00 PM	Michael Gore, Cornell University, Ithaca, NY	Genetic Diversity and Population Structure of *Brassica napus*
2:20 PM	Terry Isbell, USDA-ARS, Peoria, IL	Rapid Non-Destructive and Wet Chemical Methods for the Analysis of Glucosinolates, Chlorophyll, Oil, and

		Fatty Acids in Brassica Germplasm
2:40 PM	Dan Long, USDA-ARS, Adams, OR	In-Line Optical Sensing of Seed Oil Concentration to Improve Extraction Efficiency
3:00 PM	**Break**	
3:20 PM	David Archer, USDA-ARS, Mandan, ND	Development of an Economic model for HRJ oilseeds in the Wheat Belt
3:40 PM	Dan Ellig, UOP Honeywell, Des Plaines, IL	Production of Hydrotreated Renewable Jet (HRJ) Fuel from Oil Seed Feedstocks
4:00 PM	John Sulik, USDA-ARS, Adams, OR	A Low Cost Approach for Regional Estimation of Oilseed Supply Using Satellite Remote Sensing
4:30 PM	**Oilseed Division Meeting** Chair, Liv S. Severino, EMBRAPA, Brazil	

2. Scientific Writing Workshop – Foggy Bottom Room

Moderator: Elaine van Ommen-Kloeke, Elsevier Editorial

3:00-5:00 PM	Editors-In-Chief panel: Dennis Ray, Maria Jesus Pascual-Villalobos, and Marisol Berti

Awards Banquet

6:30 PM	Mixer	No host bar
7:00 PM	Dinner	
8:00 PM	"AAIC After 25 Years: A Generally Fact-Based Overview"	William W. Schloman, Jr. Akron, OH
8:45 PM	AAIC Awards	Colleen McMahon, USDA, ARS, Albany, CA
9:30 PM	Close	

PLENARY SESSION

ADVANCED HARDWOOD BIOFUELS NORTHWEST A MULTIDISCIPLINARY RESEARCH PROGRAM TO PRODUCE SUSTAINABLE BIOFUELS FROM WOODY BIOMASS.

R. Gustafson[1], B.J. Stanton[2]

[1]Green Wood Resources, Portland, OR

The Advanced Hardwood Biofuels Northwest AFRI CAP project (AHB) will prepare the Pacific Northwest for a renewable biofuels industry using a sustainable feedstock production system for purpose-grown woody perennial energy crops. Hybrid poplar (*Populus*) is the featured crop. AHB will mitigate technology risks along the entire supply chain so that an advanced biofuels industry emerges in the Pacific Northwest making significant contributions towards the region's Renewable Fuel Standard Two (RFS2) targets. AHB will revitalize the region's forestry and farming industries, delivering a sustainable advanced biofuels industry that brings jobs to rural communities. AHB is comprised of five core areas:

FEEDSTOCK – Large-scale hybrid poplar demonstration plantings are being managed within four strategic regions in Idaho, Washington, Oregon and California to demonstrate biomass yields, production economics, harvesting practices, and the sustainability of the feedstock system. The feedstock effort includes research in exploratory hybridization of new taxa and novel stand management techniques to increase yields and lessen farming costs and environmental impacts.

CONVERSION – Efficient processes are being developed for converting biomass into hydrocarbons that are 100% compatible with existing transportation fuel infrastructure and ones that produce high-value chemical intermediates. These processes build on ZeaChem's woody biomass-to-ethanol technology and include catalytic dehydration and oligomerization as well as advanced sensors control systems.

SUSTAINABILITY – AHB is assessing the regional economic, environmental, and social impacts of a large biofuels industry. Life cycle assessments are employed to measure environmental impacts. An economic/spatial lands model is integrated with a bioenergy systems model to find the optimal location and size for bio-refineries and hybrid poplar plantations.

EXTENSION – Extension serves as the interaction hub for all AHB stakeholders and external communities. A database of interested parties and constituents has been created in a comprehensive outreach effort that has included numerous community presentations, field tours, promotional videos, and the interactive AHB web site. A priority outreach constituency is the land owner/farming community that is needed to grow the feedstock.

EDUCATION – Successful commercialization of a biofuels industry requires a well trained work force of agronomists, engineers, scientists, analysts, and business executives. The AHB education project has developed comprehensive programs for middle and high school courses of study, community college associate's degree program and a university research-based curriculum.

The talk will outline what we have accomplished in the first two years of the project and the work planned for the remainder of the program.

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NORTHWEST ADVANCED RENEWABLES ALLIANCE: A NEW VISTA FOR GREEN FUELS, CHEMICALS, AND ENVIRONMENTALLY PREFERRED PRODUCTS (EPPs)

M. Wolcott, R. Cavalieri

Washington State University, Pullman, WA 99164

The US faces the challenge of rapidly developing and diversifying our domestic liquid transportation fuel supply supply. This goal can be reached through simultaneously developing intermediates for bioproducts and biopolymers. With established oil refining and distribution assets, a high need for military and commercial aviation fuels, and abundant woody biomass currently at scale, the Northwest is well positioned to deliver such bio- based aviation fuels and products within 5-years. Thus, the Northwest Advanced Renewables Alliance (NARA) has been created to both address and develop regional sustainable solutions for aviation fuel and key bioproducts from sustainable woody resources in the Pacific Northwest.

For years, the focus on biofuels development has aimed at the twin targets of feedstock development and conversion technologies. But despite extensive effort, no clear feedstock or technology winner in sight. Relatively little work has addressed gaining efficiencies in the biofuels industry through supply chain efficiencies. Recently, the USDA National Institute for Food and Agriculture (NIFA) funded a number of Coordinated Agricultural Projects (CAP aimed at developing regional feedstock supply chains for the biofuels industry. The Northwest Advanced Renewables Alliance is one such effort aimed at development of sustainable aviation biofuels from woody biomass. Unlike other efforts to develop new energy crops, NARA is focused on the capacity of the Pacific Northwest to sustainably supply feedstocks from the residuals of our existing timber supply chain. The challenge to envision a biofuels industry must not only consider the feedstock and technical demands of a specific conversion technology but must also consider the existing forest products infrastructure that generates and consumes feedstock as well as the petroleum industry which supplies the current fossil fuels and would have to integrate the new biofuel into its infrastructure. The capacity of regional communities to act collectively and provide a skilled workforce, the local and national governments to develop effective policy, and the regional environmental capacity to sustainably supply the feedstock, water, and air resources are key to a successful development. Efficient and resilient supply chains will only prosper where these factors align to work in concert.

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RENEWABLE JET FUEL: MARKETPLACE PULL AND COMMERCIALIZATION PROGRESS

S. Csonka

CAAFI (Commercial Aviation Alternative Fuels Initiative)

This presentation will provide context for the interest of the jet-powered aviation enterprise in pursuing the near-term, wide-spread introduction and commercialization of renewable, drop-in jet fuel. Details around current efforts and explorations will also be discussed, including interest in multiple feedstocks, conversion methodologies, and commercial approaches. Current challenges, and various efforts being pursued by CAAFI and its participant coalition to overcome such challenges, will also be highlighted and discussed.

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OILSEEDS FOR BIOENERGY AND BIOMATERIALS I

ABSTRACTS PRESENTATION

BUILDING A CASTOR (*Ricinus communis* L., Euphorbiaceae) GERMPLASM COLLECTION IN SPAIN

M.J. Pascual-Villalobos [1], L. Velasco[2], A. Robledo [3], X. He[4], T. McKeon [4], M.D.López[1], J.M. Fernández[2]

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Castor plant (*Ricinus communis* L.) is a member of the spurge family and a minor non-food oilseed crop at a world scale, and this plant has great potential as a raw material for biorefineries. Over 95% of the castor oil production is based in India, China, Mozambique, and Brazil, but there is potential to grow *R. communis* in semiarid temperate regions.
Accessions of the major castor germplasm collections come from tropical or subtropical areas. Therefore, the objective of our research was to collect genetic resources from the semi-wild castor populations in Spain or at least from a representative group of samples that would include the main variability present in the Mediterranean region.
A total of 119 castor populations were surveyed between 2010 and 2012 in south and southeast Spain. Data on the plant growth type and height, capsule dehiscence, colour of stems and capsules, and seed size were recorded. Seeds were analysed for oil content, fatty acid composition and tocopherol content and profile. The ricin (toxic protein) content of the extract was separated by SDS-PAGE and Western blot analyses for a group of 17 accessions. The relative abundance of the protein was determined by comparison with the standard Hale variety.
The seeds varied greatly in colour, mottling and size (113-718 mg). Two common plant phenotypes were observed: 1) tall with an extremely red colour that is usually associated with indehiscence and 2) short green dehiscent plants. Some genotypes were noted for growing like trees, having spineless capsules or exhibiting huge, round seeds. The average seed oil content was 49.77% and ranged from 42.50 to 55.91%. All accessions had high ricinoleic acid contents, ranging between 84.96 and 91.16% of the total fatty acid content and resulting in a high oil viscosity. The total tocopherol content ranged from 88.27 to 405.05 mg/kg of seeds. The gamma-tocopherol (56.14%) and the delta-tocopherol (39.29%) were the main homologues present in the profile, though small amounts of alpha-tocopherol (4.06%) and beta-tocopherol (0.51%) were present. Some populations were noted for having over 65% gamma- or over 55% delta-tocopherol. Seed from wild plants synthesize more ricin than cultivated plants and if castor is grown, the location has an influence in its content too. The collection contains populations that are lower ricin compared with Hale but further experiments are needed to confirm these results.
We have built a Spanish germplasm collection of *R. communis* that includes local populations in risk of extinction and represents the main variability present on the Iberian Peninsula. Accessions include high yielding types with compact racemes of large seeded, indehiscent capsules. The characterisation and sharing of these genetic resources is important for the development of castor varieties that will grow in temperate regions.

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ROOT PHENOTYPING OF NEW OILSEED CROP LESQUERELLA GERMPLASM

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The utility of germplasm collections rely on the availability of associated characterization and evaluation data for researchers and germplasm users. The information enables users to select accessions with characters of interest thereby saving time and resources. Most germplasm collections in the US National Plant Germplasm System have been characterized and the phenotype data made available through the GRIN database. These data consist mostly of measurements on above ground traits with the exception of germplasm whose primary plant part of interest are roots, bulbs, and tubers. An increasing volume of publications point to roots as the next frontier in plant science since improvements in above ground parts seem to have plateaued. Several genebanks have ongoing research on root characterization to anticipate the need for additional information on their conserved materials, or directly assist in research and crop improvement programs. At the National Center for Plant Genetic Resources Preservation, initial efforts on root characterization focus on lesquerella (*Physaria*) germplasm.

Here we report the results of preliminary root phenotyping activities using root growth pouches on eighteen accessions and field established plants of two accessions (WCL-LO4 and PI 596434) grown in Maricopa, AZ.

Lesquerella plants in the growth pouches were kept for 21 days under two temperature regimens (21/13^{o}C and 30/21^{o}C) and the roots analyzed for nine root parameters. Plants in the field were sampled at the crop's vegetative, flowering, and pod maturity stages during the growing season (25, 84, 114, 137, and 180 DAE), and root measurements were taken from soil core samples and whole washed root systems. Comparisons between results from the pouches and the vegetative stages were made and the root development in the documented species. Succeeding work on root screening in lesquerella germplasm will be discussed including root characterization of other new crop oilseed collections as part of routine genebank operations.

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AIR TEMPERATURE INFLUENCING CASTOR SEED GROWTH

L.S. Severino[1], D.L. Auld[2]

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Castor (*Ricinus communis* L.) is a tropical heat-loving plant that sometimes is cultivated in regions that experience chilling temperatures for some weeks prior to harvest. We observed in previous studies that fruit maturation was very slow at the end of the growing season even when air temperatures would not have limited a temperately-adapted crop. The slow maturation would probably reduce seed yield because the plant had many immature racemes when the killing frost occurred. In most species, the linear phase of seed growth (in which the reserves accumulate) is not sensitive to the physiological condition of the mother-plant but more significantly influenced by environmental conditions.

The objective of this study was to measure the influence of air temperature during early Fall on castor seed growth rate and to calculate the base temperature for this physiological process.

The experiment was conducted in field conditions at the Experimental Farm of Texas Tech University (Lubbock, TX, 33˚ 36' N latitude, 990 m of altitude). Twenty castor plants cv. Brigham grown under irrigation were used in this study. Racemes were tagged when female flowers were just opened, and capsules were harvested every five days until they reached maturity (brown color). Seeds were manually extracted, weighed, oven dried, and weighed again. Data on air temperature at 5-min intervals was registered from tagging the raceme through harvesting the fruits. Calculations were made using regression analysis with the Logistic Model and the data on thermal time, seed moisture content, and seed dry weight. Simulations were made with base temperatures (T_b) varying from 0 to 25˚C with 1˚C increments in order to determine the temperature that the best explained castor seed growth using a degree-days approach.

We found that the base temperature for castor seed growth was 15˚C. This level of T_b is typical of a tropical plant and considerably higher than most temperate-adapted crops. A castor seed required 464 degree-days to reach physiological maturity. In the conditions of Lubbock, TX, the seed growth rate varied from 13.8 g day^{-1} in the racemes initiated at 31-July to 4.3 g day^{-1} in the racemes initiated at 20-Aug. The reduction in seed growth rate was closely related to the air temperature observed during the growth of each raceme. The linear phase of seed growth took around 17 days in the racemes initiated early in the growing season but as much as 53 days in the racemes initiated in late summer. Air temperature during seed maturation should be regarded as a major factor influencing castor seed yield.

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PERFORMANCE OF FIVE CASTOR (*Ricinus communis* L.*)* CULTIVARS IN GEOGRAPHICALLY DIVERSE ENVIRONMENTS IN NORTH AMERICA

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Castor is an important industrial crop which produces the unique fatty acid, ricinoleic acid. Ricinoleic acid is used in the production of nylon, cosmetics, lubricants, and also has medicinal uses. Currently most North American castor is imported from the world's top producers (India, China, and Brazil).

Our objective for this study was to find suitable growing environments and cultivars to increase North American production of seed and oil.

Over the past two years, five cultivars were planted at six geographically diverse locations across North America. The study was planted in a Latin square plot design with five replications. Each plot was four rows wide, five meters in length, and spaced one meter apart. Data were collected from one meter of each of the center two rows. Seed weight and oil content were measured from seed grown at all locations.

Our results indicated that castor was well suited to several diverse environments of North America and appears to be adapted to areas with shorter growing season of temperate regions while still producing good seed and oil yields.

In the future it is hoped that with this information castor can be grown competitively across most of North America.

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HIGH OIL CANOLA BREEDING IN NORTH DAKOTA

M. Rahman

Department of Plant Sciences, North Dakota State University

North Dakota is the leading canola producing state in the USA with about 88% of the US production. The 2012 acreage in ND was over 1.6 million acres. North Dakota State University (NDSU) initiated a canola breeding program in 2006. The goal of this program is to increase the competitiveness of ND in the production and processing of canola oils and biodiesel. Breeding for high oil per acre canola is the prime objective of the NDSU canola breeding program. A wide range Brassica germplasm have been obtained from both private and public sector across the world. Crossing and backcrossing have been conducted between genetically diverse winter type and spring type canola, spring type and spring type canola to develop new breeding lines with desirable traits. Interspecific crosses were also made among *B. napus*, *B. rapa*, *B. juncea*, and *B. carinata* to modify and improve the oil profile of canola. Canola double haploid production and molecular marker technology is already in place to accelerate the line development program. Both greenhouse and wide range growth chamber are being utilized to grow canola in controlled environment. The capacity of field plot testing and harvesting program is over 5,000 plots per year at eight trial locations across the state. Off-season (winter) nursery is located in Santiago, Chile that significantly reduced the breeding cycle to get homozygous breeding lines and sufficient seeds for following summer trials. The field testing program is fully equipped with Hege 6-row planter, new R-Tech swater, Wintersteiger combine with harvest master, tractor, cultivator, truck, trailer etc. The seed quality lab is equipped with near infrared spectrophotometer for seed oil, seed protein, and fatty acid profile analysis. Although the breeding program is comparatively new, the first high oil variety (NDSU-662c) was released from this program in 2011. Several hybrids showed outperforming in the state run canola variety trials with other commercial hybrids. One of the selected hybrids produced the highest oil yield per acre over 39 different commercial hybrids in 2012. The selected hybrid is in progress to be released in North Dakota.

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CAMELINA GROWTH AND YIELD RESPONSE TO PLANTING RATE AND DEPTH

R.W. Gesch[1]

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Camelina (*Camelina sativa* L.) holds good potential as an oilseed feedstock for biofuels and bioproducts. Developing sound agronomic practices for its production is vital to optimizing its oil yield potential. Plant stand establishment for camelina in some environments has been problematic. This may in part be related to its small seed size and current recommendations to plant it relatively shallow (surface to ≤ ~1 cm). Shallow planting can diminish seed to soil contact and expose seeds to greater fluctuations in temperature and moisture, which greatly affect germination and emergence.

The objective of the following study was to determine the influence of seeding depth and rate on emergence, plant growth, and seed yield of camelina. To accomplish this, a 2-year field study (2011 and 2012) was conducted on a Barnes loam soil in west central Minnesota, USA using spring camelina (cv. CO46) in a split-plot randomized complete block design to test the effects of three planting depths (1, 2, and 4 cm) and three seeding rates (2, 3, and 6 kg ha^{-1}).

Seedling emergence and final plant stands decreased with increased planting depth and decreased seeding rate. However, in 2012, the difference between the 1 and 2 cm depths was not significant. In both years, seed yields were affected by planting depth but not rate. Seed yields on average were decreased 21 to 29 % when seeded at 4 cm, but there was no difference between the 1 and 2 cm depths. Harvest index of camelina was unaffected by depth and rate of planting. However, the amount of seed per plant increased with decreased plant population associated with increased planting depth and decreased rate.

Results indicate that camelina has good yield plasticity and further shows that planting depth can be increased from what has been commonly recommended without sacrificing yield. Planting deeper may be beneficial for certain soils prone to large temperature and moisture fluctuations at planting time.

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WINTER CANOLA ADAPTATION IN NORTH DAKOTA

B.L. Johnson[1], P.J. Petersen[1]

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Cropping systems including winter annuals improve pest management in systems traditionally dominated by small grain production, and potentially enable double and extended cover cropping systems. The study objective was to screen winter canola genotypes for winter survival under the rigorous over-wintering conditions presented in North Dakota. Winter canola genotypes have been screened from fall of 2002 to present in a RCBD replicated field study conducted at the Prosper research site 24 km northwest of Fargo, ND. Each fall (late Aug. to mid Sept.) genotypes (20 to 50) were sown at 5.6 kg/ha into standing hard red spring wheat stubble approximately 25 cm tall. Plots are 6 rows each spaced 30 cm apart and 7.6 m in length sown with a six-row plot drill with double-disk openers and twin-vee packer wheels. Traits evaluated include fall stand, winter survival, spring stand, flowering, plant height and lodging, seed yield, test weight, and oil content. Mean genotype fall stand establishment has been greater than 80% each year, but mean genotype winter survival, recorded the following spring, has ranged from 2 to 98%. Consequently, spring stands are often below minimum densities for high seed yield production and also lack uniformity in plant spacing. Among the ten years of genotype screening, the trial was abandoned two years because of near zero winter survival, and seed yield was poor five years, with some genotypes yielding from 185 to 451 kg/ha. However, in years 2003/04, 2005/06, and 2007/98, mean genotype seed yield ranged from 1240 to 1240, 1701 to 2109, and 1195 to 2894 kg/ha, respectively. Plant breeding has tremendously improved winter survival as compared to winter canola evaluations in the mid 1980s, when trials consistently had no winter survival among genotypes. Current and future evaluations will probe the relationships between genotype, plant size at onset of fall dormancy, stubble and snow cover/plant crown temperature, soil fertility, and spring weather conditions with winter survival and subsequent spring stands and their performance.

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MODIFICATION OF OIL CONTENT IN COTTONSEED USING CHEMICAL MUTAGENESIS

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During the period of 1991 to 2006, U.S. growers planted in excess of 13 million acres of cotton annually. However, over the past seven years the U.S. has planted an average of only ~11 million acres of cotton annually due to increased competition with of corn, soybean, and wheat production. One of the ways to enhance the economic competitiveness of cotton production in the U.S. is to increase the oil content of cottonseed. Today, we are focusing on its importance, history, and current work at Texas Tech University in modifying cottonseed oil content. Since 1899 cottonseed oil has been a major co-product of fiber production in the U.S. In 2013, cottonseed ranked third behind soybean and corn oils in U.S. annual production. Cottonseed oil has been used to produce margarine and frying oil. Since most cotton seed oil and meal is marketed domestically, improving the value of cottonseed represents a potential strategy to enhance the gross value of cotton produced in the U.S.

The work at Texas Tech University initially concentrated on decreasing the total oil content under the assumption that if photosynthetic energy normally used to make lipids in the seed were diverted to enhanced cellulose deposition perhaps there would be an increase in total lint yield. Lines with as low as 11 to 15% oil were identified from our mutant populations. However, the low oil lines did not demonstrate an increased cotton lint yield. Currently, our hypothesis is that by enhancing oil content in cotton seed we might improve the economic competitiveness of cotton.

Delinted oil contents ranged from 15 and 33% in Upland cotton varieties (*G. hirsutum* L.) and higher percentages might be identified. Work in ours and in Dr. Kent Chapman's laboratory have identified individual lines with 26 to 30% oil content as determined by Time Domain Nuclear Magnetic Resonance (NMR).

Currently, we are evaluating several thousand mutant lines for developing high oil lines of cotton. Hopefully, these high oil lines will help ensure the continued economic viability of U.S. cotton production without negatively impacting total lint production.

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LOW TEMPERATURE HYDROGENATION OF SOYBEAN OIL AND MODELING STUDIES FOR SELECTIVITY ENGINEERING

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A green functional fluid based on vegetable oils must present oxidation and thermal stability without loss of anti-wear performance and cold temperature flow properties while performing the desired mechanical function.

The aim of the present investigation was to conduct the selective hydrogenation of refined soybean oil for the maximum conversion to oleic acid with minimum formation of stearic and trans-fatty acids and to obtain the stable basestock for green functional fluid.

The selectivity engineering in nickel catalysed hydrogenation of soyabean oil in high pressure stirred tank reactor was examined through variation of reaction temperature (100-150°C), hydrogen pressure (2-6kgf/cm^2), catalyst concentration (0.00125-0.1%), stirrer speed (500-900 rpm), and holding period (1/2-8hrs) and subsequent monitoring of the progress of the hydrogenation through evaluation of RI, IV, GC analysis for % fatty acid composition, FTIR analysis for trans fatty acids, and low temperature characteristics of the finished product. Overall, hydrogenation was modelled as series (reduction reactions) - parallel (isomerisation reactions) reactions through nonlinear regression of kinetic and thermodynamic expressions.

The quantitative interpretations of hydrogenation conversion, oleic yield, linoleic, and linolenic selectivity, and production rate of desired fatty acid composition in relation to the reaction parameters have been presented along with the discussions on various feasible reactor options. The present research paper highlights the use of selectivity engineering in processing of vegetable oils as functional fluids with correct Tribological characteristics.

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OILSEED FOR BIOENERGY AND BIOMATERIALS I

POSTER PRESENTATION

SEED OIL CHARACTERISTICS OF WILD FIELD PENNYCRESS (*Thlaspi arvense* L.) POPULATIONS AND USDA ACCESSIONS

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The common winter annual weed *Thlaspi arvense* L. (field pennycress) has been identified as a potential new source for fuel and industrial products. Field pennycress offers a very short life cycle allowing opportunities for double cropping in the Midwest region.
The objective of this study was to collect and evaluate diverse wild populations of field pennycress (*Thlaspi arvense* L.) for potential inclusion in plant breeding programs.
In the springs of 2009-2013, 80 wild populations of field pennycress seed and corresponding GPS data were collected throughout the central United States. An additional 33 accessions from the North Central Regional Plant Introduction Station in Ames, IA were also evaluated. All samples were analyzed for total seed oil on a dry weight basis, oleic acid (c18:1), linolenic (c18:3), and erucic acid (c22), and 1000 seed weight at 9% moisture. Total oil content was determined by nondestructive pulsed NMR on whole pennycress seed, and fatty acid methyl esters were quantified utilizing gas chromatography.
Total oil content ranged from 24.43% to 38.71% across the populations collected in the central US with the highest level being seen in a population from Hope, Michigan. A similar range was seen for the USDA accessions of 24.73% to 38.73% with the highest levels found in Alberta, Canada. Oleic acid ranged from 7.72% to 17.13%, linoloenic acid levels ranged from 8.39% to 15.25%, and erucic acid levels ranged from 27.46% to 38.41%. For the wild populations: latitude, longitude, and altitude data were not strong predictors for total seed oil content, oleic acid, and 1000sw. However, linolenic levels are correlated with longitude and latitude, while eurcic levels are only correlated with latitude. Thousand seed weights ranged from 0.43 to 1.34 g and were not correlated to any GPS data.
Pennycress's unique short growing season, high levels of total oil, and erucic acid content increases its viability for commercialization and potential for plant breeding programs.

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SYNTHESIS AND PHYSICAL PROPERTIES OF NEW ESTOLIDE ESTERS

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Because of their outstanding biodegradability, lubricating, and low temperature properties, interest in estolides has grown significantly over the past three years primarily due to the increase in petroleum prices and the search for acceptable green materials. Estolides are a class of esters based on vegetable oils that in this case are formed when the carboxylic acid functionality of one fatty acid reacts at the site of unsaturation of another fatty acid to form an ester linkage. The secondary ester linkages of the estolides are more resistant to hydrolysis than those of triglycerides and the unique structure of the estolides result in materials that have far superior physical properties for certain applications than vegetable and mineral oils.

The objective of this preliminary study was to synthesize new esters of estolides from either branch or linear chained alcohols and evaluate the physical properties: viscosity, acid value (AV), Gardner color, pour points (PP), and cloud points (CP).

The free acid estolide mixture was synthesized from oleic acids and catalytic amounts of perchloric acid at 60^{o}C. The oleic estolide mixture was separated using the Myers Pilot 15 Molecular Distillation Unit into monomers and oleic free acid estolides. These oleic free acid estolides then underwent an esterification process with either branch or linear chained alcohols under standard conditions with BF_3 to yield the new oleic estolide esters. To ensure low AVs for these new oleic estolide esters, Magnesol®XL was added to the estolide oil at 85^{o}C for 10 min followed by filtration. The physical properties of the material were then measured and recorded.

The oleic free acid estolide that were esterified with branched alcohols had the best low temperature physical properties, PP and CP. The best PP performers from the branched series were 2-hexyldecanol, a 16 carbon chained branched material, and 2-octyldodecanol, a 20 carbon branched material, with a PP at -39^{o}C. The best CP performers from the same series were 2-octyldodecanol, with a CP lower than -50^{o}C, followed by the 2-hexyldecanol at -42^{o}C. In general, the branched alcohols produced materials with better cold temperature properties than current commercially available materials. The viscosities and VIs were as expected in terms of trends and ranges. The iso-stearyl alcohol had the most interesting viscosity at 40^{o}C of 209.3 cSt, which was higher than all other materials tested in this study.

These new oleic estolide esters showed potential as commercial lubricants, many industrial crops that are high in oleic acid would have an advantage in supplying this demand. This could be accomplished either through the use of sunflower, new crop seed oils or even through breeding advancements of traditional crops such as soybean. Whatever the choice, the development of these novel estolide esters will have a significant impact on industrial oleic oils in the future. Additionally, these estolide esters require no additional additives to obtain the improved low temperature performance observed, thus limiting our impact on the environment and reducing our dependence on foreign oil.

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SALINITY OF SODIUM, CALCIUM, AND MAGNESIUM AFFECTING THE EMERGENCE AND EARLY GROWTH OF CASTOR, COTTON, AND SAFFLOWER

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Salinity impacts the plant through osmotic stress in the short term and through ion accumulation to toxic levels in the long term. Na^+ is the most frequent salt affecting crops, but other salts can also cause yield reductions. The toxic effect of Na^+ can be partially alleviated by other cations such as K^+, Ca^{2+}, and Mg^{2+}. The Trans-Pecos is a large region in the States of Texas and New Mexico of the U.S. in which the agricultural production has been historically limited by excessive salinity of the irrigation water. Previous studies found that selected crops were able to tolerate the high levels of salinity of that region.

The objective of this study was to test the hypothesis that the high content of Ca^{2+} and Mg^{2+} in the water of Trans-Pecos region alleviates the toxic effect of Na^+.

A greenhouse experiment was conducted at Texas Tech University (Lubbock, TX). The treatments were 0, 50, 100, 150, 200, and 250% of the water predominantly found in that region (36 mM of Na^+, 22 mM of Ca^{2+}, and 12 mM of Mg^{2+}). The same treatments were repeated without Ca^{2+} and Mg^{2+}. Saline solutions were prepared with tap water in 120-L containers. Commercial fertilizer was added to all solutions in order to reach 18 mM of N, 2 mM of P, and 4 mM of K. The electric conductivity (EC) varied from 0.7 dS m^{-1} in the control treatment to 13.7 dS m^{-1} in the highest salinity. EC was used as a surrogate for the osmotic potential of the saline solution. The tests were made on plants of castor (*Ricinus communis* cv. Brigham), cotton (*Gossypium hirsutum* line DN-1), and safflower (*Carthamus tinctorius* line 672). The effect of salinity on the emergence was also tested in trays with Metromix® as substrate. The effect of salinity on early growth was tested in 12-L pots filled with 0-20 cm soil. Salinity treatments were imposed immediately after the seedlings emerged. Irrigation with the saline solution was performed daily in a volume to allow at least 20% of drainage. Destructive analysis were made after 30 days after emergence.

We did not find evidence of Na^+-alleviation by Ca^{2+} and Mg^{2+} in castor, cotton, and safflower. In general, the plant growth (shoot and root biomass and leaf area) were reduced in a linear proportion to the electric conductivity of the saline solution. A mild salinity (<8 dS m^{-1}) promoted a faster emergence of castor seedlings (priming effect) than the control, but the emergence rate was reduced. Safflower emergence was only marginally affected by salinity. Comparing the EC 0.7 and 13.7 dS m^{-1}, the reduction in shoot biomass was 81% in castor, 83% in cotton, and 96% in safflower. Castor and cotton plants survived 30 days under 13 dS m^{-1}, but most safflower plants died with salinity levels higher than 10 dS m^{-1}.

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CAMELINA-BASED BIOLUBRICANT DEVELOPMENT IN PARTNERSHIP WITH INDUSTRIAL CONSUMERS

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Significant gains have been made in bio-based lubricants since the introduction of a bio-based engine oil in 1996 by Agro Management Group, LLC. Bio-lubricant market demand has increased to an estimated 95 million liters in the United States alone. The American Petroleum Institute (API) has recently implemented approval of bio-based lubricants and the U.S. Government has established independent testing protocols (BEES) for federal marketing of bio-based products. Biolubricants remain off the BEES product listing. Politically, bio-lubricants seem to be continually lumped with bio-fuels such as ethanol, biodiesel, and biojet fuels. However, when considered independently from fuels, bio-lubricants show significantly better performance in terms of emissions reduction, metal wear, and superior metal-working properties.

Camelina has a reputation of heterogeneity of fatty acids unsuitable for manufacture of biolubricants and constraints in direct use as biofuels. Consequently, there is considerable effort in genetic modification of the oil to make it resemble GMO canola- or GMO soy-oleic oils. Our approach provides flexibility by modifying the conventional camelina oil chemically to suit specific needs beyond genetic conversion to a mono-unsaturated fatty acid source application.

Camelina oil was extracted using a cold-press system. The crude oil was fractionated into free fatty acids and glycerin using an acid catalyst and an ultrasonic protocol. The free fatty acids were isolated and subjected to a ClearSkies' protocol to cross-link proprietary phenolics to generally targeted unsaturated PUFA positions (delta-12 and delta-15) on the camelina fatty acid chains and linked linearly into long-chain wax-esters by propyl alcohols. The resulting wax esters mimic the heterogeneity generally found in petroleum-based lubricants and became the basis of manufacture of motor oils, gear oils and extreme pressure lubricant applications.

Test results from industrial laboratories have shown the potential for commercial use of several related products derived from camelina oil.

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DEHULLING OF CORIANDER FRUITS BEFORE OIL EXTRACTION

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Coriander (*Coriandrum sativum* L.) is summer annual traditionally grown for use as fresh green herb or as spice. The essential oil extracted from coriander fruit is also widely used as flavoring in a variety of food products. The triglyceride (oil) fraction in the fruit is rich in petroselenic acid (cis 6-octadecenoic acid) which has the potential to be converted into lauric and adipic acids. Lauric acid is a raw material in the manufacture of emulsifiers, detergents, soaps, and other personal care products. Adipic acid, on the other hand, is used in the production of engineering plastics. A survey of known coriander germplasm has identified accessions with short growing seasons (84 days from planting to harvest). This rapid growth and maturation make coriander suitable for a double crop rotation through much of the Midwestern US where winter wheat is produced. Winter wheat is planted in fall and harvested around the first week of July providing nearly 100 days of frost-free days for coriander production. Integrating coriander as a second crop will provide oil for industrial use without displacing a crop for food production. The coriander fruit is globular or ovate and made up of two mericarps. Each mericarp contains one seed. The coriander fruit has low bulk density (274 g/L) due to the void space between the mericarps and the high proportion of the fruit's weight as hulls (44%). Dehulling is employed whenever it is practical to do so. Removing the seed hulls increases the throughput of the oil extractor, reduces wear of screw press parts, and increases the protein content of the meal. In pressing, hulls act as a pressing aid and improve press performance.

The objective of this study was to evaluate the feasibility of dehulling coriander fruits as part of the seed preparation before oil extraction.

Mechanical dehulling was carried out by first splitting the fruits using and impact mill, removing the fines using a 16-mesh screen, and then aspirating the free hulls from the seeds and split fruits. The denser seed fraction had 30% oil content. The fines and free hulls recovered accounted for about 45% of the total weight and contained <4% oil. The residual oil in the hulls was lower than what one would expect in a press cake but higher than that of the hexane-defatted meal. This simple method of dehulling can be easily incorporated as part of seed preparation for oil extraction by screw pressing.

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MODELING SOIL ORGANIC CARBON CHANGE IN OILSEED CROPPING SYSTEM IN NORTH DAKOTA

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An important driver for the adoption of renewable fuels is the reduction in greenhouse gas (GHG) emissions, and the quantity of greenhouse gas reductions achieved is used in determining the fuel feedstocks and conversion pathways that can be used for fuels to meet the U.S. renewable fuels standard. Estimating GHG emissions from cropping system is an important component in quantifying GHG emissions through the entire process from feedstock to final product use for oilseed based renewable fuels. Soil organic carbon (SOC) change is a key measure for calculating GHG emission from cropping systems because an increase of SOC is regarded as CO_2 deposition from atmosphere to soil. Even though many researchers have simulated long term impacts of cropping system on SOC, the calibration and validation for C dynamic parameters using long-term soil profile data have been limited.

The objective of this study is modeling long-term SOC change under impact of *Brassica* oil seed cropping systems with calibration and validation of soil C dynamics parameters in the EPIC model.

We validated crop growth parameters from several areas of Northern Great Plains regions using field scale crop yield and management data at Mandan, ND. Soil C dynamics parameters (transformation rate constants of C pools) were calibrated and validated using soil profile data in 1983, 1991, and 2001 from long-term soil quality studies conducted at Mandan, ND since 1983. After calibration and validation, SOC and crop yields were modeled for each SSURGO soil map unit in Ward County, ND, one of pilot counties being evaluated for potential oilseed supply for hydrotreated renewable jet fuel production. The simulation was conducted under two rotation scenarios, canola-spring wheat-spring wheat and continuous spring wheat with no-tillage. The soil parameters from SSURGO were initialized by 100 year run with continuous spring wheat before imposing the two rotation scenario treatments.

Initial results from 50 years simulation indicate SOC increases for the rotation that includes canola relative to the continuous spring wheat rotation on most soil map units. However, differences vary across soil map units.

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NITROGEN AND POTASSIUM APPLICATION ON CRAMBE (*Crambe abyssinica* Hochst) IN FURROW AT PLANTING

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Crambe (*Crambe abyssinica* Hochst) has been known in Brazil for its short growing season (90-100 days) which can be sown between summer seasons, after soybean cultivation as a part of existing crop rotations. Crambe production requires the same machinery as soybean cultivation. Another interesting fact is that crambe culture can be used to produce biodiesel and the erucic acid is very useful for industrial purposes.

The objective of this work was to evaluate the effect of nitrogen and potassium fertilization at sowing on crambe grain yield.

The trial was conducted in the county of Marechal Candido Rondon-PR on an Oxisol soil with a pH of 5.7 ($CaCl_2$) using the cultivar "FMS Brilhante". The location of this trial was 24°31' S and 54° 01' W at an altitude of 420 m. The experimental design was randomized block design with a 4 x 2 factorial distribution of treatments. The first factor consisted of four nitrogen rates in sowing furrow (0, 45, 90, and 135 kg ha^{-1}) and the second factor consisted of two potassium rates in sowing furrow (0 and 60 kg ha^{-1}). The source of nitrogen was urea (45% of N) and potassium was potassium chloride (58% of K_2O). The planting and harvest dates were 05/24/2011 and 09/26/2012, respectively. Precipitation during this period was 625 mm. The furrows were opened to 5 cm depth, and the fertilizer was placed on the bottom of the furrow, then the fertilizers were covered with soil, and the seed was manually sowed 3-cm deep. Data were collected on number of seeds per plant, 1000 seed weight, and total yield.

There was no significant effect of nitrogen rate on the number of grains per plant or on the weight of 1000 grains, or grain yield. This suggests that the requirement for nitrogen by crambe in the early stages of growth is low. Over time, the nitrogen was leached because of precipitation and became unavailable to the plant at later growth stages. Potassium did not have an effect on the mass of 1000 grains, however, the application of potassium promoted an increased number of grains per plant and grain yield.

Potassium applied in sowing furrow increased the grain yield of crambe. The nitrogen applied into the furrow at sowing had no effect on grain yield of crambe.

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PERFORMANCE OF CASTOR CULTIVARS GROWN AT THREE FERTILITY LEVELS

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Castor is usually grown in Brazil under low levels of fertility using long-season cultivars that must be hand harvested. Hybrids could greatly enhance castor yield due to heterosis, uniform maturity, earliness of maturation, and reduced plant height necessary for mechanized harvesting. A castor breeding program led by Dr. Mauricio Zanotto from São Paulo State University has been developing hybrid castor varieties that show great potential for Brazil.

The objective of this study was to compare the seed yield of two hybrid cultivars with two conventional cultivars when grown under three fertility levels.

The trial was conducted in 2009 in the Lageado Research Farm at São Paulo State University, in Botucatu, SP. The experimental design was a complete randomized block with treatments arranged in 4 x 3 factorial distribution consisting of four castor cultivars (Hybrid A, Hybrid B, IAC-2028, and FCA-PB) and three levels of fertilization (0, 50 and 100% of the fertilization with NPK recommended after soil analysis). Biometric and agronomic traits were measured during the study.

Both conventional cultivars (IAC-2028 and FCA-PB) were taller, had increased height to the primary raceme, more nodes to the primary raceme, and had greater stem diameters when compared with the hybrid cultivars (Hybrid A and Hybrid B). The highest level of fertility resulted in greater values than the 0 and 50% level in all characteristics except total number of nodes. A positive response to increased fertility has demonstrated little environmental influence, corroborating with other fertility studies on castor. The two hybrid cultivars had a lower number of seeds per raceme and hundred seed weights than the conventional cultivars, but the number of racemes per plant was higher. The conventional cultivars produced larger racemes and heavier seeds but they required more time to develop each raceme. This observation was particularly true for the cultivar IAC-2028. Among all of the cultivars, Hybrid B had the highest seed yields. As expected, the 100% fertilizer levels also produced the highest seed yields.

It was concluded that the hybrid cultivars had the reduced plant height necessary for mechanized harvesting. However, the hybrids were not more responsive to fertilization than the conventional cultivars.

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IMPACT OF UNEVEN EMERGENCE ON CASTOR PERFORMANCE

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The low yield of castor observed in Brazil is often due to the use of low quality seed which are produced by farmers with limited quality evaluation. Many of those seed lots have a high degree of heterogeneity in maturity and other characteristics. Naturally, castor seeds display a highly irregular emergence due to delayed absorption of water by the seed due to the thickness of the integument. Under field conditions, castor seedling emergence can take as long as 30 days. Late-emerged plants have a reduced ability to compete for nutrients, water, and light with older castor seedling and weeds.

This study had the objective of quantifying the effect of uneven emergence on the agronomic characteristics and productivity of castor plants.

The trial was conducted in 2012 in the Lageado Research Farm at São Paulo State University, in Botucatu, SP. The experiment consisted of five treatments with four replications arranged in a randomized block design. The treatments were: T1) 100% of the seeds were planted on day 1; T2) 50% of the seeds were planted after a 5-days delay; T3) 50% of the plants were planted after a 10-days delay; T4: 50% of the plants were planted after a 15-days delay; T5: 50% of the plants were planted after a 20-days delay. Regression analysis was performed for normal and delayed plants as well as for the average of the plot. The cultivar utilized in this study was FCA-PB developed by Dr. Mauricio Zanotto from São Paulo State University. The traits evaluated were the number of racemes per plant, number of seeds per raceme, 100 seeds weight, and seed yield.

The plants with delayed emergence had a strong reduction in all yield components except for the 100-seed weight which showed only a slight decrease. The early emerged plants had higher yield components when compared with the delayed plants except for the 100 seed weight which showed no response. The number of racemes per plant decreased in response to the delayed emergence. The number of seeds per raceme and seed yield had a parabolic curve. Our data indicates that the plants with 5 to 10 days of delay showed the greatest reduction in seed yield characteristics due to competition with the early emerged plants. Interestingly, the plants with 20 days of delay in emergence produced seed yields similar to the initially emerged plants.

It was concluded that a short delay on castor emergence was more detrimental than longer delays to crop productivity.

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COTTON HYBRIDIZATION AS A TOOL FOR DEVELOPING INTEREST IN UNDERGRADUATE RESEARCH

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Cotton (*Gossypium hirsutum* L.) is a very important industrial crop that produces natural fiber that is used around the world. The United States are the third largest producer of cotton behind China and India. Because of its importance as an industrial crop, many areas of research are dedicated to cotton.

The objective of this study was to master the techniques of flower emasculation and cross-pollination needed for the study of trait inheritance and to gain experience in research usually only taught primarily in classroom settings.

In the spring of 2013, cottonseeds containing several naked seed phenotype were planted in 1gallon pots in a greenhouse at Texas Tech University. The seeds contained the dominant N_1 gene, the recessive n_2 gene, the recessive n^t_4 gene, and two unknown naked seed genes (Atlas-ns and Tejas-ns). The experiment was set up in a partial diallel crossing block.

Flower emasculation was made using the water method in which water was used to sterilize the pollen, followed by hand emasculation of the anthers to create a female flower. A male flower was picked and used to pollinate between 1-3 female flowers. A paper straw was then placed over the stigma and style to prevent pollination by any other flower. The F_1 seeds were harvested when bolls reached maturity for further study.

Learning the terms and techniques associated with cotton hybridization as well as getting experience working in a research greenhouse were very valuable experiences that helped to give a better understanding of how hands on research is conducted. Exposing more undergraduate students to similar experiences could help with graduate recruitment.

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GENETIC AND PHENOTYPIC VARIATION FOR GERMPLASM IMPROVEMENT IN THE BRASSICACEAE

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The Brassicaceae includes numerous species with potential for further development as an effective feedstock for the production of hydrotreated renewable jet (HRJ) fuel. Historically, one of the most productive oilseed species is *Brassica napus* (L.), existing as either a winter or spring annual crop, with diverse oil compositions. To increase the economic return on investment in use of *B. napus* as a source of biofuel, genetic improvement for oil yield and quality across diverse environments is needed. In that light, we are creating a collection of nearly 1,000 genetically diverse accessions (diversity panel) from the widest available germplasm worldwide to use as a resource for genetic improvement. At the same time, we are expanding our capacity to apply high-throughput phenotyping tools and strategies to quantify traits associated with specific germplasm lines. The objective of this study was to: a) create and advance, through selfing, a diversity panel from nearly 1,000 accessions; b) apply new phenotyping tools toward quantifying trait diversity in the population, to include the application of: i. traditional scoring of morphological traits, ii. new high-throughput lab based methods for lipid analysis, and iii. new high-throughput field-based platforms for proximal sensing. Seeds from geographically diverse locations worldwide were collected and greenhouse- or field-grown plants were established in multiple locations across the US. A set of target traits was identified, and quantification methods defined. Development and application of high throughput lipid analysis tools were established and a high clearance vehicle outfitted with sensors is now being tested in the field for rapid measurement of several canopy traits. To highlight an initial data set, leaf cuticular waxes were collected and the chemical composition quantified for three replicates of 520 *B. napus* accessions growing in Maricopa, Arizona, using new robotic workbench instrumentation. Leaf waxes play a major role in controlling plant water use and drought tolerance. Variation in wax chemical profiles, as well as visible glaucousness, was quantified. Initial data from the field based phenotyping platform indicates that traits such as visible canopy reflectance due to surface waxes, canopy temperature, height, and architecture will soon be available for the entire diversity panel.In addition, high-density SNP genotyping of all accessions in the *B. napus* diversity panel is near completion. The application of high throughput approaches to quantify genetically controlled phenotypic variation within the world's natural diversity for *B. napus* is expected to provide a major step forward in plant breeding, and useful tools for advanced genetic studies. The potential to use these tools to exploit the existing worldwide genetic diversity of bioenergy crops like *B. napus* is especially promising.

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COMPARISON OF SEVERAL CASTOR HYBRIDS IN GREECE

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Castor (*Ricinus communis* L., family Euphorbiaceae) is a crop indigenous to the south eastern Mediterranean Basin, Eastern Africa, and India and it is cultivated for its non-edible oilseed. Castor seed is the source of castor oil that has a variety of uses. The castor seed contain between 40% and 60% oil that is rich in triglycerides, mainly ricinolein. The seed also contains ricin, a toxic protein. The world production of castor seeds is around 1,200,000 tonnes (2008) and the main producers are: India (830,000 tonnes), China (210,000 tonnes), and Brazil (91,510 tonnes). In South Europe, castor can be cultivated as annual spring crop sown in March to April and the growing period last 120 to 140 days. It can be inserted in the existing agricultural systems, and when in a rotation scheme maize follow castor the yields of maize can be increased.

In Greece for a period of two subsequent years (2011 & 2012), a total number of seven castor hybrids (provided by KAIIMA company, www.kaiima.com) were cultivated in central Greece. In 2011, two castor hybrids were cultivated (Kaiima 71, Kaiima 75), while in the 2012 a total number of five hybrids were rested (C-855, C-856, C-854, C-864, and Kaiima 93). In 2011 the sowing was done in April (26/4), while in 2012 the sowing was postponed to the middle of May (19/5). In the first trial, the spacing was 50 cm between rows and 50 cm between plants, while in second trial the spacing was 100 cm between rows and 25 cm between plants. After sowing, the plants were irrigated in order to have a good emergence, and until the beginning of flowering the irrigation was as low as possible.

The flowering in both years occurred at the end of June and thus the vegetative phase in the second trial was quite shorter (40 days in 2012 compared with 57 days in 2011). The plant height averaged over all hybrids was 100 cm (varied from 88 to 108 cm) and each plant developed 26 leaves (23-28 leaf/plant) and 4.5 racemes (3.9 to 5.2 raceme/plant) and each raceme had a total number of capsules that ranged from 29 capsule/plant (C-864) to 39 capsule/plant (C-855). In 2011, the seed yields were higher than in 2012. More specifically, in 2011 Kaiima 71 produced 3,800 kg/ha of seeds and Kaiima 75 produced 3,471 kg/ha. In the following year, the seed yields for the five castor hybrids were quite lower compared to the yields of the two hybrids in 2011. In more detail, the seed yields for the tested castor hybrids were: 2,065 kg/ha for C-855, 1,907 kg/ha for C-856, 2,032 kg/ha for C-854, 1,680 kg/ha for C-864, and 1,869 kg/ha for Kaiima 93. The oil content of the castor seeds in the first trial was 48.91% for Kaiima 71, and 52.12% for Kaiima 75. In the second trial the oil content of the five tested castor hybrids by descending order were: 49.6 % for C-854, 48.9% for C-856, 48.8% for Kaiima 93, 46.7% for C-855, and 45.8% for C-864.

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BIOFUEL OILSEEDS FOR THE DAKOTAS

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Agriculture's role, in the continuing development of the biofuel industry, is to produce feedstocks for conversion into fuels that reduce dependence on foreign and domestic crude oil, fossil fuel based feedstocks. The study objective was to determine the interaction between oilseed crop performance and geographic location to identify crop/location combinations that optimized crop seed and oil yield. A RCBD replicated study was conducted at four North Dakota (Carrington, Hettinger, Minot, and Prosper) and four South Dakota (Bison, Brookings, Pierre, and Wall) locations during the 2012 growing season. Six oilseed crops crambe (*Crambe abyssinica* Hochst.), brown mustard (*Brassica juncea* L.), flax (*Linum usitatissimum* L.), canola-quality mustard (*Brassica juncea* L.), canola (*Brassica napus* L.), and safflower (*Carthamus tinctorius* L.) were evaluated under dryland conditions using standard agronomic practices (seeding date, seeding rate, fertility, pest, and harvest management) for optimum production at each location. The greatest mean yield for each crop in North Dakota occurred at the following locations: flax at Prosper; crambe at Hettinger; and juncea and napus canola, brown mustard, and safflower at Minot. The greatest mean yield for each crop in South Dakota occurred at the following locations: flax, crambe, juncea and napus canola, and brown mustard at Brookings, and safflower at Wall. Canola produced the highest seed oil content (>40%) among the oilseed crops. Several different abiotic (heat and moisture) and biotic (insects) stress factors reduced crop performance at several locations and resulted in exceptions to the general crop response. Cool season crops tended to perform better at more northern and eastern locations in the Dakotas.

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EFFECT OF GENOTYPES ON *IN VITRO* PROPAGATION OF *Jatropha curcas*

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Jatropha *(Jatropha curcas* L., Euphorbiaceae) is a drought tolerant, non-food, biodiesel crop widely grown in the tropical and sub-tropical regions of the world. It is a species regarded suitable to grow on unproductive agriculture lands as well as marginal lands and yields 30-40 oil by seed weight. However, it can't be grown as a crop in the temperate regions because of its susceptibility to cold stress. Cold tolerance can be introduced to *Jatropha* through genetic engineering with cold binding factors (e. g. *CBF3*). An efficient *in vitro* regeneration system is essential to develop cold tolerant *J. curcas* through genetic transformation. Different authors have reported considerable variation in the *in vitro* regeneration potential of *J. curcas*.

We hypothesized that a major reason for this variation could be the difference between genotypes. Therefore, we studied the *in vitro* regeneration potential of 10 genotypes *J. curcas* grown in the greenhouse at Penn State Harrisburg. We used young nodal segments (2.0-3.0 cm), and approximately 1.0 cm leaf segments from immature, fully opened leaves as explants. Explants were disinfected with a detergent was (10 min) followed by 5.0 min each in 10% bleach and 0.1% $HgCl_2$ followed by 5.0-6.0 rinses with sterile water. Callus induction was achieved on CI medium; Murashige and Skoog 1962 (MS) medium modified with 1.5 mg/L Benzylaminopurine (BAP) and 0.05 mg/L indole-3-butyric acid (IBA). Axilary bud break was achieved in one week on SI medium; MS medium supplemented with 3.0 mg/L BAP and 0.1 mg/L IBA irrespective of the genotypes. MS medium supplemented with 2.0 mg/L BAP and 0.5 mg/L Kinetin (Kn) (SM medium) was used to generate multiple shoots. Callus induction occurred in 10-30 days depending on the genotype. By week 6, the rate of callus induction ranged from 17.65% in genotype (Jat2) to 75.56% in (Jat5). The axillary shoot multiplication rate varied from 2.0 – 4.0 shoots per explant amongst the genotypes studied. Only 4/10 genotypes regenerated directly from leaf explants cultured facing the adaxial side on the CI medium and the regeneration rate varied between 20%-60% among these genotypes.

Callus induction *and in vitro* regeneration of *J. curcas* are genotype dependent.

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LIFE -CYCLE ASSESSMENT OF POPPYSTRAIGHT VEGETABLE OIL FUEL PRODUCTION: ACASE FOR SMALL-SCALE, LOCAL USE, AND PRODUCTION

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The seeds of *Papaver somniferum* (poppy) contain a large fraction of oil (45-55%), which is viable as a fuel. This paper presents a life cycle assessment (LCA) of the production and use of straight vegetable oil (SVO) extracted from poppy in Northeastern Afghanistan. A key goal was to compare on-farm versus centralized production in terms of energy (net/gross mmBTU output) and greenhouse gas (GHG) emissions per 1 mmBTU produced. This study assesses the production of SVO from Afghan poppy fields as a local energy resource. A detailed model of the energy system was developed, based on the Argonne National Laboratory life cycle assessment tool, GREET-Beta Platform, and included agricultural production (e.g. fertilizers, pesticides) and transport inputs/outputs (e.g. field-to-oil extraction, oil extraction-to-use). As a comparison for the production and use of the poppy-derived SVO, two scenarios were modeled: (1) an energy system in which individual farmers harvest, extract oil and use the oil on-farm as a 0 km transportation scenario; and (2) an energy system in which groups of farmers harvest their seeds, then send the product to a centralized extraction mill for the oil to be returned to farmers, households and/or blenders. These two base models resulted in a total of 16 scenarios based on two acreage schemes (1 and 50 acres), two harvest intensity schemes (700 and 1,500 kg/acre) and four transportation schemes (0, 5, 10 and 25 km). In addition to these 16 scenarios, we also included two fertilization schemes in which the basic a basic fertilizing regime was implemented on the low-acre, high-harvest intensity model at the 0 km transportation distance (on-farm) and the high-acre, low-harvest intensity model at the 10 km transportation distance. We calculated that the on-farm scenario is up to15 times less global warming potential (GWP) than the centralized system (per 5km distance from farm-to-extraction plant) per 1mmBTU produced. This work is a unique addition to the literature for two key reasons: (1) although recent LCA research in biofuel production tends to conform to economies of scale, the results of this research indicate that the minimal emissions and superior energy efficiency of small-scale, local use and production is a more viable scale than a centralized model in this region; and (2) it is rare that SVO is presented as a viable alternative to bio-diesel production. The nutritional value of the seed mash after oil extraction makes the mash useful as both a soil and animal supplement.

The global war on narcotics has continued to play an increasing role in international relationships. With 80-93% of opium originating from Afghanistan, the agricultural production of poppy in Afghanistan is one of the international community's top concerns in the illicit narcotic trade. The results of this study suggest that SVO production is a viable alternative from the perspective of GHG emissions and energy efficiency.

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LOGISTIC AND CONVERSION PANEL

ABSTRACTS PRESENTATION

COST-EFFECTIVE LOGISTICS FOR FOREST HARVEST RESIDUALS: THE UPSTREAM PART OF THE SUGAR STREAM

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Forest harvest residues, created as a byproduct of logging operations, are renewable resources that have the potential to develop liquid fuels. In 2011, the Northwest Advanced Renewables Alliance (NARA), a group of US public universities, government laboratories and private industry led by Washington State University was formed to build a sustainable supply chain for aviation fuel from softwood forest harvest residues under a grant from USDA. Forest residues consist of branches, tops, breakage, defect, and trees not meeting utilization specifications for saw timber and pulp (paper production). One of the most important distinctions of the use of forest residues for energy purposes is that they are not used for other commercial purposes and do not compete with human food supply chains. Fuels derived from forest residues from non-federal lands and certain federal lands qualify under the current US Renewable Fuel Standard.

After timber harvesting, most forest harvest residues are piled and burned to clean the areas for replanting, reduce fuel loadings, and potential insect and rodent problems. It is estimated that a total of 127.4 million m^3 of logging residues were produced in the United States in 2006. To economically handle and transport forest residues, biomass has to be mechanically reduced in particle size (comminution). This process reduces the heterogeneous composition of the material and facilitates the handling and delivery process. After comminution, processed residues are transported using chip-vans for long distance transportation.

Feedstock cost is a major cost component in the production of biofuels from forest harvest residues. Delivered feedstock costs depend on collection, comminution, and transport costs. Factors affecting these costs include species, harvest system, distance from road and topography, wet and dry bulk density after comminution, access for large trailers, truck transport time, and equipment utilization rates as affected by operational variables.

Simulation, and use of mathematical optimization were used to estimate collection and transport costs of forest harvest residues in typical situations in the western United States as a function of moisture content, truck-trailer configuration, grinder size, and road configuration considering on-site and centralized processing. Feedstock delivery costs were found highly dependent on distance from road, machine and truck interaction, road system configuration, wet and dry bulk density and round trip travel time. Structured grinding tests are underway to evaluate effects on forest residue bulk density, particle size distribution, and fuel consumption for comminution as a function of moisture content, grate size and bit configuration. The effect of comminution on post-comminution moisture content is also measured. Ground residues from the structured tests are evaluated downstream to determine the optimal combination of primary reduction in the field on diesel with secondary reduction at the plant using electricity prior to pretreatment and fermentation in the supply chain.

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PREPROCESSING AND CONVERTING FOREST RESIDUAL SUGARS INTO ADVANCED BIOFUELS

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Gevo is a leading renewable chemicals and advanced biofuels company. We have developed bio-based alternatives to petroleum-based products using a combination of synthetic biology and chemistry. We produce isobutanol, a versatile platform chemical for the liquid fuels and petrochemical market. Isobutanol has broad market applications as a solvent and a gasoline blendstock that can help refiners meet their renewable fuel and clean air obligations. It can also be further processed using well-known chemical processes into jet fuel and feedstocks for the production of synthetic rubber, plastics, and polyesters. Gevo's technology was designed to retrofit existing ethanol plants of all kinds. Through the NARA project, Gevo will optimize our conversion technology to convert carbohydrates from woody biomass hydrolysate feedstocks into isobutanol, biojet fuel and other renewable chemicals. Gevo has analyzed pretreated hydrolysate from SPORL, wet-oxidation, and mild bisulfite pretreatments for carbohydrate and inhibitor content. Using SPORL and wet-oxidation hydrolysate from FS-03 residuals, Gevo has determined growth and fermentation performance for a wild-type ethanol producing yeast strain (for benchmark purposes) and for an isobutanol producing yeast strain. We are currently adapting yeast strains for isobutanol production using pretreated hydrolysate from NARA feedstocks FS-03 and FS-10 and have evaluated the performance of advanced strains. Significant external outputs to date are an adapted biocatalyst that produced a nearly two-fold increase in isobutanol over pre-adapted strains on diluted FS-03 pretreated hydrolysate indicating that isobutanol can be generated and that strain adaption can improve biocatalyst.

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THE PYROLYSIS/BIOCHAR LOGISTICS AND CONVERSION PROCESS FOR PERENNIAL GRASSES

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Cellulosic biomass can be converted to transportation fuels and other biobased products through either biological or thermal processing. We are exploring the technical and cost advantages of thermal processing of grassy biomass. Specifically, fast pyrolysis is able to convert biomass into gaseous, liquid, and solid products that serve as intermediates in the production of sustainable transportation fuels. The gases serve to heat the pyrolysis process; the liquids are upgraded to renewable gasoline and diesel; and the solid, a carbonaceous residue known as biochar, is used to recycle plant nutrients, build soil quality, and sequester carbon from the atmosphere. Pyrolysis lends itself to distributed processing of biomass, which improves problems associated with feedstock logistics for large centralized processing plants. This talk describes the issues of logistics and conversion associated with the pyrolysis of perennial grasses to transportation fuels.

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ADVANCES IN FEEDSTOCK SUPPLY CHAIN LOGISTICS FOR ADVANCED BIOFUELS IN THE SOUTHEAST

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Nearly 200 million acres of forests and 30 million acres of pine plantations distributed throughout the southeast U.S. can provide a significant source of biomass feedstock for biofuels production. Logistics systems design specifically for short-rotation southern pine and hardwood plantations hold great potential for reducing supply chain costs. This presentation discusses design concepts for harvesting and transport systems for short-rotation woody biomass systems in the southeast U.S.

Recent research has resulted in the design of a high-productivity system to harvest, process, and transport woody biomass from southern pine plantations. The system, which consists of a track-type feller buncher, wheeled skidder, knuckelboom loader, whole-tree in-woods disk chipper, and high-capacity chip trailers, has been designed to do complete harvests of 10- to 15-year-old pine plantations. Preliminary results show that several engineering innovations and operational techniques like transpirational drying have resulted in more fuel-efficient operations, lower operating costs, higher productivities, and lower overall delivered costs for the biomass. These initial results show that there are opportunities to reduce woody biomass costs, which will in turn improve the economic feasibility of biofuel production systems. Further research is currently underway to evaluate existing and develop new concepts for harvesting short-rotation hardwood plantations.

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CONVERSION OF ENERGY CANE INTO BIOFUELS AND CHEMICALS: A MODELING APPROACH

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The need for decreasing greenhouse gas emissions, exhaustion of fossil resources and the desire for energy independence, have encouraged worldwide interest in fuels and chemicals obtained from renewable sources. In the U.S., for example, 36 billion gallons per year of renewable fuels are to be produced by 2022, of which 16 billion must originate from cellulosic material. Biomass is currently the only renewable source for production of liquid substitutes of petroleum-based fuels for transportation. However, first experiences with biomass conversion to liquid fuels have not resulted in cost-effective solutions. Alternative products, such as biobased chemicals and power generation must be considered, to make the integrated biorefinery concept more viable. Regional scenarios that take advantage of specific growth areas, types of feedstock and available infrastructure must be considered. Energy cane (hybrid of commercial sugar cane, *Saccharum officinarum*, and wild sugar canes) and sweet sorghum (*Sorghum bicolor* L. Moench) are potential crops for conversion into fuels and chemicals due to their low agricultural input requirements, potentially high fiber content and processing similarities with established sugarcane crops.

Material and energy balances are calculated to determine the extent to which energy cane and sweet sorghum bagasse can be used as a source of sugars after steam and power requirements for the extraction and conversion processes are met. The capability of electric power generation for export is also evaluated.

A conceptual approach to a biorefinery producing fuels and chemical from these crops is developed. A front-end of the plant processes 10,000 ton/day of feedstock to extract convertible sugars and concentrate them into storable syrups. The latter can be processed into gasoline, jet fuel and isoprene using proprietary technologies. The fiber remaining after extraction, called bagasse, is used in boilers of the front-end plant for steam and power generation and, possibly, to produce additional second generation sugars by pretreatment and hydrolysis in the lignocellulosic conversion plant. The front-end plant and the lignocellulosic conversion plant were modeled using Sugars™ software.

Results show that bagasse is available for further lignocellulosic conversion resulting in production of additional sugars. However, surplus electricity production is reduced significantly. When a milling tandem is used, a one percent reduction in fiber content of energy cane reduces power export by more than 5 percent and second generation sugars by 3 percent.

This study demonstrates that the integrated biorefinery approach based on energy cane is feasible in terms of fiber availability. The economics of the approach needs to be evaluated taking into account all costs (feedstock production, harvesting and transportation; primary extraction; lignocellulosic conversion and product purification) and prices of fermentable sugars and electricity.

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LOGISTICS AND CONVERSION PANEL

POSTER PRESENTATION

BUILDING HERBICIDE RESISTANCE FOR SHORT ROTATION HARDWOOD CROPS

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Short rotation hardwood tree species such as *Populus* and *Eucalyptus* are the target of many biomass/biofuel crop research projects, but only a very small percentage of the total tree seedling market in the southeast is planted in hardwood. The expense of establishment and maintenance to reduce plant competition within hardwood plantations is one of the main barriers to growth of this market. Herbicides commonly used for site preparation and maintenance easily damage or kill hardwood tree species, forcing the tree grower to employ labor intensive weed management strategies or lose crop yield due to competing plant species.As part of the Woody Crop Development project within IBSS, we are investigating the impact that planting herbicide tolerant *Populus* and *Eucalyptus* trees might have on reducing establishment and maintenance costs and improving yields for biomass production. We have successfully introduced genes providing tolerance of sulfometuron, metsulfuron, and imazapyr (commercially available as Oust, Escort and Arsenal) into *Populus* and *Eucalyptus*. These trees will be screened to assess herbicide resistance and select lines field tested to determine any cost benefit or yield improvements that could be applied to short rotation hardwood biomass crops in the southeast.

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THE SEED FELLOWSHIP: AN INNOVATIVE APPROACH TO BIOENERGY EDUCATION

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The Southeast Partnership for Integrated Biomass Supply Systems (IBSS) project is funded by the U.S. Department of Agriculture-Agriculture and Food Research Initiative (AFRI) program. The main goal of IBSS is to demonstrate real-world solutions towards economically and environmentally sustainable production and conversion of biomass-to-biofuel in the southeast United States (SE US). This partnership is helping to meet the USDA goal of producing almost 50% of the next generation of biofuels in the SE US, while supporting robust and innovative research, education and extension activities. As a part of the project, the Southeast Energy Development (SEED) Fellowship has been created. This is the second year of the program.

The objective of the SEED program is to train a capable, effective and safe workforce for biomass production and harvesting, and biofuels processing.

The SEED Fellows are expected to work in a multidisciplinary team and are assigned real-world problems that could include either research or field deployment challenges in feedstock production, feedstock logistics, conversion, or markets and distribution of biofuels. The Fellows are selected from universities that are members of IBSS program. The Fellows spent most of their time learning basic tools (experimental and modeling but they traveled to biofuel industry, national laboratories and universities learning different aspects) of biofuels production. The fellows experience was enriched by providing a number of professional development activities including how to communicate effectively to public. At the end of the summer, all the Fellows presented their posters in a national meeting.

This SEED program will continue for two more years, and so far students had really enjoyed. Some of the SEED fellows had decided to continue for PhD and Master's levels, and some of them had even published their research work in journals.

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THERMOCHEMICAL CONVERSION: EFFECT OF BIOMASS CHARACTERISTICS

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The USDA Biofuels Strategic Production Roadmap concludes that the southeastern US, with its long growing season, mild climate, relative abundance of water, and private land ownership patterns has the potential to produce almost 50% of the nation's biofuels. The recent announcements of commercial operations by Kior and Ineos are examples of this potential being realized. Both of these production processes are based on thermochemical technology platforms, pyrolysis and gasification, respectively, and use biomass resources such as pine and hardwoods, which are already commonly produced across the southeast. Both processes can also take advantage of perennial biomass resources, such as switchgrass, that can also be grown across the southeastern US.

Pyrolysis Molecular Beam Mass Spectrometry (Py-MBMS) is a fast, universal, real-time analytical tool for measuring biomass composition, and a screening tool for the thermochemical processing of biomass. Py-MBMS data can be analyzed with Principal Component Analysis (PCA), Partial Least Squares Regression (PLS) and Multivariate Curve Resolution (MCR) tools to better understand the details of the samples and thermal reaction processes.

In this work more than 600 southeastern biomass samples were analyzed with Py-MBMS and PCA tools to identify differences in the samples due to site, genetics, age, harvesting and storage. Additionally the pyrolysis and gasification processes were studied with Py-MBMS at temperatures between 500^{o}C and 900^{o}C. The resulting data was then analyzed by PCA, PLS and MCR. Correlations between spectral data and the physical properties of the biomass (fixed carbon, volatile, ash, CHNO) are built by PLS. MCR analysis of time-resolved profiles showed the evolution of the different biomass components. There were also significant differences in the structure and reactivity of the chars depending on the biomass source.

This work shows that for both biomass pyrolysis and gasification the source of biomass has an effect on the composition of the primary reaction products and the reactivity of char residues.

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IMPACT OF BIOMASS CHARACTERISTICS ON LOGISTICS

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Biomass logistics often require the use of silos and storage containers to hold biomass feedstocks for certain amount of time. This requires that the feedstocks flow as a bulk material when released from these storage/holding vessels. Biomass feedstocks therefore will have the typical flow problems associated with bulk materials. The objective of this work is to quantify the impact of biomass characteristics on the flow properties (cohesion, flow index, angle of internal friction, and angle of wall friction) of ground loblolly pine chips that were obtained from different harvesting operations (clean chips, dirty chips, and residues). The effect of particle size (0.5 mm to 3.2 mm) on the frictional properties was also quantified. Despite differences in chemical characteristics, particle to particle friction of ground clean and dirty chips were not significantly different ($P<0.05$). Ground residues however had higher particle to particle frictional properties. The wall friction reduced with increase in ash content of samples. When ground loblolly pine was fractionated into different sizes (0.5 mm to 3.2 mm), decreased screen size resulted in significant increases in angle of internal friction, cohesion and flow index. This implies that the finer fraction in ground biomass play important role in their flowability (hence ease of handling). The information obtained from this study will be used in the design and selection of biomass storage and handling containers and equipment.

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SUSTAINABILITY / DECISSION TOOLS / LCA

ABSTRACTS PRESENTATION

BIOFUELS ON THE LANDSCAPE: MODELING TO BALANCE THE ENVIRONMENTAL FOOTPRINT OF FEEDSTOCK PRODUCTION ON MARGINAL LANDS

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The sustainable production of large quantities of biomass from dedicated energy crops will be necessary to meet renewable fuel and power mandates being implemented in the United States at the federal and state level. However, fundamental questions about the relative merits of intensification versus extensification (or land-sharing versus land-sparing) strategies remain unsettled. Production on marginal lands is an attractive prospect, though some recent field trials suggest that inherently low yields of perennial grass crops in these areas may be problematic.

Our objective was to apply a well-validated biogeochemical process model at fine scale across a representative bioenergy feedstock production landscape to predict switchgrass yields and soil greenhouse gas (GHG) balances, compute associated biomass transport burdens, and use multi-criteria optimization techniques to identify practical cultivation strategies and landscape designs that maximize total system GHG mitigation within certain economic constraints.

The DayCent soil biogeochemistry model was parameterized to reflect the productivity of upland and lowland switch grass cultivars across a variety of climates and soil types, incorporating results from recent field trials on marginal lands. The model was then applied to a case study representing the production of second-generation biofuels in a heterogeneous landscape in the Great Plains. Productivity and soil GHG balance (CO_2, N_2O, and CH_4) were simulated spatially across the landscape and in a third dimension representing management intensity. These data were integrated into a lifecycle assessment framework and a crop production budget tool to estimate total supply chain environmental impacts and economic viability, and algorithms were used to identify optimal landscape designs.

Preliminary results suggest that a) variations in land productivity and emissions balance driven by soil type, climate, and land use history result in large variations in biomass cost and GHG footprint, b) such variations are greater than biomass transport costs and GHGs at many scales, and c) optimal landscape designs will likely draw heavily on lands currently uncultivated.

We suggest that the coupling of biogeochemical simulations, LCA frameworks, and enterprise budget tools can start to address fundamental questions of sustainable bioenergy landscape design, including a) what is the maximum GHG mitigation capacity of a landscape?, b) how does the concept of economies of scale change with feedstock production and collection over a heterogeneous land scale and what are the associated implications for GHG emissions?, and c) in what instances do the goals of maximizing profits and minimizing environmental impacts diverge? Development of these tools can also help support LCA and GHG analyses for other research projects within the AFRI biofuel program.

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SUSTAINABILITY ASSESSMENTS OF BIOFUELS AND RELATED POLICIES

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Recent regulations have resulted in increased production of biofuels from a variety of agricultural feedstocks. Many of these new policies call for the evaluation of the greenhouse gas emissions reductions of biofuels using Life Cycle Assessment (LCA). LCA is a tool that enables one to quantify environmental impacts of a product or process throughout its entire life-cycle, from raw materials acquisition to combustion of fuels, while including the manufacturing, agricultural production, and other processes in between. This talk will explore how LCA can be utilized to quantify the environmental impacts of biofuels and related policies and the resultant environmental impacts of meeting future fuel needs. The feedstocks of focus for this talk include switchgrass and miscanthus perennial grasses for the production of drop-in biofuels. In addition, we will address the policy ramifications and unintended consequences of using several different biomass feedstocks and conversion pathways for producing low biofuels and other useful bioproducts in the U.S. context. For example, preliminary results show that biofuel production in some regions of the US has a higher likelihood of experiencing greenhouse gas emissions reductions with tradeoffs related to increased water quality degradation. This talk will conclude with a discussion of different tools and metrics that can be used to evaluate the sustainability (i.e. environmental, economic, and societal impacts) of different biofuel production scenarios.

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DEVELOPING A SUSTAINABLE BIOFUELS SYSTEM IN THE PNW: ECONOMIC, POLICY AND COMMERCIALIZATION ANALYSIS

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A unique opportunity exists to explore the development of a regionally-appropriate oilseed crop production system in the Pacific Northwest as part of a demand-driven supply chain for aviation biofuel production (Farm to Fly Initiative). This demand for aviation fuel creates an opportunity to integrate a viable bioenergy crop, camelina, into the dryland cereal agricultural production system of the region.

Our collective effort will evaluate this initiative and other policy options and commercialization opportunities, and assess the economic and environmental sustainability of oilseed production systems as part of a regional biomass feedstock. This will be accomplished utilizing a science-based policy integrative framework that incorporates multiple scales and multiple production and processing stages. The focus on integration and multiple scales is deliberate. Characterizing producers and processors in the region, and the use of a suite of integrated economic-environmental research components, all calibrated to represent the region's biofuel processing and production systems and associated environmental outcomes, is critical to fully capture and assess the sustainability of the biofuels systems. The outputs of this project will include: (a) a set of enterprise budgets and processing costs that reflect the production of camelina under alternative scenarios and management schemes and are responsive to policy-induced prices changes for energy and commodities; (b) an integration framework that employs the economic and environmental models, and (c) a suite of empirical results that capture the sensitivity of the economic and environmental outcomes for this regional biofuels system to changes in prices for energy inputs, to the presence of an aviation biofuels mandate(s), and to changes in related federal, state and local policies.

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RECENT PROGRESS IN SUSTAINABILITY METRICS FOR ADVANCED BIOFUELS IN THE SOUTHEAST

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The thermochemical conversion (TC) of biomass to fuels shows potential, especially for biomass prevalent in the southeast which includes a significant fraction of softwoods. The objective of this study is to develop a methodology and set of metrics to evaluate advanced biofuels produced in the southeast using an environmental life cycle analysis (LCA) approach. In this work, supply chain models of several types of biomass have been developed in a flexible spreadsheet format. These models detailed the biomass supply chain including both, financial costs and environmental burdens for loblolly pine, eucalyptus, unmanaged hardwoods, forest residues, switchgrass, and sweet sorghum. The thermochemical conversion process including biomass gasification, syngas clean-up and conditioning, and fuel production was modeled using an Aspen Plus simulation developed by NREL. The life cycle inventory was developed using the feedstock supply chain model results, the TC simulation, US LCI, and GREET data and input into SimaPro LCA software. The environmental impacts quantified were global warming potential (GWP), eutrophication, acidification, carcinogenics, non-carcinogenics, respiratory effects, ozone depletion, ecotoxicity and smog.

The cradle-to-grave environmental impacts of biofuels produced via this TC process from several model feedstocks were determined and compared to gasoline. Greenhouse gas (GHG) emission reductions of this biofuel were 65%-77% that of gasoline, depending on the biomass feedstock. This outcome would qualify these biofuels as Advanced Biofuels under the Renewable Fuels Standards. Effects of direct land-use change could be significant (~18%) and could increase the GHG emissions for switchgrass derived biofuel above the federally targeted GHG reduction thresholds. The production and use of this biofuel reduced fossil fuel consumption by 95%-97% and 81% using forest or switchgrass feedstock, respectively. This TC derived biofuel did not, however, reduce all environmental impact categories (such as eutrophication, ozone depletion respiratory effects, acidification, and smog) compared to gasoline. The methodologies developed here serve as a robust method to evaluate the cradle-to-grave sustainability impacts of biofuel production.

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ENVIRONMENTAL IMPLICATIONS OF ADVANCED BIOFUELS IN THE PACIFIC NORTHWEST: AN LCA APPROACH

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Typical forest harvest operations in the Inland West region of Pacific Northwest leave a considerable volume of unused woody biomass in the forest in the form of treetops and branches. Despite the environmental benefits, the economic feasibility of extracting these residuals from the forest is limited due to low market demand and high collection and transportation costs. Most of the unused woody biomass is collected, piled and burned in the forest or it is simply left on the forest floor to decompose. To address the market failure of more fully utilizing woody residues, new technologies are being developed to utilize forest residuals for conversion into high value advanced bio-fuels.

The Northwest Advanced Renewables Alliance (NARA) research project is exploring the potential of converting woody biomass into bio-jet fuel within the Inland West region. This paper assesses the environmental implications of producing woody biomass based bio-fuel within the Inland West region. In order to document the environmental benefits of substituting biofuel for fossil fuel, a detailed Life Cycle Assessment (LCA) is being conducted to evaluate the environmental impacts of using woody biomass as a feedstock for conversion into bio-jet fuel.

This paper presents the preliminary results of a framework 'cradle-to-grave' life-cycle of woody biomass based bio-jet fuel. In this paper 'cradle' is defined as beginning with the natural regeneration of young trees within the forest and 'grave' is defined as the burning of bio-jet fuel in an intercontinental passenger aircraft. To evaluate the various logistical/procedural pathways, this paper explores a range of biomass transportation scenarios and incorporates the avoided environmental costs associated with piling and burning the woody biomass within the forest into the LCA calculations. For this paper, the primary LCA assumes a 'greenfield model' (similar to the NREL process), where the biomass collection, pretreatment and fuel conversion processes are all undertaken at the same location. However, the environmental implications of a depot model for local collection and pre-treatment sites are also explored in this paper. The environmental burdens for each of these scenarios are assessed in terms of global warming, acidification, smog, and ozone depleting potentials.

Preliminary results suggest that there is a 61.6% reduction in the global warming potential and a 60.7% reduction in fossil fuel depletion potential by substituting NARA bio-jet fuel for fossil fuel-based jet fuel.

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LIFE CYCLE ASSESSMENT FOR ADVANCED BIOFUEL PRODUCTION FROM POPLAR FEEDSTOCK

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Drop in bio-jet fuels show promise as an industry compatible alternative fuel source. Produced from poplar trees the bio-jet fuel is identical in chemical composition to current jet fuel and can be used in existing jet engines without modification. Life cycle assessment is used to investigate potential environmental impacts of using bio-jet fuel derived from poplar trees. To convert the wood to jet fuel a biorefinery capable of producing 350 million liters of bio-jet fuel per year is simulated. The process diverges from previous lignocellulosic bioconversion technology by using acetic fermentation followed by hydrogenation to produce a hydrocarbon fuel. Two methods are proposed to produce the necessary hydrogen within the biorefinery: natural gas reforming and gasification of lignin. Two separate cradle to grave simulations are performed using the two hydrogen production processes to obtain life cycle data. Relative to petroleum based jet fuel, a global warming potential reduction range of 37 to 41% is found for the life cycle of bio-jet fuel. Fossil fuel consumption is reduced by 4 to 13% for the bio-jet fuel but freshwater use increases by 80 to 130%. The large amount of water use is a concern and development of better metrics are needed for analyzing water use impact and in citing future biorefineries.

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PERENNIAL BIOMASS CROP ESTABLISHMENT AND ITS ENVIRONMENTAL IMPACTS IN THE MIDWESTERN UNITED STATES

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Agricultural lands exceed 70% in the U.S. Midwest. Intensive cropping has caused various environmental problems such as soil erosion and water pollution. In past decades, several U.S. farm policies have been established to mitigate these problems by converting cultivated lands back to permanent covers. The Billion-Ton Annual Supply study estimates that biomass feedstocks in the United States could replace 30% of the domestic petroleum consumption by 2030. Recently, the Biomass Crop Assistance Programs (BCAPs) were approved in several project areas, including contrasting perennial species in Missouri and Kansas, to fund land owners and operators in support of biomass production. Switchgrass and other warm-season perennial grasses, native to the pre-colonial tallgrass prairie, make the Midwest great potential in leveraging bioenergy feedstock and environment protection.

This study aims to explore an integrated approach to documenting land use and conversion of perennial biomass crops using satellite time series. The focus site covers 39 counties in Missouri and Kansas that are designated as the BCAPs Project Area 1. With time series analysis of MODIS imagery in 2000-2009, a set of phenology metrics are extracted and a decision tree is developed to delineate perennial energy crops from other land covers. Assisted with the Crop Data Layers (CDL) at USDA/NASS, a regional crop inventory database is framed. Fusion of less frequent, medium-resolution images such as Landsat TM/ETM+ are being processed to increase classification accuracy in the focus site. Field equipments are being installed in selected HUC 8-scale watersheds to continuously collect soil/water quality data. The preliminary results reveal spatially explicit insights for current and future land use patterns of perennial biomass crops. In next two years, these data will be applied in the Soil and Water Assessment Tool (SWAT) to assess soil and water quality in the BCAP lands and the environmental consequences in the Midwest region.

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AT THE ROOT OF SUSTAINABLE BIOENERGY PRODUCTION: USING GENETIC VARIATION IN ROOT TRAITS TO MAXIMIZE SOIL CARBON SEQUESTRATION AND BIOMASS YIELDS

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Land-use change for bioenergy production can create greenhouse gas (GHG) emissions through disturbance of soil carbon (C) pools, but native species with extensive root systems may rapidly repay the GHG debt, particularly when grown in diverse mixtures, by enhancing soil C sequestration upon land-use change. Native bioenergy candidate species, switchgrass (*Panicum virgatum L.*) and big bluestem (*Andropogon gerardii*) show extensive within-species variation, and our preliminary data show that increased cultivar diversity can enhance yield. With this project we wish to assess: (1) how shifting C_3-dominated nonnative perennial grasslands to C_4-dominated native perennial grasslands for use as bioenergy feedstock affects soil C sequestration; (2) how within-species biodiversity in native grassland feedstock affects the efficiency of nutrient use and C sequestration; and (3) whether energy gain resulting from an increase in soil C storage and yield, along with a decrease in nutrient inputs and losses in low-input diverse mixtures of perennial grasses, is sufficient to offset energy gain from relatively greater biomass production in high input monocultures of perennial grasses. Our experiment is conducted at the Fermilab National Environmental Research Park, and compares different approaches for perennial feedstock production ranging across a biodiversity gradient, where diversity is manipulated at both the species- and cultivar level, and nitrogen (N) is applied at two levels (0 and 67 kg/ha). Preliminary results indicate that switchgrass and big bluestem differentially affect soil C sequstration rates, and that enhanced diversity may enhance soil C sequestration rates. Ultimately the goal of our project is to evaluate which method of land-use change for bioenergy production maximizes yields, while minimizing the negative impacts of land-use change on the environment.

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LANDSCAPE SCALE WATER QUALITY MODELING FOR BIOENERGY SYSTEMS

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Emerging technologies such as a biofuel production from perennial feed stocks may provide significant environmental gains in the form of improved water quality and reduced carbon emissions. However, the extent of these benefits is expected to vary considerably depending on the location in which the feed stocks are produced and the surrounding land use. In this presentation the use of biophysical landscape scale models as a means of informing policy design for second generation biofuels is discussed. Examples of the value of these models in informing tradeoffs associated with different land uses in a watershed are provided for intensively managed agricultural landscapes in the Corn Belt. Specifically, the tradeoff between the production of food via corn grain, fuel production from corn grain and cellulosic production, and water quality will be visually depicted.

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SUSTAINABILITY/DECISION TOOLS/LCA

POSTER PRESENTATION

DIRECT EFFECTS OF CONVERTING CONVENTIONAL CROPPING SYSTEMS TO BIOFUEL CROPPING SYSTEMS ON ECOSYSTEM SERVICES FOR THE SOUTHEASTERN U.S.A.

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Conventional food, feed, and fiber agricultural landscapes are already being converted to biofuel cropping systems, and this is expected to intensify as demand for bioenergy grows. However, the implications of this conversion for agroecosystem services are not well understood. The objectives of this project are thus to quantify and compare the effects on aboveground primary production, water use and water quality, and greenhouse gas regulation of converting current conventional cropping systems in the Southeast to emerging biofuel cropping systems, with and without land application of bio-char and evaporated vinasse generated from the conversion of the crop to biofuel. Two large field experiments, one comparing an annual sweet sorghum biofuel cropping system to a cotton-peanut rotation and the other comparing a perennial elephantgrass biofuel cropping system to a perennial bahiagrass pasture system were established in 2012/2013. Passive wick drainage lysimeters were installed below plots (n=4) of the conventional crop, low-input biofuel crop, biofuel crop with bio-char, biofuel crop with evaporated vinasse, and high-input biofuel crop. Bioenergy cropping systems were quick to establish and preliminary data indicated differences in water use and water quality during establishment. Passive wick drainage lysimeters have worked well to date for assessing the impacts of bioenergy cropping systems on water cycling and quality, and future data will be collected on net primary productivity and soil carbon dynamics.

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IMPACTS OF BIOFUEL INDUCED LAND USE CHANGE ON ENERGY, WATER, CARBON AND GREENHOUSE GAS BALANCES OF THE SOUTHWEST U.S. COTTON BELT REGION

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We are facing an unprecedented challenge in securing America's energy future. To address this challenge, increased biofuel crop production is needed. Although first-generation biofuels like corn ethanol are available, second-generation biofuels are gaining importance because they don't directly compete with food production. Second-generation biofuels are made from the by-products of intensive agriculture or from less-intensive agriculture on more marginal lands. The Southwestern U.S. Cotton Belt can play a significant role in this effort through a change from more conventional crops (like continuous cotton) to second-generation biofuel feedstocks (biomass sorghum and perennial grasses). While we believe there would be environmental benefits associated with this change in land use, their exact nature and magnitude have not been investigated for this region.

The objectives are (1) to evaluate the nature and scale of energy, water, C and GHG fluxes using flux measurement sites established at locations representing the major second-generation biofuel feedstock production systems (perennial grasses and biomass sorghum) in the Southwestern U.S. Cotton Belt region; (2) to determine the role of energy, water, C and GHG fluxes associated with land use change on key agroecosystem functions and sustainability; and (3) to synthesize and model the results from field site studies to develop regional estimates of C capture and mass fluxes.

We are conducting a multi-year project involving flux measurements, remote sensing observations, and soil, plant, and climatic measurements. Field-based measurements will be expanded to the regional scale using spatial interpolation based on remote sensing, along with regional simulations using the geospatial model ArcAPEX.

We are currently in the first year of the field studies. Eddy covariance flux measurements of carbon dioxide, water and components of the energy balance shows considerable variation among the sites. We are currently analyzing these data along with collecting field measurements and remote sensing imagery of the sites. Concurrent with the field studies, ArcAPEX is being evaluated for the study region. Preliminary form these efforts will be presented at the 2013 AGU Fall Meetings in San Francisco, CA.

Since we are in the initial stages of this project, conclusions await detailed analysis of the data to be collected in the project and results of the modeling effort.

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IMPACTS OF FOREST BIOMASS REMOVAL ON SOIL QUALITY AND BIODIVERSITY

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Utilizing forest biomass to produce biofuels will increase opportunities to maintain tree vigor and resistance to wildfire, drought, pests and disease. However, excessive biomass removal will degrade site quality by removing detritus and its contained carbon, energy and nutrients, which are vital to soil productivity and genetic diversity. Our goals are to develop indicators of potential detrimental impacts of small diameter tree removal from forest thinning operations on soil chemical and physical properties, soil biological activity, microbial diversity, and forest tree growth. We have three project objectives: 1) determine the effects of biomass removal from thinning forest stands on soil properties and tree growth, 2) assess the impact of biomass removal on fungal and invertebrate diversity, and 3) evaluate the capacity of soil amendments to compensate for biomass removal impacts on soil properties, biological diversity and tree growth. To accomplish these objectives, we have installed monitoring plots in stand thinning operations on two forest land ownerships. The plots include various levels of biomass retention, fertilizer applications, and biochar amendments. We have begun monitoring the response of soil quality indicators, such as carbon, nitrogen, and organic matter levels, soil acidity and exchangeable nutrients, soil physical properties (available water-holding capacity, CEC), wood decomposition rates, soil respiration and microbial biomass, and the relative activity of soil extracellular enzymes. Possible cascading effects of removing different levels of biomass and amendment treatments on the ecosystem will be evaluated on residual tree growth and genetic diversity of wood-rotting fungi and ground-dwelling invertebrates. Our study will establish initial guidelines on the amount of biomass retention required to maintain critical ecosystem functions in western forests.

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FULL COST ACCOUNTING OF ECOSYSTEM SERVICES FROM BIOMASS PRODUCTION LANDSCAPES IN THE MIDWEST UNITED STATES

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Guiding the burgeoning bioenergy industry toward greater sustainability requires careful consideration of land-use/land-cover change and ecosystem services. Woody biomass is but one of many ecosystem services that biomass production systems provide. Others such as carbon sequestration, water quality, and wildlife habitat also have real economic value. Our objective is to understand how and where woody biomass can be produced to both provide a vital feedstock to the advanced biofuels industry and to deliver additional ecosystem services that benefit farmers, landowners, and the public as a whole. Our hypothesis is that changes in the landscape as a result of increased demand for woody biomass will lead to changes the ecosystem services provided, and that developing the biofuels industry will enhance the net ecosystem services provided. We will test this by estimating the physical nature of these changes in ecosystem services and their associated monetized values, and explore whether certain scenarios for developing the biofuel industry may maximize the net value of the ecosystem services provided. This project will utilize the InVEST (Integrated Valuation of Ecosystem Services and Tradeoffs) model from the Natural Capital Project to estimate the provision and economic value of ecosystem services of various biomass production landscapes, including both those proposed by various agencies (USDA, DOE, and EPA) and those determined in-house through the use of econometric models. Simultaneous consideration of multiple ecosystem services will allow exploration of the relative importance of each in various biomass production regimes. Expected outcomes include explicit descriptions of tradeoffs associated with growing the biofuels industry.

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BIOCHAR IMPACTS ON FOREST SOIL CARBON STOCKS

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Biochar is often promoted as a panacea for agricultural and environmental problems, but its actual beneficial results may not be realized due to differences in material characteristics, soil properties, and agricultural systems. To date, the mechanisms for providing multiple ecosystem services and the conditions under which they may be realized are poorly understood. In this study, the forestry agroecosystem has been chosen in response to an increasing need to improve sustainable management of forest plantations and new sources of bioenergy.

The primary goal of this study is to determine if biochar soil amendments produced by pyrolysis of biomass from forest thinning for bioenergy can maintain, or enhance, the carbon storage in forest soils. The specific objectives of the project are to: 1) create biochar from trees cut to thin forests and relate pyrolysis temperature to specific physical and chemical properties of biochar; 2) place the results from biochar characterization in the larger context of biofuel and biochar research by incorporating results into the UC Davis Biochar Database to compare to other feedstock materials; 3) to adapt the molecular marker method using benzene polycarboxylic acid (BPCA) to examine pyrogenic carbon from soil and charcoal for analysis of aqueous samples specific to our experiments; and 4) conduct soil column experiments to evaluate the potential of biochar to enhance native soil carbon storage to soils representative of a range of California forest during repeated wetting and drying cycles.

Ponderosa pine trees have been harvested, chipped, and dried to produce biochar at 500, 700, and 900°C. The biochar is currently being characterized for a host of physical and chemical properties including total C/H/O, ash content, surface area, cation exchange capacity, and pH. These data will be included in our recently developed UC Davis Biochar Database (biochar.ucdavis.edu) and compared with biochars of similar and contrasting feedstocks. Saturated and unsaturated soil column experiments to evaluate biochars potential to sequester native carbon are ongoing. Effluent analysis focuses on total dissolved organic carbon (DOC) and molecular markers, utilizing the benzene polycarboxylic acid (BPCA) method, to evaluate transport of pyrogenic carbon versus native soil carbon.

Biochar created for these studies fit well among the library of biochars within the UC Davis Biochar database and demonstrate some ability to predict biochar physical and chemical properties based on feedstock and pyrolysis temperatures. Column experiments indicate that biochars impact is largely dependent on soil textural class and biochar amendment levels. However, the strong sorption of DOC to biochar suggests that there is potential for biochar to serve as a site for priming sandy soils for enhanced carbon storage.

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LIFE CYCLE ASSESSMENT OF RAPESEED HYDROTREATED RENEWABLE JET FUEL: REGIONAL VARIATIONS IN N_2O EMISSIONS

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Hydrotreated Renewable Jet (HRJ) fuel from oilseed plants has increasingly become important for the aviation sector to address energy security and climate change mitigation. Rapeseed (*Brassica napus* L.) is a favored candidate feedstock for HRJ because of its high quality oil content and the potentially attractive agroeconomic benefit to replace the fallow period in wheat/fallow rotations in the Great Plains. According to the revised renewable fuel standard (RFS2), all renewable biofuels must meet specific greenhouse gas (GHG) emission thresholds.
To this end, we conducted research to evaluate regional differences in N_2O emissions, one of the main contributors to GHG emissions in rapeseed HRJ fuel production. To determine regional N_2O emissions for rapeseed cultivation in several counties in 10 U.S. states, the Roundtable on Sustainable Biofuels (RSB) methodology was applied and results were compared to those obtained from the Intergovernmental Panel on Climate Change (IPCC) guidelines.
The results show that the N_2O emissions for RSB and IPCC methods are the same across U.S. regions except for the N_2O releases from ammonia (NH_3) volatilization and nitrate leaching. The RSB-calculated N_2O emissions varied for different U.S. states, though regional differences were very small. N_2O emissions were lowest in Nebraska (0.72 kg N_2O Mg^{-1} seed) whereas Oregon had the highest N_2O emissions (0.73 kg N_2O Mg^{-1} seed), while N_2O emissions from IPCC were the same for all sites, 0.87 kg N_2O Mg^{-1} seed. The life cycle GHG emissions of rapeseed HRJ using RSB method were in the range 42.66 - 42.97 g CO_2 eq/MJ compared to 45.86 g CO_2 eq/MJ using IPCC method.
The RSB methodology could be used to distinguish the N_2O outcomes of different sites, but these differences are small compared to total GHG emissions for rapeseed HRJ. The GHG savings of greater than 50% compared to petroleum jet fuel for multiple regional scales were achieved when applying the RSB method, while the IPCC method did not meet the GHG savings threshold. The cultivation of rapeseed as a cropping system during the fallow period in wheat rotation is not in competition with food and hence reduces the GHG of the rapeseed HRJ life cycle.

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CARBON SEQUESTRATION AND GREENHOUSE GAS EMISSIONS FROM BIOENERGY CROPS

ABSTRACTS PRESENTATION

PARTITIONING OF MACRO-NUTRIENT ANIONS DEPENDS ON BIOCHAR FEEDSTOCK

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In Midwestern U.S. agriculture, synthetic fertilizers and livestock manures are routinely applied to meet the nitrogen (N) and phosphorus (P) requirements of agricultural crops. The mobility of these anionic forms of these nutrients are either limited as an agricultural issue or become an environmental issue to cause pollution of non-point surface and ground water resources. The production of bio-oil through pyrolysis of biomass could become important in an energy-limited world. A byproduct of pyrolytic process is biochar which has potential for use as soil amendment to improve soil health of degraded agricultural landscapes. Our study includes characterization of different types of biochar (corn stover, Ponderosa pine wood residue, and switchgrass) after optimization of pyrolysis of bio-oil production. One aspect of this study is to examine the interaction biochar with added nutrients, especially its influence on partitioning behavior of macro-nutrient anions. Biochar and nutrient interactions were studied using sorption and desorption batch studies. Sorption-desorption characteristics of biochar were found to be strongly dependent on the feedstocks used in the pyrolysis process. The range of biochar properties suggest that type of biochar applied will need to be carefully chosen depending on specific soil management objective.

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ASSESSMENT OF LIFE CYCLE GREENHOUSE GAS EMISSIONS FROM BIOENERGY SORGHUM PRODUCTION IN CENTRAL TEXAS.

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Estimating life cycle greenhouse gases (GHGs) from biofuel production scenarios are important for compliance with federally mandated reduction goals as well as quantifying the 'carbon footprint' of a bioenergy cropping system. Federal legislation has mandated increasing biofuel production to more than 136 billion liters of fuel by the year 2022 while minimizing overall carbon intensity. Both direct and indirect GHGs can have a significant impact on overall life cycle efficiency. Cellulosic biomass feedstocks, such as bioenergy sorghum, must reduce life cycle GHG emissions by 60% compared to the 2005 gasoline standard. This study utilized life cycle analysis to quantify well-to-wheel greenhouse gas emissions from eight different bioenergy sorghum production scenarios. The effects of crop rotation, N fertilization, and residue return on life cycle greenhouse gas emissions from bioenergy sorghum production in central Texas were examined from 2010 through 2011. Field measured values were combined with published and modeled GHG estimates to evaluate biofuel production efficiency. Nitrous oxide emissions from crop production contributed the most CO_2-eq emissions. Urea fertilizer production, ethanol production, and transportation and distribution were other major carbon-intensive activities. Net change in SOC to 90 cm was utilized to estimate net CO_2 emissions to the atmosphere. Large annual SOC accrual from sorghum led to more CO_2-eq sequestered than lost per MJ ethanol. Nitrogen fertilization significantly increased life cycle GHG emissions across both years of study and fertilized treatments had lower biofuel production efficiency than unfertilized treatments. All treatments examined resulted in net negative life cycle GHG emissions and exceeded federally mandated reduction goals.

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LOBLOLLY PINE-SWITCHGRASS INTERCROPPING FOR SUSTAINABLE TIMBER AND BIOFUELS PRODUCTION IN THE SOUTHEASTERN UNITED STATES

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Diversifying the nation's energy supply portfolio may stimulate new economic sectors, decrease risk associated with volatile foreign markets, and development of renewable sources could yield environmental benefits. Bioenergy production systems in particular are compatible with existing agronomic practices, and may enhance soil properties and decrease CO_2-climate forcing by increasing regional carbon storage.

The objectives of the current project are to evaluate the productivity, resource-use efficiencies, and sustainability of a novel loblolly pine-switchgrass intercropping system for production of timber and a bioenergy crop in the southeastern U.S. We hypothesize that the asynchronous physiology and growth of the C_3 trees and C_4 grass, along with different soil layers exploited by the respective root systems, will allow for greater nutrient retention and more efficient site water use. We also hypothesize that the additional soil volume exploited by switchgrass roots and increased plant litter inputs will increase soil organic C, thus increasing C sequestration of the system.

The work is being conducted at a 28 hectare replicated field experiment installed and managed in the lower coastal plain of North Carolina by Catchlight Energy LLC, a joint venture between Chevron and Weyerhaeuser NR companies. Ecosystem-level carbon and water cycling are being studied by a multidisciplinary team of scientists from academia, industry, and government to evaluate sustainability, multi-functionality, and ecosystem services inherent to this novel forest intercropping system. The loblolly pine trees and switchgrass were planted in 2009 and results on plant and soil C stocks, water use, and nutrient cycling after four years of growth will be presented.

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CARBON SEQUESTRATION AND GREENHOUSE GAS EMISSIONS ASSOCIATED WITH SHORT-ROTATION WOODY BIOMASS PRODUCTION IN THE UPPER GREAT LAKES REGION

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Short-rotation woody biofuels crops (SRWC) have been proposed as one of the major feedstocks for bioenergy generation in the Midwest region. While the general consensus is that these crops have a favorable energy and greenhouse gas (GHG) balance compared to fossil fuel alternatives, the environmental impacts of widespread land conversion and the magnitude of potential GHG benefits are highly uncertain. In our study, we are investigating the effects of converting open lands to willow and hybrid-poplar plantations on soil N cycling, N_2O emissions, and NO_3^- leaching at seven sites of varying soil and climate conditions across northern Michigan, Wisconsin and Minnesota.

All seven sites responded to establishment with increased soil GHG emissions in the first year following conversion. GHG debts incurred varied greatly across the seven sites and were strongly associated with soil texture, hydrology and pre-conversion levels of soil organic matter. We investigated the potential for no-till and reduced-tillage establishment methods to reduce environmental impacts associated with land conversion: we did find reduced GHG emissions and eutrophication but extremely low survival in these treatments suggesting they will not be viable for commercial plantings. Across our network of study sites we observed a nearly 8-fold difference in feedstock productivity. We observed highest productivity on well-drained, sandy-loam soils and lowest productivity on sites with heavy texture and/or impeded drainage. A significant proportion of marginal, non-forested lands in the region occur on heavy-textured, poorly-drained soils suggesting that the potential landbase suitable for SRWC is likely to be smaller than that indicated by surveys of land cover which do not take into account underlying site conditions.

Our regional analysis has detected a major land-use shift in the region since 2006, namely the expansion of corn. A high-resolution land-change detection analysis has indicated that corn lands have expanded largely at the expense of open grasslands, similar to those being considered as candidates for conversion to SRWC plantations. This expansion – which likely has been driven at least in part by ethanol subsidies – has decreased estimates of land potentially available for conversion to poplar or willow plantations. The continuation of corn ethanol subsidies and the corresponding expansion of corn lands would hinder the widespread development of a poplar and willow plantation bioeconomy. However, if the recently expanded corn lands are taken out of production, the land based on which plantations could become established will improve.

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CARBON SEQUESTRATION AND GASEOUS EMISSIONS IN PERENNIAL GRASS BIOENERGY CROPPING SYSTEMS IN THE NORTHEASTERN U.S.

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This project seeks to help define the sustainability of perennial grass bioenergy production on marginal lands in the Northeast US by characterizing crop yields, sequestration of soil carbon (C), and emissions of nitrous oxide (N_2O) and methane (CH_4). These impacts will be determined under current production practices on wetness-prone marginal soils, for which very little relevant research exists. We are presently in the third of five years of field-scale research.

In 2011 we established a perennial grass strip trial on a 10-ha (16 ac) site (denoted S1; 42N28.20', 76W 25.94') where, due to wetness of the predominant Caneseraga-Dalton-Madalin soils, prior use over the past 50 years was limited to occasional mowing or haying. Quadruplicate ~0.4 ha strip-plot treatments are switchgrass (*Panicum virgatum* v. Shawnee), switchgrass + fertilizer N, reedcanarygrass (*Phalaris arundinaceae* v. Bellevue) + N, and non-converted control (fallow grassland).

Nitrogen loadings were 74 kgN/ha (applied April-May for reed canarygrass starting 2012; June for switchgrass starting 2013). Permanent sampling subplots (5 per strip plot) were established along natural moisture gradients, representing 80 sampling points at which biomass yield, soil characteristics, soil moisture content, emissions, and soil C are being monitored. Given the variable nature of emissions, we use an integrated approach, with monthly large chamber campaigns (n=120 chambers, operated April to November 2012 and April 2013 to date) used to compare N_2O and CH_4 emissions among treatments, while an eddy-covariance flux tower system monitors the temporal field-scale N_2O response to temperature or precipitation events. Annual tracking of soil health parameters (including aggregate stability, available water capacity, hardness, active carbon) cover pre- and post-conversion conditions. Due to severe overwintering losses in 2011-2012, switchgrass plots were no-till reseeded in 2012. Typically low first year and second year yields were observed and substantial weed competition has required repeated control measures.

In 2012, we began similar monitoring of a second smaller site (S2) with mature switchgrass (v. Shawnee) stands planted in 2008. Three subplots were located on upslope, sideslope and bottom slope positions to capture soil drainage gradients on each of three strip plots that had preexisting N treatments of 0, 56, and 112 kg N/ha. Frequent emission chamber campaigns (n=36 chambers) began just prior to the June 2013 N application. Proximity to and concurrence of field operations with the S1 field site suggests that responses to temperature and rainfall measured by the S1 flux tower can be used to help interpret S2 chamber trends as well. We report here soil analysis trends through 2013, as well as N_2O and CH_4 emission and biomass yield data available to date.

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HIGH PLANTING DENSITY SOUTHERN PINE FEEDSTOCK PRODUCTION: BELOWGROUND CARBON PARTITIONING AND DECOMPOSITION

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In the Southeast, southern pines are a promising woody biomass feedstock, and are already widely grown throughout the region. Loblolly pine (*Pinus taeda* L.) is the most commercially important southern pine species making up over 50% of the standing pine volume (1.4 billion cubic meters) and occupying 11.7 million hectares. This research fills a gap in the region by investigating modifications and optimizations of pine plantations for biofuel feedstock production or for integrated product objectives including traditional resources of timber and fiber along with biofuel feedstock production. Project PIs have been investigating high planting densities (up to 4448 trees/ha (1800 trees/ac) as opposed to the common 1483 trees/ha (600 trees/ac) as a means to augment the product outputs from pine plantations such as thinnings for biofuel feedstocks at relatively young ages. This component of the research focuses on the potential for belowground accumulation of carbon and the influence of initial planting density. Early results for installations in the lower coastal plain of Georgia indicate that planting density impacted biomass partitioning aboveground with greater partitioning to stems biomass at higher density. In contrast, partitioning to belowground taproot mass does not appear to be impacted by density; data on coarse lateral roots mass are not presently available. Modeling of taproot decomposition based on size fractionation of taproots, suggest smaller diameter material under higher planting densities may reduce belowground carbon storage.

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MEASURING THE BIOCHEMICAL INVENTORY OF CROPPED ECOSYSTEMS USING NMR

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The biochemical composition of feedstocks influences their use in energy production, with some biochemicals preferred for specific applications (e.g. cellulose for cellulosic ethanol, or lipids for bio-oil). Relatively small changes in feedstock biochemical composition can alter the cost-effectiveness of fuel production, making it valuable to know the anticipated biochemical composition of particular feedstocks. The biochemistry of belowground biomass is also relevant, as the decomposition rate of organic matter can vary depending on its chemistry.

While a full biomass biochemical inventory is valuable information, historically obtaining these types of data has been labor-intensive and prone to error. Nuclear magnetic resonance (NMR) spectroscopy has recently emerged as a rapid and accurate approach to understanding the biochemistry of whole plant biomass. Here we apply this tool to a range of cropped ecosystems and report aboveground yield of carbohydrate, protein, lignin, and lipids per hectare for corn, canola, soybean, miscanthus, switchgrass, and a variety of natural and planted grass ecosystems. Additionally, we report the effects of N fertilization on both above and belowground biochemical inventories for switchgrass. Managing root biochemistry in sandy soils is one tool available to increase soil carbon inventories, and we explore the effects of N fertilization on root biochemistry. In a best-case scenario, belowground biochemistry would be optimized without sacrificing aboveground yields and quality. To determine if this is possible, we compare aboveground yields with belowground chemistry for a range of N fertilization rates.

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EVALUATING PLANT-SOIL-MICROBIAL INTERACTIONS IN LOW-INPUT HIGH- DIVERSITY BIOFUELS: ENHANCING ABOVEGROUND ECOSYSTEM SERVICES WITHOUT A LOSS IN BELOWGROUND SERVICES

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Recently, it has been suggested that the native prairie species, switchgrass (*Panicum virgatum*), can provide a sustainable, low-input biofuel feedstock, while at the same time sequestering large amounts of soil C. Perhaps the most promising approach in producing C-negative bioenergy (maximizing feedstock production while sequestering C) utilizes mixed-species perennial ecosystems. Research on restored prairie communities indicates that, for low-input systems, long-term yields can be greater with higher plant diversity than with low diversity or monocultures. Low-input high-diversity (LIHD) cultivations are better equipped to deal with annual variations in climate and typically have fewer problems with pathogen buildup than monocultures. Also, including legumes is a low-input alternative to N fertilization. Diverse grassland plantings provide multiple benefits such as habitat for invertebrates and wildlife. LIHD cultivation reduces fertilizer input and nutrient leaching, while increasing arbuscular mycorrhizal (AM) fungi, potentially leading to improved soil health and C sequestration.

The major goal of our project is to assess if LIHD cultivation (both intra- and inter-specific diversity) will produce high biomass without increased nutrient inputs, while also providing wildlife habitat and increasing carbon sequestration.

Our study assessed mycorrhizal hyphal abundance, soil carbon and aggregate stability, and biomass production under LIHD cultivation in established plots at Argonne National Laboratory, Illinois. We compared intra-specific diversity with 3 different switchgrass cultivars and inter-specific diversity with combinations of switchgrass and other native prairie grasses and forb species. Annual productivity of extra-radical AM hyphae and inter-radical colonization was assessed. Phospholipid and neutral-lipid fatty acid analyses were used to determine soil microbial community composition and AM fungal biomass. Aboveground productivity for each plant species was assessed at harvest.

Our data indicates both inter-specific and intra-specific plant species biodiversity had similar aboveground biomass production compared to monocultures of switchgrass, and multiple genotypes of switchgrass had equal or greater annual production of arbuscular mycorrhizal fungi, compared to the switchgrass monocultures. Previous studies have shown that invertebrate species richness is positively correlated with plant species richness, and floral species richness and abundance led to greater bee abundance and bee species richness. Therefore, we predict that higher inter- and intra-specific plant species diversity will support greater invertebrate abundance and diversity, and these assessments are currently in progress.

Because mycorrhizal symbioses facilitate plant growth in infertile soil, while also mediating soil C accrual, these plant-fungal associations need to be considered in the design of feedstock management. Our study indicates that it is possible to decrease fertilizer inputs, improve aboveground ecosystem services, such as wildlife habitat, with no loss in belowgound services (such as soil aggragate stability and soil carbon sequestration), all without a loss in production.

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CARBON SEQUESTRATION AND GREENHOUSE GAS EMISSIONS ASSOCIATED WITH CELLULOSIC BIOENERGY FEEDSTOCK PRODUCTION ON MARGINAL AGRICULTURAL LANDS IN THE LOWER MISSISSIPPI ALLUVIAL VALLEY

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The Lower Mississippi Alluvial Valley (LMAV) has good potential for growing bioenergy crops due to its long growing season and well-developed agricultural industry. Soils in the LMAV with optimum characteristics for growing conventional agricultural crops will likely continue to be used for this purpose due to the relatively high value of these crops, so crops grown as biofuel feedstock will likely be grown on soils marginal for conventional crops. Switchgrass and cottonwood have high yield potentials on marginal soils in the region, and growing these crops may increase C sequestration in biomass, accumulate C in soils, and with adequate markets provide additional market opportunities for landowners. The objective of this study is evaluate the above- and belowground biomass C production, C accumulation and biological C dynamics within the soil profile, and gaseous emissions of CO_2, N_2O, and CH_4 in switchgrass, cottonwood, and a soybean and grain sorghum rotation on three retired agricultural sites in Arkansas and Louisiana. In 2009, switchgrass, cottonwood, and a soybean and sorghum rotation were established at sites in northeast and southeast Arkansas and northeast Louisiana. Aboveground and belowground biomass C, soil C, and soil labile C, microbial biomass C, and microbial activity of all crops were measured at the end of growing seasons in 2011 and 2012, monthly soil CO_2 flux measurement was initiated at all sites in January 2012, and monthly soil N_2O and CH_4 emission measurement began at the southeast Arkansas and northeast Louisiana sites in March 2013. Switchgrass had the highest cumulative removal of C in aboveground biomass, whereas soybean-sorghum had the highest cumulative aboveground biomass C returned to sites as residue. Cottonwood had the highest coarse root biomass C at two sites, and cottonwood and switchgrass had greater fine root biomass C than soybean-sorghum at two sites. Cottonwood had lower cumulative soil CO_2 emissions in 2012 than switchgrass and soybean-sorghum at two sites. Soil C and microbial characteristics were similar among all crops. Switchgrass and soybean-sorghum had the highest aboveground biomass C among the crops being evaluated. More C leaves the site in harvested biomass for switchgrass than for soybean-sorghum because more of the soybean-sorghum biomass is returned to the site as residue. Switchgrass and cottonwood had more C in belowground biomass than soybean-sorghum. Conversion of these retired agricultural sites to cottonwood and switchgrass has not yet affected soil C and soil microbial characteristics that serve as indicators of sustainability.

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CARBON SEQUESTRATION AND GREENHOUSE GAS EMISSIONS FROM BIOENERGY CROPS

POSTER PRESENTATION

SOIL CARBON AND NITROGEN AFFECTED BY PERENNIAL GRASS, COVER CROP, AND NITROGEN FERTILIZATION

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Soil C and N sequestration and the potential for N leaching can be influenced by the type of perennial grass, cover crop, and N fertilization due to differences in crop yields and the amount of residue returned to the soil. We evaluated the effects of the combinations of perennial grasses (energy cane vs. elephant grass), cover crops (clover cover crop vs. none), and N fertilization rates (0, 100, and 200 kg N ha^{-1}) on soil organic C, total N, NH_4-N, and NO_3-N concentrations at the 0-90 cm depth from 2011 to 2012 in central Georgia. Soil organic C at 15-30 cm and total N at 0-5 cm were greater for elephant grass with cover crop and 100 kg N ha^{-1} than for energy cane and elephant grass with no cover crop and N fertilization. In contrast, soil NO_3-N at 0-5 cm was lower for energy cane with no cover crop and N fertilization than for energy cane with cover crop and 100 to 200 kg N ha^{-1}. Elephant grass increased soil total N at 0-5 cm compared to energy cane. Cover crop increased soil organic C at 5-30 cm, total N at 5-15 cm, and NO_3-N at 15-30 cm compared to no cover crop. Nitrogen fertilization increased soil organic C and total N at 0-5 cm and NO_3-N compared to no N fertilization, but soil organic C at 15-30 cm was lower with 200 than with 100 kg N ha^{-1}. Soil organic C, total N, and NO_3-N decreased from 2011 to 2012, regardless of treatments. Preliminary results suggest that elephant grass with clover cover crop and 100 kg N ha^{-1} can sequester more soil C and N than other treatments and increased N fertilization rate can increase the potential for N leaching.

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DRIVERS OF SOIL RESPIRATION IN ARID BIOFUEL PRODUCTION SYSTEMS

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Carbon balance is an important component of sustainability of a biofuel production system. Soil respiration (R_s) is one of the largest components of the terrestrial carbon cycle. Production of forage sorghum (*Sorghum bicolor*) for lignocellulosic biomass is under consideration in the high-heat, high-irradiance, and thus high productivity, environment of the Imperial Valley, low desert of California. This seasonally very hot environment may reflect future production scenarios following ongoing climate change. Our objective in this system is to engage a data-model fusion paradigm to characterize the controls on soil surface CO_2 flux. We contrast fallow and vegetated conditions, dry and pulse-wetted conditions, and diurnal and seasonal courses of temperature and canopy photosynthesis, in order to adapt and further develop the Dual Arrhenius Michaelis Menten kinetics model (DAMM; Davidson *et al.*, 2012).

We combine single leaf-scale (LI 6400; assimilation, A_n) and canopy-scale (eddy covariance; net ecosystem exchange, NEE) measurements of CO_2 flux with measurements of continuous soil CO_2 fluxes to parameterize CO_2 emission with respect to (1) temperature, both a (2) labile and a (3) recalcitrant pool of soil carbon, and (4) soil oxygen.

Sorghum achieved high rates of A_n , exceeding 50 µmol CO_2 $m^{-2}s^{-1}$, NEE of 45 µmol CO_2 $m^{-2}s^{-1}$ and soil surface CO_2 flux of 20 µmol CO_2 $m^{-2}s^{-1}$, with maxima in early afternoon. R_s was increased by a wetting pulse during fallow periods but reduced by wetting with extensive vegetation. At seasonal scale, Rs increased with temperature, although this was confounded with increasing plant biomass. At diel scale, hysteresis between R_s and soil temperature increased with crop growth, reducing the correlation between Rs and temperature. Canopy height was significantly related to the degree of hysteresis, suggesting that hysteresis increased with the lag between CO_2 fixation and transport of sugars below-ground. Hysteresis of R_s in the presence of vegetation increased with the magnitude of CO_2 surface flux, however, this was less pronounced under fallow conditions. This indicates that the degree of hysteresis is not a function of flux magnitude, but is related to plant-derived C contributions to soil respiration.

Hysteresis in the diel relationship between R_s and soil temperature is not a simple physical relationship, e.g. with diffusivity of heat, CO_2 and O_2. The modified DAMM model provides an accurate description of observed R_s under fallow and vegetated conditions, and explains the observed diel hysteresis, by explicit consideration of direct effects of temperature on metabolism below-ground, effects of diurnal variation of light and temperature on photosynthetic C fixation above ground, and effects of soil wetting on diffusivity and oxygen partial pressure. Sorghum is a productive and water use efficient biofuel feedstock that is well adapted to this environment. Temperatures above 40ºC had no inhibitory effect on carbon acquisition, and light saturation of A_n was over 2000 µmol $m^{-2}s^{-1}$. Soil CO_2 fluxes were large, but episodic, driven largely by soil moisture. The modified DAMM model adequately predicts these fluxes, and may be used to evaluate the carbon footprint and sustainability of sorghum production for cellulosic biofuel.

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EFFECTS OF BIOCHAR SOIL AMENDMENT ON SWITCHGRASS YIELD, SOIL C DYNAMICS AND WATER AVAILABILITY

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Biochar-amended soils are thought to positively impact soil carbon sequestration, water holding capacity, and nutrient retention, leading to increased biomass production and reduced loss of reactive N through leaching and nitrous oxide emissions. However, the need for surface application and incorporation limits options for biochar application to perennial species such as switchgrass. The objective of this research was to examine the effects of biochar that was either surface applied and incorporated prior to planting vs. four years of biochar injections into existing switchgrass stands on switchgrass yield, and to determine in laboratory experiments the influence of biochar soil amendment on soil C dynamics and water availability. The study is being conducted at two excessively wet (fine-textured soils) and two drought-prone (coarse-textured soils) sites in central Pennsylvania. Switchgrass biochar was produced by high-temperature pyrolysis then either surface applied at 10 Mg biochar/ha and rototilled into the soil, or applied to chiseled furrows in four yearly applications of 2.5 Mg/ha. The first of the four furrow applications was made in autumn 2011 and the second in 2012. Switchgrass seedlings were transplanted into the field plots in spring 2012. Complementary laboratory experiments are performed to examine the influence of biochar amendment on soil C dynamics (using glass jars First year switchgrass yield was not significantly affected by the presence of biochar (P = 0.17) or biochar application method (P = 0.13), although a trend existed for plots with biochar to have slightly greater yield (8759 vs. 8476 kg/ha). Yield was significantly affected by location (P < 0.001) with the wettest site (fine-texture soil) having the highest yield (10,901 kg/ha) and the driest site (coarse-textured soil) the lowest (7152 kg/ha). In laboratory studies, addition of soil to biochar increased the size of the labile biochar-C pool and the amount of CO_2 evolved from biochar. The mean residence times of both the labile and stable biochar-C pools were generally decreased when soil was added to biochar, and the magnitude of change depended on the soil type. The presence of biochar had no significant effect on emission of CO_2 derived from native soil organic matter, irrespective of the soil type. In further laboratory studies, addition of biochar to fine-textured soils did not significantly influence available water content (difference between water content at field capacity and at the wilting point). However, addition of biochar to coarse-textured soils did significantly increase available water content, primarily by decreasing the water content at the wilting point. Initial results show no clear advantage of either biochar application method on switchgrass yield. Future years will determine whether the effects on available soil water will influence switchgrass yield. We will also be determining the life cycle effects of biochar addition on greenhouse gases.

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BIO-CHAR BASED ACTIVATED CARBON AS A KEY MATERIALS FOR RENEWABLE ENERGY PRODUCTION AND STORAGE

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Physical and chemical activation processes are investigated for upgrading the solid bio-char into higher value activated carbon. The influence of process parameters such as temperature, reaction time, flow rates, and gas composition on the response variables including burn off %, BET surface area and total pore volume are quantified. Biochar based activated carbon was applied as separation media in a continuous cyanobacterial platform to convert sunlight and CO_2 into energy dense fuels and organic chemicals which could be used for sustainable chemical production in the specialty fragrance industry. An adsorption column loaded with activated carbon was attached to the photobioreactor's exhaust for gas stripping. Prior to the adsorption column, the exhaust vapor proceeded through an ice water condenser to remove excess moisture. This effectively enhanced the chemical product's concentration before adsorption. The activated carbon column was thermally regenerated and coupled with a condenser to capture the desorbed products. Different activated carbon materials were developed and compared to optimize the adsorption dynamic and equilibrium for each individual chemical product. The hydrophobicity and hydrophilicity of activated carbon were determined to be important factors for chemical product recovery. The regeneration characteristics, desorption point and heat of desorption, were measured using a Differential Scanning Calorimeter (DSC). Simultaneously, the lifetime of activated carbon adsorbents were quantified. Developing an integrated, recirculating adsorption recovery system, which harvests volatile products by gas stripping the photobioreactor's exhaust, will be critical for expanding novel algal technologies. The CO_2 requirement for algae growth already limits its accessibility for widespread geographical applications, but a synergistic combination of PBR's with commercial ethanol plants could further improve the carbon efficiency and economics of ethanol production. This technology will allow us to exploit two under-utilized resources in the Midwest and Great Plains (sunlight and CO_2) by converting them into storable, transportable, energy-dense, biorenewable fuels and chemicals.

Multiple herbaceous biochar based activated carbon was also evaluated as energy storage materials in supercapacitors, the hierarchical carbon, with different specific surface area (500~2959 $m^2\ g^{-1}$) and different pore volume (0.4~1.65 $cm^3\ g^{-1}$) were prepared from sustainable feedstock - herbaceous biochar, which was a waste from a thermochemical process optimized for bio-oil production, using chemical activation with different activation agents. This hierarchical carbon, as electrode materials, showed improved specific capacitance from 170 to 260 F g^{-1} in 6 mol L^{-1} KOH at a current density of 0.6 A g^{-1}. Hydrothermal treatment with nitric acid significantly increase capacitance of carbon materials, while the specific capacitance of carbon without oxidation exhibits relative high (200 F g^{-1}) at a higher current density (0.5A g^{-1}) in 6 mol L^{-1} KOH and it can also shows 150 F g^{-1} in the typical organic solution of 1 mol L^{-1} tetraethylammonium tetrafluoroborate in acetonitrile after 1000 cycles. More importantly, the capacitive performances of the hierarchical carbons are much better than general petroleum or coal derivate activated carbons, ordered mesoporous carbons and commercial graphene, thus highlighting the success of preparing high performance supercapacitor electrode material from biochar and potential for improving economic viability of thermochemical biofuel processes by converting biochar to a high value added carbon materials.

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MANAGEMENT, PRODUCTIVITY, AND NUTRIENT RELATIONSHIPS IN BIOMASS SORGHUM SYSTEMS

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Bioenergy sorghum (*Sorghum bicolor* L. Moench.) productivity and nutrient uptake may be affected by management practices. The goal of this research was to optimize the efficiency and sustainability of high biomass (bioenergy) sorghum production systems. Results are reported for the last three years (2010, 2011, and 2012) of a four-year field study conducted near College Station, TX. The study utilized a complete factorial design with four replications of the following factors: Rotation: continuous biomass sorghum vs. biannual rotation with corn (*Zea mays* L.); stover return: 0, 25, or 50% of the sorghum biomass and all corn stover; and N rate: 0 vs. non-limiting N. The bioenergy sorghum used was a high-yielding photoperiod-sensitive hybrid. Sorghum was harvested for yield, and C, N, P K, Ca, Mg, Mn, Zn, Fe, and Cu concentrations and contents were determined. All three study factors affected plant growth, yield, and nutrient uptake ($p < 0.05$). Total yields and tissue concentrations of C, N, P, Ca, Mg, Mn, Zn, Fe, and Cu in sorghum biomass were significantly ($p < 0.05$) affected by rotation and N fertilization. Rotation and N fertilization increased sorghum yield, but variably affected elemental composition. Not returning any sorghum residue in previous years decreased continuous sorghum yield in 2011 and 2012. Highest yields in 2012 were seen under the 25% return rate ($p < 0.05$). A regression equation was developed relating sorghum biomass yield and rotation, nitrogen fertilization rate, soil total N, and extractable P in the surface 15 cm ($r^2 = 0.75$).

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GENERAL CROPS

ABSTRACTS PRESENTATION

PERENNIAL GRASSES - IMPORTANT BIOMASS SOURCE FEEDSTOCK FOR BIO-BASED PRODUCTS AND BIOENERGY

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Perennial grasses considered as ideal crops for both bioenergy production and biobased products for a many reasons that the most important are: a) higher biomass yields compared to annual bioenergy crops, b) better water and nitrogen use efficiencies, c) positive environmental impact compared to annual crops in terms of CO_2 and energy balance, d) cultivation in marginal lands avoiding the competition with areas used for food production, e) due to their long life time (15-20 years) have positive effect to the soil erosion problems.

In the framework of the 4FCROPS project, four perennial grasses were selected as the most promising: reed canary grass (*Phalaris arundinaceae* L.), switchgrass (*Panicum virgatum* L.), giant reed (*Arundo donax* L.), and miscanthus (*Miscanthus x giganteus*). Switchgrass and miscanthus can be cultivated in most climatic areas in EU27, while reed canary can be cultivated in the North of Europe and giant reed in the South. Two of them are being cultivated in Europe in a total area of 24,500 ha for solid biofuels (reed canary grass and miscanthus).

Reed canary grass is considered as an ideal perennial grass for the Nemoral climatic area of Europe. In Finland, the production area of reed canary grass in 2008 was about 20,000 ha, while in Sweden was under 1,000 ha. It has been set in Finland a target of 100,000 ha in 2016. It is a crop suitable in Nordic countries, where the winter is cold and the realistic yields of the crop in Finland varied from 4 to 7 dry t/ha.

Miscanthus is a perennial grass appropriate in all Europe apart from the Nemoral climatic area (due to low temperatures in winter) and Mediterranean southern area (due to its relatively higher needs for water compared to the other perennial crops). During the last two decades the crop has been investigated in several European research projects and it is cultivated in a total area of 4,500 ha and its yields ranged from 10 to 30 t/ha dry yields. It has been investigated or being investigated in several European research projects AIR CT92, CT0294, Miscanthus handbook, OPTIMISC, and OPTIMA.

Giant reed is a perennial grass that has been selected for two climatic zones; the Mediterranean North and South. In Europe, yields from 7 to 61 t/ha have been reported. Its realistic dry yields varied from 20 to 30 t/ha. It is considered as a feedstock with great potential for second generation biofuels. It has been investigated or being investigated in several European research projects (FAIR CT 96 2028, ENK CT 2002 00524, and OPTIMA).

Switchgrass is a perennial grass that has the advantage to be established by seeds and can be cultivated successfully in most climatic areas of Europe due to the fact that there are appropriate varieties for both cold and hot areas. The yields vary from 8 to 25 t/ha depending on the site and the variety. In European context, the crop has been investigated in the projects FAIR-CT97-3701 and ENK6-CT2001-00524, while recently it has been included in the projects OPTIMA and Grass Margin.

The yields of the four most important perennial grasses, the age effect of the grasses on biomass yields (yields from fields up to 15 years old), the area of their cultivation, the main end-uses, as well as the research gaps that needs further investigation will be further discussed in final paper.

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THE SWEETFUEL PROJECT: SWEET SORGHUM, AN ALTERNATIVE ENERGY CROP

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The SweetFuel (5.1 M€) is a 5-year project (2009-2013) supported by the European Commission (5.1 M€) in the FP7 Programme with the aim at exploiting the possibilities of sweet sorghum as a feedstock for bioethanol production in temperate, semi-arid, and sub-tropical regions.

Bio-ethanol from crop plants is a promising short-term option for displacing fossil transport fuel as testified by the success of sugarcane bio-ethanol industry in Brazil. However, sugarcane cannot be successfully grown under water-limited or temperate environments. Compared to sugarcane, sweet sorghum has a broader environmental adaptability and a shorter cycle. In Brazil, it has a tangible potential to be a second crop, namely 'safrinha', after sugarcane in order to increase the processing period of the sugarcane distilleries by up to additional 100 days/yr (sugarcane processed from mid April to December, while sorghum harvested in December).

The project partnership comprises 10 participants from research, academia and industry: CIRAD (France), ICRISAT (India), EMBRAPA (Brazil), KWS, IFEU, and WIP (Germany), Universities of Bologna and Piacenza (Italy), ARC-GCI (South Africa), Universidad Autónoma de Nuevo León (Mexico). Project activities include molecular-genetic and physiological breeding for ideotypes specially adapted to temperate climates, drought prone environments and poor soils; studies on agro-ecological adaptation and sustainable agricultural practices in marginal areas; social, economic, and environmental sustainability assessment; promoting the exchanges between RTD experts, stakeholders and key actors; and finally, identifying ethical risks resulting from ethanol production thus to propose guidelines for policy makers.

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CAN FORAGE SORGHUM BE A DEDICATED ENERGY CROP IN THE NORTHERN GREAT PLAINS?

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Forage sorghum [*Sorghum bicolor* (L.) Moench] is grown in many semi-arid regions of the world as forage for hay and grazing and it is just starting to be considered as a lignocellulosic feedstock for biofuel generation. The objective of this multi-location, multi-year study was to determine the potential of forage sorghum as a dedicated energy crop for biofuel in the northern Great Plains. Forage sorghum and sorghum x sudangrass hybrids were tested in North Dakota from 2009 to 2012. Twenty eight entries were evaluated at each location including Brown Mid Rib (BMR) hybrids. Forage sorghum biomass yield fluctuated between 9 and 20 Mg/ha and was greater for non-BMR sorghum than BMR sorghums. The principal component analysis indicated that ethanol yield, and N content were correlated with the presence of the BMR character which is a marker for low lignin content and it is assumed to also have a greater conversion to ethanol. Chemical analysis results indicated that BMR and non-BMR sorghums had the same cellulose content, 33.7 dry wt%, as compared with that of corn (*Zea mays* L.) stover with 37.3% dry wt%. Hemicellulose content was higher in corn stover and BMR-sorghum, than in non-BMR sorghum. Lignin content was higher in corn stover (18.1%) compared with BMR- (15.8%wt) and non-BMR sorghum (13.9%wt). The pretreatment of forage sorghum biomass at 160°C, 10 min, and 1 wt% acid concentration, led to maximum hemicellulose and cellulose hydrolysis. Contrary to what is believed by regional growers, sorghum can outperform the yield of any other biomass crop in the northern Great Plains and has the potential to produce up to 20 Mg/ha. Also, certain sorghum hybrids can yield as much as 35 Mg/ha in certain seasons. The non-BMR sorghums have about a 2 Mg/ha advantage in yield over the BMR sorghums, but because of their lower lignin content the estimated ethanol yield is greater than non-BMRs. I nterestingly, when visualizing the relationship between biomass and ethanol yield and quality parameters, the principal component analysis indicated biomass yield was strongly associated to the environment and components of the cell wall, while ethanol yield was mainly associated to the presence or absence of the BMR character and the N content of the biomass. The yield of fermentable sugars during pretreatment and enzymatic hydrolysis increased to certain extent in both sorghums. Many growers do not envision sorghum growing well in short-growing season areas, but the results of this study indicate forage sorghum is an excellent candidate as dedicated energy crop in the Northern Great Plains.

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EVALUATION OF SWEET SORGHUM GERMPLASM FOR MATURITY IN ARIZONA

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The potential for sweet sorghum [*Sorghum bicolor* (L.) Moench] to be a viable biofuel crop in Arizona relies on optimizing growing and harvesting in order to deliver a reliable feedstock for fermentation over a greater period of time. We have shown previously that the main components of ethanol yield are biomass, sugar, and juice yields. A traditional, late-maturing line might produce more than a fast-growing hybrid, but an efficiently-operating ethanol processing facility requires a steady supply of sweet sorghum juice as feedstock. A double-cropping system composed of shorter-season varieties could effectively expand the harvest window. Our objective was to examine the available germplasm, which included older lines such as Sugar T and Wray and newer hybrids from Texas A&M, to determine if a more efficient cultural scheme might provide a more continuous supply of feedstock.

Seed was sown at the University of Arizona West Campus Ag Center on May 26, 2011 and May 8, 2012 at nine plants per meter in a split plot design, with maturity as main plot and variety as sub-plot, and four replications each year. Sixteen varieties in 2011 and nine in 2012 (five common to both years) were evaluated for maturity as measured by number of days after planting (DAP) until physiologically mature (defined as 30 days after half the plot was flowering). Plants were harvested by hand at the soil line and the weight of two-3.05m sections of the middle two rows of the four-row plots was recorded. A subsample of 15 plants was weighed, stripped of leaves and panicles, weighed again, and pressed through a roller mill. Juice collected was weighed and then analyzed in the laboratory by High Performance Liquid Chromatography (HPLC) with a Refractive Index Detector for fructose, glucose, and sucrose. Theoretical biomass, juice, sugar, and ethanol yields per hectare were calculated for each variety and the data analyzed using JMP software.

In 2011, maturities ranged from 106 to181 DAP, and 2012 was similar with maturities between 113 and 178 DAP. Generally, the longer the plants were in the field, the higher the biomass and other yield components. In both years, the "short-season" hybrids (maturing at 106 DAP in 2011 and 113 in 2012) had yields that were about half that of the top performers for biomass, juice, sugar, and ethanol that matured between 162 and 179 DAP. The "short-season" types tended to be smaller in diameter and did not produce tillers. This indicates that with the "short-season" types double cropping would give the same yield per area, but spread over a longer time frame, and since they do not tiller higher yields might be achieved if planted at higher densities. Alternately, the second crop could be planted so the harvest windows would overlap. A combination of double cropping and changing the plant density might increase the yields of the short-season hybrids to twice that of the longer-maturing types.

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VARYING DATES OF PLANTING AND HARVEST TO MAXIMIZE PRODUCTIVITY OF SWEET SORGHUM FOR ETHANOL PRODUCTION IN ARIZONA

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If production of ethanol from sweet sorghum [*Sorghum bicolor* (L.) Moench] juice is to become a reality, optimizing the delivery of feedstock to fermentation plants needs to be a priority. One way to accomplish this is to have as wide and productive a harvest window as possible. Our objective was to determine if commercial varieties planted in April or May could be harvested earlier than physiological maturity without sacrificing biomass, juice, or sugar yield, the main components of ethanol yield.

In 2012, four varieties (350FS, Dale, M81E, and Sugar T) were planted on April 24 [Date of Planting (DOP) 1] and May 29 (DOP 2) in a split-split-plot design with four replications each. All four lines in each DOP were harvested at 90, 120, 150 and 180 days after planting (DAP). Plants were harvested by hand and the weight of two-3.05m sections of the middle two rows of the four-row plots was recorded. A subsample of 15 plants was weighed, stripped of leaves and panicles, weighed again, and pressed through a roller mill. Juice collected was weighed then analyzed by High Performance Liquid Chromatography (HPLC) with a Refractive Index Detector for fructose, glucose, and sucrose. Theoretical biomass, juice, sugar, and ethanol yields per hectare were calculated for each variety, date of planting, and date of harvest.

Harvest dates ranged from July 23 to November 26. For DOP 1, there were no differences for field weight, biomass yield, and juice yield for any of the four harvest dates. Sugar yield and ethanol yield were significantly lower at 90 DAP than the other three harvests, and those harvests were not different from each other, implying that there is no loss in yield by harvesting these lines as early as 120 DAP. There were no differences among lines. For DOP 2, biomass yield was significantly lower for the last harvest (180 DAP). This was in late November and the plants were desiccated due to near-freezing temperatures and little rainfall. While there was less juice, it was more concentrated and the sugars were as high as the previous two harvests. Where there were differences among lines, Dale was lower than the other three lines. Juice yield was significantly lower for the third (150 DAP) and fourth (180 DAP) harvests, due to less moisture in the plants, but it did not affect sugar or ethanol yield; both were not significantly different from the previous two harvests.

In order to maximize the productivity and efficiency fermentation of sweet sorghum juice, creative cultural schemes will need to be employed to supply feedstock. One such scheme for the arid Southwest United States would involve planting in April and harvesting anywhere from 120 to 180 DAP, whenever needed by the processing facility. A May planting is also possible, and would allow a similar harvest window, even potentially overlapping with earlier plantings. For the varieties studied, 90 DAP is too early for maximum potential ethanol yield.

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INDUSTRIAL CROPS TO HELP MEDIATE CLIMATE WARMING IN THE SOUTHWESTERN U.S.

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The climate is predicted to change toward a warmer, drier, and more variable climatic pattern over Southwestern North America which could significantly extend the eastern boundaries of the Chihuahua Desert into the Lower Great Plains of Texas. Simultaneously, existing aquifers such as the Ogallala have declined drastically threatening the future production of millions of hectares of cotton, corn, sorghum, and wheat. For this region's $9.2 B agricultural industry to survive an increasingly arid environment, crop species with higher levels of drought and salt tolerance need to be identified.

Over the past several years we have identified nine potential crop species which may meet these stringent adaptive requirements. It was interesting that four of these species will be grown in this region primarily as industrial crops. These crops are guar (*Cyamopsis tetragonoloba* (L.) Taub), castor (*Ricinus communis* L.), safflower (*Carthamus tinct*orius L.), and camelina (*Camelina sativa* L.). With exception of camelina, these crops are relatively short season annuals which would optimize growth in the wetter summer months; potentially fit in existing crop rotations; and provide commodities for a wide range of high value markets including the extensive livestock industry of this region. Camelina and other winter annual Cruciferae species may provide a valuable cover crop and a source of vegetable oil as a biodiesel feedstock.

We are conducting agronomic adaptation studies at three sites in a west to east transit that extends from the existing edge of the Chihuahua Desert at Clovis, NM, eastward for a distance of 330 km to Vernon, TX. If only a few of these industrial crop species are shown to be adapted and economically competitive in this rapidly changing climate, it will provide growers with the production tools necessary to sustain the agricultural industry and conserve the fragile environment of this region.

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TEPARY BEAN – A NATIVE AMERICAN CROP FOR CHANGING WORLD

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Tepary bean (*Phaseolus acutifolius* A. Gray), a truly Native American crop, is a short life-cycle annual desert legume indigenous to northwestern Mexico and the southwestern USA and is considered drought and heat tolerant. Extensive research conducted in Virginia (Mid-Atlantic region of United States of America), over several years since 1997, has indicated that tepary bean has considerable potential as a field crop in Virginia. Agronomic research has indicated that planting dates significantly affect seed yield, however, even plantings in July after winter wheat harvest could result in about 1300 $kg.ha^{-1}$ seed yield. Highest seed yield (2239 $kg.ha^{-1}$) was obtained from planting done in May. Virginia State University maintains about 200 accessions of tepary bean. Tepary bean germplasm contains considerable variation for seed composition traits. Extensive Biological N Fixation research has indicated that a strong interaction exists between rhizobial strains and tepary bean host genotype; however, efficient combinations have been identified. Tepary bean has shown to highly suitable as a short-duration forage crop. Tepary bean forage, 59 days after planting, contained 21.4 percent protein, 37.5 percent ADF, 41.1 percent NDF, 0.48 Mcal/pound NE, 60.8 percent TDN, and 1.12 percent fat. Extensive research related to drought tolerance of tepary been is on-going at Virginia State University. Even though tepary bean is considered a drought tolerant crop plant, considerable variation among germplasm for drought tolerance has been observed. We grew 31 tepary bean lines in a tunnel (Without any water) and in an adjacent area under ambient conditions (With rainfall). The mean plot yield of 31 lines grown in the tunnel was 632 g/row as compared to 360 g when grown outside the tunnel. Moreover, seed yield under the tunnel (Without water) varied significantly indicating tremendous variation for drought-tolerance among the 31 lines included in this study. Breeding efforts to combine drought tolerance, high seed yield, and superior nutritional quality are underway under a USDA-NIFA funded project. Details of various studies, relative to potential of tepary bean on a worldwide basis, will be presented and discussed.

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DEVELOPMENT OF HERBICIDE RESISTANCE IN INDUSTRIAL CROPS WITH CHEMICAL MUTAGENESIS

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The commercial use of transgenic technology to confer herbicide resistance in industrial crops (cotton, guar, castor, camelina, Brassica, safflower, and pennycress) is usually not economically feasible because of the limited production area usually dedicated to a single industrial crop. Major seed companies will usually invest millions of dollars into GMO based crop improvement programs only on major crop commodities where they will see a significant return on their investment. Consequently, using chemical mutagenesis for development of herbicide resistance is an alternative to transgenic technology to improve weed control in industrial crops.
Herbicide resistance is defined by the Weed Science Society of America as "the inherited ability of a plant to survive and reproduce following exposure to a dose of herbicide normally lethal to the wild type plant… herbicide tolerance is the inherent ability of a species to survive and reproduce after herbicide treatment".
Mutation breeding methods using chemical mutagenesis are especially well suited for developing herbicide resistance. Herbicide resistance often occurs at very low frequencies within a mutant population of plants. However, screening for potential herbicide resistance is a very efficient and cost effective process even when several thousand mutated plants need to be screened. Published studies have shown that it is possible to screen for herbicide resistance to both PRE and POST herbicide applications.
We have identified several classes of herbicides that would be ideal candidates for potential development of herbicide resistance with chemical mutagenesis. These herbicides should have a well described mechanism of action at a single site (often inhibiting the synthesis of a single amino acid), have a short soil residual activity, have a low volatility, be compatible with other herbicides for potential tank mixing, and allow for broad spectrum weed control within the crop. It would also be easier to market the technology if the targeted herbicides were either off-patent or were protected by recently issued patents.

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GENERAL CROPS

POSTER PRESENTATION

FIELD PEA YIELD RESPONSE TO PHYSICAL PLANT INJURY

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Developing yield response charts for crops subjected to physical injury from hail damage is important to both the crop hail insurance industry and insured producers since yield reductions may result in substantial financial losses. The study objective was to determine the response of field pea plants to physical plant injury (simulated hail damage) treatments through application of plant cut-off treatments at various stages of plant development. The study was a RCBD, with four replications, in a 4 x 5 factorial arrangement conducted in 2010 and 2012 at Prosper, ND. Plant growth stage (V4, V8, V12, and V16/R1) and plant cutoff level (main stem nodes removed from the top of the plant: 0%-control, 25%, 50%, 75%, and 100%) were the two factors evaluated. Plots consisted of 6 rows spaced 30 cm apart and 7.6 m in length with data collected form the four-center rows. A yellow seeded variety 'Agassiz' was sown at 802,570 PLS/ha using standard best management agronomic practices. Characteristics determined included seed yield, seed weight, maturity, and plant regrowth response. Yield reductions, averaged across years, at 25% cutoff ranged from 6 to 12% among growth stages and were greatest at the V16/R1 stage. At 50% cutoff yield reductions were 13, 13, 20, and 25% for growth stages V4, V8, V12, and V16/R1, respectively. At 75% cutoff yield reductions were 23, 25, 32, and 50% for growth stages V4, V8, V12, and V16/R1, respectively. Yield reductions at 100% cutoff were 37, 79, 96, and 99% for growth stages V4, V8, V12, and V16/R1, respectively. Maturity was delayed as cutoff level and growth stage advanced. Plant regrowth response (plant death, basal stems, and aerial branches) was influenced by cutoff level and growth stage of treatment. The 100% cutoff treatment resulted in basal stems at all growth stages and high plant death at later growth stages. Basal stems and aerial branches were regrowth responses observed for the other treatments where plant death incidence was low. In general, yield reduction increased as cut-off level increased and as treatments were applied at later stages of plant development. The primary yield components associated with yield loss were plants/ha and pods/plant.

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INTRODUCTION AND ESTABLISHMENT OF CHICKPEA AND SESAME IN VIRGINIA (USA)

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Availability of a ready market for chickpea (*Cicer arietunum* L.) and sesame (*Sesamum indicum* L.) for hummus production prompted New Crops program of Virginia State University to initiate a concerted effort in 2010 to study production of these crops in Virginia. Chickpea effort started with evaluation of a world collection of about 1250 accessions when planted as a summer or winter crop. It was known that hot and humid climate in Virginia will be a challenge for chickpea production due to potential incidence of Ascochyta blight in summer planted crop whereas winter-hardiness will be a factor in fall-planted winter crop. Several *kabuli* chickpea accessions with tolerance to Ascochyta blight when planted as a summer crop and winter-hardy accessions when planted as a winter crop have been identified. Considerable effort is also being devoted to development of a system for chickpea production in Virginia. Extensive research with five proprietary sesame cultivars from SESACO Corporation, during 2011, indicated that planting date effects on seed yield were significant whereas effects of row spacings and cultivars were largely non-significant. May 23 and July 1 plantings resulted in mean seed yields of 1479 and 750 kg/ha and oil contents of 45 and 46 %, respectively. Planting date of May 23 resulted in increased concentration of C16:0 (+3 percent), C18:0 (+5 percent), C20:0 (+1 percent), C16:1 (+7 percent), C18:1 (+12 percent), and C20:1 (+5 percent) over planting date of July 1. Later planting resulted in increased concentration of C22:0 (+9 percent), C18:2 (+11 percent), and C18:3 (+8 percent) fatty acids. Oil content in sesame produced in Virginia was 6.8 percent higher than that produced in Texas (45. 5 vs. 42.6 percent, respectively). Details of various chickpea and sesame experiments will be presented and discussed.

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SWEET SORGHUM PRODUCTION LOGISTICS FOR A SUB-TROPICAL ENVIRONMENT

H.P. Viator

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A regional multidisciplinary project utilizing sweet sorghum (*Sorghum bicolor (*L.) Moench) and energy cane (*Saccharum sp*.) crops for the manufacture of bio-based fuels and chemical by-products was initiated in Louisiana in 2012. The feedstock production model being evaluated calls for delivery of sweet sorghum biomass from mid-summer to the fall followed by energy cane delivery to late winter or early spring.

A primary feedstock logistics objective was to identify sweet sorghum hybrid/planting date combinations that would produce without irrigation a sustained supply of feedstock for a three-month period. Hybrids of early, medium and late maturity were planted (30°15'57"N, 91°05'56"W) on April 11, May 7 and May 30, 2012 on a silty-clay loam (fine-silty, mixed, superactive, nonacid, thermic Fluvaquentic Endoaquepts) in a split-plot experimental design with planting date as the main plot and hybrids within maturity class as sub-plots. Maturity class was assigned at random within planting dates, with each maturity class represented by two hybrids. Plots consisted of three rows spaced 183-cm apart, 12.2 m in length and were replicated four times. Harvest commenced when grain reached the hard-dough stage of physiologic development. Fresh-weight biomass yield was determined by harvesting one middle row with a single-row combine (John Deere,Thibodaux, LA, USA) in each plot and weighing with a weigh wagon instrumented with electronic load cells. Fifteen stalks were randomly selected from each plot for determination of juice and fiber quality analyses. The ranking of fermentable sugar yields was consistent for each planting date, with the medium-maturity hybrids producing the most for each planting. Averaged over planting dates the early, medium and late maturing hybrids yielded 3.90, 6.91 and 5.48 Mg ha^{-1} of fermentable sugar, respectively. While relatively low yields were expected for the early-maturing hybrids, the inability of the full-season hybrids to yield the greatest was a surprise, as those plots were the tallest and possessed the highest populations. Average planting date fermentable sugar yields were 5.60, 6.25 and 4.44 Mg ha^{-1}, respectively, for the April 11, May 7 and May 30 planting dates. Pre-panicle emergence growth was adversely affected by dry soil conditions for the first planting date. On August 29, Hurricane Isaac caused significant leaf shredding and stalk lodging. Presumably yield was adversely affected, especially for plots planted late in May. Hybrid maturity differences allowed for a sustained supply for the 90-day harvest season, although the late-maturing hybrids chosen for this study matured at a more rapid pace than anticipated and tended to overlap with the medium-maturity hybrids. Averaged across planting dates, the early, mid and late maturity groups required 98, 123 and 130 days, respectively, to reach hard-dough. Achieved biomass yield levels suggest that a 1000 metric ton per day bio-refinery would require approximately 2400 hectares to operate from July 15 to October 15. Bio-refinery viability based on sweet sorghum is particularly feasible when included in a model with energy cane. Sorghum's competitive advantage is that it can be grown on fallow land of the energy cane production cycle and can be harvested and transported with existing sugarcane equipment.

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FIBERS AND CELLULOSIC CROPS FOR BIOENERGY AND BIOMATERIALS

ABSTRACTS PRESENTATION

OPTIMIZING THE VALUE OF AG-DERIVED FIBERS BASED ON THEIR SOURCE & PROPERTIES

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After years of delay, biorefineries that convert cellulose to biofuels are starting to come on line; however, this emerging industry has a long way to go until it can profitably meet its targeted production levels. Cellulosic-ethanol production has been delayed by technical challenges. The industry needs assurances that technology exists to convert agriculturally-derived fibers to value-added products.

The USDA research team from Albany California is developing biorefinery strategies relevant to the Western US by utilizing biomass feedstocks that are prevalent in the West. Beyond biofuels, it is critical to produce multiple products from these feedstocks. Data will be presented on development of (1) novel enzymes and microbes, and (2) novel chemical/mechanical methods for making value-added chemicals and polymer composites from these same feedstocks.

Specifically, this presentation focuses on production of products from agriculturally-derived fiber sources and compares their functionality as it relates to fiber source. Applications include creation of drop-in-replacement biodegradable polymers, sustainable composites, and novel nanocomposites. This presentation also represents a successful collaboration between USDA and Brazilian researchers whereby we compare results for fibers traditionally found in North America with those more prevalent in the tropics (i.e. sisal, jute and coconut fiber). In one study, for example, blends of sisal fiber with biopolymers of starch and poly(caprolactone), a degradable biopolymer, showed increases in both tensile strength by as much as 30% and elastic modulus (resilience) by 2-fold with the addition of 5% and 10% fiber. These results were significantly different from those obtained using flax fiber, a traditional fiber found in North America. In another study, nanocrystalline cellulose derived from coconut husks reveal longer fibrils than those obtained from rice straw, wheat straw, or cotton. Implications of these property differences will be discussed.

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INTEGRATED BIOREFINERIES USING HYDROTHERMAL PROCESS: A CASE STUDY FOR WHEAT STRAW

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Due to environmental considerations concerning sustainable development, the production of renewable energy as bioethanol and high added-value chemicals from lignocellulosic materials require efficient technologies and processes. In the recent years, the concept or philosophy called biorefinery has drawn much attention. The term "biorefinery" of lignocellulosic materials from agricultural residues and industry is analogous to the classical petroleum refinery concept and refers to biomass conversion into biofuels and chemicals with high added value through the integration of clean processes and the biorefinery philosophy demands efficient utilization of the main components (cellulose, hemicellulose and lignin) of these raw materials. Hydrothermal processing is a potential clean technology to convert raw materials such as lignocellulosic materials into bioenergy and high added-value chemicals. In this technology, water at high temperatures and pressures is applied for hydrolysis, extraction and structural modification of materials. On the other hand, wheat straw is one of the most abundant agricultural by-products in the world and according to Food and Agriculture Organization of the United Nations statistics reported a world annual wheat production in 2010 of 651 million tons, proving to be a promising raw material in the application of biorefineries.

This work is focused on providing an updated overview on the application of biorefinery concept on the main components of wheat straw into value-added products as polymeric blend films and xylooligosaccharides (prebiotics) from hemicellulose, lignin production with high purity and bioenergy as bioethanol from cellulose fraction using hydrothermal processing. The fundamentals, modelling and separation of hydrothermal are also studied.

The methodologies are based on a series of studies performed by the authors.

The extraction and application of hemicellulose from wheat straw indicate that it is a promising material for making new renewable polymer blend films. Moreover, the bioactive compound production, as the xylooligosaccharides are applied as prebiotics in food industry, also the lignin extraction using a sequential hydrothermal process prove a material highly pure. Additionally, hydrothermal processing is an effective pretreatment that increased the cellulose content of wheat straw, making it a good substrate for the bioethanol production of second generation. In conclusion, hydrothermal processing can cause several effects including hemicellulose depolymerization (oligomers, monomers), alteration/degradation of lignin (phenolic compounds) and increased availability of cellulose. Due to these effects, the products obtained area valuable source of materials for the chemical, pharmaceutical, food and energy industries according to an integrated biorefinery concept.

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EFFECT OF FILLERS OBTAINED FROM AGRICULTURAL, INDUSTRIAL AND FOOD PROCESSING WASTES ON NATURAL RUBBER MECHANICAL PROPERTIES

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Natural rubber is currently one of the most important industrial crops in the world, due to its use as raw material for the production of over 40,000 products. Much research has been driven by the need to obtain alternative rubber sources to satisfy the increasing global demand for natural rubber. Fillers are known to be used to reduce the amount of rubber in a product, and reduce polymer cost per product. However, most current filler materials (apart from nano-silica) are either diluent mineral fillers, which reduce the performance properties of the rubber composite, or petroleum-based reinforcing fillers, such as carbon back.

The objective of this study is to determine the effect of low cost fillers on physical properties of cured rubber compounds made from different types of waste-derived, sustainable fillers. The effect of particle size and loading was determined using a standard compound in which 35 phr carbon black 300 was gradually replaced by specific waste-derived fillers until no carbon balck remained.

Hevea rubber, obtained from Centrotrade, and Guayule rubber were used in this study. The fillers included calcium carbonate derived from eggshells, carbon fly ash, tomato peels and guayule bark bagasse. Fillers were ground to macro and micro size. The macro fillers were dry milled and sieved to a particle size of 300 microns to 38 microns. The micro fillers were wet milled in water using a pebble mill (Glen Mills, PM 100), dried and dry milled and sieved to a maximum particle size of 38 microns. Particle size was confirmed using SEM and TEM at the Molecular and Cellular Imaging Center, OARDC. Evaluation of the tensile mechanical properties was performed using a tensiometer (Instron) following ASTM D 412. Four dumbbell specimens of each composite were cut and tested.

In general, the rubber composites tested had stronger tensile properties with smaller particle sizes at lower loadings. The tensile strength of the rubber composites was, in most cases inferior compared with the control which contained 35 phr carbon black w/o other filler. Reduction of particle size increased elongation to break as well as modulus at 500% elongation and tensile at break while the increase of the filler load in the composite increased elongation to break but decreased modulus at 500% and tensile at break.

The results of this study open the possibility to replace or decrease the use of existing fillers with more sustainable equivalents materials capable of reproducing desirable properties. Further research includes the evaluation of nano particle s, given that particle size have shown to have great influence on the rubber mechanical properties. The use of these fillers can create novel materials and decrease cost of manufacture by utilizing other industries byproducts.

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EVALUATION OF ACOUSTIC ABSORBERS PRODUCED FROM AGRICULTURAL BYPRODUCTS AND MYCELIUM

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Previous studies have evaluated various biomass composites for use in acoustic absorbers with varying degrees of success. However none of these acoustic studies have ever evaluated the use of biomass composites glued together with the mycelium fruiting body of a fungi. Given the recent success of the authors for using this unique binder in developing packaging materials; of particular interest was to examine the acoustical properties of bio-based acoustic tiles bound together with mycelium from the fungi from the phylum of the Basidiomycetes in its vegetative stage on various agricultural by-products.

A set of experiments was conducted on bio-based acoustic absorption tiles that were made with fungi that were grown on semi-hydrophobic agricultural by-product substrates such as cotton by-products {burs, sticks and leaves} as well as other agricultural by-products such as switchgrass, rice straw, sorghum stalks, flax shive, kenaf and hemp. The acoustic testing of the material utilized an impedance tube and measured the reflected standing wave ratios in accordance to ISO standard 10534-1.

The results of the study indicate the mycelium based boards provided a significant performance improvement in comparison to the absorption provided by a standard acoustic tile insulation board and provides improvements at the key automotive road noise at the frequencies near 1000Hz, where most of the automotive noise resides. A further advantage provided by this new material is that it can be produced economically in comparison to the traditional petroleum based foams with the further advantage of bio-degradation when the product is disposed of at its end-of-life use.

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DEVELOPMENT OF LOW DENSITY FIBER BOARDS FROM AGRICULTURAL FIBERS

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The last decade has seen a significant progress in the utilization of biomass feedstock for producing renewable energy; value added products, as well as a wide range of biochemical and biomaterials to replace current petroleum analogs. There is an increasing pressure on agricultural biomass utilization for developing sustainable building products. Increased demand of wheat straw and decreasing acreage has contributed to significant increase in the price of wheat straw in the Upper Midwest Region.

A study was conducted to understand the feasibility of soy and corn stalks to replace wheat straw for manufacturing low density fiber boards for application in the building products industry.

The soy and corn stalk bales were first hammer-milled to size the material. The second step involved refining and drying. Particle size analysis was conducted to understand the effect of processing on the amount of fines. Third step involved laying of mats and application of adhesive before pressing them into boards. Low density fiber boards (18 lbs/ft^3) with varying composition of soy and corn stalk were pressed and their physical and mechanical properties were analyzed.

Initial trial results showed that soy stalk is a more promising feedstock than corn stalks. Some of the mechanical properties of soy and wheat straw blend boards were similar or better than 100% wheat straw boards.

Agricultural biomass has a lot of potential to serve as an alternative feedstock for a variety of industrial products. Increase in the demand for sustainable raw materials and rising prices of agricultural biomass has created a greater interest in crop based feedstocks for commercial applications.

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FIBRE CROPS AS BIOBASED MATERIAL SOURCE FOR INDUSTRIAL PRODUCTS IN EUROPE AND CHINA

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For thousands years (6000 BC), mankind has been strongly dependent on fibre crops (flax, hemp, cotton, jute, sisal, kenaffor numerous purposes. During the last two decades, non-textile applications have attracted growing interest by research and industry, with considerable investments in R&D for the reinforcement of existing markets, or to boost innovative markets. Fibre crops are and will be the future raw materials not only for the textile industry, but also for eco-friendly building materials, particleboards, insulation boards, cosmetics, medicine and source for other bio-polymers, agro and chemicals. Interest in fibre crops as a primary source for the manufacture of interior parts in the automotive industry, or for supplying cellulose and hemicellulose for second generation biofuels are two instances that may testify the renewed interest of the industry sector towards natural fibres. Fibrous materials extracted by kenaf and bamboo for bio-building applications are perfect examples of growing interest in fibre crops. In Europe the major fibre crops are cotton, hemp and flax. Along with bast fibre crops, high yielding crops like miscanthus, arundo, switchgrass and cardoon are alternative and innovative fibre crops. Whether their fibres quality is lower than that of bast fibres (i.e. fibre fineness, length and lignin content), the high productivity associated with a low energy requirement, could make them interesting feedstocks for papermaking, bio-building or biopolymers, and bioenergy purposes. Miscanthus is one of the main raw materials used in the Republic of China for paper making, and in several studies in Europe is considered a valuable alternative to wood fibre both for bio-building and paper pulp purposes in Europe. In the light of a strong renewed interest in fibre crops and sustainable biobased production chains as well as the relevant research activity on fibre crops carried out from both counterparts', a sound link between EU and China will lead to a wider stakeholders' participation, while providing a long term vision on future and common research activities between EU and the Republic of China. The main objective of FIBRA network is to link the research activities carried out on both EU and China and to provide a long term vision on future common research activities on fibre crops and will improve researchers' training opportunities. The specific objectives are: 1) To develop a resource efficient system via optimisation of raw material from fibre crops for multiple uses, 2) To support the biorefinery concept for processing fibre crops, 3) To facilitate future collaborations between European and Chinese industries in the field of fibre crops and bio-based products, 4) To ensure a wide-range networking of the relevant scientific communities and stakeholders and the systematic establishment of linkages such as broad networking twinning of large sets of research projects and consortia and short exchange/visits of researchers and summer schools, 5) To improve training opportunities in the area of fiber crops to European and Chinese scientists, 6) To provide a long term vision on future common research activities that will contribute to the international policies of the EU. FIBRA project 311965 (www.fibrafp7.net) is being funding by the European Commission through FP7 (DG Research) and by funding by Chinese Academy of Agricultural Sciences (CAAS); started in Sept. 2012 and will be completed in Nov. 2015. In the first year of FIBRA all the fibre crops were evaluated (bast fiber, hair, grass crops, woody, etc.) but from the beginning of the second year the project will be concentrated in bast fiber crops (hemp, flax, kenaf, ramie, jute, and nettle) and grass fiber crops (miscanthus, switchgrass, giant reed, bamboo and giant reed).

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BIOBASED ABSORBENTS PRODUCED FROM SEASHORE MALLOW STEM TISSUES

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Seashore Mallow (SM), *Kosteletzkya pentacarpos* (L.) Ledeb. (formerly classified as *K. virginica* K. Presl. ex Gray), a perennial halophytic member of the Malvaceae, is native to coastal areas of North America as well as Eurasia. SM can grow in saline soils up to salinity levels of 0.9%, and thus could be grown on land unsuitable for traditional crops. Individual SM plants produce up to 44 stems annually once maturity (3 years) is reached, with up to 20 stems per plant depending on growing conditions. Because SM stems are similar to kenaf (*Hibiscus cannibinus* L.), there is potential for these to be used in a variety of industrial applications. Recent research indicated that isolated bast (phloem) fibers from SM stems possessed excellent properties for novel textiles, with greater physico-mechanical properties than cotton fibers, as well as possessing unidentified gums. Our research team has been studying the utilization of agricultural coproducts (e.g., dried distillers grains, oilseed press cakes) for a variety of novel uses, including as biodegradable cat litter, and as hydromulch, material that is used to prevent erosion and for enhanced revegetation of disturbed sites. Preliminary research by our group indicated that ground SM stems absorbed large amounts of both water and organic liquids.

The objective of this research was to determine if SM stems, either with bark intact, or mechanically processed to remove the bark, could be employed in a variety of bioabsorbent applications.

Larger, debarked stems were milled and separated into three fractions by sieving. The largest fraction absorbed water readily and appeared to be an excellent bedding material for birds and small animals. The mid-sized fraction made an excellent base for biodegradable cat litter. The finest fraction efficiently absorbed diesel fuel which could be subsequently burned as a fuel. Smaller stems with bark (bast fibers) intact were milled to produce a material which performed excellently as hydraulically-applied mulch (hydromulch), with comparable properties to a commercial hydromulch.

The present study indicates that ground and fractionated SM stems could potentially be processed into several commercial products which are equal to or superior than current products.

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HOW SUSTAINABLE IS THE PRODUCTION AND USE OF KENAF?

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Relationships between the environment and crops are varied and complex. It is generally considered that the production and use of biomass crops have more beneficial than harmful effects on the environment. However, the outcomes can significantly be influenced by site-specific factors and by management and processing options.

The objective of this study was to identify how sustainable is the production and use of kenaf, focusing on the impact on biotic and abiotic resources, through the analysis of the crop's interaction with its environment and management and processing practices.

In order to identify sustainable issues related to the kenaf production and use, several categories were studied: replacement/conservation of fossil energy sources, emission of greenhouse gases and acidifying gases, effects on the quality of soil and water, use of resources, waste generation and utilization, biodiversity and landscape. In this study, the assessment of data retrieved from literature was supplemented with results obtained from the Biokenaf project. In addition, through an integrated approach, minimization of environmental hot spots in the systems and options for improvement are indicated, in order to provide new insights for the future development of this crop in a sustainable agriculture context.

Results show that kenaf can be considered as a more environmentally acceptable crop than other annual fiber crops, since it requires fewer inputs (fertilizers, pesticides). But, due to the short permanence period in the ground, it stands to be as burdening as other annual crops regarding erodibility and biodiversity. Risks associated with losing soil quality and use of water, nutrients and land are also comparable to most annual energy crops. Impact reduction strategies are limited to crop management options which can influence emissions, nutrient status and mineral depletion. All other impacts are site specific dependent, intertwined with the crop traits. Therefore, the implementation of an impact-lean kenaf system should root also on the adequacy between crop and location.

In addition, the substitution of fossil fuels and materials through the use of kenaf can lead to energy savings and reductions in greenhouse gas emissions, but a negative impact can be witnessed in terms of acidifying emissions. It is worth noting however, that environmental benefits will occur only if the production and conversion processes are carefully managed and guidelines followed.

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INVESTIGATING SEED DORMANCY IN SWITCHGRASS (*Panicum virgatum* L.): UNDERSTANDING THE EFFECT OF TEMPERATURE AND PLANT HORMONES ON EMBRYO DORMANCY

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Switchgrass (*Panicum virgatum* L.), a perennial warm season grass, possesses valuable characteristics as a biofuel crop. However, its commercial potential is at risk as seed dormancy can delay germination, affecting a uniform stand in the establishment year. Seed dormancy in switchgrass is classified as non-deep physiological dormancy, where the embryo condition and seed covering tissues may prevent germination. Our lab previously demonstrated that seed-coat dormancy is primarily caused by the pericarp/testa, and secondarily by the lemma/palea, acting as a barrier to oxygen diffusion and mechanical restraint (Duclos et al., 2013. Industrial Crops and Products: 45, 377-387). The primary focus of this research was to explore embryo physiological dormancy and its interaction with environmental cues and surrounding seed layers. Specific objectives involved: 1) assessing the effect of different temperature/light regimes and exogenously applied compounds (abscisic acid [ABA], gibberellin [GA], and fluridone [FLU]) on the germination of both upland and lowland switchgrass cultivars 2) examining the response of physically-altered seeds to exogenously applied ABA, GA, and FLU in stratified (moist chilling) and non-stratified Cave-in-Rock seeds germinated under inhibitory temperature.

Temperature alternation (30/15°C) enhanced germination while constant temperature (30°C) reduced it in both upland (Cave-in-Rock and Trailblazer) and lowland (Alamo and Kanlow) dormant cultivars. In contrast, the low-dormant cultivar Expresso germinated well at both temperature regimes. Seed germination was unaffected by light regime. ABA decreased germination considerably in all dormant cultivars studied at both temperature regimes, but the magnitude of the response was less under alternating temperatures. GA slightly improved germination at a constant temperature and varied in its effect at the alternating temperature regime. FLU had no effect on germination in intact seeds.

Under inhibitory temperatures for germination (30°C), the effect of exogenously applied plant growth regulators depended on the covering layers and dormancy level of the seed. In non-stratified seeds, the highest effect of ABA and GA was measured in seeds with bracts, followed by seeds without them, while excised embryos only responded to ABA. FLU promoted germination only in seeds without bracts. The combination of both GA and FLU had a larger effect than either compound separately. In stratified seeds the only significant response was observed when exogenous ABA was applied to seeds with bracts, yet the relative decrease in germination was half of that obtained in non-stratified seeds.

Results show that the effect of temperature on germination has an important hormonal component that is highly influenced by the genetic background and seed-covering layers, and supports the role of ABA as a germination inhibitor and that of GA as a dormancy-release agent.

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FIBERS AND CELLULOSIC CROPS FOR BIOENERGY AND BIOMATERIALS

POSTER PRESENTATION

POTENTIAL BARRIERS TO GROWING HYBRID POPLAR AS BIOFUEL FEEDSTOCK

K.W. Zobrist, P. Townsend, S. Kar, N. Haider

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Advanced Hardwood Biofuels Northwest (AHB) is a USDA-funded project to develop biofuels from fast-growing hybrid poplars. The fuels produced will be direct replacements for fossil fuels, fully compatible with existing infrastructure and certified to run in car, truck, aircraft, and other types of engines. The goal is to lay the foundation for an industry that will produce enough biofuel to meet 75% of the Pacific Northwest region's 2022 Renewable Fuel Standard (RSF2) target. The project is led by the University of Washington and includes a consortium of university and industry partners. The project is divided into five teams: Feedstock, Conversion, Sustainability, Education, and Extension. A key role of the Extension Team, led by Washington State University, is to prepare growers and Extension personnel in the region for hybrid poplar as new crop opportunities. There may be barriers to adopting this crop, however.

The objective of this study is to begin identifying potential barriers to growing hybrid poplar as a biofuel feedstock crop. This will allow us to 1) develop appropriately-targeted education and assistance programs and 2) to assess the overall feasibility of getting enough adoption by growers to support a poplar-based biofuel industry. We engaged stakeholders around the region through meetings, presentations, exhibits at conferences, a community open house, and a survey of Extension personnel to gather some initial data and feedback on issues around growing hybrid poplars.

Based on anecdotal feedback and data from the Extension survey, we have developed a preliminary list of issues and barriers that may need to be addressed. These include environmental concerns, negative experiences with hybrid poplar as a pulp and paper crop, market uncertainty, competition with food crops, available land, and water rights. We also found that the majority of Extension personnel have little or no experience with bioenergy and low interest incorporating biofuels into their programs.

These preliminary results illustrate some of the types of barriers to and issues around growing hybrid poplars for biofuel feedstock. While not insurmountable, these issues, along with others that are identified as the project continues, will need to be addressed through education and outreach in order for the AHB project to be successful.

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GENETIC ENGINEERING FOR SEPTORIA DISEASE RESISTANCE IN HYBRID POPLAR

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Septoria musiva, one of the most damaging pathogens in *Populus spp.*, causes leaf spot and canker diseases and is directly responsible for plantation failure. Chemical and cultural control has proven problematic and largely ineffective. To date, planting of resistant clones appears to be the best means of controlling this pathogen. The objectives: of this seed grant were to generate and test transgenic hybrid poplar plants that carry candidate disease resistance genes and to identify key genes that are involved in the response to *S. musiva* infection.

Agrobacterium tumefaciens strain EHA105 carrying candidate gene(s) were used to transform a *S. musiva* susceptible hybrid clone OGY (*P. deltoides* × *nigra*). A whole-plant *S. musiva* assay was used for pathogen inoculation. Differential gene expression in leaf tissues of two resistant (DN34, *P. deltoides* x *nigra*; NM6, *P. nigra* x *maximowiczii*) and two susceptible clones (DN164, *P. deltoides* x *nigra*; NC11505, *P. maximowiczii* x *trichocarpa*) was analyzed by RNA-Seq.

Several transgenic lines have been obtained for the candidate genes. We are currently propagating the plants for whole-plant *S. musiva* assays. Individual expression of the wheat oxalate oxidase gene and several antimicrobial peptide genes having a similar structure as ESF39A was able to enhance resistance in OGY to *S. musiva*, although the plants ultimately succumbed to the disease. By combining 2 or 3 resistance genes with different action mechanisms, we expect to achieve a higher level of and more durable resistance. In total, 511 million reads were generated via RNA-Seq. An average of 78% of the reads was successfully aligned to the *P. trichocarpa* genome. Functional annotation of differentially expressed genes based on comparisons between resistant and susceptible clones revealed that there were significant differences in the expression of genes involved in disease/stress resistance and oxidation reduction in mock treated leaves. Four days post inoculation of *S. musiva*, differentially expressed genes were most enriched with GO terms of leucine-rich repeats and disease defense. Among them were 23 loci involved in plant-type hypersensitive responses (GO: 0009626), corresponding to 8 kinds of proteins: NB-ARC domain-containing disease resistance protein (11 loci), flavin-dependent monooxygenase 1, phospholipase A2A, MAC/Perforin domain-containing protein, MutT/nudix family protein, EF-TU receptor, mitogen-activated protein kinase 3, and elicitor-activated gene 3-1.

In conclusion, transgenic lines carrying candidate resistance genes have been generated. These plants will be further tested in the field after initial evaluation in the greenhouse. Genes responsive to Septoria infection have been identified. The results from this study indicate that strong defense mechanisms involved in the pathogen perception, oxidation reduction, and accumulation of defense-related gene products may contribute to Septoria resistance in DN34 and NM6.

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EFFECT OF SHADING ON SWITCHGRASS PHYSIOLOGY, ABOVE- AND BELOWGROUND BIOMASS AND LIGHT-USE EFFICIENCY

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There is growing interest in using switchgrass (*Panicum virgatum* L.) as a biofuel intercrop in forestry systems. However, there are limited data on the longevity of intercropped bioenergy crops, particularly with respect to light availability as the overstory tree canopy matures. Therefore we conducted a greenhouse study to determine the effects of shading on switchgrass growth. Four photosynthetically active radiation (PAR) levels were investigated inside a greenhouse: control (no shade), low, medium and heavy shading. We determined the effect of shading on switchgrass from March to October 2011, by quantifying tiller number, tiller height (cm), gas exchange rates (μmol m^{-2} s^{-1} and mmol m^{-2} s^{-1} for photosynthesis and stomatal conductance, respectively), leaf area (m^2), above- and belowground biomass (g pot^{-1}), and light-use efficiency (g MJ^{-1}). We also compared PAR levels and associated aboveground switchgrass biomass from inside the greenhouse to PAR levels in the inter-row regions of a range of loblolly pine (*Pinus taeda* L.) stands from across the southeastern United States (U.S.) to estimate when light may limit the growth of intercropped species under field conditions.

In the greenhouse, there was a reduction in tiller number, tiller height, gas exchange rates, leaf area, biomass and light-use efficiency with increasing shade. Total biomass in the control measured 374 ± 22 g pot^{-1} compared to 9 ± 2 g pot^{-1} under heavy shade. Corresponding light-use efficiencies were 3.7 ± 0.2 and 1.4 ± 0.2 g MJ^{-1}. Results from the light environment of loblolly pine plantations in the field suggest that switchgrass biomass will be significantly reduced at a loblolly pine leaf area index greater than 2, which corresponds to a 65% reduction in PAR from open sky, which occurs on average between ages 6 and 8 years across the U.S. Southeast in intensively managed pine plantations.

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EFFECT OF FIBER TREATMENT ON SORPTION CHARACTERISTICS OF PLANT FIBERS

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The U.S. Department of Energy estimates that on average 4.9 million liters of oil is spilled into U.S. waters every year. The most common technologies for removing oil from water bodies include oil absorbent polypropylene booms and skimmers. Although these materials are highly efficient in absorbing oil, they do not degrade easily and add to the burden on environment. Some of the past studies have shown that plant fibers are excellent absorbent materials and can absorb 80-100% of its weight in oil. It is still significantly less than the 700% oil absorbance of polypropylene.

This study was conducted to evaluate two fiber treatment methods to evaluate the oil sorption characteristics of 5 plant fibers, oak wood, cotton burr & stems (CBS), corn stalk, soybean stalk, and cattail under different fiber treatments in different mediums.

Three of these fibers, CBS, corn stalk and soybean stalk are agricultural byproducts. Cattail is an invasive plant found near water bodies and on wetlands. Oak wood fiber is a byproduct from furniture manufacturing and flooring. The fiber treatments included control (untreated), heat treatment at 80ºC, heat treatment at 125ºC, mercerization at 300ºC for 1 h, and mercerization at room temperature for 48 h. Sorption efficiency of the fibers were evaluated in four different mediums including water, motor oil, crude oil, and a mixture of 20% water and 80% crude oil by volume using ASTM F716 standard. Oil sorption was calculated as the percentage weight gain in each medium.

Corn, cattail and soybean showed the highest sorption capacity under all four mediums when untreated. Heat treatments and mercerization at 300ºC significantly increased the water sorption of all fibers except oak. Corn and cattail showed the highest increase in sorption capacity of 350 – 550% after heat treatment compared to 170-360% when not treated. High temperature mercerization increased sorption capacity of agricultural fibers (CBS, corn and soybean) to 660-720% in water, 355-630% in motor oil, 515-525% in crude oil, and 675-815% in crude oil-water mixture.

The mercerized agricultural fibers have shown great potential for further development to oil/water absorbent materials.

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PLENARY SESSION

A REGIONAL PROGRAM FOR PRODUCTION OF MULTIPLE AGRICULTURAL FEEDSTOCKS AND PROCESSING TO BIOFUELS AND BIOBASED CHEMICALS

D.F. Day

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The rationale for this project is to drive the expansion of biofuel crops throughout the Southeast, a region of great agricultural productivity in the United States. Much of the region is agricultural, populated with rural family farms in desperate need of a new economic base. By the same token, the biofuel industry has been limited by a shortage of readily convertible feedstocks (other than corn). This program targets both these problems. The Southern Regional Agricultural Sector can be expanded through utilization of sweet sorghum and energy cane, for the manufacturing of bio-based fuels and by-products. Both are crops capable of being produced in underutilized land. A significant gap exists in the knowledge base regarding the economic feasibility and sustainability of growing and processing these crops. A regional multidisciplinary consortium of agricultural scientists, biotechnologists, technology and engineering providers, economists and educators was formed to facilitate conversion of these regionally appropriate crops into a portfolio of bio-based fuels and chemicals with the help of biofuel companies trying to secure sufficient carbohydrate and fiber feedstock to meet production goals comparable with fossil-based industries. Our program includes: improving agronomic production of energy crops through breeding for selected parameters, screened using NIR; harvesting trials for energy cane and sweet sorghum using modified sugarcane harvesters. Utilizing a pilot facility to process selected feedstocks into fermentable sugar syrups, for industrial partners to test production of a suite of fuels and products. Supplying input for economic models addressing agricultural and processing and cost structures for feedstock -bioproducts possibilities. Initiating training programs for future biofuels workers and extending information to extension units in multi-state areas on the potential for agricultural development using these target crops. We have established that sweet sorghum and energy cane are suitable crops for the production of biofuel and bio-based chemicals in the Southeastern Region, and that the approach of using crops with staggered harvest times is feasible. Plant breeding programs have made a number of successful crosses which are being evaluated for cold tolerance and range. A pilot plant facility was constructed and is processing experimental crops to syrups for testing by industrial partners for suitability for biofuel and biochemical production. Economic and life cycle analysis is being conducted on the proposed crops and processes. An extension program has been established to familiarize farmers with these crops. An education program has been established for training people for work in the biofuels industry.

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NEWBio: NORTHEAST WOODY WARM-SEASON BIOMASS CONSORTIUM

T. Richard

Penn State University

The Northeast has substantial demand for transportation fuels, an educated and capable rural workforce, and over 3 million acres of marginal, degraded and abandoned land that could become productive, profitable sources of biomass with improved management. Under-utilized agricultural land is already being used to grow swithgrass, miscanthus, and short-rotation willow to provide a sustainable, reliable, and affordable feedstock supply for biofuels, bioenergy, and biomaterials production in the region. The NorthEast Woody/warm-season BIOmass (NEWBio) Consortium is helping this emerging industry develop robust and scalable value chains for these biomass feedstocks. NEWBio is a unique collaborative network of public and private universities, businesses, non-profit organizations, and government agencies organized around a set of four large-scale demonstration sites, each forming the basis of a 500 to 1200 ton/day supply chain of lignocellulosic biomass suitable for advanced transportation fuels. These demonstrate sites provide a real world focus for research, outreach, and education programs targeting biomass production and logistics, evaluating new business models, and engaging community stakeholder processes designed to grow biomass feedstocks and biofuel for the region.

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DEVELOPING NEW MARKETS FOR BIOBASED PRODUCTS

R. Buckhalt

Manager, BioPreferred Program

The presentation will discuss the journey from the research bench to commercialization and how USDA is helping to develop new markets for biobased products through the BioPreferred® program. The BioPreferred biobased markets development program has two pathways to increase purchases of biobased products: (1) by the Federal government under a procurement preference program and (2) by commercial buyers and consumers through a voluntary labeling program.

The first is designed to harness the purchasing power of the Federal government to pull biobased products. The second is a consumer-based label designed to raise general awareness of biobased products. Some 97 categories of biobased products, representing about 10,000 individual products have been designated since the program started in 2002 as part of that year's farm bill. More recently, since the beginning in February 2011 nearly 1,000 individual products have received the voluntary "USDA Certified Biobased Product(s)" label and labeled products are appearing in retail outlets like grocery, home goods, and hardware supply stores.

USDA is the lead agency for the BioPreferred program. This Farm Bill-mandated biobased products program helps create jobs in rural communities, adds value to agricultural commodities, decreases environmental impacts, and reduces our dependence on imported oil

The procurement preference applies not only to direct Federal purchases of biobased products but also to procurement of services where biobased products may be used such as construction and operations and maintenance. USDA designates categories of biobased products, each of which is associated with minimum biobased content. The procurement preference applies to individual biobased products that fall under a designated category and meet or exceed the minimum biobased content for that category as set by USDA. Government purchasers and Federal contractors are bound by the procurement preference.

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RUBBER AND RESIN SOURCES OF BIOMATERIALS, BIOMASS AND BIOENERGY FEEDSTOCK I

ABSTRACTS PRESENTATION

GUAYULE: HOW FAR HAVE WE COME?

D.T. Ray

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Parthenium argentatum Gray (guayule) is a perennial shrub of the Compositae family, native to the Chihuahuan Desert of north-central Mexico and the Big Bend area of Texas. For well over 100 years guayule has been known as a source of natural rubber, resin, and different bioactive compounds. At the turn of the 19th century guayule rubber from wild stands supplied 10-20% of the rubber used in tires in the USA. However, since this time, commercialization efforts have started and stopped, including research and development activities, in response to different societal events.

Guayule has advantages in today's society by being an industrial (non-food/non-feed) crop that does not compete against food or fiber crops for the best farm land and highest quality water. Guayule is a renewable source of natural rubber/latex that can replace petroleum-based synthetics, as well as help meet the increasing global demand for natural rubber. Toward this end there are now three different companies in Arizona (Yulex Corporation, PanAridus L.L.C., and Bridgestone Corporation) involved in guayule research and development. That guayule is now an industrial crop in Arizona is due in large part to a long and storied history of research and development efforts by many individuals over the past 30 years, the goal of which has always been the development of a sustainable cultivation of guayule and commercial production of guayule products.

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OVERVIEW AND FOCUS OF BRIDGESTONE AMERICAS, INC. GUAYULE RESEARCH OPERATION

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Currently, *Hevea* is the sole source of natural rubber on a commercial scale. With the changes in the economies of Southeast Asia, the threat of leaf blight (*M. ulei*) infections on *Hevea* and changes in the demand for natural rubber, Bridgestone Americas, Inc. started investigating the use of the guayule plant as a sustainable, domestic and alternative source of natural rubber. This initiative is being accomplished through Bridgestone Americas Tire Operations (BATO) in collaboration with Bridgestone Japan.

A research Farm in Eloy, AZ and a process research center in Mesa, AZ are being developed to fully understand the potential of guayule from both agronomic and industrial perspectives.

Bridgestone's agricultural research is focused on: 1) supplying guayule shrub to the process research center, 2) determining best growing practices for guayule to optimize yield and rubber production and 3) increasing rubber content and improving agricultural characteristics through a traditional plant breeding approach.

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IMPROVED TISSUE CULTURE PROTOCOLS FOR GUAYULE

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Natural rubber is the largest industrial agricultural import in the USA, valued at over $2.9 billion in 2010 (faostat.fao.org). Development of additional sources of natural rubber represents a huge opportunity to create new biobased materials and industrial products. Natural rubber from plant sources, such as guayule (*Parthenium argentatum*) may be more economically sustainable with improved yields, through breeding or molecular engineering of rubber biosynthesis. Although the plant is drought-tolerant and readily cultivated in semi-arid regions, guayule can be recalcitrant with respect to regeneration and transformation for *in vitro* plant tissue culture, limiting the progress of metabolic engineering.

Basal media including Murashige and Skoog (MS), Woody Plant Medium (WPM), and Driver and Kuniyuki (DKW) media were compared for use in guayule regeneration and propagation. Explants grown on MS basal medium showed large size calli with multiple shoots, but the calli produced on DKW medium were of higher quality, and longer true shoots were produced. Adventitious root formation was best in WPM basal medium.

A comparison of macro and micro nutrient levels in MS, DKW, and WPM media revealed significant differences in the calcium levels. Under controlled conditions,

guayule plants *in vitro* incorporated calcium into plant tissues in proportion to the amount available. Moreover, the addition of calcium nitrate tetrahydrate at moderate levels into MS medium significantly improved the emergence of single, elongated true shoots, suggesting a requirement for calcium in guayule tissue culture. We have further explored selection agent (antibiotic) concentration for the identification of transgenic plants using a spectinomycin resistance gene (aadA). Based on the results, we have improved tissue culture protocols for guayule including spectinomycin as the selection agent.

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GUAYULE FROM MÉXICO: OUTSTANDING SHRUB`S SOURCE FOR INDUSTRIAL DEVELOPMENT

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The arid (AZ) and semi-arid zones (SAZ) of Mexico covering an area of 1,028,055 km2, distributed in 19 states, with annual rainfall less than 350 mm in AZ and 350-600 mm annual rainfall in SAZ. The guayule region is located in the states of Coahuila, Chihuahua, Durango, Nuevo Leon, San Luis Potosi and Zacatecas. It has been reported the existence of more than 2,600,000 tons of srubs in 570,000 ha. The industrial development of guayule rubber and latex may be based on the exploitation of shrubs that grow in the wild stands, but would require a reforestation program to ensure the development of new plants in the medium term. Also parallel development would be made of guayule as a crop in the regions where they have the features that the bush needs for its development, as to soil and environmental climate.

The objective of this paper is to present outstanding results of research conducted in guayule in Mexico.

In Mexico guayule exploitation began in 1903 and reached its highest level in the decade of the 40s. In Universidad Autonoma Agraria Antonio Narro conducted research from 1970 in order to obtain information to support the industrial use of guayule. The results of our Team showed that the guayule shrubs of wild stands in Coahuila, Durango and Zacatecas have reported high rubber content up to 21%. Also in the region of Mapimí, Durango were located and identified the only scientifically reported diploid materials. The rubber content of the shrubs of this region was assessed as 17%, higher than the resins content, which was up 11.5%.

The industrial and commercial development of guayule may be a social promoter in the AZ and SAZ, since the inhabitants of marginal areas, are those involved in the collection of wild material, and it should be noted that it is the poorest in Mexico.To achieve this objective requires a great project that includes: researchers from universities, federal agencies-private agencies and Mexico-USA international collaboration.

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GUAYULE WETSUIT PRODUCT LAUNCH AND INCREASING GUAYULE MATERIAL SUPPLY

L. P. Christoffersen, J. Mitchell, R. Manzone, J. Martin

Yulex Corporation, Phoenix, AZ 85040

After Yulex commissioned its new processing facility during the first quarter of 2012 for guayule materials in Chandler, Arizona, launching guayule material products with its customers became a top priority. This led to Patagonia's November 2012 launch of "a guayule-based wetsuit" made from "a renewable biorubber that is the first alternative to traditional fossil-based neoprene." This closed-cell foam material was, and continues to be, considered a game changer for Patagonia and the wider outdoor action sports market since it represents the first alternative to neoprene in more than 80 years. In parallel, enabling significant increases in the near-term future supply of guayule materials was enabled through a strategic partnership formed between ENI Versalis and Yulex in January of 2013. This was followed by immediate project development activities to manufacture guayule-based biorubber materials via the launch of an industrial production complex in Southern Europe. In support of these major commercialization milestones, Yulex made a major investment in its crop breeding program through a $3 million five-year grant for the University of Arizona focused on breeding and agronomic development of guayule. These three major developments within the past 12 months strengthen Yulex's commercialization capabilities for continued game changing product launches, significant guayule material supply growth through the construction of new processing facilities, and a continuation of its comprehensive crop improvements tailored to each production center's unique growing conditions.

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FORMATION OF NOVEL NATURAL RUBBER- PLASTIC NANOFIBER COMPOSITES VIA ELECTROSPINNING

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Nanofibers are useful in applications ranging from filtration systems, sensors, textiles, acoustic insulation, battery separators, and cellular substrates. Nanofibers are fibers with diameters less than 100 nanometers, and therefore have physical properties such as high surface area, low density, small pore sizes, high pore volume, and high porosity. Nanofibers are primarily manufactured using a method called electrospinning, utilizing an electrical charge to draw out fibers from a liquid polymer. Most electrospun nanofibers are petroleum-derived plastics that often fracture under a mechanical load, degrading too quickly in biological applications.

The objective of this study was to develop natural rubber-plastic nanofiber composites via electrospinning, and assess fiber diameter and morphology using SEM at the Molecular and Cellular Imaging Center, OARDC.

Natural rubber used in this study include: Hevea STR5L (STR5L), and Guayule (GNR). The plastics in this study include poly(lactic-coglycolic acid) (PLGA), polylactic acid (PLGA), and polycaprolactone (PCL). Solvent systems to create solvated co-polymers include hexane, THF, and chloroform.

Electrospinning is a processing technique that utilizes a high electric potential between a needle tip of polymer solution (5-35 kV) and a collector at ground (0 kV). The polymer solution becomes charged, and electrostatic repulsion from the large potential counteracts surface tension of the solution and the droplet is stretched into a liquid stream. The charge in the liquid stream begins to move to its surface as current flow in the fiber changes from ohmic to convective. The resulting electrostatic repulsion in the fiber creates a whipping process that dries, thins, and elongates the fibers. The fibers are collected at ground potential (0 kV), when the jet and whipping are stopped.

Evaluation of novel composites include SEM to determine fiber diameter and morphology. Future work includes determination of tensile properties of nanofiber bundles utilizing a dynamic mechanical analyzer, and biological substrate characterizaton such as fiber surface hydrophobicity.

In general GNR and STR5L can be successfully electrospun, but often lapse into thin films, loosing fiber morphology. Electrospinning natural rubber with plastics such as PLA, PLGA, and PCL retains fiber morphology that have consistent geometries.

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ESTABLISHING 57 MILES OF BUCKEYE GOLD (*Taraxacum kok-saghyz*) IN NORTH EAST OHIO

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Buckeye Gold (*Taraxacum kok-saghyz*) is an alternative natural rubber-producing crop suitable for cultivation in temperate zones with a cold winter. This year we have produced and planted approximately 1.2 million transplants, so that we can generate the largest amount of rubber from this species from a single planting in at least the last 50 years.

For this planting, we selected and pooled 42 seed lots collected from plants grown in high tunnels and outdoor raised beds from autumn 2011 to spring 2012, which upon harvest, had roots of at least 7 g fresh weight and a rubber concentration of at least 5% rubber/g dw (determined by accelerated solvent extraction). The pooled seed lot contained two million clean seeds. The seeds were planted into transplant trays containing 264 cells/tray, the cells being formed by a continuous paper pot strip designed for a 5-inch plant center to plant center spacing (Nippon Beet Sugar Manufacturing Co., Ltd., Japan), and filled with Pro-Mix potting medium. A Blackmore Needle Seeder (The Blackmore Company, Belleville, MI) was used to seed the trays. The needle-like shape of the raw seeds made it difficult to singulate and 2 million seeds were planted into 1.2 million cells. Three trays were hand seeded to determine germination/establishment rate, which averaged 83%, in close agreement with the controlled tests of the individual seed lots. The trays (3,861) were seeded between April 3 and May 24, 2013 and established in greenhouses with no supplemental light and temperatures of 65-70°F during the day and 60-70°F at night. Watering consisted of misting the plants with mist nozzles 2-3 times per day for the first 10 days after seeding. After 10 days (and plant emergence), we were able to use a higher pressure hose nozzle to water twice a day. After 3 weeks, we began a fertilizing schedule of 20-20-20 fertilizer 3 times a week at 50 ppm.

Seedlings (3,420 total trays) were transplanted into seven fields (~6.8 acres) at Fry Farm and Horticultural Unit One in Wooster, Ohio, and at Muck Farm in Willard, Ohio between May 16 and July 26 using two hand-drawn tranplanters (Circle-Kiko Co. Ltd., Japan). Fields were prepared using a disc cultivator followed by culti-mulching and rototilling. Rain forced fields to be re-prepared several times. Row spacing was approximately 8 inches in all fields, and 57 miles of transplants were established. Excessive rainfall prevented much planting in June, and flooding caused some plant loss. Stand counts will be determined. Weeds were controlled using a combination of pre-emergence and post-emergence herbicides as well as mechanical methods. The results from this crop will allow us to more accurately project commercial scale crop biomass and rubber yields.

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HYBRIDIZATION BETWEEN *Taraxacum kok-saghyz AND T. officinale*

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Taraxacum kok-saghyz (TK) is a species of dandelion which can produce substantial amounts of high quality rubber in its roots; however, TK competes poorly with weeds. In order to overcome this shortcoming, there is interest in developing transgenic, herbicide resistant TK germplasm. The potential release of such germplasm raises the question of transgene introgression into the ubiquitous weedy relative of TK, the Common Dandelion, *T. officinale* (TO).

In order to evaluate this risk, controlled crosses between the two species have been conducted. As the weedy TO exhibits obligate apomixis, its pollination of TK is the most likely avenue of hybridization. To this end, 400 unidirectional crosses were conducted and progeny were evaluated with a complement of 5 Cut Amplified Polymorphism (CAP) markers.

Of these progeny, 16% proved to be the result of true hybridization rather than induced selfing; furthermore, 8% of these hybrid progeny exhibited aberrant TK phenotypes, while the remainder exhibited morphologies characteristic of TO. The apparent dominance of this phenotype may be due to multiple chromosome set contributions. Approximately 70% of hybrids have demonstrated the inheritance of a full complement of apomixis genes from TO. While the inheritance of apomixis will prevent backcrossing and preclude introgression, it may also allow adaptive hybrids to reproduce while being held in a constant state of heterosis. Preliminary results show that some vigorous hybrid dandelions can produce significantly more rubber than their paternal TO populations, suggesting that a vigorous growth habit can be liberated from a low rubber production background through interspecific breeding efforts.

Overall, this research demonstrates that hybridization between TK and weedy TO is possible under controlled conditions. To determine the potential ecological impact of such hybridizations, the ability of hybrids to form under realistic conditions and the fitness of hybrid populations must be determined. In addition to informing the risks associated with transgenes, this work has created hybrid germplasm, which could potentially be used to introgress a vigorous growth habit and apomixis into high rubber TK backgrounds.

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HYDROPONIC GROWTH OF *Taraxacum kok-saghyz* AND THE EVALUATION OF PARTIAL ROOT HARVEST

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Taraxacum kok-saghyz (Kazak dandelion) is being evaluated as a domestic rubber crop due to the high quality rubber it produces and its resilience in a wide range of environments. Yet while a promising option, the Kazak dandelion's rubber yield can vary due to genetic factors or external conditions. Hydroponic growth methods have been utilized with many other crops as a way to monitor nutrient supply and its effect on plant growth. Thus a similar method might provide more insight into the Kazak dandelion to help produce a reliable high yield source of domestic rubber.

The objective of this study was to implement hydroponic growth methods to observe the growth of the Kazak dandelion in a liquid solution, as well as to evaluate the root regeneration abilities of this plant.

Taraxacum kok-saghyz cuttings were placed in an 8 by 8 fully randomized hydroponic system with an automated drain and fill cycle. Using liquid medium similar to Hoagland's solution, the cuttings grew for 3 months under constant aeration. Once mature, the plants were grouped by leaf phenotype and root sizes.

After quantitative data was gathered on the Kazak dandelions, vertical and horizontal cuts were made to remove sections of the adventitious roots. The plants were placed back into the system for 5 weeks to look at the effect of the partial harvest. The final growth could be compared to the control plants in each group, which had been left untouched.

While not considered to like wet environments, the *Taraxacum kok-saghyz* grew well in the liquid solution. The initial hydroponic growth was a success and many dandelions from the sample set grew to an average soil grown rosette size or larger. The Kazak dandelions did not grow a typical taproot as seen in soil, but rather small adventitious roots were grown on the exterior with larger roots running along the interior of the root mass. The partial harvest was also a success as both cut directions showed healthy regeneration of roots. The horizontal cut showed more promising results than the vertical cut likely due to the severing of fewer roots. This resulted in a quicker growth of roots and an overall thicker root mass.

The growth of *Taraxacum kok-saghyz* in hydroponic conditions could offer a new insight into the nutrient requirements of this species. Additionally hydroponics could provide a new method of rubber cultivation and improve the commercialization of this species as a domestic rubber crop.

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RUBBER AND RESIN SOURCES OF BIOMATERIALS, BIOMASS AND BIOENERGY FEESTOCKS I

POSTER PRESENTATION

TISSUE SPECIFIC AND INDUCIBLE PROMOTER EVALUATION IN BUCKEYE GOLD

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Buckeye Gold (*Taraxacum kok-saghyz*) is an alternative natural rubber-producing crop. As it can be easily established in tissue culture and transformed using *Agrobacterium* as compared to other rubber-producing plants, Buckeye Gold becomes a model plant for studying rubber metabolism.

Although some studies have described the genetically modified Buckeye Gold, no investigation of promoter availability in Buckeye Gold transformation has been conducted. Therefore, candidate promoters for plant transformation were selected and evaluated in Buckeye Gold. Promoters evaluated in this study will be useful for generating transgenic Buckeye Gold for both research and application purposes.

Agrobacterium rhizogenes–mediated transformation system was developed in Buckeye Gold for rapid and efficient promoter analysis. The constructs, containing promoter coupled to green fluorescence protein (GFP), were generated and then introduced into Buckeye Gold. In specific types of tissue, or under certain conditions, the expression of GFP can be directly activated. The intensity of GFP signal in transformed hairy root will be quantified to assess promoter performance. Moreover, the detection assay will be performed at various growing stages as well as after cold and dehydration treatments.

As the activation and localization of GFP indicates the spatial and temporal patterns of gene expression, we can more easily manipulate the exogenous genes introduced into Buckeye Gold.

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CHLOROPLAST GENOME SEQUENCING AND PLASTID ENGINEERING OF KAZAK DANDELION

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Natural rubber is an irreplaceable strategic resource, for which there is a growing demand and increasingly volatile prices. This is largely due to shortcomings of the near-exclusive rubber resource Rubber tree (*Hevea brasiliensis*), which include the threat of South American Leaf Blight, high labor costs, narrow genetic diversity and long generation times. These shortcomings have fueled interest in alternative sources of natural rubber; one of these sources is Kazak dandelion (*Taraxacum kok-saghyz*, aka Buckeye Gold), a species of dandelion which produces high quality rubber and is adapted to a wide range of environments. As a new crop, the yield of Kazak dandelion has not yet been fully realized and weed control is the most difficult challenge; one approach to expedite its commercialization is the use of plastid engineering to increase herbicide resistance and also rubber yield. This strategy is advantageous as it allows for a high level transgene expression, transgene containment by maternal inheritance, as well as multigene engineering by a single transformation. However, in order to achieve efficient plastid transformation, the use of species-specific constructs informed by the chloroplast genome is needed.

The objective of this research was to sequence the chloroplast genome of Kazak dandelion and utilize this sequence to build constructs capable of efficient plastid transformation. A stable plastid transformation system will be developed to increase rubber yield and herbicide resistance.

Pure chloroplast genome DNA was obtained and sequenced on the Illumina GAII platform. The complete genome was annotated by the Dual Organellar Genome Annotator. Comparative analysis was carried out by MEGA 5.1 and two barcodes were developed. Plastid transformation constructs were then built using Gibson Assembly® Master Mix (NEB, Inc.) and the species-specific *trnI-trnA* region was identified and cloned into these constructs as flanking sequences.

This preliminary work has enriched the chloroplast genome database and provided a foundation for the efficient plastid transformation of Kazak dandelion. This work demonstrated plastid transformation to genetic engineer rubber-producing plants at the first time, which has a great potential to increase rubber yield and herbicide resistance, as well as other desired traits.

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MAGNESIUM AFFECTS RUBBER PARTICLE STABILITY AND BIOSYNTHESIS IN *Ficus elastica, Hevea brasiliensis* AND *Parthenium argentatum*

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Natural rubber biosynthesis occurs in laticifers of *Ficus elastica* and *Hevea brasiliensis*, and in parenchyma cells of *Parthenium argentatum*. Natural rubber is synthesized by rubber transferase using allylic pyrophosphates as initiators, isopentenyl pyrophosphate as substrate and magnesium as co-factor. Magnesium concentration affects rubber transferase activity and rubber molecular weight in *H. brasiliensis* and *P.argentatum* in *in vitro* studies. Maximum rubber transferase activity occurred at about 1 mM magnesium and was inhibited by magnesium concentrations above 10 mM in all three species. Magnesium ions were more readily washed from the *F. elastica* rubber particles than from either *H. brasiliensis* or *P. argentatum* during the purification protocol. Rubber transferase activity, in latex tapped from individual *F. elastica* plants, varied among plants but was below the maximum activity determined *in vitro*, suggesting that the living plants might have inhibitory magnesium levels in their laticifer cytosol. When *H. brasiliensis* rubber particles were purified in the absence of magnesium, and then assayed, they had half the activity of particles purified in the presence of magnesium, possibly due to irreversible destabilization of some of the rubber transferase enzyme complexes.

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STUDIES OF THE LATEX OF BRAZILIAN IAC SERIES CLONES FROM *Hevea brasiliensis*

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Natural rubber is an important commodity industrial crop that mainly derives from *Hevea brasiliensis*. Most natural rubber production is in Southeast Asia, but significant cultivar development takes place in Brazil, the original origin of current commercial *H. brasiliensis* cultivars. Thus it is critical to assess more productive new *H. brasiliensis* clones for high yield and quality rubber for São Paulo State, Brazil largest planted region.

Rubber transferase is an enzyme complex responsible for natural rubber biosynthesis. It requires allylic pyrophosphates as initiators, isopentenyl pyrophosphate as a substrate and magnesium as a co-factor, and its activity can be monitored *in vitro*. The purpose of this study was to investigate the seasonal effects on *H. brasiliensis* clones with respect to rubber transferase activity, magnesium concentration, latex protein content and rubber content. Seven *H. brasiliensis* clones (IAC40, IAC56, IAC300, IAC301, IAC302, IAC303 and RIMM600) were selected and latex was collected eight times from 2005 to 2006 to span different seasons from a plantation in São Paulo, Brazil. Those collected latex was preserved and shipped to USDA-ARS at Albany, California for analyses.

Latex protein and rubber content varied among different clones and seasons. Protein content reached the highest level in September during the middle of the foliation stage. Magnesium concentrations in latex determined from a single collection point also varied among different clones range from as low as 1 mM (IAC56) to as high as 5.6 mM (IAC302). Washed rubber particles were isolated from all collections (total 56) and rubber transferase activity of washed rubber particles showed significant variations among the different clones and seasons. Of those clones IAC56 had highest rubber transferase activity, the control cultivar RIMM600 at middle and clone IAC301 had the lowest activity. These findings will provide some insights together with some other important technological parameters to assist the *H. brasiliensis* breeding program in Brazil.

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VARIATION IN GENOME SIZE AND PLOIDY LEVEL IN SELECTED *Parthenium* SPECIES AND THEIR INTERSPECIFIC HYBRIDS

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Polyploidy is an important evolutionary mechanism in populations of the genus *Parthenium*. It played a significant role in species domestication, diversification and speciation. Understanding the ploidy level, genome size, and chromosome number could help determine the compatibility of various *Parthenium* species that would allow easier crossing and plant selection during the breeding process. They are also important in breaking the reproductive barriers to successfully transfer valuable traits (i.e., increase quality, yield of latex and rubber, tolerance to abiotic and biotic stresses) from within and among *Parthenium* species.

The objectives of this study were: a) to ascertain how many levels of ploidy exist; b) to estimate the genome size; and c) to determine the number of chromosomes in different *Parthenium* species and their interspecific hybrids.

Flow cytometry and chromosome counts were used to ascertain the ploidy level, estimate genome size and determine the chromosome number of selected representative accessions of *Parthenium* species and their interspecific hybrids. Seeds of *P. argentatum*, *P. incanum*, *P. hysterophorus* and *Parthenium* interspecific hybrids were planted under controlled conditions. Leaf tissue samples were collected for ploidy and genome size analysis using flow cytometry. Actively growing root tips were sampled to determine chromosome number variation from chromosome counts.

A wide range of intra- and interspecific ploidy level, genome size and chromosome number variation were observed in selected *Parthenium* species and their hybrids. The ploidy level of *P. argentatum* and *P. incanum* ranged from diploid (2*x*) to hexaploid (6*x*) and triploid (3*x*) to pentaploid (5*x*), respectively. Genome size in the genus *Parthenium* ranged from 1,624 Mb (diploid *P. argentatum*) to 5,756 Mb (tetraploid *P. integrifolium*). The genome size of the interspecific hybrids ranged from 2,523 to 4,225 Mb and can be categorized from *3x* to *5x* ploidy levels. The results of the current study are essential for identification of parental lines and selection of progeny lines with trait(s) of interest.

The availability of ploidy level, genome size and chromosome number of different *Parthenium* species plus their interspecific hybrids will be useful for the genetic and genome wide diversity, mapping population studies, and ensuring success in the guayule crop improvement program.

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CROP DEVELOPMENT, PRODUCTION AND PROTECTION

ABSTRACTS PRESENTATION

IDENTIFICATION OF GENES CONTROLLING DISEASE RESISTANCE TO MITIGATE DISEASE PRESSURE OF BIOENERGY CROPS

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The goal of this project is to leverage the powerful genetic and genomic resources available for rice to identify key genes regulating disease resistance in switchgrass. We used a rice probabilistic functional gene network called RiceNet (http://www.functionalnet.org/ricenet/), as well as expression and yeast-2-hybrid data, to identify potential candidate genes for engineering disease resistance. From this analysis, we selected two genes including *WAK25* (Wall-associated kinase) and *SnRK1A* (SNF1-related kinase) for detailed investigation. We overexpressed and silenced genes in the rice Kitaake genetic background and inoculated the resulting progeny for resistance to two biotrophic pathogens (*Xanthomonas oryzae* pv *oryzae* (*Xoo*) and *Magnaporthe oryzae)* and two necrotrophic pathogens (*Rhizoctonia solani* and *Bipolaris oryzae*). Our results indicate that *WAK25* is a positive regulator of resistance to the biotrophic pathogens but is a negative regulator of resistance to necrotrophic pathogens. In contrast, *SnRK1A* positively regulates resistance to all four pathogens. We have previously shown that overexpression of *Arabidopsis NPR1*, a key regulator of systemic acquired resistance and *NH1* (the rice ortholog of *NPR1*) in rice confers robust resistance to bacterial and fungal pathogens in an SA-dependent manner. Regulated overexpression of another *NPR1* paralog in rice *NH3*, driven by its own promoter, also results in enhanced resistance to *Xoo*.
Based on the robust resistance conferred by these three genes in rice, we generated 13 independent lines overexpressing WAK25 in switchgrass and 2 lines overexpressing NH1. Overexpression of WAK25 led to normal phenotypes. We will test these transgenic lines for resistance to the rust pathogen, *Puccinia emaculata*. Preliminary analysis of one of the NH1 overexpressing switchgrass line for rust resistance indicate that *NH1* confers resistance to *Puccinia* in switchgrass. However, overexpression of rice *NH1* under maize ubiquitin promoter retarded normal growth. Transformations experiments with *SnRK1A, NH1* and *NH3* using native promoters are in progress.

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MANAGEMENT OF THE SWITCHGRASS RUST DISEASE BY DEPLOYING HOST RESISTANT GENES AND MONITORING THE DYNAMICS OF PATHOGEN POPULATIONS

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Switchgrass is a major potential source of biomass feedstock. Diseases, especially rust (*Puccinia emaculata*), are an important current limitation on the productivity of switchgrass, and are likely to be an increasing problem as production systems move towards industrial-scale monoculture plantings. The major objectives of this project are to characterize the genetic structure of switchgrass rust populations across the country, identify resistance genes from native switchgrass accessions, and create novel genetic engineered switchgrass plants with broad spectrum disease resistance.

To study the rust fungus, we established a single rust spore whole genome amplification (WGA) protocol that allows us to amplify genomic DNA from rust isolates collected from five states (OK, SD, IA, VA, and MS). The phylogenetic analysis of *P. emaculata* isolates collected from five states and other closely related *Puccinia* species revealed that *P. emaculata* is a monophyletic species. Haplotype diversity analysis suggests the populations of *P. emaculata* maintained in growth chambers or greenhouses (OSU and NF) are less diverse than populations collected from field samples. To examine the gene space of *P. emaculata*, we performed Illumina RNA-Seq to sequence the transcripts of two rust isolates (OSU09-1 and VT2-1). Approximately 64M reads were sequenced for each isolate. The assembly of these reads into EST contigs is currently under way. These ESTs will be further analyzed to develop informative SSR markers that can be used for rust population studies.

To study switchgrass, we developed three pseudo-F_2 populations that are segregating of rust resistance phenotype. Molecular markers, including functional markers developed from the NB-LRR genes, have been used to map rust resistance genes in the F_2 populations. We developed transgenic switchgrass plants expressing two PI-3-P-binding proteins. Some transgenic lines showed enhanced resistance to switchgrass rust in greenhouse condition. Further genetic analysis will test if the resistance phenotype is conditioned by the transgene.

This project is developing both native and engineered host resistance that will help us breed elite switchgrass cultivars suitable with improved rust resistance. The pathogen population information will allow us to wisely deploy cultivars across the country. Our integrated rust management strategy will ensure the large scale sustainable biomass production in the future.

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MANAGING INSECT PESTS IN THE MULTI-USE LANDSCAPES OF BIOENERGY AND CONVENTIONAL CROPPING SYSTEMS IN THE GULF COAST

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The U.S. Gulf Coast region with its plentiful rainfall, abundant land, mild winters, transportation networks, and petrochemical industries offers considerable potential for establishing a cellulosic bioenergy industry. The Mexican rice borer (*Eoreuma loftini*) and the sugarcane borer (*Diatraea saccharalis*), are the two most prevalent insect pests of cellulosic and conventional gramineous crops grown in this region. Stem borers tunnel into culms and damage transport vessels, which directly reduces yield. Feeding injury also causes lodging due to weakening of the stems and provides entry sites for plant pathogens, which further reduce yield. Other pests of energycane and sugarcane include root knot and lesion nematodes, and the sugarcane aphid, which transmits sugarcane yellow leaf virus. Large-scale production of bioenergy crops will impact field- and regional-level abundance of these insect and disease pests, which will require modification of existing pest management programs.

The goal of this research is to develop a landscape-wide pest management program to minimize the economic impact of insect and disease pressures on cellulosic and conventional graminaceous crops. Critical data on the biology, ecology, and impact of these pests are being obtained through our research. The results are being integrated into a landscape-level forecasting system to aid in identifying optimal pest management strategies.

Based on initial estimates, unmanaged *D. saccharalis* infestations in Louisiana resulted in 8% (energycane), 11% (sugarcane), 8% (biomass sorghum), and 15% (sweet sorghum) bored internodes levels, with each percent producing a 0.9% to 2.5% loss in harvested fresh biomass. Under unmanaged *E. loftini* infestations in Texas resulted in 6% (energycane), 11% (sugarcane), 18% (biomass sorghum), and 14% (sweet sorghum) bored internodes, with each percent resulted in a 0.6% to 1.6% loss in harvested fresh biomass. These results suggest energycane is less susceptible to stem borer injury than sugarcane. However, uncontrolled stem borer populations can reduce energycane yields by > 30%.

Our research shows a number of non-cultivated weedy grass species contribute to the abundance of stem borers in nearby gramineous crops. Whereas *D. saccharalis* average densities in non-crop habitats remained below 1.0 immature per m^2, *E. loftini* average densities ranged from 0.3 to 5.7 immatures per m^2.

Our survey failed to detect sugarcane yellow leaf virus (ScYLV) infected plants in monocultures of sugarcane, while infection levels in mixed cropping areas ranged from 2% to 18%. Crop rotation does not appear to impact stunt and ring nematodes, the two most common nematodes in sugarcane (and probably energycane) in Louisiana. Preliminary results from our forecasting system suggest management of grassy weeds within field borders can impact the severity of injury to adjacent gramineous crops.

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DEVELOPING WOODY CROPS AS A FEEDSTOCK FOR ADVANCED BIOFUELS IN THE SOUTHEAST

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Almost half of the nation's supply of advanced biofuels, as mandated by the renewable fuels standard, will be met with the lignocellulosic resources of the southeast. While producing roughly 10 billion gallons of alternative fuels is well within the region's capacity, a considered and thoughtful transition is needed to insure a sustainable supply of biomass for this new industry. With more than 30 million acres of southern pine plantations distributed throughout the South, an expansive biomass source for fuels production is in place. Working closely with conversion technology collaborators, IBSS will develop today's forest resources for near-term progress while advancing energy crop supply systems optimized for infrastructure-compatible fuels production. The Woody Crop Development project within IBSS has 3 primary objectives:
1.- Gain data on biomass yield potential of multiple hardwood species and genotypes adapted for growth in the southeast U.S. for future recommendations on hardwood plantations;
2.- Assess the impact that herbicide tolerance in hardwoods might have on reducing the cost of biomass production and improving yield; and
3.- Assess if modification of the loblolly pine cell wall will improve the efficiency of deconstruction and sugar release.
Project leaders from ArborGen Inc., Auburn University, North Carolina State University and University of Tennessee-Knoxville are collaborating to accomplish these objectives. During this presentation we will summarize accomplishments to date including the establishment of pilot scale poplar, eucalyptus and sweetgum biomass plantings in AL and TN; the development of herbicide resistant poplar lines for field evaluation and the development of transgenic pine varieties that have been modified for reduced lignin or syringyl lignin production.

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20 YEARS OF SELECTION FOR INCREASED BIOMASS YIELD IN SWITCHGRASS

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Switchgrass is a candidate for cellulosic bioenergy feedstock development in many parts of North America, Europe, and Asia. Breeding for increased biomass yield is a viable and desirable research objective to improve both economic and energy yields per hectare. Economic and life-cycle analysis studies have consistently identified low biomass yield as the most important factor limiting the economic viability and sustainability of switchgrass as a perennial biofuel feedstock. The objectives of this study were to estimate progress from (i) selection for biomass yield in upland switchgrass, (ii) selection for winter survival, biomass yield, and biomass quality in lowland switchgrass, and (iii) selection for winter survival and biomass yield in advanced generations of four upland × lowland hybrid switchgrass populations.

A total of 35 switchgrass populations were planted at four locations in 2008. Locations were Arlington, Marshfield, and Spooner, Wisconsin and DeKalb, Illinois, USA. Latitude ranged from 41.9 to 45.8°N and USDA hardiness zones ranged from 3b to 5b, with a corresponding range in mean annual extreme minimum temperature of -35.8 to -24.7°C. Switchgrass populations represented the upland ecotype (n=25), the lowland ecotype (n=6), and advanced-generation selections from upland x lowland crosses (n=4). Upland populations represented three generations of selection for increased biomass yield within the WS4U tetraploid germplasm pool. Lowland populations represented one or two generations of selection for increased biomass yield and winter survival within Kanlow. Advanced-generation hybrid populations represented three cycles of selection for increased biomass yield and winter survival within crosses of Kanlow x Summer. Each location was planted with a randomized complete block design with four replicates. Biomass yield and ground cover were determined on all plots for three years (2009-2011).

Selection for increased biomass yield in upland switchgrass resulted in mean genetic gains for of 0.71 Mg ha^{-1} $cycle^{-1}$ (8% $cycle^{-1}$ = 4% $year^{-1}$) for biomass yield. Selection for increased biomass yield in lowland switchgrass resulted in mean genetic gains of 0.89 Mg ha^{-1} (18% = 1% $year^{-1}$) for biomass yield. Improved lowland populations were adapted only to the DeKalb site, of a similar hardiness zone to Lincoln, NE, where the selection was conducted. Mean high-parent heterosis between upland and lowland ecotypes was 3.57 Mg ha^{-1} (43% higher than the best parental population). Hybrid populations performed well (mean biomass yield = 9.9 to 14.3 Mg/ha) and were adapted to all four locations, regardless of hardiness zone (mean ground cover = 91 to 100%). We conclude that biomass yield is a moderately heritable trait in switchgrass and it can be readily improved in both upland and lowland populations using conventional breeding methods. Hybrid populations that combine genetics of both upland and lowland ecotypes are a mechanism to combine high performance with broad adaptation.

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EVALUATING PERENNIAL GRASSES FOR BIOMASS PRODUCTION IN DIVERSE CROPPING SYSTEMS IN THE CENTRAL UNITED STATES (cenUSA)

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Little is known about the productivity potentials, environmental impacts, and economic viability of novel, dedicated energy crops such as the native perennial grasses switchgrass (*Panicum virgatum*), big bluestem (*Andropogon gerardii*), and indiangrass (*Sorghastrum nutans*) compared to non-native perennial grasses like *Miscanthus x giganteus*. We hypothesize land capability will influence relative crop feedstock yields and environmental footprints.

Our objectives are to 1) conduct comparative analyses of the productivity and the environmental impacts of promising bioenergy crops/management systems using a field network strategically located across the Central US, and 2) produce a quantitative assessment of the net energy balance (NEB) of candidate systems and optimize feedstock production and ecosystem services on marginally productive cropland.

Field experiments (9) focus on developing cropping systems using best management practices (BMPs) for existing perennial species, and compare performance and environmental impacts to novel germplasms/systems. New BMPs specific to biomass production are under development to optimize water and nutrient use efficiencies. Data from field studies is being used to calibrate/validate the Soil Water Assessment Tool (SWAT) in order to extend findings to landscapes/watersheds and predict large-scale environmental impacts of biomass production.

Large differences in biomass yield exist among perennial systems grown on marginal lands. Significant nutrient cycling within perennials occurs and this may alter BMPs. Species also differ markedly in biomass composition; a trait that may impact bioconversion processes. Nitrous oxide emissions are low in perennial systems when compared to maize.

System optimization considering both NEB and Life Cycle Assessment will inform system efficiencies and environmental impacts. Taken together, these metrics will help match biomass production system to land capability.

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CROP DEVELOPMENT, PRODUCTION AND PROTECTION

POSTER PRESENTATION

LANDSCAPE STRUCTURE AND NATURAL PEST-SUPPRESSION SERVICES IN BIOENERGY LANDSCAPES: IMPLICATIONS FOR REGIONAL FOOD AND FUEL PRODUCTION

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Societal demand, policy, and economics are driving an increase in land devoted to bioenergy production, altering the composition and configuration of agricultural landscapes.
Theoretical and empirical and work suggests that changes in the structure of agricultural landscapes will affect crop yields, through indirect effects on crop pests and their natural enemies. Despite its importance to both conventional food and bioenergy production, this hypothesis remains to be rigorously tested. A major challenge in quantifying this link is the scaling of pest-suppression services from small-plot studies to field-level crop yields and regional patterns of production. We are conducting field and model-based research on a valuable biofuel crop (soybean), its principle pest (soybean aphid), and its natural enemies (generalist predators such as ladybeetles) across a 19-county region of southern Wisconsin.
Our study involves field studies along landscape gradients to investigate links between landscape structure, soybean aphid colonization, soybean aphid suppression by natural enemies, soybean photosynthetic rates, and soybean yield. We are conducting greenhouse studies to quantify the effects of aphids on soybean photosynthetic rates and spectral reflectance. Information from field and greenhouse studies is being used to incorporate aphid affects into a process-based agroecosystem model (AgroIBIS), and to explore the use of remotely-sensed hyperspectral data to detect plant stress due to soybean aphid outbreaks.
Improved crop models, remotely-sensed data on soybean stress, and empirical measures of soybean yields will further enhance our ability to link land-use change in agricultural landscapes to soybean yields, and to forecast variation in soybean yields under different bioenergy and land-use scenarios. This presentation will describe our work to date.

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THE ROLE OF DIVERSIFIED BIOENERGY CROPPING SYSTEMS IN ENHANCING BIOLOGICAL CONTROL OF THE SOYBEAN APHID

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The development of production systems and landscapes organized around optimizing a combination of food, bioproducts, and ecosystem services is critical for the long-term viability of agriculture. This study will focus on the sustainable integration of diversified perennial-based cropping systems that not only supply feedstock for bioproducts applications, but also provide ecosystem services, including those that offer crop protection for other bioenergy crops such as soybean. Our proposal aims to combine the benefits of sustainable bioenergy production with tangible ecosystem services, specifically biological control of the soybean aphid, *Aphis glycines*. These dual benefits should spur increased adoption of sustainable bioenergy production in the U.S. leading to decreased dependence upon fossil fuels for energy production.
The objectives of this study are to 1) develop an agronomically realistic platform for the production of perennial bioenergy crops, and 2) support a knowledge-based strategy for integration of bioenergy cropping systems in a way that supports ecosystem services that lead to reduced pest pressures in surrounding crops.
We focused on four bioenergy cropping systems; a polyculture mix comprising forbs, legumes, and tall grass prairie species, a monoculture of willow, a mix of willow and herbaceous polyculture crops in an alley cropping configuration and a monoculture of soybean that serves as the control. Information on crop growth and productivity is used to estimate net energy balance and biomass conversion rates. Biological control of soybean aphid is determined adjacent to each of these cropping systems and the control site. This will be done using a combination of sampling to determine the abundance of soybean aphids and their natural enemies, determinations of the extent of resource use in the biofuel plantings, and estimation of a biocontrol services index, which defines the contribution of surrounding landscapes to biological control. The biological control objective also includes releases of approved, exotic parasitoids of the soybean aphid. Preliminary findings are presented that support the proposal that diversified, perennial bioenergy crops can promote populations of beneficial arthropods and enhance ecosystem services when integrated within monoculture crops.
An understanding of the implications of diversified multi-species bioenergy cropping systems in the context of providing crop protection and ecosystem services benefits is critical to the long-term sustainability of multi-use landscapes. This research will provide information that will help make decisions on biomass cropping systems design, placement, and potential scale of influence as it relates to the surrounding landscape.

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THE IMPACTS OF LIGNIN MODIFICATIONS ON FUNGAL PATHOGEN AND INSECT INTERACTIONS IN SORGHUM

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Sorghum (*Sorghum bicolor* (L.) Moench), is currently being developed as a dedicated bioenergy feedstock. Modifying lignin content and composition are major targets for bioenergy feedstock improvement. However, lignin has long been implicated as playing a critical role in plant defense responses against pathogens and insect pests. Therefore, it is critical to determine whether changes to lignin synthesis affect susceptibility to pathogens and pests prior to deployment in the field.

Our goals are to improve sorghum biomass for both biochemical and thermal bioenergy conversion by developing experimental lines that have altered lignin content and composition beyond normal levels, and to understand how lignin modifications will affect biotic interactions.

To reduce lignin content and alter lignin composition, *brown midrib* (*bmr*) mutants, generated through chemical mutagenesis, are being utilized. To increase lignin content for thermal bioenergy conversion, a series of transgenic lines overexpressing phenylpropanoid biosynthetic genes and a pathway regulatory gene are being developed. We are examining whether the lignin-modified lines have altered susceptibility to key sorghum insect pests (phloem feeding greenbugs, *Schizaphis graminum*; chewing insects fall armyworms, *Spodoptera frugiperda* and corn earworms, *Helicoverpa zea*) and fungal pathogens that cause foliar (anthracnose; *Colletotrichum sublineolum*) and stalk (stalk rot; *Fusarium thapsinum* and charcoal rot; *Macrophomina phaseolina*) diseases.

Our findings indicated *bmr6* and *bmr12* plants do not have increased susceptibility to the pests and pathogens tested, and in some instances showed increased resistance. Likewise, the transgenic lines overexpressing elements of the phenylpropanoid biosynthetic pathway tested did not show increased susceptibility to the pests and pathogens tested. In some instances, specific transgenic lines appeared to be more resistant to a pathogen or pest than the corresponding wild-type.

Overall, our data suggests that altering the lignin content and composition to improve bioenergy feedstocks will not inevitably result in increased susceptibility to pathogens and insect pests.

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IMPACT OF BIOENERGY CROPS ON PESTS, NATURAL ENEMIES AND POLLINATORS IN AGRICULTURAL AND NON-CROP LANDSCAPES

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Sustainability of the nation's bioenergy feedstock production relies on selection and placement of energy crops that efficiently generate biomass without compromising existing agricultural systems. Pest and beneficial arthropods (e.g., pollinators, predators) will occur in these feedstock crops, but the effects of habitat utilization are unknown, as there is little experience with expansive monocultures of biofuel crops. These crops may serve as a nursery (source) producing pests or beneficial arthropods, or may serve to attract or trap these organisms (sink). These source/sink relationships can be beneficial or deleterious to the feedstock crop or to the surrounding agricultural habitats. The project seeks to identify direction and magnitude of these impacts. Our objectives are to determine source/sink relationships in a first-generation biofuel crop (canola) and a second-generation biofuel crop (switchgrass) by: 1) identifying the arthropods using the energy crop, 2) evaluating the importance of beneficial organisms maintaining pest control in the energy crop, and 3) determining the extent and timing of movement of the important pest and beneficial species among the energy and proximal agricultural crops. For the first three years of this study (2011-2013), we intensively sampled pests, beneficial insects, including pollinators, and floral resources in and around canola production systems in Kansas and Oklahoma. In addition, arthropod movement was evaluated in simple (predominately wheat:canola landscapes) to diverse habitats (largely unmanaged grasses mixed with canola and wheat production systems). through novel protein mark recapture studies using protein-specific ELISAs. In addition, exclusion studies were conducted to evaluate natural enemy efficacy; and 3) The findings from this research will advance our knowledge of risks or benefits from placing large biofuel crop monocultures into established agricultural landscapes. The methods developed will be directly transferrable to other energy crops.

Over the 3-year survey and marking study, canola (biofuel crop) contributed significantly to populations of two important beneficial insects (predators) in neighboring wheat fields. The impact of the biofuel crop was far greater in more diverse habitats compared to habitats restricted to only wheat and canola. Green lacewings (largely aphid predators in these systems) were present in high numbers and their movement to wheat from canola was well documented, both in trap captures and number of protein-marked individuals. Other predators like lady beetles also moved among habitats, but results are not as defined. In both cases, the timing of the movement is an important consideration that will need clarification before we conclude that the biofuel crop is serving as a source for these beneficial species. Furthermore, the greater occurrence of insecticides used in canola may contribute to this crop serving as a trap crop (i.e, a sink) for beneficial species that are in field where insecticide applications are warranted. Mark-recapture studies demonstrated the ability to recapture individuals at all distances from marked edges of each habitat, which will allow definitive statements of directional, significant movement among biofuel crops and surrounding habitats. Confirmation by recapture of marked individuals allows us to refute and verify previous population data that suggests movement among these habitats.

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EVALUATION AND MITIGATION OF ANTHRACNOSE DISEASE PRESSURE DUE TO THE INTRODUCTION OF SORGHUM FOR FEEDSTOCK PRODUCTION

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There is increasing interest in the evaluation and promotion of sorghum as a sustainable bioenergy crop substitute for maize. Sorghum is an annual crop that can be grown across the same climate using similar agronomic practices as maize, making it a highly practical substitute. Large-scale sorghum cultivation has been limited to the more arid regions in the U.S., but more sorghum is being grown throughout the country. As sorghum acreage increases, diseases will become a significant limiting factor for production. Anthracnose is a fungal disease complex affecting both sorghum and maize. In sorghum it is caused by *Colletotrichum sublineolum*, a close relative of *C. graminicola* which causes this disease in maize. However, there is evidence that these fungi are able to cause disease on the non-host, albeit to a lesser extent. As more area comes under sorghum cultivation, maize and sorghum will be increasingly grown in close proximity or in fields previously sown with the other crop. This would result in both novel and increased disease pressures. The goal of this project is to evaluate the abilities of the native strains to colonize the non-host species and cause disease in immediate and surrounding areas. Furthermore, it is important to breed sorghum lines that are less amenable to fungal colonization and survival.

This project aims to better understand the interaction between Colletotrichum x Sorghum in order to select and/or breed sorghum cultivars for feedstock suitable for regions in PA and KY. It is an interdisciplinary project involving the expertize of plant genetisits, molecular biologist, plant breeder, plant pathologist and an agricultural extension specialist of bioenergy crops. Researchers at PSU and UKY are characterizing genetic diversity among *Colletotrichum* strains in different types of sorghums. ICRISAT researchers have screened diverse sorghum germplasm from their germplasm bank in order to identify resistant lines with variability in date of maturity, seed color and phytoalexin synthesis. We have also begun screening of association mapping parental lines to further use their RILs in eQTL analysis. We will evaluate germplasm not just for their performance during the growing season, but also on how they behave as debris after the growing season. The ultimate goal of this project is to breed sorghum cultivars that inhibit or retard development of the anthracnose in the stalk debris and thus would enable more extensive cultivation of sorghum alongside and in rotation with maize.

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CO-PRODUCTS FROM BIOENERGY CROPS

ABSTRACTS PRESENTATION

ENHANCING THE VALUE OF BIOFUELS DERIVED FROM ALGAE AND PERENNIAL GRASS FEEDSTOCKS THROUGH INTEGRATION OF A LACTIC ACID FERMENTATION

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Lactic acid is used worldwide in medicines, foods, and as a renewable chemical feedstock to replace petrochemicals in many applications. The overall goals of this project are to develop strains of *Lactobacillus casei* tailored for lactic acid fermentation at low pH of low-value substrates derived from algae and switchgrass feedstocks after biofuels production. To achieve our goals, we are employing a combination of traditional microbiology methods and systems biology approaches (i.e., genomics, transcriptomics, metabolomics, and metabolic flux analysis), to complete three objectives: 1. Identify and optimize conditions for lactic fermentation of algal carcasses by *L. casei*; 2. Develop *L. casei* strains for fermentation of glucose-depleted switchgrass hydrolysates to L-lactic acid; and 3. Identify strategies to optimize lactic acid fermentation of algal carcasses and glucose-depleted switch grass hydrolysates by *L. casei* at low pH.

Notable outcomes of our study to date include: 1) qualitative and quantitative analysis of the monosaccharide and amino acid composition of algal carcasses showed they contain 5-6% carbohydrate and approximately 24% protein. We have confirmed *L. casei* is able to grow to high cell number on algal carcasses, but efficient production of lactic acid requires enzyme action to release a greater content of fermentable sugar. Efforts are therefore underway to express these enzymes in our cells; 2) Experiments to improve lactate production by *L. casei* at low pH using compounds shown to increase acid resistance in this species show the bacterium is able to produce lactic acid in APT broth at pH 3.8, and that cyclopropane synthase activity and an extracellular supply of oleic acid together provide for a significant increase in lactic acid yield and an improved rate of lactic acid production at that pH; and 3) metabolic flux models reveal that a number of phenotypes relevant to the use of *L. casei* strains for the production of value-added co-product may be strain-specific.

Collectively, our data continue to support the hypothesis that *L. casei* can be utilized for production of lactic acid –and probably other value-added co-products- from from algae and switchgrass feedstocks after biofuels production.

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ENGINEERING SUCCINATE PRODUCTION BY *Actinobacillus succinogenes* ON GLYCEROL

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The EPA has recommended a volume increase for biomass-based diesel production to 1 billion gallons for the year 2012. With increasing biodiesel production, the market is being flooded with the byproduct crude glycerol. Converting glycerol into high-value chemicals would increase the economic sustainability of biodiesel production. Our aim is to convert crude glycerol to succinate using *Actinobacillus succinogenes.* Succinate has been listed #1 on the DOE's list of "Top Value Added Chemicals from Biomass". If succinate was fermentatively produced at a price competitive with that of oil-based maleic anhydride, it could replace maleic anhydride as the precursor of many bulk chemicals, with a total $15 billion/year market. *A. succinogenes* is among the best natural succinate producers, making it a natural choice for industrial succinate production. It does not ferment glycerol but can metabolize glycerol via respiration in the presence of added terminal electron acceptors. Minimizing this respiratory metabolism is important for achieving a balance between biomass and succinate production.

We are investigating *A. succinogenes*'s glycerol metabolism in a variety of respiratory conditions by comparing growth, metabolite production, and *in vitro* activity of terminal oxidoreductases. We are using a chemostat system to optimize succinate production in microaerobic conditions. To allow us to eliminate fermentation side products, we developed a markerless knockout method for *A. succinogenes* using natural transformation and the *Escherichia coli* isocitrate dehydrogenase gene as the positive selection marker.

During growth on pure glycerol, succinate yields were highest in microaerobic cultures, followed by dimethylsulfoxide-respiring cultures. Nitrate-respiring and fully aerobic cultures produced mostly acetate. In microaerobic batch cultures, *A. succinogenes* produced increasing levels of succinate as oxygen became limiting, with a final succinate yield of 0.69 mol/mol glycerol. In these conditions, only 5% of the glycerol was used for biomass production. Similar results were obtained for cultures grown on partially refined glycerols obtained directly from biodiesel manufacture. In microaerobic chemostats (constant gassing with 5% O_2 + 95% CO_2), the succinate yield increased to 0.75 mol/mol glycerol, suggesting that optimizing the oxygen tension in the fermentation is a powerful way to increase succinate yields. A pyruvate formate-lyase deletion mutant (strain Δ*pflB*) produced succinate with a 0.85 mol/mol glycerol yield in batch microaerobic cultures, and a 0.89 mol/mol glycerol yield in microaerobic chemostats.

We have demonstrated that *A. succinogenes* can be engineered for increased succinate yields, and that it can produce succinate from industrial waste products.

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BIODIESEL CO-PRODUCTS FROM BRASSICACEAE OILSEEDS

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Brassicaceae oilseed crops including rapeseed (*Brassica napus*), mustard (*Brassica juncea* and *Sinapis alba*), and camelina (*Camelina sativa*) exhibit rotational and environmental quality benefits making them excellent choices as rotational crops for the production of advanced liquid biofuel feedstocks, however unacceptable grower returns limit feedstock production. Our goal is to ensure economic viability of liquid biofuels production from rapeseed, mustard, and camelina by developing co-products from the 1) seed meals remaining after oil expression and 2) glycerol generated during biodiesel production. Procedures for the extraction of biopesticide precursors in the form of glucosinolates and the antioxidant sinapine were developed using alcoholic solutions. Optimal alcohol concentration, extraction times, solvent:meal ratios, and in the case of sinapine, sonication conditions were determined. Extracted glucosinolates are being formulated into products suitable for pest control and efficacy is being tested in laboratory and greenhouse experiments. Sinapine is being incorporated into biodegradable food packaging and the thermal, chemical, and mechanical properties of the products are being quantified to predict their potential to contribute to food product stability. Optimum extraction of both glucosinolates and sinapine were achieved with 70% ethanol and 70% methanol. Sonication shortened the time and temperature required for sinapine extraction without significant degradation of the compound. Phytotoxic biopesticides have been formulated that contain twice the original glucosinolate concentration as the original seed meal. However, inhibition of glucosinolate conversion to the actual bioactive compound responsible for pest control was inhibited by changes in pH. Efforts to overcome this limitation are in progress. Future work will be focused on incorporating the antioxidant-rich extracts in a meat product to inhibit spoilage and prolong shelf life. This is especially appealing given that the extracts also contain glucosinolates that hydrolyze to form biologically active compounds. Antioxidants and antimicrobials obtained in a single extract from mustard seed meal will inhibit both chemical and microbial spoilage of foods. Glycerol generated during biodiesel production is being used as a feedstock for alcohol production that could then be used to extract glucosinolates and sinapine. Studies have been initiated to convert glycerol hydrothermally to methanol or ethanol, or a mixture of both. We will develop a proprietary catalyst for the hydrogenation, dehydration, and/or cracking of glycerol, characterize the effects of major process parameters, and optimize the process for primary alcohol production. Successful completion of this project will promote the development of entirely new industries related to biofuels and bioproducts, thereby helping to revitalize agricultural communities.

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ENGINEERING HIGH VALUE OIL PRODUCTION INTO BIOFUEL CROPS

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Assuming biofuels generated via the fermentation of sugars derived from cellulosic and non-cellulosic constituents of biofuels crops will provide a substantial contribution to our future energy needs, augmenting and amending the productivity of these biofuel crops is now a major research thrust worldwide. One way of enhancing these biofuels crops will be to engineer them for value-added components such as oils that can be used for efficient fuel production and the manufacturing of other high-value products currently derived from petroleum oils. Towards this end, we are engineering optimized production of long, branched-chain hydrocarbon biosynthesis into plants suitable as biofuels crops. Branched chain hydrocarbons, like methylated triterpenes, are readily cracked into paraffins and naphthenes that can either be distilled to combustible fuels (gasoline, jet fuel and diesel), or can be used directly for the synthesis of plastics, nylons, paints and other oil-derived products manufactured by diverse chemical industries.

To better appreciate the importance of terpenes to overall growth and development, and to create a production capacity for specific terpenes of industrial interest, we have pioneered the development of strategies for diverting carbon flow from the native terpene biosynthetic pathways operating in the cytosol and plastid compartments of plants for the generation of specific classes of terpenes. In the current work, we demonstrate how difficult it is to divert the 5-carbon intermediates DMAPP and IPP from the mevalonate pathway operating in the cytoplasm for triterpene biosynthesis, yet diversion of the same intermediates from the methylerythritol phosphate pathway operating in the plastid compartment leads to the accumulation of very high levels of the triterpenes squalene and botryococcene. This was assessed by the co-expression of an avian farnesyl diphosphate synthase plus a yeast squalene synthase, or a chimeric botryococcene synthase from the algae *Botryococcus braunii*. The successful targeting of triterpene biosynthesis to the chloroplast was also extended by the introduction of plastid-targeted triterpene methyltransferases, resulting in the efficient conversion of triterpenes to their methylated forms.

Because the bulk of our engineering work has been done exclusively with tobacco, a dicotyledenous species, another objective has been to apply our engineering approach to monocotyledonous species which offer additional benefits to large-scale production platforms. Recent progress in engineering triterpene metabolism in *Brachypodium distachyon* will also be presented.

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FROM INDUSTRIAL WASTES TO A FUEL BRIQUETTE

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Our team has developed a fuel briquette from several industrial waste materials, including lignin, silica ash, anthracite fines, and a by-product binder (patent pending). This presentation will review the availability of the constituent waste materials, an overview of the technoeconomic analysis we've conducted to date, the preparation of the briquettes, the evaluation of the bricks as a fuel during several industrial scale demonstrations, and will briefly describe elements of the fundamental evolution of the chemistry and strength of the bricks following different thermal exposures. Based on our mechanical testing results (via compression tests), we conclude that lignin adds mechanical strength to briquetted anthracite fines, allowing the briquettes to be effective in high temperature cupola environments. Solid state NMR results showed the likely mechanism for this strength is the increasing aromatization of lignin during high temperature pyrolysis. Hence, lignin serves as a binding material in the thermal regime of 500°C to 1100°C, which corresponds to the "heat zone" of a foundry cupola. Unconfined compression strength tests revealed different performance from various lignin sources, and from different sources of silica.

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COGENT DESIGN OF LIGNIN-BASED PLASTICS

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Annually, more than 200 million tons of co-product lignins could be generated by biorefineries in converting enough plant material biologically to liquid fuels to meet 30% of current U.S. transportation needs. Such is the scale of biofuel production from biomass that could be in place by 2030. The transformation of biorefinery co-product lignins into useful polymeric materials would enhance the economic viability of generating biofuels through the enzymatic saccharification of lignocellulose. This project is dedicated to developing a systematic basis for formulating versatile thermoplastic blends containing 80% or higher levels of methylated biorefinery co-product lignins. Traditionally, ball-milled lignins have been considered to represent structural averages of native lignins in plant cell walls. They thus represent reasonable reference points for comparing the raw materials from different lignocellulosic sources upon which lignin-based plastics are to be produced. Here, the primary focus of our work is directed toward lignins from softwoods, the predominant form of ligno-cellulose in the northern hemisphere.

Previous approaches to creating lignin-containing materials with systematic variations in mechanical properties have employed the coupling of relatively rigid (hard) lignin segments to more flexible (soft segment) polymeric components. However, miscible polymer blends with 85% (w/w) ball-milled lignin contents can be created with tensile behavior comparable to poly(methyl methacrylate), polystyrene or epoxy cast materials. For example, the presence of 15% (w/w) poly(ethylene oxide-*b*-1,2-butadiene-*b*-ethylene oxide) or poly(ethylene oxide) in the formulation is all that is required to achieve such results with a methylated ball-milled Jack pine lignin preparation. Even more remarkable is the finding that small quantities of monomeric plasticizers such as PA or PG in materials otherwise composed solely of methylated ball-milled softwood lignin can engender tensile strengths approaching 50 MPa as elongations at break exceed 5%. Understanding the underlying mechanism(s) of such effects is of central importance to the rational design of next-generation lignin-based plastics.

An entirely novel approach has been devised to identify efficacious polymeric plasticizers in formulations for lignin-based thermoplastics. It involves recognition of target lignin substructures by analyzing the product distributions resulting from monolignol dehydrodimerization in the presence of the various corresponding methylated dilignols. To this end, syntheses of lignin β–*O*–4, β–5, 5–5 and 4–*O*–5 model dimers have been carried out, as has that of ^{13}C-labeled coniferyl alcohols. Developing conditions for the peroxidase-catalyzed dehydrogenative cross-coupling of coniferyl alcohol with vanillyl alcohol to form a mixture of dilignols has turned out to be a demanding exercise. The redox potentials of the two monolignols differ from one another substantially, and thus their respective concentrations require careful optimization in order to select for cross-coupling between them.

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BINDERLESS FILMS AS COPRODUCTS OF BIOMASS SACCHARIFICATION

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When plant biomass is enzymatically treated to release fermentable sugars from its polysaccharides, the residues in the solid stream typically consist of recalcitrant crystalline cellulose locked in a lignin-rich matrix. While an intuitive attempt is to harvest cellulose nanocrystals (an emerging nanomaterial) as coproducts of bioenergy systems, we see an opportunity to utilize a new class of raw material whose crystalline domain is readily dispersed in its matrix. If the non-crystalline portion of the residues can be thermally plasticized, a composite reinforced *in situ* by the embedded crystalline cellulose could be prepared. Such bindeless films will not require addition of synthetic binders in production.

The objective of this study was to thermally activate saccharification residues to form binderless composite films, examine the film morphology, and tune properties of the films.

Wood flour of aspen was subjected to an alkaline pre-treatment followed by enzymatic hydrolysis. The treated sample was disk-milled in an aqueous medium to sub-micron-sized fragments to increase surface areas for thermal activation. The fibrillated products were formed into mats through filtration, subsequently dried, and then compression-molded for different durations. To tune mechanical properties of the films, a solid-state plasticizer was blended at various dosing levels during mat formation. The molded films were tensile tested in both dry and wet conditions. Water absorption and weight gain after soaking were measured. Scanning electron microscopy and X-ray diffraction were performed to structurally characterize the films.

Microscopic studies showed that disk milling resulted in a network of nanofibers with thickness down to 10-50 nm. These nanofiber intermediates formed strong paper sheets even without thermal plasticization. The thermally plasticized films appeared glossy attributable to lignin melting as evidenced from electron micrographs. The plastic-like behavior was further confirmed by the higher water resistance and higher wet strength of the films compared to (nano)paper. The thermally plasticized films exhibited different tensile properties depending on if the biomass is saccharified (as opposed to alkaline-pretreated), and the dependence is attributable to mass fractions of crystalline cellulose as detected by X-ray diffraction. The ductility of the films can be variously adjusted using different levels of plasticizers.

Results of this study suggest possibilities of producing from saccharification residues binderless films with a range of mechanical properties. The co-production of sugars and nanocomposites would enhance values of biomass and increase the economical viability of our bioenergy systems.

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CO-PRODUCTS FROM BIOENERGY CROPS

POSTER PRESENTATION

NANOCONTROL OF POLYSACCHARIDE DERIVATIVE STRUCTURE AND FUNCTION: MECHANISM AND SCOPE OF TBAF-CATALYZED DEACYLATION

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Sustainable materials are immensely important to society; their importance grows daily as fossil fuel supplies diminish. Sustainable materials streams that come from biomass conversion materials help to realize the vision of a biorefinery and to enhance the economic potential of biofuels manufacturing facilities. However, even more important is the abundance of these resources, their renewable, often benign nature, and the great ability to adjust physical properties to meet demanding performance criteria. Derivatives of cellulose, one of the most abundant and readily collected biopolymers, are of special importance in this regard; as a result utilization of cellulose derivatives is already of great commercial importance to humanity.

We sought new ways to make derivatives of cellulose and other polysaccharides possessing highly specific structures, often never before made or characterized, to better understand structure-property relationships and prepare polysaccharide derivatives of superior performance in high value applications. We describe herein our efforts to understand the mechanism of our tetrabutylammonium fluoride-catalyzed deacylation of cellulose esters, that proceeds with remarkable and surprising selectivity for the more hindered secondary (2- and 3-) ester groups. Having elucidated the mechanism, we describe studies to use our mechanistic understanding in order to broaden the applicability of this reaction to a wide variety of cellulose derivatives, and even beyond cellulose to other glucan polysaccharides from nature.

Our mechanistic studies centered upon kinetic isotope effects of deacylation of cellulose acetates in which the ester group was either perdeuterated, or had natural isotopic abundance. The scope studies employed the synthesis of a wide variety of cellulose esters by conventional cellulose solvent chemistry, followed by TBAF deacylation in an organic solvent appropriate for the ester, with regioselectivity in all experiments measured by proton NMR of peracylated derivatives. Scope with regard to glucan backbone was examined by synthesis of a variety of glucan esters followed by TBAF deacylation. We were able to determine the detailed mechanism of deacylation and found surprisingly that different mechanisms were operative at O-6 vs. at the secondary positions. Furthermore, we found that the reaction is of extremely broad scope with regard to ester type and glucan backbone. This provides an efficient one step synthesis of regioselectively substituted glucan esters with no need for protecting group chemistry, opening up broad vistas towards novel, useful sustainable materials from biomass.

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CATALYTIC HOLLOW FIBER MEMBRANE MODULES FOR USE IN THREE PHASE REACTOR SYSTEMS: UNDERSTANDING THE INFLUENCE OF MEMBRANE AREA ON REACTION RATE

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Membrane contactors have been evaluated for the selective hydrogenation of model compounds. The membrane contactors considered are hollow fiber membranes, potted in bench-scale modules and coated with palladium catalyst *in-situ*. Hydrogen was supplied from the bore side of the membrane fiber and permeated from the bore side to the shell side, where it adsorbed directly onto the metal surface. Liquid reactant circulated through the shell side, allowing the liquid to come into direct contact with the metal coated surface of the membrane where the hydrogenation occurred. Our membrane contact reactor approach replaces the traditional three phase batch slurry reactor. These traditional reactors possess inherent mass transfer limitations due to low hydrogen solubility in liquid and slow diffusion to the catalyst surface. This causes hydrogen starvation at the catalyst surface, resulting in undesirable side reactions. In the case of partial hydrogenation of soybean oil (one of the model reactions considered), the undesirable side reaction is the production of *trans* fats. The objective of this study is to gather the data necessary to scale-up the bench-scale proof-of-concept results to pilot- and larger scale systems. Modules with varying numbers of membrane fibers were produced and used to evaluate the impact of the ratio (membrane area / reaction volume treated) on the overall performance of the system. The rate of reaction increases with increasing membrane area (which results in an increase in catalyst available and an increase in the availability of hydrogen). Additionally, the system is shown to be nearly zero order in hydrogen.

An increase in reaction rate with additional membrane area indicates that the reaction is rate limited (or limited by the amount of catalyst available). On the other hand, the zero-order dependence of hydrogen on the reaction rate indicates that the catalyst surface maintains high hydrogen coverage throughout the experiments as a result of the rapid transfer of hydrogen through the membrane contactor. The quantitative information gathered will be used to aid in pilot-scale reactor design.

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NANOFIBRILLATED CELLULOSE AS A BIOFUEL CO-PRODUCT

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This research is aimed at integrating the production of biofuel with nanocellulose as a forest biorefinery co-product. The morphology and properties of cellulose nanofibers created after significant sugars have been liberated by aggressive enzymatic hydrolysis using commercial enzymes have been examined. The effects of processing conditions on the physical and mechanical properties of films and composites made from these various cellulose nanofibers are being investigated, and a range of properties have been observed. Methods for improved properties and scalable processing are being explored. Production and purification of first pick endoglucanases, exoglucanases, and a beta-glucosidase are in place. These are thermostable enzymes which will allow treatment of cellulose at elevated temperatures not possible with the commercial source enzymes used in our previous studies. Sugar release from cellulose with these thermostable cellulases is being characterized. Screening for recombinant auxillary proteins that may be useful in nanocellulose treatments has begun. Chimeric GFP fusions are made with protease sites for purification of "tagless" native proteins. This strategy allows detection of previously uncharacterized proteins (e.g. from genome studies) with removal of extraneous N-terminal or C-terminal tags that can aid in purification but interfere with the function of the native protein if left in place. Research continues on enzymatic conversion of glucose to potential platform chemicals as biorefinery co-products. Work on gel spinning of continuous fibers from nanocellulose continues and the effects and limitations of material (e.g., spinning dope formulation, crosslinking agents) and process variables (e.g., cellulose dispersion methods, spinning methods, draw ratios) are being examined. Processability and performance are being characterized and related to material and process variables. Furthermore, the use of cellulose nanofibers to improve mechanical properties of thermoplastics and to facilitate the nucleation of polymers and the cellular structure of foamed composites has been examined. Cellulose nanofibers blended with various polymers, often using novel techniques, typically resulted in increased strength and modulus, as well as favorable reduction in the size of cellular structures in foamed composites.

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A SELF-EXCISING β-RECOMBINASE/*SIX* CASSETTE FOR REPETITIVE GENE DELETION IN N*eurospora crassa* AND HOMOKARYON PURIFICATION

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We are developing a new route for converting cellulosic biomass to isobutanol and gluconate. The conventional gluconic acid and isobutanol production process involves five steps: pretreatment, cellulase production, enzymatic hydrolysis to make sugars, aerobic fermentation to produce gluconic acid from cellulose hydrolysate, and anaerobic fermentation to produce isobutanol from sugars. Cellulase production or purchase represents a substantial portion of processing costs. In this proposed route, cellulase production, enzymatic hydrolysis, and aerobic fermentation will be consolidated into a single step: producing cellooligosaccharide aldonates from pretreated cellulose by an engineered cellulolytic fungus: *Neurospora crassa* in an aerobic fermentation step; and isobutanol and gluconate will be produced from cellooligosaccharide aldonates in a subsequent anaerobic fermentation step. To engineer *N. crassa* for cellooligosaccharide aldonates production, we need to delete a series of genes in *N. crassa.*

In a previous study, we developed a bacterial recombination system employing a β-recombinase acting on six recognition sequences (β-rec/*six*), which allowed repetitive site-specific gene deletion and marker recycling in *N. crassa*. However, only one positive selection marker was used in the cassette. A subsequent purification procedure is needed to purify homokaryon due to the lack of a negative selection after eviction. Besides, the *xylanase* promoter from *Penicillium chrysogenum* used in the construct is not strongly regulated in *Neurospora crassa*, which led to low efficiency in cassette eviction. Herein, we report an improved variant of the self-excising β-recombinase/*six* cassette for repetitive gene deletion in *N. crassa*, employing a new native xylanase promoter from *N. crassa* and the introduction of a bi-directional selection marker to facilitate homokaryon selection using a thymidine kinase (*tk*) gene.

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FUEL AND OXYGENATE CO-PRODUCTS FROM BIOMASS FRACTIONATION AND ADVANCED CATALYTIC CONVERSION PROCESSES

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Forests in the U.S. contain significant levels of underutilized woody biomass in the form of forest harvesting residues, small diameter unmerchantable trees, and biomass available due to forest health. In Alabama alone, over 14.6 million tons of this material is available for production of liquid fuels and chemicals on an annual basis. These levels of biomass feedstock production can contribute significantly to the nation's goals for energy security and economic viability if technological advances are achieved in the thermochemical conversion platforms.

The overall goal of this research program is to design viable hydrocarbon production strategies by integration of biomass fractionation technologies followed by technically well-informed application of thermochemical conversion approaches. Synergistic collaboration between experts in chemical engineering and biosystems engineering allows for a systems level approach to the optimization of the biomass to hydrocarbon chemical/fuel lifecycle including design/characterization of the enabling catalysts. The Auburn University team employs a holistic methodology utilizing a systematic and flexible process integration/optimization based framework to identify product distributions and processing routes for integrated biorefineries. This project leverages ongoing research by taking advantage of a unique set of testbeds at AU consisting of biomass fractionation and conversion technologies, specifically for supercritical phase Fischer-Tropsch synthesis and high value chemical co-production.

Biomass fractionation technology coupled with a pilot-scale gasification unit enables systematic analysis of the downstream conversion viability and potential for value addition for each feedstock constituent, i.e. cellulose, hemicelluloses and lignin. As a specific example, we have studied an innovative supercritical phase Fischer-Tropsch Synthesis (SCF-FTS) process developed at AU using biomass derived syngas with particular attention on the impact of novel nanoscale catalysts on reaction performance. This dense supercritical media enables significant enhancement of middle distillate products while drastically reducing undesired methane formation, thus improving the overall carbon utilization. Additionally, we have demonstrated that the use of properly selected Fe-based catalysts in supercritical fluid reaction media results in a product stream consisting of more than 30% aldehyde species plus significant concentrations of 1-olefins. This affords higher value than conventional FTS approaches.

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EDUCATION AND EXTENSION

ABSTRACTS PRESENTATION

BIOENERGY AND BIOPRODUCTS EDUCATION PARTNERS (BBEP): HIGH SCHOOL STUDENTS' AND EDUCATORS' ATTITUDES TOWARD RENEWABLE ENERGY EDUCATION (REE)

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BBEP is a consortium of nine institutions of higher learning in the Northeastern US that provides professional development workshops to Science, Technology, Engineering and Math (STEM) teachers, grades six through undergraduate level. Surveys conducted at the conclusion of each workshop demonstrate teachers rank the workshop very useful for their classrooms. However, an over-arching goal of the program is to provide teachers with educational tools that will encourage their students to pursue careers in STEM topics. In fiscal year 2010, 13 federal agencies invested over $3 billion in 209 programs designed to increase knowledge of STEM fields and attainment of STEM degrees. The purpose of the current study, conducted as part of a doctoral dissertation (Patel) was to determine whether or not the students of teachers who had attended a 2012 BBEP workshop were measurably influenced to pursue renewable energy education. Comparisons were made to students of teachers who had not attended a BBEP workshop. The study evaluated responses from 1587 students from 87 classrooms. Specifically, the study examines attitude-based factors and the role of attitudes on renewable energy education. The study offers clues to bridge gaps in current renewable energy literacy (REL). A survey tool was developed and administered to two groups of students and their teachers: 1) students of teachers that attended a BBEP workshop and 2) students of teachers that had not attended a BBEP workshop. The surveys were administered through the use of iclicker™ technology coupled with a paper survey, allowing instantaneous results to be collected from the participants. This method kept students engaged for the 40-minute clicker survey. Further results are being compiled for statistical analyses. By going directly to the classrooms and using iclickers, the response rate was greater than 95% for the surveyed students. Preliminary results indicate that while the professional development workshop has an effect on educators' attitudinal change, similar effects were not obvious with the students surveyed. However, the students did show an increased interest in renewable energy education if educators formalized it within their course or if it was required as part of the curriculum and standardized testing. Based on these findings, BBEP plans to include more programming approaches designed to reach directly into classrooms. While the majority of students surveyed placed a greater emphasis on the importance of world hunger and poverty, consistent awareness on REL topics was measured.

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EDUCATION AND OUTREACH EFFORTS TO ACCELERATE THE DEPLOYMENT OF ADVANCED BIOFUELS IN THE SOUTHEAST: A SOUTHEASTERN PARTNERSHIP FOR INTEGRATED BIOMASS SUPPLY SYSTEMS (SE-IBSS) UPDATE

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The Southeastern Partnership for Integrated Biomass Supply Systems (IBSS) has developed a number of key technology transfer and information dissemination tools that are designed to accelerate the rapid deployment of advanced biofuels in the Southeast. The effort involves a team from Auburn University, NC State University, the University of Tennessee and the University of Georgia. This team is responsible for providing leadership and oversight for the educational, extension and outreach (E_2O) components of the project.

The team has conducted an attitude assessment of clients, developed a project-wide website (se-ibss.org), created a webinar series (bioenergywebinars.net), supervised fact sheet review and production, coordinated an eLearning module, created a region-wide woody biomass technology transfer users group, and organized a SEED fellowship involving graduate students from host institutions. The team has also begun to update and upgrade current eXtension sites including the Wood Energy site (www.extension.org/wood_energy) and the biomass/bioenergy components of the Farm Energy site (www.extension.org/ag_energy).

The E_2O effort is unique in that the efforts for education, Extension and outreach are fully "embedded" within the scope of individual research projects at each key institution. Graduate students, faculty members, principal investigators and the core E_2O team are all responsible for outreach and Extension.

Plans for 2013 and beyond include working closely with the key conversion partner (Kior, Inc.) to understand landowner procurement dynamics and local community and economic impacts of a recently opened woody biomass to bioenergy conversion site in Columbus, Mississippi.

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INFORMATION, DEVELOPMENT AND TRANSFER TO ACCELERATE DEPLOYMENT OF ADVANCED BIOFUELS IN THE PACIFIC NORTHWEST

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Advanced Hardwood Biofuels Northwest (AHB) is a USDA-funded project to develop biofuels from fast-growing hybrid poplars. The fuels produced will be direct replacements for fossil fuels, fully compatible with existing infrastructure and certified to run in car, truck, aircraft, and other types of engines. A major component of this effort is to develop regional Extension programs to prepare growers and other stakeholders for a new industry and new crop opportunities. The region's prior experience with hybrid poplar for pulp and paper production was largely negative, so developing a strong network in advance for disseminating reliable, up-to-date information is critical to successful deployment. Washington State University (WSU) Extension is leading this effort through a multi-pronged approach that targets Extension professionals, growers, and policymakers. We are laying the groundwork for an information network through field tours, community meetings, outreach seminars and exhibits, and online media. We are developing decision support models and surveying Extension professionals throughout the region to assess existing knowledge, attitudes, and needs. Finally, we are working with a social research team to discern broader grower and community needs and opinions.

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INFORMATION DEVELOPMENT AND TRANSFER TO ACCELERATE DEPLOYMENT OF ADVANCED BIOFUELS IN THE CENTRAL UNITED STATES: CENUSA BIOENERGY NIFA CAP EXTENSION AND OUTREACH PROGRAM

S. Brown

Iowa State University Extension

The United States has embarked on an ambitious program to develop alternative transportation fuels to lesson our dependence on oil imports, reduce greenhouse gas emissions, and provide increased energy security. The Energy Independence and Security Act of 2007 sets renewable fuel standards through 2022 and mandates an increase in advanced biofuels production to 21 billion gallons annually by the end of the term covered by the legislation (H.R.6 2007). Producing these fuels in an environmentally sustainable manner that does not interfere with food production or cause adverse changes in land use represents a major challenge for US agriculture.

The CenUSA NIFA Bioenergy CAP project is addressing this challenge by developing a regional system for producing advanced transportation fuels derived from perennial grasses grown on land that is either unsuitable or marginal for row crop production. In addition to producing advanced biofuels, the proposed system will improve the sustainability of existing cropping systems by reducing agricultural runoff of nutrients and soil and increasing carbon (C) sequestration.

The Extension components of the CenUSA project are integrated across the entire supply chain and are carefully structured to impact all stakeholders. A large number of Midwest agricultural producers and industry leaders are participating in a coordinated set of "citizen science" projects and train-the-trainer programs. The project is also implementing a series of outreach activities for non-farm audiences using the highly successful Extension Master Gardener program as a delivery mechanism; and hosting workshops for industrial leaders in thermochemical processing, leaders from environmental groups and the Hypoxia Task Force. The CenUSA Extenion program also includes a series of experiential programs for youth audiences that focus on biofuels production, carbon and nutrient cycling. The project is also contributing significant content and expertise to two eXtension Communities of Practice: Sustainable Agricultural Energy and Plant Breeding and Genomics.

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BIOENERGY EDUCATION AND WORKFORCE DEVELOPMENT TO SERVE THE GROWING ADVANCED BIOFUEL INDUSTRY IN THE GULF STATES

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As the biofuel and biochemical industry develops the need for a workforce that understands the scientific and technological challenges associated with developing the bio-based feedstock/raw materials and their chemical processing to final products will increase. At LSU for example, we have both a biological engineering program and a chemical engineering program. Within the chemical engineering program there are several concentrations on environmental sciences and process systems engineering. Under this program we are exploring the introduction of a renewable energy concentration that introduces the students to certain biological engineering courses.

The education and workforce development part of the USDA-NIFA grant to the LSU AgCenter is focusing on three aspects of educational material development and dissemination. (a) undergraduate curriculum development that focuses on cross training of students in chemical process engineering on biological processes and of the students in biological engineering on chemical process equipment design, which is achieved in a creative way with a small sample of students from both programs, (b) practical training on the pilot facility for processing energy cane and sweet sorghum and building experiments for senior undergraduate students in large scale pilot facilities and (c) developing online material also for cross training of people in industry with such courses as introduction to chemical engineering for non-chemical engineers, introduction to sustainability engineering, introduction to bioreactor design etc. The long term goal is to develop a suite of online, on-demand courses that meet the needs of process engineers to train on biological aspects of renewable energy technologies and for biological scientists to train on biochemical processing needs.

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NARA'S OUTREACH EFFORTS IN PROMOTING BIOFUEL INFRASTRUCTURE IN THE PACIFIC NORTHWEST (PNW)

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Northwest Advanced Renewables Alliance (NARA), funded through a 5-year USDA NIFA grant, is facilitating establishment of a woody biomass to biofuels and bioproducts industry in the Pacific Northwest. NARA's focus is to identify existing woody biomass sources, recommend sustainable harvesting practices, evaluate existing infrastructure, integrate the most effective conversion process, and establish stakeholder coalitions for the future biofuels industry.

The outreach team serves as a conduit between NARA researchers and community stakeholders, helping to transfer the science and technology of biofuels and co-products to communities in the PNW. Our objectives are to promote bioenergy literacy and engage stakeholders in building regional coalitions for facilitating rural economic development through a sustainable biojet fuel and bioproducts industry.

Engaging regional stakeholders as partners in the project is critical in identifying local assets and developing meaningful and viable supply chain coalitions. Focus of this talk will be on collaboration between the Outreach, Education, and the Sustainability Measurement teams of NARA in conducting regional pilot supply chain studies in the Pacific Northwest to engage stakeholders, assess existing assets, and identify existing gaps for facilitating a biofuel-based infrastructure.

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DEVELOPING A COMMUNITY VISION FOR TEACHING AND LEARNING BIOENERGY AND SUSTAINABILITY CONCEPTS IN A PLACE-BASED AND CULTURALLY RELEVANT CONTEXT

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Our project “Place-based Opportunities for Sustainable Outcomes and High-hopes” (acronym POSOH means "hello" in the Menominee language) is constructing a model for supporting communities to articulate a vision and build opportunities for teaching and learning bioenergy concepts—from sustainability to the chemistry of carbon cycles—fully integrated with indigenous knowledge. Our growing cross-cultural community comprised of collaborators who have a wide range of understandings and interests in bioenergy, sustainability, and education are building a vision for local science teaching and learning. With a major effort in public and tribal schools and a high school bioenergy leadership club, a key long-term goal is that our community’s impact will reverberate throughout the region’s educational and research institutions to grow the bioenergy workforce and citizens’ environmental literacy. Our specific goals are to: 1) strengthen the regional K-16 education system, especially at underserved schools; 2) increase the number and diversity of students from rural and tribal communities with opportunities to creatively collaborate and contribute to bioenergy fields; 3) increase participation in internships in industry or university summer research programs, ultimately entering undergraduate science programs. Our project is now beginning to document the model we have been constructing for co-designing place-based, culturally-relevant science materials—a model that will be widely disseminated to support more equitable science education and involvement in bioenergy and sustainability related studies and careers.

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POLICY / SOCIOECONOMICS

ABSTRACTS PRESENTATION

EFFECTS OF SUGAR AND BIOENERGY POLICIES ON POTENTIAL PRODUCTION OF ADVANCED FUEL ACOHOLS IN THE SOUTHEASTERN US

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Sugarcane-based ethanol from Brazil has thrived due to a very favorable cost of production. Moreover, sugarcane-based ethanol provides very attractive net energy and lifecycle GHG profiles relative to other biofuels. The US has substantial sugarcane production potential that is employed in producing sugar for sale at artificially inflated prices due to federal sugar marketing allotments and tariff rate quotas (TRQs). Alternative policy configurations would shift incentives in favor of US production of sugarcane biofuels. The fortunes of the nascent US energy cane biofuel industry will interact in complex ways with sugarcane-based and other biofuel production through alternative sugar policies, land markets, biofuel markets and biofuel policies. Changes in sugar policies could result in production of large quantities of advanced fuel alcohols in the southeast US, but little is known about the potential effects of alternative sugar policies and the interactions of alternative sugar policies with bioenergy policy. The agricultural potential of the southeast US is clearly a tremendous energy resource that is under-exploited. Yet, the extent of this potential and the influence of public policy on optimal exploitation of this potential are scarcely understood.

The overall goal of this project is to evaluate the effects of current and alternative sugar and bioenergy policies on 1) US production of advanced and cellulosic, sugarcane and energy cane-based fuel alcohols, 2) US petroleum imports, 3) indirect land use change due to biofuel production, 4) national and global food insecurity 5) southeast US rural economies, 6) global trade of ag and energy commodities. The objectives of the first year of this three-year project are to collect information about costs of producing advance fuel alcohols from sugarcane and energy cane, and to incorporate TRQs into the model being used for the project.

The project will employ 1) a computable general equilibrium (CGE) model of the world economy, with substantial detail related to agriculture and bioenergy production and policy; 2) firm-level simulation models of advanced fuel alcohol production; and 3) linear activity (IMPLAN) modeling.

In the first months of the project, we have a) explored methods for incorporating TRQs into the CGE model; b) collected information about costs of production for energy cane, and biofuels produced using energy cane as a feedstock and three separate production technologies, and c) incorporated US production of sugarcane and energy cane-based biofuels into the CGE model.

This project is on schedule, and well positioned to conduct the planned research.

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EFFECTIVENESS OF A PACIFIC NORTHWEST REVENUE-NEUTRAL CARBON TAX IN THE CONTEXT OF THE FEDERAL BIOFUEL POLICY

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The rationale of the study is to understand how the federal biofuel policy on cellulosic feedstock, along with a tax structure that seeks to control carbon dioxide emissions, will help achieve sustainable biofuel production in the Pacific Northwest. Biofuel industries in the region are relatively undeveloped despite state programs to promote their development. However, federal biofuel policy mandates and otherwise supports significant increases in cellulosic biofuel consumption over the next decade. Washington, Oregon and Idaho have comparative advantage in cellulosic feedstock supply for biofuel production relative to other feedstock options. Thus, the regional industry could benefit from federal increases in biomass-based biofuel consumption requirements. State-level policy should complement the federal policy to capitalize on these mandates.

The study's objectives are to: (1) model and estimate impacts of federal biofuel policy on the forest, energy, and agricultural sectors in the Pacific Northwest; (2) model and simulate the economic welfare effects of a state-level revenue-neutral carbon tax given the federal biofuel policy; (3) model and simulate the effects of an integrated tax-subsidy policy within the local energy sector given the federal biofuel policy; and (4) incorporate economic input substitutability into life-cycle analysis (LCA) of biofuel carbon emissions, and integrate LCA into the economic and policy modeling.

We will examine two related energy/carbon tax structures that have a revenue-recycling component conditional on the existing federal biofuel mandates. The first regime is a revenue-neutral carbon tax with a structure similar to British Columbia's carbon tax where carbon tax revenues are used to offset distortionary taxes. The second regime is an integrated tax-subsidy policy contained within the biofuel industry and uses revenues from high-carbon fuels to subsidize low-carbon fuels within the fuel industry. The carbon tax levels under either tax structure will depend on carbon emission levels. To fully capture the carbon emissions from fuel use, we will also examine the life cycle of fuel production. Geographically, we will focus on Washington, Oregon and Idaho, each of which has a very different state tax structure. Together they provide an excellent laboratory for examining welfare effects of these alternative policies in different economic/fiscal environments.

During the study's first year, we developed a preliminary three-sector baseline model to calibrate the effect of economic incentives from the renewable fuels standards in H.R.6 on intermediate output of cellulosic feedstock and final output of fuel; and completed a preliminary meta-analysis on estimates of elasticities of substitution relevant to biofuel production in the Pacific Northwest.

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POLICIES TO DEVELOP PERENNIAL GRASS-BASED ADVANCED BIOFUEL SUPPLY CHAINS IN THE SOUTHEAST U.S.

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The long-term goal of this project is to develop a robust policy evaluation model that can rigorously evaluate federal or state policy mechanisms affecting the development of perennial grass-based biofuel industry in the Southeast region of the U.S. This project is specifically targeted at addressing development of a regional system to meet the liquid transportation fuel Energy Independence and Security Act targets. Our work will focus on: (1) regional marketing and distribution systems and (2) regional Sustainability analysis, data collection and management, and tools to support decision making.

The efficacy of any policy tool depends on the economic context in which it is applied. With these factors in mind, we propose the Southeastern Biofuels Policy Analysis Model (SEBPAM) as the overarching framework for our research. This model will build on our previous work and integrate several policy analysis issues into a common, logically consistent system. A key first step is developing a comprehensive framework of the perennial grass-based supply chain that incorporates stochastics to address risk issues. We will focus on implications of the Renewable Fuel Standard, incentives to intermediate firms, and the necessary incentives and risk management tools to induce farms to produce perennial grasses for drop-in biofuels production. Environmental policies such as the Conservation Reserve program will be considered among the policy instruments. By constructing a model of the entire supply chain and focusing on risk, we will be able to assess more appropriately the incentives for various agents to participate in the industry.

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THE EFFECT OF EXISTING AND NOVEL POLICY OPTIONS ON THE SUSTAINABLE DEVELOPMENT OF REGIONAL BIOENERGY SYSTEMS

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The unique characteristics of the Southeastern United States require a thoughtful approach if policy is to be successful in fostering sustainable bioenergy systems in the region. The region is energy intensive, home to only 36% of the population but accounting for 44% of the nation's total energy consumption. In contrast to other areas of the country, state-level renewable energy mandates are largely absent. Landownership is largely private, and is often managed for diverse market and non-market goods under objectives other than pure profit-maximization.

In light of these challenges and opportunities, this project will compare alternative policy options for encouraging bioenergy production in the Southeastern United States and their attendant effects on environmental, economic, and social objectives.

We begin by surveying the available literature to assess the drivers of private landowner bioenergy market participation. We then use the output of that exercise to qualitatively evaluate the potential effectiveness of three separate regional policy mechanisms in encouraging the stable, long-term production of bioenergy in the region: 1. regional public/private biomass supply partnerships; 2. regional biomass reserve program; and 3. integrated regional renewable energy standard. Next, we use findings from the literature review exercise to develop behavioral parameters and constraints on total biomass supply potential to improve on the short-comings of large-scale simulation modeling exercises, performing various sensitivity analyses around these parameters. Finally, we quantitatively assess the effectiveness of each policy mechanism, beginning with the Forest and Agricultural Sector Optimization Model with Greenhouse Gases (FASOMGHG), then using aggregate results to feed into the more spatially refined SubRegional Timber Supply (SRTS) model to further explore disaggregated forest biomass supply.

Presented in this talk will be results from the initial literature review and findings from early model integration efforts. We will describe our approach for specification of the three policy mechanisms, will review early stakeholder outreach initiatives to ensure applicability of project findings, and will elaborate on next steps and expected outcomes.

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EVALUATING POLICY INCENTIVES FOR REGIONAL BIOFUELS PRODUCTION SYSTEMS WITH A SCENARIO-BASED DECISION SUPPORT TOOL

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Policy promoting bioenergy production must be compatible with the production of food, feed, fiber, and other valuable ecosystem services, such as climate regulation, water quality regulation, and biodiversity support. Public policy involves tradeoffs, and policymakers face the difficult challenge of understanding the relative value of these tradeoffs to achieve multidimensional goals. This challenge is exacerbated by a lack of easy-to-use, spatially-explicit tools for policyevaluation.

We are building a user-friendly decision support tool (DST) to allow policy analysts to evaluate how hypothetical landscapes arising from different bioenergy policies will perform along a range of sustainability criteria.

The DST is an open-source, web-based (JavaScript, Play Framework), mapping (Open Layers, GeoServer), modeling (Java), and analysis (ExtJS) application. It runs in a web browser, allowing users to (1) view maps of the current landscape, (2) select portions of the landscape for transformation to energy crops, (3) specify the crop and management regime for selected land, (4) select a range of environmental (soil carbon sequestration, nitrous oxide production, phosphorus loading, beneficial insect support, grassland bird support) and economic (producer income, net-energy production, energy costs) metrics for evaluation, (5) view graphical and map-based output on screen, and (6) save results in reports for comparison of multiple scenarios.

The prototype is being built for southern Wisconsin, though design decisions are being made with scalability in mind.

We are working with a diverse team of regional stakeholders (farmers, state, regulators, industry, conservation groups, federal agencies) to design the DST. Upon completion, the stakeholder group will use the tool to create and evaluate bioenergy and land-use policy scenarios. Designing and assessing policy options in a place-based, participatory context is likely to foster stakeholder acceptance, and the probability of attaining regionally-appropriate sustainable bioenergy systems.

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REGIONAL BIOENERGY POLICY EFFECTIVENESS: COMPATIBILITY, INNOVATION, AND COORDINATION ACROSS THE FOREST SUPPLY CHAIN

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The United States is in the midst of a rapid proliferation of state and federal policies to create a bioeconomy that simultaneously addresses energy and food security, economic development, and environmental sustainability. An expanding bioeconomy may also enhance the flow of ecosystem services, reduce hazardous fuels, and provide a means to restore forest health. Yet there is little information about policy effectiveness, especially how state and federal bioenergy policies interact. As more states seek to develop their bioeconomy, many struggle to understand what strategies and policies will develop and sustain their natural assets most effectively.

The goal of this project is to identify synergies and policy gaps in regional bioenergy systems and to enhance effectiveness through increased policy alignment. Our objectives are to build understanding of (1) the extent to which policies are synchronized across the regional supply chain (feedstock production, transport, conversion); (2) which mix of policy instruments (regulations, tax incentives, etc.) enhance forest-based bioenergy production; and (3) how federal and state policies complement or contradict one other to foster or inhibit bioenergy development and innovation in biofuels, electricity production, and heating.

The project is organized into three phases. First, we characterize existing policies in the Pacific Northwest (CA, OR, WA) and Lake States (MN, WI, MI) regional bioenergy systems for forest feedstocks. Second, we solicit perceptions of policy alignment and effectiveness from business producers and government sponsors and intermediaries in each region. Third, we develop an index of policy effectiveness based upon a quantitative analysis of the relationship between policy adoption and policy outputs and outcomes at the state level.

Comparing and contrasting state policies and institutions and their interaction with federal efforts may illuminate particular innovations or mixes of policy instruments that effectively promote bioenergy production.

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SOCIOECONOMIC IMPACTS OF WOOD-BASED BIOFUELS DEVELOPMENT STRATEGIES ON NORTHERN ROCKY MOUNTAIN COMMUNITIES IN THE NORTHWEST

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This project will help determine the optimal system or mix of systems for integrating Northern Rocky Mountain woody biomass feedstocks into a planned regional liquid biofuel production system in the Northwest in the context of existing biomass uses and resources and community needs. Specific objectives and activities are to:

1. utilize discreet event simulation and mathematical modeling techniques to develop effective system pathways for each technology from source to point of sale, determine boundaries where benefits and impacts move outside of the study area, and assess the number of jobs created and other benefits.
2. model the overall viability and profitability of bioenergy strategies for woody biomass from community, state and regional perspectives.
3. utilize county and state input/output methodologies to evaluate the economic impacts and contributions of each technology, including backward economic linkages and the appropriateness of each strategy.
4. interview local and state elected officials, economic development professionals, industry, and other key stakeholders about knowledge and perceptions of benefits, obstacles and tradeoffs of different bioenergy development scenarios
5. engage an advisory board in guiding the project and helping interpret project results.

This is the first year of a three year project. When complete, the project will provide a model for understanding bioenergy development from community, county, state and regional perspectives to maximize benefits and minimize tradeoffs of a regional liquid biofuels industry.

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DECISION SUPPORT SYSTEMS FOR REGIONAL PLANNING AND IMPACT ASSESSMENT OF BIOREFINERIES

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The Energy Independence and Security Act of 2007 mandates use of 21 billion gallons of cellulosic and advanced biofuels by 2022, but scaling up the advanced biofuel sector poses major economic and logistical challenges for regional planners and biofuel entrepreneurs in terms of feedstock supply assurance, supply chain development, and assessment of socioeconomic impacts.

The objective of this research is to develop support tools to help biorefinery managers and regional planners make a series of decisions necessary for setting up and operating biorefineries. Example decisions include: where should the biorefinery be located, what is the optimal mix of feedstocks, what is the optimal configuration of the biomass supply chain, how to ensure small, minority, and tribal farmers participate and benefit, and how would the land use in the region evolve over time due to the presence of biorefinery?

Decision support tools being developed in this research include: (i) survey research assessing the acceptability of biorefineries and non-technical barriers in biorefinery location; (ii) A biomass harvest-shed design tool to determine the optimal mix of woody biomass, annual crops and perennial grasses, taking into account the necessary contract terms, feedstock costs, transport costs, GHG emissions, other environmental impacts etc.; (iii) a logistics decision support tool to help evaluate alternative feedstock supply chain configurations; (iv) focus group protocols for analyzing implications for small scale and minority/tribal producers; (v) contract design research aimed at helping selection of appropriate governance/institutional mechanisms to coordinate supply, which may range from markets to hierarchical mechanisms such as contracts, alliances, franchising, co-operatives or vertical integration; and (vi) a dynamic agent based simulation modeling tool that can help predict the evolution of the harvest shed over time, under alternative market development scenarios. The trans-disciplinary modeling approaches are highlighted and preliminary findings are presented.

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OPTIMAL LOCATION OF CELLULOSIC BIOFUEL FACILITIES AND THEIR IMPACT ON EMPLOYMENT IN THE SOUTHEAST REGION

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The 2007 Energy Independence and Security Act mandated that 36 billion gallons per year of biofuels be produced in the United States by 2022, with 21 billion required to be from advanced biofuels. Cellulosic materials from dedicated energy crops such as switchgrass, crop, and forest residues will be needed to achieve production targets. The southeastern US has climatic and geographic comparative advantage in cellulosic biomass production. Under the right market conditions, this region has the potential to meet 52% of the advanced biofuel targets converting feedstock materials such as switchgrass.

We use a facility locator model to determine the optimal location and number of biomass-to-ethanol facilities for the southeast region, subject to these constraints and an advanced biofuel production target of 11 billion gallons per year (bgy). We modify the constraints of the facility locator model to reflect the premium that may be attributed to skilled labor in the site selection decision of conversion facilities. We hypothesize that that aggregate industry costs will increase when more importance is placed on this criteria in the firm's location decision. Changes in aggregate costs will impact the geographic configuration of the industry, which will augment the indirect and induced effects on income and employment associated with a mature industry capable of meeting the 11 bgy target.

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ECONOMIC AND ENVIRONMENTAL IMPACTS OF WOODY BIOMASS UTILIZATION IN THE CENTRAL APPALACHIAN REGION

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While the impact of increased utilization of biomass has not been specifically studied in the central Appalachian region, there is evidence that increased use can provide significant benefits to a region that has faced enduring economic hardship. This project is examining the increased utilization of wood biomass as an energy feedstock for the production of liquid fuels; and evaluating the impacts of increased utilization of this feedstock on rural economic development and environmental quality throughout the central Appalachian Region. This project is focusing on three areas that are necessary for success of biomass projects: resource availability, environmental impact and economic impact. Through the first three quarters of the project progress has been made in each of these areas. Preliminary analysis of potential harvesting system capability along with data collection about potential feedstock availability is underway, with production equations for harvesting systems and geospatial coverage being completed for use in the analysis of feedstock availability. Additionally, preliminary life-cycle inventories are being completed for both the feedstock harvesting and conversion processes, including chemical and process analysis of conversion methods. Finally, the analysis of the economic impacts is also making positive strides, as the preliminary aggregation scheme of industries and the social accounting matrix that will be used for both the Input-Output and Computable General Equilibrium models has been completed. The economic modeling work is continuing now with parameterization of both models as well as preparing for the integration of the life-cycle analysis in to the models. In all phases of the project, the work is on schedule with no variance to report on any front.

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ASSESSING SOCIOECONOMIC IMPACTS OF FOREST BIOMASS BASED BIOFUEL DEVELOPMENT ON RURAL COMMUNITIES IN THE SOUTHERN UNITED STATES

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The thirteen southern states spanning from Texas to Virginia with around 5 million private landowners, accounting for 28 percent of total forestlands and 62 percent of the country's total growing stock removal in 2006 are expected to play a dominant role in woody biofuel market development. Another factor that supports the importance of southern states in woody biofuels future is the fact that forest inventory in the South has responded to increased management and harvesting since the 1990s, when more of the harvest shifted to private lands. Woody biofuel markets can contribute to rural development, benefiting local communities by generating additional revenues to nonindustrial private forest landowners and other economic agents, stimulate employment and diversify rural economies. However, economic impacts on rural communities in the region have not been systematically analyzed.

We analyze the impact of woody biofuel development on rural communities in the Southern US. Specifically, we will: 1) assess key stakeholders' participation along the supply chains of loblolly pine (*Pinus taeda* L.) and slash pine (*Pinus* elliottii L.) based woody biofuel markets; 2) analyze potential direct economic and employment impacts on forestland owners and rural communities; and 3) estimate region-wide socioeconomic and distributional impacts of woody biofuel development.

We will develop woody biofuel expansion scenarios based on market emergence in future and socio-economic acceptability considerations. Direct, indirect, and induced impacts on stakeholders will be estimated through Input Output Analysis and Social Accounting Matrix approach. Region-wide socio-economic and distributional impacts will be assessed using a Computable General Equilibrium model to identify winners and losers. We will discuss farm and regional impacts of woody biofuel expansion on non-metro (rural) counties in US South, including impacts on persistent poverty and minority dominated counties.

The preliminary results from the stakeholder meetings conducted in the three states of Alabama, Virginia, and Texas indicate that forestland owners were mostly aware of bioenergy production but were unsure about the price they expect to receive. The landowners who expressed their price preference tend to expect higher offers compared to pulpwood price to account for inconvenience and assumed risks. The information so generated is being used to develop a survey instrument that will be administered to 1800 randomly selected landowners in the three study states using Tailored Design Method. Our study will further understanding of the short and long-term impacts of woody biofuel expansion in US South and the ensuing socioeconomic impacts on rural landowners, minorities, and other rural groups. Research results will help generate public awareness, and develop education and outreach programs as well.

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SOCIAL ACCEPTABILITY OF BIOENERGY IN THE U.S. SOUTH

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As bioenergy continues to develop in the U.S. South, it will utilize forest lands in new ways and have different effects on a number of stakeholders: forest landowners, local communities, extant industries, policymakers, investors, and others. As more types of stakeholders become involved in bioenergy, and as the general public becomes more aware of it, understanding public perceptions of, and reactions to, bioenergy development will become increasingly important. Because of the multiple values and perspectives at play across the Southern landscape, we analyze social acceptability of bioenergy in the South broadly, taking into account diverse values, governance processes, and equity concerns. Our analysis seeks to recognize and elucidate the multiplicity of and dynamics between various stakeholders and to pay particular attention to the multi-scalar dimensions of bioenergy development.

We use an integrative analytical framework designed to illuminate different perspectives and trade-offs in order to address the following objectives: 1) identify the range of regional stakeholders; 2) document the ways that different components of bioenergy systems are valued; 3) identify policies, procedures, and institutions that influence bioenergy development; 4) identify how different stakeholders shape the processes of bioenergy development; and 5) identify trade-offs and synergies arising in bioenergy development.

Using a complementary array of qualitative social science methods (participant observation, interviews, content analysis, and collaborative event ethnography), we are conducting ethnographic research in three communities with bioenergy facilities in Georgia and Mississippi and visiting secondary sites in Georgia, Alabama, North Carolina, Florida, and Louisiana. An ethnographic approach allows us to collect detailed contextual social data and to examine how different elements of sustainability are interpreted and traded-off depending on economic, environmental, social, and cultural conditions.

Our preliminary results suggest that most landowners and community members are cautiously optimistic about a bioenergy industry and related markets. There is limited investment due to uncertainty, careful attention to long-term job creation and development potential, and interest in environmental sustainability. In some sites, there has been opposition to bioenergy development. Interest in bioenergy is usually justified on the basis of energy independence and rural development. Our research will enhance understanding of the complexity arising from differences in opinion and diverse framings of bioenergy among numerous stakeholders.

Our approach enables a comprehensive and dynamic understanding of social acceptability that can guide efforts to maximize the sustainability of bioenergy development, focus attention on areas where negative impacts of bioenergy development need to be addressed, improve our ability to communicate with stakeholders, and ultimately lay critical groundwork for bioenergy development by providing a foundation for collaborative planning in bioenergy sites.

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SOCIO-ECONOMIC FACTORS AND ADOPTION OF ENERGY CROPS

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The goal of this project is to analyze the socio-economic factors that impact farmers' adoption of energy crops in Missouri and Iowa. This research will enhance the knowledge of socio-economic factors that will impact the establishment of biomass feedstock supply, which is required for bioenergy production. The first objective of this project is to measure the impact of farm size, education, and off-farm employment on adoption of energy crops. The second objective is to measure the impact of producer attitudes, social acceptability, and being a minority limited resource farmer on adoption of energy crops. Finally, the last objective is to measure the impact of farmers' attitudes toward risk and uncertainty, and being part of an agricultural cooperative on adoption of energy crops. To achieve these objectives, a comprehensive survey among livestock and crops farmers in Missouri and Iowa will be conducted through USDA-NASS. The survey data will be analyzed using an ordered-probit regression model.

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SOCIOECONOMIC IMPACTS OF BIOFUELS ON RURAL COMMUNITIES

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Most studies on the availability of woody biomass for energy production assume private forest landowners are able and willing to provide feedstock for biofuel production and will do so because of their opportunity to increase profits. Little, if any, attention has been paid to social and cultural factors that may affect landowner decisions to participate in this evolving market.
The proposed project addresses this shortcoming by asking three nested questions: (1) Will private forest landowners produce raw materials for wood-based biofuel production in sufficient quantities to meet their needs? (2) What are the opportunities and concerns of communities, residents, and existing wood-based industries? (3) How will communities and residents respond to these opportunities and concerns?
Based on these questions, a series of mixed-methods research tasks have been identified to engage selected communities in a process of identifying sustainable community development opportunities. These include key informant interviews to identify ecological, social, cultural, and political barriers on biomass supply; facilitated group discussions with forestland owners and the larger community to assess receptivity to the biofuels industry; a landowner survey to assess willingness to provide needed biomass for biofuel production; and a resident survey to determine interest in biofuel production.
Through the proposed process, we will identify key factors in acceptance of biofuels industry by landowners and residents, assess the relative importance of the various owner objectives, citizen attitudes, and biophysical factors in estimating the supply of biomass to the biofuels industry; and create initial community dialogues on biofuels industry and community development.

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MEDICINAL AND NUTRACEUTICAL PLANTS

ABSTRACTS PRESENTATION

STABLE ISOTOPE TECHNOLOGIES TO ASSESS PHYTOCHEMICAL ABSORPTION AND METABOLISM IN HUMANS

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Plants synthesize a vast array of organic compounds, including phytonutrients and various bioactive phytochemicals, with the potential to contribute to human health. Many groups have surveyed food crops for useful compounds and have determined the concentrations of phytochemicals across species, genotypes, and in response to differing environmental conditions. These quantitative measures are useful for determining the composition of different food crops, but they do not reveal the extent to which these compounds are absorbed, utilized, or metabolized within the body (i.e., the compound's 'bioavailability'). To assess a phytochemical's nutritional potential and to determine dietary recommendations, it is important to establish the effective dose of a phytochemical that is provided in a quantified serving of a given food. This can be determined only when both the actual concentration and the bioavailability of the phytochemical from a given food are known. Numerous analytical methods are available to measure these compounds in plants, but tools for determining their bioavailability are more limited.

Over the past 23 years, we have developed and utilized several methods for labeling plants with stable isotopes of different elements, yielding 'tagged' compounds that are intrinsically incorporated into the plant food matrix. Our objective has been to generate food-based tools for bioavailability studies that are safe for use in human clinical trials and can be generated in a cost-effective manner. Stable isotopes are non-radioactive forms of elements that can be used in foods that are fed to any human subject, including children, pregnant or lactating mothers, or individuals in poor health. Most elements have low abundant isotopes that can be purchased from commercial sources. Growing plants in an environment enriched with the low abundant isotopic forms of an element can provide unique mass signatures for any biosynthesized compound. These 'labeled' or 'tagged' compounds can be quantified in blood, breath, urine, or fecal samples using mass spectrometry methods, and they can be easily distinguished from the same compounds originating from other foods in a meal or from pre-existing, endogenous sources in the body.

The various methods and strategies that can be employed for incorporating stable isotopes into plants, the types of labeled products that can be produced, and the cost considerations for producing these labeled materials will be discussed. An overview of how these labeled phytochemicals can be used in clinical studies to assess absorption, and in some cases, their subsequent metabolism will also be presented.

The intrinsic incorporation of stable isotopes into a plant food matrix provides a useful tool to determine phytochemical bioavailability from a food as it is commonly consumed. These techniques offer many opportunities to improve our understanding of phytochemical bioavailability from diverse medicinal and nutraceutical plants.

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THE NC ARBORETUM MEDICINAL GERMPLASM REPOSITORY ASHEVILLE, NC

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The North Carolina (NC) Arboretum Germplasm Repository (TNCAGR) is a collaborative effort by public and private organizations to advance the conservation, authentication, and economic development of plant based natural products by collection, development of chemical extracts and, long-term storage of germplasm. Germplasm includes but is not limited to seed, DNA, endophytic fungi, and entire plants when applicable. In addition voucher specimens, and representative extracts for chemical analysis are collected and stored. Located at the NC Arboretum in Asheville, in situ collection efforts commenced in spring 2008.

The establishment of robust germplasm collections is an important tool for the development of natural product biotechnology through the long-term conservation of valuable research selections. As biotechnology research becomes more sophisticated, there is increased demand from peer research agencies to require plant materials of known genetic origins in order to produce high quality, reproducible research results, however, access to a recognized source of known-origin material for many research projects are not currently available. TNCAGR specializes in this area and will focus primarily as a supplier and long-term storage facility for medicinal and nutraceutical germplasm associated with project collaborations. The collections will be suitable for a wide variety of research purposes including but not limited to analysis of metabolites of interest for pharmaceutical purposes, cultivar breeding studies, and genetic population analysis.

Due to the extraordinary genetic diversity available in the southern Appalachian bioregion along with a long history of medicinal plant trade and supply, western N. Carolina is the ideal location for a repository and the development of an extensive extract collection site for potential drug discovery and product development. The NC Arboretum is located adjacent to one million acres of national forest land, which provides ideal conditions for the development of in situ preservation, maintenance, and collection sites.

This presentation will summarize how analytical researchers can collaborate to utilize the NCAGR. The collections will be suitable for a wide variety of research ranging from chemical analysis of interested metabolites to endophyte isolation, phylogenetic studies, and cultivar breeding. Examples of current research projects will be discussed. Illustrations of field collection methods, seed and control-pollinated cage propagation, and facilities utilized for seed cleaning, testing and storage will be included.

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QUALITY AND CHEMISTRY OF NEW SPICES FROM THE GUINEA FOREST OF LIBERIA

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Forests have been increasingly recognized as reservoirs of valuable biological resources other than timber. The term non-timber (or non-wood) forest products (NTFP) emerged as a group of products derived from these various forest resources. In Liberia, communities use a wide variety of products for their daily needs, of which spices constitute an important group of products with potential to generate income. An ethno-botanical survey was conducted in Liberia to identify the NTFP with highest potential to generate income for communities, and based on this surevey, we found that spices were one of the most used products by forest dwellers.
The objective of this work is to assess the sensory, physical and chemical properties of spices from Liberia, West African black pepper (*Piper guineense*), country spice (*Xylopia aethiopica*) and grains of paradise (*Aframomum melegueta*).
The aroma, color of spices, quality (moisture, foreign materials), chemistry of essential oils, and pungent principles were determined in the samples. Samples from Ghana of bush pepper and country spice were used for comparison purposes.
Samples showed variations in the quality parameters and chemical composition of essential oils and other bioactive principles. In particular, West African black pepper essential oil content appeared to be higher in the Liberian sample (1.36%) than in the Ghanaian sample (0.86%). The pungent principle piperine was very low in the Liberian samples (0.08-0.22%) and the highest value was observed in the Ghanaian sample (0.86%). The essential oil composition of the Liberian pepper showed a characteristic essential oil profile characterized by high levels of linalool. Samples from Ghana were characterized by high levels of sesquiterpenes. The aroma was in accordance with the chemical profile. The samples from Liberia showed sweet and floral aromas while samples from Ghana were characterized by woody and higher spicy aromas. Studies on the safety of this spice showed that all samples showed low levels of aflatoxins (less than 20 ppb). Moisture, foreign matter, and acid insoluble ashes content of all spices tested showed low values suggesting that these products were clean and properly processed.
This study has shown that Liberian spices, particularly West African black pepper showed a unique sensory profile. This study also is contributing to the generation of trade standards to support the commercialization of these new products from the Liberian forests.

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EVALUATION OF FENUGREEK (*Trigonella foenum-graecum* L.) GERMPLASM FOR DIOSGENIN, GALACTOMANNAN, AND 4-HYDROXYISOLEUCINE

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Fenugreek (*Trigonella foenum-graecum* L.) is an annual legume that has shown anti-cancer, anti-diabetic, and anti-hypocholesterolemic properties in previous studies. Diosgenin, galactomannan, and 4-hydroxyisoleucine are major biochemical compounds for these beneficial effects. Fenugreek is grown under conditions (mostly in India) similar to those found in western Nebraska. Therefore, fenugreek may be a new and industrially important crop in western Nebraska to promote health.

The objective of this project was to evaluate global germplasm of fenugreek for diosgenin, galactomannan, and 4-hydroxyisoleucine content.

A set of 97 fenugreek lines from 17 countries were grown in the field and the harvested mature seed were used in the analysis.

Galactomannan ranged from 3.48% to 19.3% with an average value of 12.0%. The highest galactomannan content (19.3%) was in a line from Iran. Diosgenin ranged from 5.80% to 29.70% with an average value of 11.88%. The highest diosgenin content (29.70%) was in a line from Pakistan. 4-Hydroxyisoleucine ranged from 1.79% to 2.79% with an average value of 2.13%. The highest 4-hydroxyisoleucine content (2.79%) was found in lines from Pakistan and Bulgaria.

This data will be useful for the development of high yielding fenugreek cultivars with high levels of these important nutraceutical compounds for western Nebraska and neighboring regions.

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ALOE VERA BAGASSE EXTRACTS AS POTENTIAL CONTROL OF POSTHARVEST FUNGAL DISEASES

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Chemical treatment is one of the primary means for control of postharvest fungal diseases on fruit and vegetables and applied during storage allows for shelf life extension and reduced spoilage. However, many fungicides are being removed from postharvest treatment due to their potential toxic hazards. The use of plant extracts (in some cases with strong bioactivity) is one attractive alternative, and has already proven their efficacy against some important postharvest pathogens.

This work aims at evaluating extracts from *Aloe vera* bagasse (AvB) in terms of their antioxidant activity, phenolic content, and to identify their antifungal activity.

Aloe vera leaves (bagasse) were separated from the inner gel and the liquid fraction was dried at 40°C. AvB was ground to reduce the particle size (mesh No. 50), then the bagasse was added to a Soxhlet extractor and continuously extracted during 48 h with absolute ethanol or distilled water as solvent (1:20), at 78.4 and 99.4°C, respectively, thus obtaining an ethanolic (EE) or an aqueous (AE) extract. Bioactive extracts were then filtered with Whatman No. 1 paper and the solvent was separated in a rotary evaporator. Yields of extraction were determined. Total phenolic content (TPC) was measured using the Folin-Ciocalteu method (results expressed as mg of gallic acid per g of extract). The antioxidant activity was measured by the DPPH-scavenging method and expressed as percentage of radical scavenging activity (RSA). Antifungal activity of AE and EE were evaluated against four postharvest fungal pathogens (*Botrytis cinerea*, *Rhizopus stolonifer*, *Penicillium expansum* and *Alternaria* sp.) by the poisoned culture medium technique at concentrations of 0, 50, 100, 500, 1000 and 2000 ppm.

The results showed that the yield of extraction can vary according to the solvent used (47.41% and 9.63% for AE and EE), respectively. The ethanolic extractd showed a higher value of TPC (196.62 $mg_{gallic\ acid}$/g extract) and a similar antioxidant activity (19.57 % of RSA) as AE (60.57 $mg_{gallic\ acid}$/g extract and 24.76 % of RSA). In addition, the treatments with EE presented a major antifungal activity against the fungal pathogens tested with an inhibition percentage ranging from about 40% -90%.

Aloe vera bagasse extracts showed good antifungal activity, and therefore could be an alternative for fungal control. Furthermore, antioxidant activity detected in both AvB extracts could be applied to increase fruit and vegetable quality.

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SUSTAINABLE PRODUCTION OF GUAR (C*yamopsis tetragonoloba* L.) IN THE ARID SOUTHWEST

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Guar, an annual legume that requires only about 25-30 centimeters of water, has traditionally been grown in India. Guar is adapted in West Texas due to the similar arid climates found both in Texas and India. Interest in domestic production is growing rapidly in the United States due to guar gum use in hydraulic fracturing. Oilfield service companies such as Halliburton, Schlumberger, and Baker Hughes are paying very high prices to import guar gum to the United States. Historically, guar was produced as a catch crop planted only after a catastrophic weather event. Our objective was to determine if guar can produce profit margins equivalent to two-bale cotton crop. However, before guar can become a viable alternative crop on the Texas High Plains, there needs to be evidence of profitability, high seed yield, high quality galactomannan gum quality, and improved agronomic practices.

The objective was to conduct agronomic trials in Lubbock, Texas to determine: 1) optimal irrigation rates; 2) response to different nitrogen application rates; 3) herbicide management practices; 4) cultivars adapted to drip irrigation; 5) and finally perform an economic analysis.

Five different, agronomic trials were planted at Lubbock, Texas on subsurface drip irrigation with emitters every 30 cm placed approximately 20 cm below the soil surface. Drip tape was spaced 1 m apart and placed directly under the planted row. Each plot was planted in double rows, 25 cm apart centered on the drip tape. For the irrigation rate trial, twelve breeding lines and six commercial cultivars were grown under four irrigation rates (100, 200, 300, and 400 mm) of supplemental irrigation. The nitrogen trial consisted of two cultivars that were monitored under six different rates (0, 15, 30, 45, 60, and 75 kg/ha) of urea (46-0-0) and was replicated four times. Metribuzin was applied at three different stages of growth (pre-plant incorporated, pre-emergence, and post-emergence) at three different rates (0.33, 0.66, and 1 kg ai/ha). Seventy-four cultivars with five commercial cultivars were compared under drip irrigation for seed yield and gum quality. Economic analysis will be conducted to compare the economic return of adding water, nitrogen, and other inputs to guar to identify the most profitable proposed impacts. The 2013 study represented the first year of a two year study.

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MEDICINAL AND NUTRACEUTIAL PLANTS

POSTER PRESENTATION

GENETIC VARIABILITY FOR PHENOTYPE, SEED PRODUCTION, OIL CONTENT, AND FATTY ACID COMPOSITION AMONG 17 ROSELLE (*Hibiscus sabdariffa* L.) ACCESSIONS

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Seed oil and fatty acids in plants have human health implications. Oil from roselle (*Hibiscus sabdariffa* L.) seeds are used in Taiwan as a diuretic, laxative, and tonic.
The objectives of this study were to evaluate seeds from 17 roselle accessions for oil and fatty acid variation in a greenhouse. Seventeen roselle accessions were planted in 27.5 cm^2 plastic pots containing potting soil and grown in a greenhouse from August 1, 2010 – April 1, 2012.
The seed oil content was measured on a Mini-spec mq10 NMR analyzer. The NMR was maintained at 40°C and operated at a resonance frequency of 9.95 MHz. A total of 16 scans were recorded for each sample. For establishing an oil standard curve, nine standards were prepared by weight using cotton oil. The mass of each measurement was converted to a percentage of the total weight of each sample.
Approximately 50−100 mg of ground seed material was transferred to a glass tube, and 3.0 mL of n-heptane was added to extract the oil. For conversion of fatty acids to methyl esters (FAMEs), 500 μL of 0.5 M sodium methoxide ($NaOCH_3$) in methanol solution was added to the tube and mixed with the sample. After 2 h, 7 mL of distilled water was added to separate the organic layer containing FAMEs from the seed residue. An aliquot was transferred to a 2.0 mL autosampler vial for analysis. Fatty acid composition was determined using an Agilent 7890A GC equipped with a flame ionization detector (FID) and an autosampler. Peak separations were performed on a DB-23 capillary column.
The experimental design was a randomized complete block with 4 replications assigned to roselle accessions. All statistical analysis were accomplished using SAS.
Significant variation for all traits was found. PI 274247 from Poland produced significantly more oil (20.1 %) than many other accessions. PI 274245 produced significantly more linoleic acid (58.4 %) than most of the other accessions while PI 256039 and 256038 from Bangladesh produced more oleic acid (25.7 % and 24.9 %, respectivley) than all other accessions. Several correlations were observed among traits evaluated.
Principal component analysis revealed sufficient variation in these roselle accessions for oil and fatty acid breeding projects and use as a nutraceutical crop.

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Jatropha dioica ANTIFUNGAL EFFECT ON *Fusarium oxysporum* CONTROL IN TOMATO

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Tomato (Solanum l*ycopersicum* L.) is the world's second most important vegetable. Mexico ranks second in production of this crop and the major cultivated areas are in Sinaloa state. However, this vegetable is strongly affected by diseases caused by viruses, bacteria, insects and fungi. One of the major diseases in tomato is produced by *Fusarium oxysporum*. A low-cost alternative for the control of this plague are the use of plant extracts, since they can prevent environmental degradation and do not affect productivity or food quality. Stems and rhizomes of *Jatropha dioica* Sessé ex Carv. (Sangre de Drago) contain phenolic compounds that could confer significant biological activity as potential antifungal phytochemicals.

The aim of this study was to evaluate the antifungal effects of *J. dioica* stem and rhizome extracts against greenhouse-grown tomatoes diseases caused by *F. oxysporum* f. sp. *lycopersici*. *Jatropha dioica* plants were collected at Rocamontes, Coahuila, Mexico. The extract EJD was obtained from stems and rhizomes of *J.dioica* using an ethanol-water solution (25:75 v/v). Tomato cultivation was carried out in plastic pots (4 gallons) containing a mixture of sterilized substrate of perlite-peat moos-soil (weight proportion of 33.3% each). The experiments were conducted in a greenhouse under a completely randomized design with eight treatments and ten replications: T1: absolute control, T2: Witness inoculated; T3: 100ppm EJD; T4: 300 ppm EJD; T5: 500 ppm EJD; T6: 1000 ppm EJD; T7: 2000 ppm EJD and T8: 3000 ppm EJD. The seedlings were inoculated with a solution of 1.7×10^6 spores ml^{-1}. *J. dioica* extract was applied to transplants and at 10, 20 and 40 days after planting of transplants. Irrigation and fertilization were applied according to crop development requirements. The evaluated variables were plant height, stem diameter (weekly), number of fruits per plant, fruit radius (polar length / equatorial diameter), fruits fresh and dry weight, number of leaves per plant, leaves fresh and dry weight, total fresh and dry weight of plant, percentage of dead plants, incidence and severity of the disease per plant, total soluble solids content and fruit pH (at harvest).

The analysis results showed that the application dose of 100 ppm *J. dioica* extract presented the best performance in terms of stem diameter and plant height. This treatment had a superior effect against the pathogen in relation to the control and the rest of the treatments administered during the experiment.

Jatropha dioica stem and rhizome extracts showed disease control of the *F. oxysporum* pathogen in tomato, and the highest results were observed at the lowest tested concentration (100 ppm).

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Flourensia cernua POTENTIAL ANTIFUNGAL FOR *Fusarium oxysporum* CONTROL IN TOMATO

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Tomato (*Solanum lycopersicum* L.) is one of the most widely consumed vegetables in the world and provides high economic value. However, this crop is commonly affected by *Fusarium oxysporum* fungus that causes root rot disease and plant wilt of tomato, resulting in considerable economic losses. The search of novel alternatives to control plant pathogens is a priority, especially for the use of green technologies with minimal damage to the environment. Among these, natural products as plant extracts have presented positive effects in controlling soil and foliar pathogens.

The aim of this study was to evaluate the antifungal effects of *Flourensia cernua* extracts in controlling *F. oxysporum* f. sp. *lycopersici* in tomato plants.

Flourensia cernua plants were collected in semi-arid zones of southeastern Coahuila, Mexico. The ethanol extract of *F. cernua* (EEFC) was prepared using only the plant leaves. Tomato plants were grown in plastic pots (4 gallons) containing a mixture of sterilized substrate of perlite, peat moss and soil (weight proportion of 33.3% each). The experiments were established in a greenhouse using a completely randomized design with eight treatments and ten replicates: T1: absolute control; T2: Witness inoculated; T3: 100 ppm EEFC; T4: 300 ppm EEFC; T5: 500 ppm EEFC; T6: 1000 ppm EEFC; T7: 1500 ppm EEFC and T8: 2000 ppm EEFC. Tomato seedlings of T2 to T8 assays were inoculated with a solution of 1.7×10^6 spores ml^{-1}. The *F. cernua* extract was applied to transplants at 10, 20 and 40 days after transplantation. Irrigation and fertilization were applied according to crop development requirements. The variables evaluated were plant height, stem diameter (weekly), number of fruits per plant, fruit radius (polar length / equatorial diameter), fruits fresh and dry weight, number of leaves per plant, leaves fresh and dry weight, plant total fresh and dry weight, dead plants percentage, incidence and severity of plant disease, total soluble solids content, and fruit pH at harvest.

The results showed that a treatment of 500 ppm of *F. cernua* extract reduced disease incidence (significant effect of $p \leq 0.001$) caused by *F. oxysporum* at 45 days after transplantation. This value is in agreement with the stem diameter data collected during the experiments.

Flourensia cernua extract at a low-dose concentration showed antifungal effects against *F. oxysporum* on tomato plants.

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PLENARY SESSION

NEW DIGITAL COMMONS DATABASE TO DEPOSIT DATA FOR LIFECYCLE ANALYSIS

P. Arbuckle

National Agricultural Library, Washington DC

Differentiating the environmental, economic, and social impacts for different products is complex. The complexity is driven by the multiple indicators to be measured and balanced against competing priorities. Life cycle assessment (LCA) is a science-based process which can serve as a foundation upon which to make informed decisions.

Wide-spread implementation of LCA practice requires three principal elements: 1) readily available data in compatible formats; 2) a robust data management system to handle the large volume of data; and 3) a trained workforce of practitioners. At present North American life cycle inventories are limited. A coordinated and well planned initiative is essential to provide industry with the support needed to remain competitive in a global marketplace, where sustainability measures are required for trade.

Agricultural products are the raw materials for product sectors including: fuel; chemicals; food; fiber; even pharmaceuticals. The United States Department of Agriculture (USDA) collects a wide array of high quality data supporting its mission. This data with proper preparation can be successfully re-used to conduct LCA analysis. The superior statistical representation of the USDA data will dramatically improve the reliability of future LCA analyses based on this data.

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CENUSA: AN AGRO-ECOSYSTEM APPROACH TO SUSTAINABLE BIOFUELS PRODUCTION VIA THE PYROLYSIS-BIOCHAR PLATFORM (USDA-NIFA AFRI CAP, PROJECT #2010-05073)

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The US has embarked on an ambitious program to develop alternative transportation fuels to lessen our dependence on oil imports, reduce greenhouse gas emissions, and provide increased energy security. The Energy Independence and Security Act of 2007 sets renewable fuel standards through 2022 and mandates an increase in advanced biofuels production to 21 billion gallons annually by the end of the term covered by the legislation (H.R.6 2007). Producing these fuels in an environmentally sustainable manner that does not interfere with food production or cause adverse changes in land use represents a major challenge for US agriculture. We are addressing this challenge by developing a regional system for producing advanced transportation fuels derived from perennial grasses grown on land that is either unsuitable or marginal for row crop production. In addition to producing advanced biofuels, the system will improve the sustainability of existing cropping systems by reducing agricultural runoff of nutrients and soil and increasing carbon sequestration. The North Central US is one of the most agriculturally productive areas in the world. However, intensive crop production on land within this region that is not well-suited to row crop production has impaired soil and water quality and led to loss of productivity. Growing dedicated biomass crops on land that is unsuitable or marginal for row crop production would mitigate these problems and provide additional ecosystem services. This research, education and outreach project focuses on herbaceous perennials that provide potentially high biomass production and ecosystem services. Objectives are to: 1) develop cultivars and hybrids of perennial grasses optimized for bioenergy production, 2) develop sustainable production systems that optimize perennial biomass yields and ecosystem services, 3) develop flexible, efficient, and sustainable logistics systems, 4) identify and characterize sustainable bioenergy systems to achieve social, economic, and environmental goals and understand socioeconomic and environmental consequences of perennial bioenergy systems, 5) identify germplasm characteristics amenable to pyrolytic conversion and evaluate performance of pyrolytic biofuels, 6) evaluate policy, market, and contract mechanisms to facilitate broad adoption by farmers, 7) develop procedures for managing risks and protecting health for each component of the biofuel production chain, 8) provide interdisciplinary education and engagement opportunities for undergraduate and graduate students, and 9) develop outreach programs for all stakeholders of the bioenergy system.

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THE IBSS PARTNERSHIP: DEPLOYING AN ADVANCED BIOFUELS INDUSTRY IN THE SOUTHEAST

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Almost half of the nation's supply of advanced biofuels, as mandated by the renewable fuels standard, will be met with the lignocellulosic resources of the southeast. While producing roughly 10 billion gallons of alternative fuels is well within the region's capacity, a considered and thoughtful transition is needed to insure a sustainable supply of biomass for this new industry. With more than 30 million acres of southern pine plantations distributed throughout the South, an expansive biomass source for fuels production is in place. Working closely with conversion technology collaborators, IBSS will develop today's forest resources for near-term progress while advancing energy crop supply systems optimized for infrastructure-compatible fuels production. The program's overarching goals are:

Demonstrate implementable 'real-world' solutions to the economic and environmental barriers that limit sustainable and reliable biofuels production.

Introduce new tools and metrics for effective decision-making in site selection and regional deployment of biofuels production from lignocellulosic biomass.

Provide credible, impactful, and integrated education, extension and outreach (E_2O) programs that train the workforce needed, and inform stakeholders and policy makers with the knowledge necessary to thoughtfully enable the southeast's biofuels industry.

In addressing these goals, The IBSS Partnership has met an important milestone. About 1,000 gallons of renewable diesel have been produced with our commercial partner, and are available for demonstration and outreach purposes. The regional biomass was procured, preprocessed, and shipped to Colorado for processing. In demonstrating the technical feasibility of the system, valuable data on process performance was obtained. This presentation will highlight the insights that the IBSS team gained through this achievement, as well as the program's response to external events imposed by the changing energy climate.

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MACHINE VISION FOR QUANTIFYING DYNAMIC PHENOTYPES IN MUTANT AND NATURALLY VARYING POPULATIONS

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Most often, genotype information exceeds its phenotypic counterpart in all dimensions and manners. Our Phytomorph project is motivated by the belief that improved technologies for quantifying growth and development will reduce this mismatch by producing more reliable and detailed phenotype data sets, resulting in more efficient functional genomics research. The Phytomorph approach utilizes parallelized and automated image capture and computational analysis to extract phenotype information from time lapse images. The primary roots of Arabidopsis and maize seedling are good subjects with which to develop this approach because their simple cylindrical shape facilitates the image processing step and their responses to environmental perturbations such as reorientation with respect to gravity are rapid enough to be studied in a few hours. One study to be described in this talk utilized a bank of CCD cameras to monitor Arabidopsis seedling roots every 2 min for 8 h. Because of the high-degree of automation it was feasible to measure the responses of a population of recombinant inbred lines in order to perform quantitative trait locus (QTL) mapping. This approach added a time axis to the phenotype data and therefore to the resulting QTL map. When particular loci start and stop to influence variation in the response of roots to gravity was shown by this analysis because machines acquired the phenotype data precisely and automatically with high time resolution. Essentially the same studies are being performed with mapping populations of maize, tomato, and carrot. A major goal of the Phytomorph project is to find predictive relationships between highly quantified phenotypes. Proof of the concept has been achieved with seed features measured very accurately from images and near-infrared spectra then combined with root growth behavior data to reveal relationships between pre- and post-germination events. If some phenotypic features in seeds and seedling roots grown in a lab can be mathematically linked, will it be possible to link lab-grown root features to an important field-expressed trait? How far can predictive relationships between phenotypes be pushed? The easier we can make the process of acquiring large sets of accurate phenotype measurements, the greater the chances of finding useful predictive models. What impedes the community of plant scientists from more readily adopting image-based phenotype approaches in their research will be discussed for the purpose of finding effective solutions.

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ROOT TRAITS CONTRIBUTING TO PLANT PRODUCTIVITY UNDER DROUGHT

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Breeding plants with roots that more effectively take up water from soil and make it available to leaves is critical for increasing crop productivity. However, we need a better understanding of root traits and when they benefit plants. Root traits that generally benefit plants under drought stress include small root diameters, long specific root length (root length per weight), great root length density (root length per soil volume), and deep rooting (if deep soil water is available). Anatomical traits that make xylem more air tight and less prone to cavitation can also benefit plants grown with limited water without plant costs or limitations in wet conditions. Fast root growth in response to soil water may benefit plants experiencing episodic drought. Several recent reviews have covered methods for screening root traits but, to screen effectively, breeders need to understand the organization and complexity of root systems. Screening of root traits at early stages in plant development may provide information on traits at mature stages but verification is needed on a case by case basis. The genetic control of many root traits should allow breeders to breed them into plant lines.

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OILSEEDS FOR BIOENERGY AND BIOMATERIALS II

ABSTRACTS PRESENTATION

GENETIC AND PHENOTYPIC VARIATION FOR GERMPLASM IMPROVEMENT IN THE BRASSICACEAE

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The Brassicaceae includes numerous species with potential for further development as an effective feedstock for the production of hydrotreated renewable jet (HRJ) fuel. Historically, one of the most productive oilseed species is *Brassica napus* (L.), existing as either a winter or spring annual crop, with diverse oil compositions. To increase the economic return on investment in use of *B. napus* as a source of biofuel, genetic improvement for oil yield and quality across diverse environments is needed. In that light, we are creating a collection of nearly 1,000 genetically diverse accessions (diversity panel) from the widest available germplasm worldwide to use as a resource for genetic improvement. At the same time, we are expanding our capacity to apply high-throughput phenotyping tools and strategies to quantify traits associated with specific germplasm lines. The objective of this study was to: a) create and advance, through selfing, a diversity panel from nearly 1,000 accessions; b) apply new phenotyping tools toward quantifying trait diversity in the population, to include the application of: i. traditional scoring of morphological traits, ii. new high-throughput lab based methods for lipid analysis, and iii. new high-throughput field-based platforms for proximal sensing. Seeds from geographically diverse locations worldwide were collected and greenhouse- or field-grown plants were established in multiple locations across the US. A set of target traits was identified, and quantification methods defined. Development and application of high throughput lipid analysis tools were established and a high clearance vehicle outfitted with sensors is now being tested in the field for rapid measurement of several canopy traits. To highlight an initial data set, leaf cuticular waxes were collected and the chemical composition quantified for three replicates of 520 *B. napus* accessions growing in Maricopa, Arizona, using new robotic workbench instrumentation. Leaf waxes play a major role in controlling plant water use and drought tolerance. Variation in wax chemical profiles, as well as visible glaucousness, was quantified. Initial data from the field based phenotyping platform indicates that traits such as visible canopy reflectance due to surface waxes, canopy temperature, height, and architecture will soon be available for the entire diversity panel.In addition, high-density SNP genotyping of all accessions in the *B. napus* diversity panel is near completion. The application of high throughput approaches to quantify genetically controlled phenotypic variation within the world's natural diversity for *B. napus* is expected to provide a major step forward in plant breeding, and useful tools for advanced genetic studies. The potential to use these tools to exploit the existing worldwide genetic diversity of bioenergy crops like *B. napus* is especially promising.

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GENETIC DIVERSITY AND POPULATION STRUCTURE OF BRASSICA NAPUS

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Industrial rapeseed (*Brassica napus* L.) is a winter or spring annual crop that produces seed oil with a high level of erucic acid. The non-edible oil of industrial rape has the potential to be a sustainable source of hydrotreated renewable jet (HRJ) fuel, but a significant increase in the domestic production of industrial rapeseed oil is needed. In part, this could be accomplished through the large-scale introduction of industrial rapeseed as a rotation crop in the western U.S. non-irrigated wheat production system. Such introduction across the diverse environments that constitute the wheat belt, however, necessitates the development of high yielding, locally adapted industrial rapeseed varieties that are compatible with HRJ fuel conversion processes.
In that light, we are constructing translational genomics platforms to support the molecular breeding of improved winter and spring type industrial rapeseed varieties.
Nearly 900 rapeseed lines that cover a wide geographic distribution were assessed for growth habit and scored with a low-density SNP genotyping array.
The evaluation of growth habit resulted in the classification of the 870 rapeseed lines as 644 and 226 winter and spring types, respectively. On average, the 260 SNP markers had a polymorphic information content (PIC) value of 0.36 and minor allele frequency (MAF) of 0.31. Through an analysis of the SNP marker data with a model-based clustering method, three distinct clusters were revealed. The three clusters were defined as winter I, winter II, and spring subpopulations, a naming convention based on the majority of lines with a specific growth habit in a given cluster. Of the three subpopulations, winter I was the largest and captured the highest number of alleles. With this improved understanding of the genetic relationship among these lines and how genetic diversity is partitioned among them, we have initiated high-density SNP genotyping of the rapeseed lines in combination with genome-wide association studies (GWAS) to identify genetic markers that are associated with important agronomic and oil quality traits.

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RAPID NON-DESTRUCTIVE AND WET CHEMICAL METHODS FOR THE ANALYSIS OF GLUCOSINOLATES, CHLOROPHYLL, OIL AND FATTY ACIDS IN BRASSICA GERMPLASM

T.A. Isbell

USDA-ARS-NCAUR

This research supports the development effort to provide a renewable feedstock for the production of jet fuel from an oilseed crop that is in rotation with wheat in the Western U.S. The project is a nationwide effort of 22 investigators funded under the National Institute for Food and Agriculture (NIFA) Biomass Research and Development Initiative (BRDI). Part of the project is the evaluation of a large number of Brassica accessions for genetic variability in addition to a couple dozen lines that are being thoroughly evaluated in a multi-location stress trial. Combined, these trials will generate thousands of samples that will require a number of chemical evaluations to determine their suitability for the extraction of oil and its subsequent conversion to jet fuel.

Initial analytes include; total oil, protein, moisture, total glucosinolates, chlorophyll, and fatty acid composition. Near Infrared (NIR) spectroscopy calibrations were made for all of the analytes except the fatty acid composition which was analyzed as the methyl ester by gas chromatography (GC). Outliers from the NIR total oil calibration curve were subsequently analyzed by pulsed nuclear magnetic resonance spectroscopy (pulsed NMR). Outliers for total protein by NIR were analyzed by CHN combustion analysis. Outliers for chlorophyll and total glucosinolates by NIR were analyzed by High Pressure Liquid Chromatography (HPLC). In addition, calibration curves were initially established by first developing a wet chemical method for the analyte and their subsequent measurement by direct spectroscopic methods; oil by pulsed NMR, glucosinolates and chlorophyll by HPLC and protein by combustion analysis.

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IN-LINE OPTICAL SENSING OF SEED OIL CONCENTRATION TO IMPROVE EXTRACTION EFFICIENCY

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Spatial variability in seed oil concentration can negatively affect the recovery of oil from the seed at the crushing plant. The objective of this study was to determine how well in-line near infrared (NIR) spectroscopy can determine the seed oil concentration of canola (*Brassica napus* L.) and whether this information might be used in real-time to adjust a cold press for maximum efficiency. Reflectance spectra from 850 nm to 1650 nm were obtained for numerous grain samples using an in-line Polytec 1721 NIR reflectance analyzer. The resulting prediction equation with eight eigenvectors resulted in an R^2 of 0.95 and standard error of prediction of 7.3 g kg^{-1}. Validation results confirmed the ability of the instrument to predict seed oil concentration in a moving stream with standard errors <4.8 g kg^{-1}. Theoretical fractions of expelled oil and meal were then calculated as a function of seed oil concentration and choke setting. For each seed oil content value, there was an optimal choke setting that maximized the volume of oil that could be extracted. In-line NIR reflectance spectroscopy can provide accurate information about variability of grain quality at a high measurement rate. Ability to be installed on a press to control the choke setting could increase capacity and profitability for many oilseed crushing plants in the US that use cold-press extraction.

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DEVELOPMENT OF AN ECONOMIC MODEL FOR HRJ OILSEEDS IN THE WHEAT BELT

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Brassica oilseeds have been identified as potential feedstocks for hydrotreated renewable jet (HRJ) fuel production. While these oilseeds have relatively high oil content, have characteristics that make them suitable for fuel production, and are generally adapted to wheat producing areas of the United States, there is little information on where and how these crops can be profitably grown, and the oilseed crop prices that would be necessary for these crops to be competitive with existing crops across the wheat belt.

The objective of this project is to develop a spatial economic model to identify where oilseeds can be profitably produced at the lowest costs, assess resulting oilseed supplies, and impacts of shifts toward oilseed production on energy use, greenhouse gas emissions, and soil and water resources.

The model is being developed first for three pilot counties, one in each of three primary wheat producing regions of the western U.S. Management information for current cropping systems and oilseed production alternatives are developed for each pilot county, utilizing published agricultural statistics, field research trial information, and information collected from producers and agricultural professionals. These are used to develop standardized crop enterprise budgets and used as inputs for the ALMANAC and EPIC crop simulation models. Model simulations are conducted for each SSURGO soil map unit within the pilot counties. Breakeven analysis is conducted on each soil map unit to determine the oilseed price necessary for oilseed production to be as profitable as the current cropping system. Within each county, oilseed supply curves are generated relating the quantity of oilseed supplied to breakeven oilseed price. Model simulated impacts on soil organic carbon, soil erosion, nutrient runoff and leaching, and pesticide runoff and leaching are determined for each map unit for oilseed production systems relative to current practices. Analysis for the pilot counties will be expanded to the entire wheat belt. Enterprise budgets and simulation model outputs will be aggregated to the agricultural statistical district and used as inputs to the POLYSYS model which will be used to evaluate any regional and national shifts in crop production and resulting effects on crop prices. These will provide a feedback to the soil map unit breakeven analysis.

Initial results for a North Dakota pilot county show substantial variation across soil map units in oilseed prices needed for profitable production.

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PRODUCTION OF HYDROTREATED RENEWABLE JET (HRJ) FUEL FROM OIL SEED FEEDSTOCKS

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UOP – Honeywell

There is currently great interest in producing transportation fuels with lower greenhouse gas (GHG) emissions over the life cycle of the fuel's production and use. While much effort has gone into the production of renewable oxygenated fuels, e.g. ethanol and FAME biodiesel, this work is directed towards the conversion of triglyceride oils from renewable sources into fuels that are fully fungible with the existing hydrocarbon fuel system infrastructure. Triglyceride oils from several oil seed sources including camelina, canola, soybean and jatropha have been converted to jet fuel using technology adapted from petroleum refining processes. A combination of hydroprocessing and isomerization has been used to produce high quality fuels.
This presentation will give an overview of the UOP Renewable Jet Fuel Process, a process for the conversion of triglyceride feedstocks into jet fuel. The development of this technology from lab to commercial scale will be reviewed.
This technology will be applied to make HRJ from oils produced in the ongoing grant funded under USDA-NIFA Biomass Research and Development Initiative.

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A LOW COST APPROACH FOR REGIONAL ESTIMATION OF OILSEED SUPPLY USING SATELLITE REMOTE SENSING

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Satellite remote sensing is routinely used to estimate the field acreage of oilseed crops under production in a region. Near real-time knowledge of spatial variability in oilseed production would improve seed procurement efforts seeking to optimize the flow of feedstock through a crushing facility. This information is also potentially useful for economic interests further downstream such as airline service centers that purchase hydrotreated renewable jet fuel.

The objective of this study was to assess the feasibility of using freely available multispectral satellite imagery to produce geographic information about in-season oilseed acreage as well as to efficiently disseminate this information to any interested stakeholder along the supply chain.

Landsat data were acquired during late spring and early summer for several locations in the inland Pacific Northwest including portions of Oregon, Washington, and Idaho. Image acquisition dates were chosen to correspond to the presence of flowers in the plant canopy. The expression of flowers allows these areas to be easily separated from other crops and land covers through the use of well known multivariate techniques (rotational transformations) that enhance features of interest and suppress unwanted content from multispectral images. Custom image transformations were derived for each operational Landsat sensor and applied to archival imagery for the years 2011, 2012, and 2013. Accuracy assessments were conducted using National Agricultural Statistics data and geographic coordinates of known canola fields.

Two Landsat satellites are currently operational and provide a combined revisit capability of 8 days over any given location, which results in 3 or 4 images per month. Unfortunately, extensive cloud cover during a satellite overpass limits our ability to delineate the full extent of oilseed fields and negatively impacts accuracy. If cloud free imagery is available for a location at any time a field is in bloom, then this technique performs very well.

The use of freely available imagery and open source software ensures that there is little overhead cost for stakeholders to produce or access this information. A computer program is under development by USDA-ARS scientists in Pendleton, OR to automatically perform the necessary image processing. Efforts are underway to create a web-based decision support tool that decision makers can use to acquire near real time in-season information.

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