

Next-generation sweet sorghums: Sustainable production of feedstocks for fuels, chemicals and value-added products



Wilfred Vermerris
University of Florida Genetics Institute
and Agronomy department

USDA-DOE Biomass Research and Development Initiative

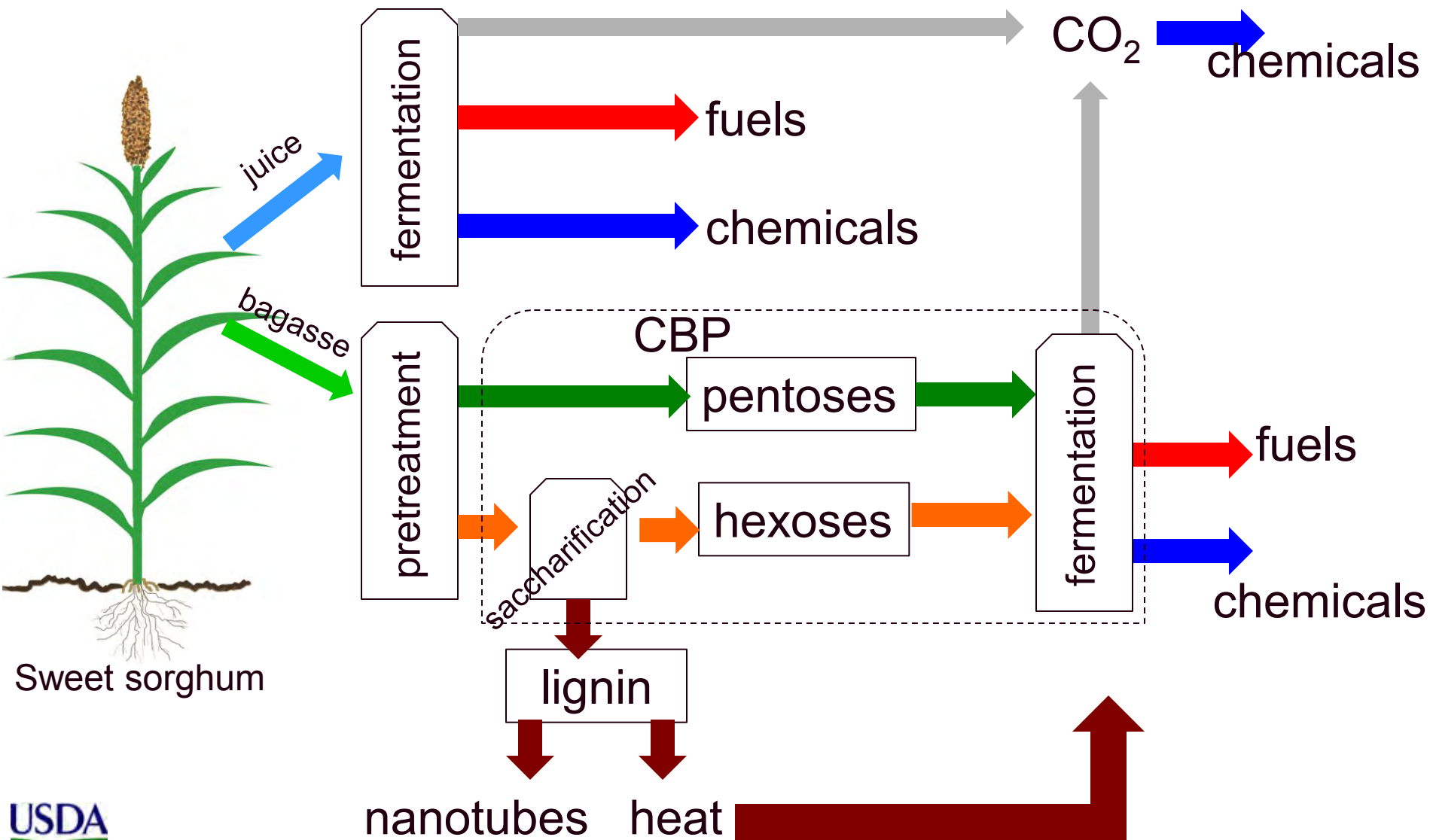
- 4-year projects with mandatory 20% cost share and industry involvement
- \$6M projects (seven funded in 2011)
- Funding rate of 1%
- Pre-proposal submitted 6 Sept 2010
- Decision on pre-proposal 'early' October 2010
- Full proposal due 17 November 2010
- Funding decision March 2011
- Budget paperwork took until 30 April 2011 to complete



Project team

- Wilfred Vermerris (PI; AGR, associate professor)
- John Erickson (AGR, assistant professor)
- Lonnie Ingram (MCS, professor)
- Jim Preston (MCS, professor)
- K.T. Shanmugam (MCS, professor)
- Amelia Dempere (MSE, engineer)
- Julene Tong (ABE, assistant professor)
- Brad Krohn (Highlands Envirofuels, CEO)

Combining juice and bagasse processing for a commercial biorefinery in Highlands County



How did we do it? A great team

- Interdisciplinary team with existing collaborations
- Balance between unique individual expertise and ability to communicate effectively
- Mix of assistant, associate, and full professors and company director
 - Balance between experience, new ideas, and other responsibilities
- Involvement of the first commercial biorefinery in the state of Florida

PI Vermerris

TA1: Feedstocks Improvement

Technical
Advisory Board

Kresovich (USC)

Genetic basis of efficient water use

- Root system architecture
- Water transport
- Photosynthesis/ photorespiration

Erickson, Vermerris

High- biomass, high-sugar sweet sorghums

- Breeding and selection for good performance in Southeastern US
 - Incorporation of *brown midrib* mutations to enhance biomass conversion
- Vermerris, Krohn*

TA2: Biofuels and Biobased Products Development

Fermentation of sorghum juice sugars

Thermochemical pretreatment of bagasse

- Optimization (temp, time, catalyst)
- Co-fermentation of fermentable sugars**
- Microbial conversion of both hexoses and pentoses to chemical feedstocks
- Production of cellulases and endoxylanases

Ingram, Preston, Shanmugan, Tong

Development of lignin-based nanotubes

- Impact of lignin composition
- Scale-up of nanotube and membrane synthesis

Development of lignin-PLA composites

- Effect of pretreatment on lignin/CHO
- Physico-chemical characterizations

Dempere, Tong, Vermerris

Glas (Myriant)

TA3: Biofuels Development Analysis

Evaluation of advanced generation sweet sorghums, including bagasse-to-ethanol

- Life cycle analysis and economic analysis
 - Input (water, nitrogen, agrichemicals, fuel, labor, equipment)
 - Output: fuel, 'waste streams', CO₂, lignin, co-products, heat, electricity
 - Comparison to current business model of sugar-only conversion
 - Employment opportunities

Krohn, Erickson

Bennett

Levenstein

How did we do it? A great plan

- The idea for the project has to be good
 - Novel and relevant
 - *Aha!* reaction – the best ideas are simple
 - Include a mix of experiments, some that will definitely work, some that are high-risk, but with a high payoff if successful
 - This leads to some practical applications as well as new basic knowledge
 - Think about pitfalls. Address any weaknesses/limitations in the project

“Scientists are their own worst enemies”



“My God! It is Professor Dickle! ... Weinberg, see if you can make out what the devil he was working on, and the rest of you get back to your stations.”

How did we do it? Write a recipe for success

- Write in an engaging and convincing manner
 - Not too many qualifiers
 - may, might, has the potential, could
 - Instead: WILL, IS GOING TO
 - Assume not all reviewers are experts in your area of research
 - Provide enough information so that reviewers can follow along even if they lack specific expertise in a specific area
 - What do 'we' get in exchange for the funds?

How did we do it? Persuade your audience!

- Letters of support from collaborators (always)
- Letters of support from researchers who will benefit from your work
 - Companies
 - Trade organizations
 - Professional societies
- Make it easy: send a draft that the letter writer can finish and paste onto letter head paper
 - Modify each draft!
- For large projects: include an advisory board of respected scientists



8 November 2010

Dr. Wilfred Vermeris
University of Florida Genetics Institute
PO Box 103610
Gainesville, FL 32610-3610

Dear Dr. Vermeris and Colleagues:

I was pleased to learn of your proposed BRDI project "Next-Generation Sweet Sorghums: Sustainable Production of Feedstocks for Fuels, Chemicals and Value-Added Products". This project will represent a major impetus for sorghum production in the state of Florida, where sorghum is currently a relatively minor crop, despite its great potential as a bioenergy feedstock.

Compared to many other crops, sorghum performs well under hot and conditions and with limited irrigation and fertilizer. The conditions in Florida are, however, very different from the growing conditions in the areas where the majority of the U.S. sorghum is currently produced. Hence, the availability of sorghum germplasm that is adapted to the climate and soils of Florida has great potential to expand the sorghum acreage.

Your project contains many elements that can enhance the biofuel industry. The use of sweet sorghum juice and the bagasse as a source of fuels and co-products not only will increase the fuel output and revenues of the processing plant, but also provide new employment opportunities.

The National Sorghum Producers represents the sorghum producers and affiliated industry in the entire United States, and both groups will benefit from your research. I therefore wholeheartedly endorse your project and wish you good luck with your proposal.

Sincerely,

Jeff Dahlberg, Ph.D.
Research Director, NSP



Cornell University

Institute for Genomic Diversity
130 Biotechnology Building
Ithaca, NY 14853
t: 607.255.2300 f: 607.255.6249
http://www.igt.cornell.edu

Dr. Wilfred Vermeris
University of Florida Genetics Institute
PO Box 103610
Gainesville FL 32610-3610

16 November 2010

Dear Wilfred,

I am pleased to provide this letter to accompany your BRDI proposal "Next-Generation Sweet Sorghums: Sustainable Production of Feedstocks for Fuels, Chemicals and Value-Added Products".

As you know from our interactions as part of the DOE-funded project "Genetic Dissection of Bioenergy Traits in Sorghum", I have developed a high-throughput single nucleotide polymorphism (SNP) genotyping array based on Illumina's GoldenGate platform. The array contains 1,536 SNP assays that were based on sequence data obtained from a panel of 14 different sorghum genotypes. We will score the two parents of your mapping population, BK7 and Early Hegari, for these SNPs and provide you with a set that are polymorphic between them and that have a low failure rate. From this set, you will be able to choose 384 SNPs assays that you can have synthesized by Illumina for standard genotyping.

I wish you good luck with your proposal.

Sincerely,

Marsha T Hamblin



Unit 65a, Boyne Business Park
Drogheda, Co. Louth, Ireland

5th November 2010

Dear Dr. Tong and Colleagues,

I would like to confirm our collaboration with you on your proposed BRDI project "Next-Generation Sweet Sorghums: Sustainable Production of Feedstocks for Fuels, Chemicals and Value-Added Products".

SCF Processing, Ltd focuses on providing processing solutions to plastic and ceramic processors in the aerospace, healthcare, construction, and energy sectors. The company is registered in Ireland. We have recently formed SCF Processing, LLC in Gainesville FL and this company will begin trading from January 2011. We will be opening a 3,000-sq-ft facility in Gainesville, FL. The choice of this location reflects the presence of technical expertise and the anticipated availability of feedstocks that can be used for the production of bio-based products.

We are excited about the prospect of working with you on the development of poly-lactate-based polymers that are reinforced with residues from the processing of bioenergy crops. This has the potential to create novel bio-polymers that can serve as replacements for petroleum-based plastics, while at the same time offering opportunities to off-set some of the costs associated with the production of fuels from lignocellulosic biomass. The market potential for these green polymers is very large.

Our facility in Gainesville will have extrusion and injection molding facilities that we will make available for production trials using conditions that have been tested on a lab scale. Our twin screw extrusion facilities will be world class and will allow you to develop pilot scale processing and full production processing for your Next-Generation Sweet Sorghums. We will be providing these facilities and expert processing staff at a reduced cost of \$800 per day.

I look forward to working with you and your colleagues on this project and wish you best of luck with your proposal.

The National Sorghum Producers represents the sorghum producers and affiliated industry in the entire United States, and both groups will benefit from your research. I therefore wholeheartedly endorse your project and wish you good luck with your proposal.

4201 North Inverness

Sincerely,

November 10, 2010

Wilfred Vermeris, Ph.D.
University of Florida Genetics Institute
PO Box 103610
Gainesville, FL 32610

Dear Dr. Vermeris:

I am pleased to offer my expert economic analyses to participate *Sweet Sorghums: Sustainable Value-Added Products*.

I will perform an economic impact proposed commercial adoption hybrids for advanced biofuel production the local economy in Highlands County of describing and quantifying generation feedstocks will impact the production of energy and contribute to energy efficiency, rural economic development, job creation in the region.

The integrated biorefinery proposed by Highlands EnviroFuels, LLC is designed to convert sugars from the sugarcane juice and sweet sorghum into advanced biofuel ethanol through microbial conversion. A key feature of this process is the treatment of the bagasse as a source of heat and electricity to meet the biorefinery's energy requirements. Initially, I will conduct a local economic impact study for my client Highlands EnviroFuels by the end of first quarter 2011, which will serve as the benchmark for a follow-up economic impact analysis for the BRDI grant project.

As part of the project, you propose to investigate converting the polysaccharides in the bagasse to fermentable sugars as an additional stream of feedstock for the production of fuels, chemicals, and value-added products. I propose to use data from pilot-scale studies at the University of Florida Ethanol Pilot Plant to project the cost of implementing such an operation at the Highlands EnviroFuels integrated biorefinery and similar operations. I also propose to determine the economic benefits relative to the existing operations, taking into consideration the value of the additional fuel and anticipated market value of the products produced from the residues, specifically lignin-reinforced poly-lactate and lignin-based carbon nanotubes. As the proposed process requires an addition to the existing processing scheme, I will also include the employment impact from implementation of such a process, not just at the processing

Jeff Dahlberg, Ph.D.
Research Director, NSP

...RESEARCH AGREEMENTS BY THE RESEARCHERS OF MYRIANT TECHNOLOGIES. MYRIANT TECHNOLOGIES RESEARCH HAS BEEN PRODUCTIVE FOR MYRIANT. MYRIANT CURRENTLY HOLDS FOUR LICENSES FROM UFRPL BASED ON PATENT APPLICATIONS DEVELOPED BY PROFESSOR INGRAM. ONE PRODUCT, D-LACTIC ACID, HAS BEEN COMMERCIALIZED, AND ANOTHER, SUCCINIC ACID, IS IN ADVANCED DEVELOPMENT BY MYRIANT. THE PROPOSED RESEARCH GRANT IS SUPPORTIVE OF AND COMPATIBLE WITH THE RESEARCH AGREEMENT MYRIANT ENJOYS WITH PROFESSOR INGRAM.

Improvements in the digestibility and fermentability of biomass sugars will enhance the competitive position of biomass derived chemicals while reducing our National dependence on imported petroleum feedstocks.

Sincerely,

Joseph P. Glas, PhD
Executive Vice President
Myriant Technologies
1 Pine Hill Drive
Batterymarch Park II, Suite 301
Quincy, MA 02169-4801

Avon Park Office
(863) 452-0101
601 W Main St

Footprint Office
(863) 633-6426
127 Reedy Creek Dr.

...that has major role to play a major role throughout most of the environment that

...use it tolerates heat, is fertilizer inputs, own well in a high-value surrounding

...m, Vice-President for Avon Park

...County Economic Development Commission. I have been involved in several new endeavors in the bioenergy area and know that the local community is supportive of these efforts. Management Experts, Inc. is a business consulting and accounting firm through which I work closely with businesses in developing growth opportunities, and I see a great amount of opportunity in Highlands County bioenergy.

I am excited to serve as Technical Advisor on your proposed BRDI project "Next-Generation Sweet Sorghums: Sustainable Production of Feedstocks for Fuels, Chemicals and Value-Added Products". I look forward to providing you and your colleagues with advice on how to maximize the economic impact on Highlands County and surrounding areas and on practical considerations associated with expanding the operations from pilot scale to commercial scale.

I wish you good luck with your proposal.

Sincerely,

William D. Bennett

How did we do it? Work with the support staff

- Large proposals involve many players
 - Co-PI's
 - Department heads, Deans, VPRs
 - Business offices
 - DSR
 - Program manager
 - Funding agency's admin and fiscal staff
- Be respectful and respond in a timely manner whenever possible
- Indicate when you will have a response if you don't have an instant answer
- Keep a record of correspondence (email!)
- Follow up as needed



Thank you!