Campus Location
Integrated Bioprocessing Research Laboratory: From Benchtop to Proof of Concept

Agenda

• History
• Mission
• Projects
• Bioproducts
• Illinois PSM program
History

• 2000: Planning started for building IBRL
• 2010: First cohort of bioenergy Professional Science Masters students
• October, 2014: Celebration of Construction
• December, 2014: Ground breaking
• Spring, 2016: Anticipated building completion
Mission

• The IBRL was designed to advance research and education focused on renewable fuel, food and fiber-based processing platforms and to stimulate bio-economic development in the State of Illinois through translational scale-up of developed technologies leading to commercialization.

• IBRL is a hybrid facility involving development of innovative, multi-disciplinary teams (faculty and industry partners) focused on the nexus of plant and microbial genetics and bioprocessing.
IBRL Unique Attributes

• The IBRL has been designed as a flexible, state-of-the-art plug-and-play pilot scale facility.

• Moving from basic research discoveries to commercial products requires a unique facility where various plant and plant co-products can be tested for their suitability for bioprocessing to value-added products.

• The IBRL was designed to fill this gap in the channel from innovative research to market application and commercial products.

• Feedstocks will be tested in IBRL to assess their techno-economic feasibility for sustainable production of bioproducts.

• The IBRL will be the site for testing of re-engineered microbes for production of next generation fuels and chemicals.
Cross-sectional view of IBRL
Utility Bays
Grinding

Pre-Treatment
Complete Fermentation Suite

3L

80 L

300L
Projects

Scholarly Expertise:

• IDOT
• DOE

• Multi-disciplinary teams focused on agronomics, microbiology, strain development, processing, engineering and policy issues.
In addition to various energy grasses and food-related co-products, examples of sustainable bioenergy crops that have been recently developed include Tropical maize, a high-biomass, high-sugar corn hybrid that accumulates sucrose in the stalk and produces negligible grain and Lipid cane, a sugarcane engineered to produce non-food oil, as a drop-in fuel.
TROPICAL MAIZE AND LIPID CANE AS SUSTAINABLE BIOENERGY CROPS
What is Tropical Maize?

- Tropical Maize is Corn
  - Reproductive Asynchrony
  - Tropical Maize = Tropical x Temperate Maize Hybrid
  - High Biomass
  - High Stalk Sugars
  - Less Nitrogen requirement
History of Tropical Maize

Sweet Beginnings

Stalk Sugar and the Domestication of Maize

by John Smalley and Michael Blake

Teosinte (Zea mays ssp. parviglumis) appears now to be the most widely agreed-upon candidate for the ancestor of domesticated maize (Z. mays spp. mays), but there are, at best, only partial answers to questions of how, when, and where this process took place (Wilkes 1967, 1985; Beadle 1980; Iltis 1972, 2000; Matsuoka et al. 2002). In a break with conventional wisdom, Hugh H. Iltis (2000:36 and quoted in Crosswhite 1982) has recently suggested that the direct ancestor of maize “was initially domesticated not for its grain but for its sugary pith or other edible parts.” We elaborate on his suggestion by proposing that during Zea’s initial period of domestication the stalk provided a key source of sugar for many uses, including the making of alcoholic beverages. Furthermore, we suggest that the social importance of
Nutrient Use Efficiency

TM produces more biomass and more sugar than commercial corn hybrids with < 50% N fertilizer requirement
Tropical Maize

Conventional Sugarcane Ethanol Process

Cane → Crushing → Extracted Juice → Fermentation → Stripping/Rectifying Columns → Ethanol

Overhead Product (Recycled Back) → Mole Sieves → CO₂ → Yeast → Centrifuge → Vinassee → Evaporator → Process Water

Bagasse → Process Water

CO₂
Tropical Maize

- Tropical maize requires few crop inputs such as nitrogen fertilizer, chiefly because it does not produce any ears.
- Require less processing than corn grain, corn stover, switchgrass, miscanthus.
- 25 percent or more sugar -- mostly sucrose, fructose and glucose
  - Easily fermented to ethanol
- Can be used in sugarcane to ethanol plant during the Inter-harvest
Lipid Producing Sugarcane (Lipid Cane)

Make World’s Most Productive Sugar Crop as the Oil Crop

- Plants already naturally produce oil
  - Use it as part of their metabolism
- By up-regulating the genes that make oil and down-regulate the genes that use it
  - Oil is stored in stems
- Currently we have achieved lipid cane with 2% oil (dry basis)
- Goal is to achieve 20% oil (dry basis) in Lipid cane
Lipidcane

- Increase Photosynthesis
- Increase Cold Tolerance
Potential Production of Biodiesel from Lipid Cane

Using only the 23 million acres of marginal land in the area on the map, we estimate that PETROSS crops will be able to produce 24.89 billion gallons of biodiesel—easily meeting 2/3 of the needs set forth by the Renewable Fuel Standard mandate of 36 billion gallons of biofuel by 2022.
Techno-Economic Analysis of Lipid Cane with Different Lipid Content

- Lipid cane techno-economic models were developed and compared with the current existing soybean and corn processing plants
- Lipid cane process model with lipid content of 0%, 2%, 5%, 10% and 20%
- Soybean-biodiesel process model with solvent (hexane) exaction
- Corn-ethanol process model with oil extraction from thin stillage
Both Ethanol and biodiesel production cost decreased with increasing in lipid content in sugar cane.
Lipid Cane

- Sugarcane producing lipids
- 2% lipid in stems, higher photosynthesis efficiency and improved cold tolerance
  - Goal – 20% oil in stems, 50% improvement in phytosynthesis
- Grown in land not used for food or other crops and can produce 40 billion gallons of biodiesel in the US
Bioenergy Professional Science Masters

- Started in 2010 - University of Illinois is the only one in Bioenergy
- 16 month program
- 42 Credit hour/non-thesis Masters
  - Science (32), Business (10)
- Bioenergy specialty areas:
  - Plants, soils and feedstocks
  - Production, processing and use
  - Environment, economics, policy & law
  - Tools and methods
- 10 students per cohort
Next Steps

• Conferences & Workshops

• IBRL Advisory Board

• Engagement with Industry
Questions?

Integrated Bioprocessing Research Laboratory
University of Illinois Urbana-Champaign
1300 Pennsylvania Ave. (future address)
Urbana, IL 61801
www.bioenergy.illinois.edu
bioenergy@illinois.edu

Hans Blaschek blaschek@illinois.edu
Vijay Singh vsingh@illinois.edu