Lignocellulosic Feedstocks
Texas A&M AgriLife Research

Improving lives through science and technology

Adam Helms
Assistant Director, Corporate Relations & Bioenergy Program
Texas A&M AgriLife Research
October 4, 2012
Agriculture and life sciences research arm of one of the US’s largest and most comprehensive ag-focused university systems

• Unique geographic location provides opportunity for global impact

• Corporate partnerships generate impact through market-driven approach

• Major programs align with bioenergy industry needs
Why Texas and Texas A&M AgriLife Research?

A Global Impact

We can replicate production conditions for many parts of the world

Average Annual Precipitation (in.)
- Under 14: 34 - 38
- 14 - 18: 38 - 42
- 18 - 22: 42 - 46
- 22 - 26: 46 - 50
- 26 - 30: 50 - 54
- 30 - 34: Above 54

Texas AgriLife Research & Extension Centers
State Headquarters
Research Stations
Why Texas and Texas A&M AgriLife Research?
A Global Impact

We can replicate production conditions for many parts of the world.
Why Texas and Texas A&M AgriLife Research?
A Global Impact

We can replicate production conditions for many parts of the world.

Texas Soil Map
- Southern Desertic Plains, Mountains & Basins
- Southern High Plains
- Central Rolling Red Plains
- Edwards Plateau
- Texas Central Basin
- Rio Grande Plain
- Texas North Central Prairies
- Grand Prairie
- Texas Blackland Prairie
- Texas Claypan Area
- Western Coastal Plain & Flatwoods
- Flood Plains
- Gulf Coast Prairie
- Gulf Coast Saline Prairie

Texas AgriLife Research & Extension Centers
State Headquarters
Research Stations
Specific Research Areas

• **Feedstock Crops**
  - Develop dedicated feedstock crops.
  - Advanced lignocellulosic & sugar feedstocks
  - Oilseed crops
  - Algae

• **Modeling**
  - Develop, screen, and characterize land for biomass production
  - Models (farm, region, national, global)
  - GIS
  - Satellite imagery.

• **Agronomic Practices**
  - Develop agronomic practices for sustainable production systems.

• **Production Logistics**
  - Develop production logistics
  - Production
  - Harvesting
  - Transport
  - Storage

• **Microbial/enzymatic systems**
  - Optimize microbial/enzymatic systems.
  - Develop new conversion systems for liquid fuels.

• **Conversion technologies**
  - Optimize conversion technologies.
  - Cellulosic
  - Thermal (Fluidized bed gasifier/pyrolysis unit)

• **Economic, policy, and environmental issues**
  - Evaluate economic, policy, and environmental issues.
  - Production economics
  - Energy Balance
  - Life cycle cost analysis
  - Farm Bill/Energy Bill
  - Air/water/rural infrastructure
  - Carbon issues
• RFS2 Standards by 2022
  
  • Corn ethanol – 15 billion gallons (buy)
  
  • Biobased diesel (FAME) – 1 billion gallons (buy)
    • Block Produced
  
  • Non-cellulosic – 4 billion gallons – green diesel/green jet
    • ~27,000,000 acres at 150 gallons produced/acre
  
  • Cellulosic Advanced – 16 billion gallons
    • ~16,000,000 acres at 20 dry tons produced/acre
Value Chain of Biofuels Market

- Feedstock Improvement
- Seed Production
- Crop Production
- Transportable Intermediate Production
- Logistics
- Refining
- End User
Purpose-Built Germplasm
(Specifically designed & customized for bioenergy applications)

Domesticate Wild Germplasm
(e.g. Miscanthus, switchgrass)

Repurpose Existing Germplasm
(e.g. grains, oilseeds, energy cane)
### Lignocellulose and Sugar Based Crops

<table>
<thead>
<tr>
<th>Crop Traits</th>
<th>Energycane</th>
<th>Miscanthus</th>
<th>Sorghum</th>
<th>Pennisetum spp.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Efficient photosynthesis</td>
<td>■</td>
<td>■</td>
<td>■</td>
<td>■</td>
</tr>
<tr>
<td>Long canopy duration</td>
<td>■</td>
<td>■</td>
<td>■</td>
<td>■</td>
</tr>
<tr>
<td>Nutrients recycled to roots</td>
<td>■</td>
<td>■</td>
<td>■</td>
<td>■</td>
</tr>
<tr>
<td>Low crop inputs</td>
<td>■</td>
<td>■</td>
<td>■</td>
<td>■</td>
</tr>
<tr>
<td>Low fossil fuel inputs</td>
<td>■</td>
<td>■</td>
<td>■</td>
<td>■</td>
</tr>
<tr>
<td>Adapted to marginal land</td>
<td>■</td>
<td>■</td>
<td>■</td>
<td>■</td>
</tr>
<tr>
<td>Minimal pests/plant diseases (right now)</td>
<td>■</td>
<td>■</td>
<td>■</td>
<td>■</td>
</tr>
<tr>
<td>Non-invasive or sterile</td>
<td>■</td>
<td>■</td>
<td>■</td>
<td>■</td>
</tr>
<tr>
<td>Easily removed</td>
<td>■</td>
<td>■</td>
<td>■</td>
<td>■</td>
</tr>
<tr>
<td>Winter standing</td>
<td>■</td>
<td>■</td>
<td>■</td>
<td>■</td>
</tr>
<tr>
<td>High water-use efficiency</td>
<td>■</td>
<td>■</td>
<td>■</td>
<td>■</td>
</tr>
<tr>
<td>Planted by seed</td>
<td>■</td>
<td>■</td>
<td>■</td>
<td>■</td>
</tr>
<tr>
<td>Harvest first year</td>
<td>■</td>
<td>■</td>
<td>■</td>
<td>■</td>
</tr>
</tbody>
</table>

Can we combine positives across species into a single crop?
## Global Average Total Crop Water Use

<table>
<thead>
<tr>
<th>Crop</th>
<th>Water Requirement (mm)</th>
<th>Planting Date (Texas)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheat</td>
<td>450-650</td>
<td>September - November</td>
</tr>
<tr>
<td>Rice</td>
<td>900-2500</td>
<td>February - March</td>
</tr>
<tr>
<td>Cotton</td>
<td>700-1300</td>
<td>April - May</td>
</tr>
<tr>
<td>Castor</td>
<td>500</td>
<td>April - June</td>
</tr>
<tr>
<td>Soybean</td>
<td>450-700</td>
<td>May - July</td>
</tr>
<tr>
<td>Maize</td>
<td>500-800</td>
<td>April - June</td>
</tr>
<tr>
<td>Sorghum</td>
<td>450-650</td>
<td>March - May</td>
</tr>
<tr>
<td>Sugarcane</td>
<td>1500-2500</td>
<td>August - September</td>
</tr>
<tr>
<td>Miscanthus</td>
<td>450</td>
<td>March - May</td>
</tr>
<tr>
<td>Kinggrass</td>
<td>800-1000</td>
<td>April &amp; July</td>
</tr>
</tbody>
</table>
Beyond Sugarcane: The *Saccharum* Complex is Diverse

- *S. officinarum* "Sugarcane"
- *Erianthus*
- *Miscanthus*
- *S. spontaneum*
Natural Genetics

- Plant breeding
- Next Generation Sequencing
- Marker Assisted Breeding
- Trait Introgression
Physical Engineering

- Manipulating daylight

- Intergeneric crosses
  - Miscanthus x saccharum
  - Saccharum x erianthus
  - Saccharum x ?
In these hybrids we then looked for evidence of genetic recombination, and to see if they could be used for backcross introgression.
18 *S. bicolor* (non-recombinant) + 2 recombinant chromosomes
In 2006, we established a means to side-step this interspecific/intergeneric hybridization barrier and thus create new hybrids (Price et al. 2006).
Given our success within Sorghum, the next question was obvious:

Can we make inter-generic crosses beyond the boundaries of the Sorghum genus?
Sorghum/Energycane Hybrids

The first attempts:

- 40 pollinations:
- Produced about 500 seed
- Potted 35 confirmed F1s
- Kept 3 very vigorous hybrids in greenhouse
Sorghum/Sugarcane
Second attempts:

- 170 pollinations:
- Produced ~ 12,000 seed
- Potted 1350 confirmed F1s
- Transplanted 400 to Field Space Plant Nursery
Applicability across C\textsubscript{4} species?

- Miscanthus
- Sweet sorghum
- Zea sp.
- Erianthus sp.
- Pennisetum sp.
Contact

Adam Helms

ahelms@tamu.edu