Overall switchgrass objective

- Assess yield potential and quality parameters of switchgrass grown in different environments using standard agricultural practices
Switchgrass PIs

- **2008**
  - Alabama – David Bransby, Carla Hopkins
  - New York – Don Viands, Hilary Mayton
  - Oklahoma – Rodney Farris
  - South Dakota – Vance Owens (sustainability site: Chang Oh Hong, Shannon Osborne—ARS, Mike Lehman—ARS, Tom Schumacher, Dave Clay)
  - Virginia – John Fike
  - Nebraska – Rob Mitchell; quality analysis

- **2009**
  - Iowa – Emily Heaton
## Switchgrass Trial Information

<table>
<thead>
<tr>
<th>Location</th>
<th>Cultivar</th>
<th>Planting Date</th>
<th>Area (ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alabama</td>
<td>Alamo</td>
<td>May 2010</td>
<td>7.3</td>
</tr>
<tr>
<td>Iowa</td>
<td>Cave-In-Rock</td>
<td>8 May 2009</td>
<td>7.3</td>
</tr>
<tr>
<td>Oklahoma</td>
<td>Blackwell</td>
<td>2 Sep 2008</td>
<td>7.3</td>
</tr>
<tr>
<td>New York</td>
<td>Cave-In-Rock</td>
<td>29 May 2008</td>
<td>4.9</td>
</tr>
<tr>
<td>South Dakota</td>
<td>Sunburst</td>
<td>17 May 2008</td>
<td>9.7</td>
</tr>
<tr>
<td>Virginia</td>
<td>Alamo</td>
<td>1 July 2008</td>
<td>6.0</td>
</tr>
</tbody>
</table>
Experimental Design

- Field scale (0.4 to 0.8 ha experimental units)
- Four replicates across landscape
- Nitrogen (0, 56, 112 kg ha\(^{-1}\)) applied 2009-2012 to all sites beginning the year after planting
- Locally adapted cultivar at each location
- With exception of AL, harvested around a killing frost or after significant senescence
- Samples being analyzed at ARS lab in NE (Rob Mitchell) for chemical characterization
Switchgrass location diversity

Alabama
Iowa
Oklahoma
Virginia
New York
South Dakota
Data collection

- Initial soil characteristics utilizing minimum soil data set
  - Total organic carbon; soil pH; Total N; Bulk density; Soil-test P and K
- Yield using standard equipment
- Subsamples from plots for chemical characterization
  - Samples from windrow and/or from bales have been sent to INL
  - Samples are also being analyzed locally for other estimates of biomass quality
- Other
## Switchgrass harvest dates (2009-2012)

<table>
<thead>
<tr>
<th>Location</th>
<th>2009</th>
<th>2010</th>
<th>2011</th>
<th>2012</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alabama</td>
<td>NA</td>
<td>NA</td>
<td>13 Oct.</td>
<td>21 Sep.</td>
</tr>
<tr>
<td>Iowa</td>
<td>NA</td>
<td>18 Nov.</td>
<td>7 Nov.</td>
<td>4 Nov.</td>
</tr>
<tr>
<td>Oklahoma</td>
<td>13 Nov.</td>
<td>28 Oct.</td>
<td>16 Dec.</td>
<td>5 Nov.</td>
</tr>
<tr>
<td>New York</td>
<td>22 Oct.</td>
<td>2 Nov.</td>
<td>3 Nov.</td>
<td>8 Oct.</td>
</tr>
<tr>
<td>South Dakota</td>
<td>28 Oct.</td>
<td>5 Nov.</td>
<td>3 Nov.</td>
<td>30 Oct.</td>
</tr>
</tbody>
</table>
Fertilizer application
Switchgrass establishment based on frequency method of Vogel and Masters (2001) (OK exception)

[Graphs and data tables showing establishment frequency and N application rates for different locations.]
Switchgrass establishment

Ithaca, NY
Herbaceous Feedstock Trial
10/15/08

Ithaca, NY Herbaceous Feedstock Trial
9/21/09

Bristol, SD – 07 Aug. 2009

Bristol, SD – 12 Aug. 2010

Bristol, SD – 11 Aug. 2011
Switchgrass harvest

Virginia 2010

Ithaca, NY – 22 October 2009

Bristol, SD – 3 November 2011

Iowa 2012
Alabama 2012
Iowa 2012
New York 2012
Virginia
South Dakota—2009 (left) and 2010 (right)
South Dakota—2011 (left) and 2012 (right)
Switchgrass response to N at common treatment locations (IA, NY, OK, SD, VA) and harvest timing at NE

N application rate (kg N ha\(^{-1}\))

Biomass yield (Mg ha\(^{-1}\))

- 2009
- 2010
- 2011
- Average across years
- 2012

NS
Initial soil N and switchgrass dry matter concentration at all locations except AL

<table>
<thead>
<tr>
<th></th>
<th>Initial soil nitrogen (g kg⁻¹)</th>
<th>Switchgrass DM (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0-5 cm</td>
<td>5-15 cm</td>
</tr>
<tr>
<td>SD</td>
<td>1.93</td>
<td>1.55</td>
</tr>
<tr>
<td>NY</td>
<td>3.02</td>
<td>2.29</td>
</tr>
<tr>
<td>IA</td>
<td>2.53</td>
<td>2.26</td>
</tr>
<tr>
<td>OK</td>
<td>2.39</td>
<td>1.68</td>
</tr>
<tr>
<td>VA</td>
<td>1.12</td>
<td>0.55</td>
</tr>
</tbody>
</table>
# Total soil nitrogen (Bristol, SD)

<table>
<thead>
<tr>
<th>Year</th>
<th>N rate (kg/ha)</th>
<th>Soil depth (cm)</th>
<th>T-N (g/kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>0-5</td>
<td>5-15</td>
</tr>
<tr>
<td>2009</td>
<td>0</td>
<td>2.15</td>
<td>1.90</td>
</tr>
<tr>
<td></td>
<td>56</td>
<td>1.94</td>
<td>1.75</td>
</tr>
<tr>
<td></td>
<td>112</td>
<td>1.97</td>
<td>1.86</td>
</tr>
<tr>
<td></td>
<td>LSD&lt;sub&gt;0.05&lt;/sub&gt;</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>2010</td>
<td>0</td>
<td>2.31</td>
<td>1.94</td>
</tr>
<tr>
<td></td>
<td>56</td>
<td>2.35</td>
<td>1.97</td>
</tr>
<tr>
<td></td>
<td>112</td>
<td>2.39</td>
<td>1.87</td>
</tr>
<tr>
<td></td>
<td>LSD&lt;sub&gt;0.05&lt;/sub&gt;</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>2011</td>
<td>0</td>
<td>2.11</td>
<td>1.78</td>
</tr>
<tr>
<td></td>
<td>56</td>
<td>2.23</td>
<td>1.94</td>
</tr>
<tr>
<td></td>
<td>112</td>
<td>2.23</td>
<td>1.78</td>
</tr>
<tr>
<td></td>
<td>LSD&lt;sub&gt;0.05&lt;/sub&gt;</td>
<td>NS</td>
<td>NS</td>
</tr>
</tbody>
</table>
Visual effect of N (SD in mid July)
The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements.

http://droughtmonitor.unl.edu/
Daily soil moisture at a 5 cm depth during growing season in South Dakota

Soil moisture content (m$^3$ water m$^{-3}$ soil)

2009

2010

2011

2012
Daily soil temperature at a 5-cm depth during growing season in South Dakota

Soil temperature (°C)

2009

2010

2011

2012
Switchgrass biomass characteristics

- Sample collection at each location
  - INL
  - Local analysis
    - Total N
    - Neutral detergent fiber (NDF) and acid detergent fiber (ADF) used to estimate cellulose and hemicellulose
    - Acid detergent lignin (ADL)
    - Ash
    - Sugars and TEL at ARS in Nebraska
N concentration in harvested switchgrass at each location

![Bar charts showing N concentration (g N kg⁻¹) vs. N application rate (kg N ha⁻¹) for different locations: SD, NY, IA, OK, VA.](image-url)

- **SD**: Bars for 2009 are green, and bars for 2010 are blue. Some bars are labeled with letters (a, b, c), indicating statistical significance differences.
- **NY**: Bars for 2009 are green, and bars for 2010 are blue. Some bars are labeled with letters (a, b, c), indicating statistical significance differences.
- **IA**: Bars for 2009 are green, and bars for 2010 are blue. Some bars are labeled with letters (a, b, c), indicating statistical significance differences.
- **OK**: Bars for 2009 are green, and bars for 2010 are blue. Some bars are labeled with letters (a, b, c), indicating statistical significance differences.
- **VA**: Bars for 2009 are green, and bars for 2010 are blue. Some bars are labeled with letters (a, b, c), indicating statistical significance differences.
Ethanol (L Mg\(^{-1}\) biomass, left; L ha\(^{-1}\), right) using simultaneous saccharification and fermentation
Theoretical ethanol yield (L Mg\(^{-1}\) biomass, left; L ha\(^{-1}\), right) from all biomass sugars

![Graphs showing theoretical ethanol yield from all biomass sugars across different locations and years.](image-url)
Switchgrass root characteristics

Switchgrass roots (right) in a Typic Fragiudept soil and root development in cool season grass alleyway (left) (NY).
Switchgrass root sampling (Bristol, SD)

- Switchgrass sampled at anthesis (August)
- Two cores within row
- Two cores between rows

Soil sampling depths (cm)

<table>
<thead>
<tr>
<th>Depth</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-15</td>
</tr>
<tr>
<td>15-30</td>
</tr>
<tr>
<td>30-45</td>
</tr>
<tr>
<td>45-60</td>
</tr>
<tr>
<td>60-100</td>
</tr>
</tbody>
</table>
Switchgrass root biomass at various depths the year after establishment (Bristol, SD)
Total switchgrass root/shoot biomass ratio (Bristol, SD)

- **2009**
  - N application rate (kg N ha\(^{-1}\))
  - Biomass (Mg ha\(^{-1}\))
  - Total root biomass at 1 m depth
  - Shoot biomass

- **2011**
  - N application rate (kg N ha\(^{-1}\))
  - Biomass (Mg ha\(^{-1}\))
  - Total root biomass at 1 m depth
  - Shoot biomass

- **Biomass (Mg ha\(^{-1}\))**
  - 0
  - 1
  - 2
  - 3
  - 4
  - 5
  - 6
  - 7
  - 8
  - 9
  - 10
  - 11
  - 12
  - 13
  - 14

- **N application rate (kg N ha\(^{-1}\))**
  - 0
  - 112

- **Total root biomass at 1 m depth**
  - 0.3
  - 0.29

- **Shoot biomass**
  - 0.3
  - 0.29

- **Biomass (Mg ha\(^{-1}\))**
  - 0.43
  - 0.34
Challenges thus far

- Establishment (AL)
- Weather/field conditions
- Economics
- Tires


2013 plans

- All sites will apply treatments and harvest biomass
- Biomass chemical composition
- Continue sustainability work at SD location
- Manuscripts prepared/submitted
- Working with resource assessment group—hoping to have combined meeting of resource assessment group and field trial PIs sometime in May or June (looking at VA)