Miscanthus Production Practices: A New Missouri Bioenergy Crop

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This talk should cover:

- Context for biomass cropping
- Basic Miscanthus management
- Relevant Iowa research
Bioenergy Demand - RFS 2

Source: US Energy Independence and Security Act; Graphic courtesy Ceres, In.
Bioenergy Demand - Biopower

Source: US Energy Information Agency; Renewable Energy Consumption and Electricity 2006
Solving Problems?

- **Facility Size**
  - Cellulosic Ethanol; few, large
  - Electricity; more, smaller
  - Heat (or CHP); many, small

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**Context**

**Crop Choice**

**BCP activities**

**S. IA activities**
Biomass Crop Assistance Program

• June 15, 2011 - “project areas” announced for Miscanthus in AR, MO, OH
• also in KS and MO for other grasses
• 75% of establishment costs + 5 years of annual payments
• Must be in project area to receive
• www.fsa.usda.gov/bcap
Crop Choice

WHAT PLANTS WORK BEST FOR BIOENERGY?
Miscanthus and Switchgrass

Switchgrass
(Panicum virgatum L.)

Miscanthus (Miscanthus x giganteus)

PRG's for the Midwest
Why Miscanthus? Yield

Urbana, IL; Photo courtesy of Matt Liebman
The average annual biomass yields of Giant Miscanthus and switchgrass harvested from 3 locations (latitude) in Illinois during 2004-2006 (adapted from Heaton et al, 2008).
<table>
<thead>
<tr>
<th></th>
<th>Miscanthus</th>
<th>Switchgrass</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Yield</strong></td>
<td>😊😊😊😊</td>
<td>😊😊</td>
</tr>
<tr>
<td>Sterile</td>
<td>😊</td>
<td>😊😊</td>
</tr>
<tr>
<td>Winter Standing</td>
<td>😊😊</td>
<td>😊</td>
</tr>
<tr>
<td>N-requirement</td>
<td>😊</td>
<td>😊😊</td>
</tr>
<tr>
<td>Native</td>
<td>😊</td>
<td>😊</td>
</tr>
<tr>
<td>Summer Harvest</td>
<td>😊😊</td>
<td>😊</td>
</tr>
<tr>
<td>Forage</td>
<td>😊😊</td>
<td>😊</td>
</tr>
<tr>
<td>Establishment</td>
<td>😊😊</td>
<td>😊</td>
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</tbody>
</table>

Heaton et al. 2004 Mitigation and Adaptation Strategies for Global Change 9: 433-451
Giant Miscanthus

- High Yielding (6-15 t/acre)
- Sterile clone
- Must be planted from rhizomes or plugs
- New to US: 10’s to 100’s of acres
- Widely planted in Europe: thousands of acres
- Used for heat and power with coal
Naturally Occurring Hybrid

Miscanthus sinensis

+ Miscanthus sacchariflorus

= Miscanthus x giganteus

STERILE

Diploid

2n=2x=38

Tetraploid

2n=4x=76

Triploid

2n=3x=57

Iowa State University
Department of Agronomy

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applying science to fuel & feed our global society
Sterile - vegetative planting

Context
Crop Choice
Miscanthus
Research activities

Rhizomes

Plugs
Planting - Live Plants ("plugs")

Photo credit: Ceres, Inc
Planting - Rhizomes

www.countryplan.co.uk

www.bical.net
<table>
<thead>
<tr>
<th>Context</th>
<th>Crop Choice</th>
<th>Miscanthus</th>
<th>Research activities</th>
</tr>
</thead>
<tbody>
<tr>
<td>April</td>
<td>May</td>
<td>August/September</td>
<td>November</td>
</tr>
<tr>
<td></td>
<td>Emergence</td>
<td>Canopy Closure</td>
<td>December</td>
</tr>
<tr>
<td></td>
<td>Maximum biomass</td>
<td>Senescence</td>
<td>Dry Down</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Over winter</td>
</tr>
</tbody>
</table>

**Dry Biomass**

![Graph showing dry biomass from April to February](image)

**Iowa State University**

Department of Agronomy
Cane Harvest
Weed Control - ESSENTIAL!!

• Pre-emergent:
  - Prowl (pennimethalin)
  - Harness (acetochlor)
  - Harness Extra (acetochlor + atrazine)

* GREEN = LABELED

• Post-emergent
  - Callisto (mesotrione)
  - 2,4-D
  - Dicamba
  - Atrazine
  - CULTIVATION

Anderson et al. (2010). Weed Technology 24:453-460
Tentative Recommendations

N
• Not limiting – late spring nitrate test if possible
• Maintenance
  • 10 lb/ton cane

P
• Not limiting at planting – soil test
• Maintenance
  • 1.5 lb/ton cane

K
• Not limiting at planting – soil test
• Maintenance
  • 10-12 lb/ton cane

LIME: pH = 5 – 7.5
Carbohydrates, nutrients

**SPRING/SUMMER**

Translocation from rhizomes to growing shoot

**FALL**

Translocation from senescing shoot to rhizomes

**WINTER**

Harvested biomass is lignocellulose; nutrients stay in rhizomes

Context

Crop Choice

Miscanthus

Research activities

Nutrient Recycling

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Department of Agronomy
Challenges: Mainly planting

**Planting**

- Rhizome handling/storage
- Equipment availability
- Irrigation of live plants

**Harvesting**

- Horsepower
- Equipment design for tall, dry, high yield

Context
Crop Choice
Miscanthus
Research activities
# Crop Choice

<table>
<thead>
<tr>
<th>Miscanthus</th>
<th>Corn</th>
</tr>
</thead>
<tbody>
<tr>
<td>• 10 t/ac</td>
<td>• 150 bu/ac</td>
</tr>
<tr>
<td>• $50/t</td>
<td>• $6/bu</td>
</tr>
<tr>
<td>• = $500/ac</td>
<td>• = $900/ac</td>
</tr>
</tbody>
</table>

- Costs - after establishment, have only annual harvest and some low fertilizer
- **NO ANNUAL PLANTING COSTS, MINIMAL CHEMICAL**
- Costs - annual for seed, fertilizer, pesticides, harvest...
Biomass Crop Production Lab Activities

WHAT ARE WE DOING?
“Working to develop sustainable crop systems that provide clean fuel from agriculture year-round”

Research Areas

- Nutrient cycling of energy crops (switchgrass, Miscanthus)
- Miscanthus x giganteus propagation/establishment
- Management Practices
Complementing Corn

- Integrating perennial vegetation can ameliorate damage crop annual row crops.

Source: Iowa NRCS
STRIPS: Science-based Trials of Row-crops Integrated with Prairies
Neal Smith National Wildlife Refuge, Prairie City, IA
12 experimental watersheds, 0.5 to 3.2 hectares each
http://www.nrem.iastate.edu/research/STRIPs/

Four treatments:
100% crop (no-till)
10% buffer, toe slope
10% buffer, contour strips
20% buffer, contour strips
Experimental Watershed Treatments

12 watersheds:
Balanced Incomplete Block Design:
3 reps X 4 treatments X 3 blocks

0%
10%
10%
20%

= corn - soybean row crops
= reconstructed prairie
H-flumes monitor movement of water, sediment, and nutrients
Placing 10% of a watershed into perennial cover strongly reduced soil erosion (>95%), even with no-till crop production.

Helmers et al., unpublished data
Are Companion Crops the Solution?

- Companion crop = another crop present in the field at the same time as main crop.
- Meant to aid growth of main crop.

Source: U. of Wisconsin, Mike Rankin
Approach

TREATMENTS
1. Red Clover
2. White Clover
3. Sweet Clover
4. Crimson Clover
5. Birdsfoot Trefoil
6. Winter Wheat
7. Rye
8. Triticale
9. Oats
10. None (Control)

- 10 companion crop treatments
- 2 *M. x giganteus* planting methods – plugs & rhizomes
- 4 replications
- Established in 2009, repeated in 2010
Rhizomes

Plugs
2009 & 2010 Weather

Average Total Precipitation (mm)

- 2009
- 2010
- 2011
- 30 year Average

Month of year:
- Jan.
- Feb.
- Mar.
- Apr.
- May
- June
- July
- Aug.
- Sept.
- Oct.
- Nov.
- Dec.

Courtesy Danielle Wilson
Results

Does it work? 1st Year Data

Establishment Year

Spring Re-growth

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M. x giganteus Yields

Average M. x giganteus biomass (Mg ha\(^{-1}\))

-8
-6
-4
-2
 0
 2
 4
 6
 8

Control
Oats
R. Clover
W. Clover
W. Wheat

Plug
Rhizome

A
AB
B
C
D
DC
BC
M. x giganteus Survival

Results

M. x giganteus survival (%)

<table>
<thead>
<tr>
<th></th>
<th>2009</th>
<th></th>
<th>2010</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>0.0</td>
<td>Control</td>
<td>0.0</td>
</tr>
<tr>
<td>Oats</td>
<td>0.2</td>
<td>Oats</td>
<td>0.2</td>
</tr>
<tr>
<td>R. Clover</td>
<td>0.4</td>
<td>R. Clover</td>
<td>0.4</td>
</tr>
<tr>
<td>W. Clover</td>
<td>0.6</td>
<td>W. Clover</td>
<td>0.6</td>
</tr>
<tr>
<td>W. Wheat</td>
<td>0.8</td>
<td>W. Wheat</td>
<td>0.8</td>
</tr>
</tbody>
</table>

Plug (yellow) and Rhizome (red)
Overcoming Miscanthus Bottlenecks: Limited Planting Material

• Can we generate new plants from stem pieces instead of rhizomes?
• Do plants perform as well in the field?
Why stems?

- Potential for high multiplication rate compared to rhizomes:

  \[15 \text{ nodes stem}^{-1} \times 100 \text{ stems plant}^{-1} = \text{theoretical 1500:1 stem system}\]

vs:

- Avg. 15:1 rhizome systems

- No digging!
Stem propagation system

What does this look like?

Speedling Inc.
Does it work as well as rhizomes?
Planting Material

Context
Crop Choice
Miscanthus
Research activities
Planting Year: Some yield differences

Fall 2009 Yields

<table>
<thead>
<tr>
<th>Location</th>
<th>Propagule</th>
<th>Dry Matter Yield (t/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calumet</td>
<td>Plug</td>
<td>ab</td>
</tr>
<tr>
<td></td>
<td>Rhizome</td>
<td>a</td>
</tr>
<tr>
<td>Hinds</td>
<td>Plug</td>
<td>c</td>
</tr>
<tr>
<td></td>
<td>Rhizome</td>
<td>c</td>
</tr>
<tr>
<td>Lewis</td>
<td>Plug</td>
<td>a</td>
</tr>
<tr>
<td></td>
<td>Rhizome</td>
<td>bc</td>
</tr>
</tbody>
</table>
Year 2: Yield differences diminished

Fall 2010 Yields

<table>
<thead>
<tr>
<th>Location propagule</th>
<th>Plug</th>
<th>Rhizome</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calumet</td>
<td>ab</td>
<td>a</td>
</tr>
<tr>
<td>Hinds</td>
<td>ab</td>
<td>ab</td>
</tr>
<tr>
<td>Lewis</td>
<td>ab</td>
<td>b</td>
</tr>
</tbody>
</table>

Dry Matter Yield (t/ha)
Conclusions

- Miscanthus will be highly productive in MO climate
- Best for poor corn/soy land
- DO NOT plow pasture to plant
- Use herbicide
- Be patient
THANK YOU