Getting More from Forages

Targeted plant modifications: Pasture forages

Genetic selection to improve grasses and legumes for grazing

Michael Casler & Heathcliffe Riday
Red Clover Breeding

Red Clover
• Establishment and Management Versatility
• Less Persistent

Breeding Targets
• Increased Persistence
• Increased Yield
• Plant Vigor

Prairie du Sac, WI - Breeding Nursery
50+ years of breeding at USDFRC has dramatically increased red clover persistence

Hay Management (Smith, 2000)

Rotationally Grazed in Grass Pasture (Riday, 2009)
Kura Clover Breeding

Kura Clover
• Very Persistent
• Difficult to Establish

Breeding Targets
• Seedling Establishment
• Seed Production and Yield
• Plant Vigor

Getting More from Forages – July 29-30, 2009
Kura Breeding Results

'Kura1' Germplasm Public Release, 2006

- Joint USDA-ARS & UW-Madison release (PI 643168)
- Broad based selection for rhizomatous spreading ability and vigor
- Kura1 foundation of current breeding efforts and future varieties

<table>
<thead>
<tr>
<th>Arlington, WI Trial Established 2005</th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
<th>Trial Total</th>
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<tbody>
<tr>
<td></td>
<td>Mg ha⁻¹ DM</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kura1</td>
<td>3.5</td>
<td>9.8</td>
<td>5.5</td>
<td>18.8</td>
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<tr>
<td>'Endura'</td>
<td>3.2</td>
<td>9.3</td>
<td>4.7</td>
<td>17.2</td>
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<tr>
<td>'Cossack'</td>
<td>3.4</td>
<td>8.5</td>
<td>4.9</td>
<td>16.8</td>
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<tr>
<td>'Rhizo'</td>
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<td>7.7</td>
<td>4.3</td>
<td>14.6</td>
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<tr>
<td>Alfalfa ('Genoa')</td>
<td>5.1</td>
<td>12.5</td>
<td>8.0</td>
<td>25.7</td>
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<tr>
<td>Red Clover (DFRC-Exp.)</td>
<td>6.0</td>
<td>10.8</td>
<td>5.8</td>
<td>22.6</td>
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<tr>
<td>LSD (p &lt; 0.05)</td>
<td>0.7</td>
<td>1.1</td>
<td>0.6</td>
<td>1.7</td>
</tr>
</tbody>
</table>
Birdsfoot Trefoil Breeding

Birdsfoot Trefoil - Non Bloating Legume

New Cultivar 'WITT'

- Commercial License Granted to Allied Seed
- Seed to Market in 2-3 Years

'WITT' had Superior Persistence Across 16 MN & WI Variety Trials
Breeding-Approach Research

Leaf temperature - Selecting Increase Drought Tolerance

Non-Linkage Based DNA Marker Assisted Selection

Restricting Gametophytic Self-Incompatibility Alleles to Increase Population Hybridity

Using Near Infrared Spectroscopy to Predict Seedling Vigor

Getting More from Forages – July 29-30, 2009
Grass Breeding Activities

- Smooth bromegrass
  *Bromus inermis*
- Timothy
  *Phleum pratense*
- Orchardgrass
  *Dactylis glomerata*
- Reed canarygrass
  *Phalaris arundinacea*
- Meadow fescue
  *Festuca pratensis*
- Festulolium
  *Festulolium braunii*
Targets for Grass Breeding

• Hay/Silage production
  – The focus of grass breeding since its beginning.
  – Many excellent, well-adapted varieties exist.

• Management-intensive grazing/Pastures
  – Virtually no breeding efforts until 1990.
  – Most breeding programs have shifted toward this goal.

• The best hay types are not necessarily the best pasture types and vice versa.
Orchardgrass Varieties

Net Herbage Accumulation (Mg/ha) - grazing management

Forage Yield (Mg/ha) - hay management

- Early heading
- Medium heading
- Late heading

- Early heading, b = 0.79, R^2 = 0.44
- Medium heading, b = 1.17, R^2 = 0.22
- Late heading, b = 0.75, R^2 = 0.24
Evaluation of Timothy Breeding
Lines: 3 cuts vs. 5 cuts
Breeding Grazing-tolerant Timothy and Bromegrass
# Timothy from Old Turfs

<table>
<thead>
<tr>
<th>Population</th>
<th>3 cuts</th>
<th>5 cuts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elite forage selections</td>
<td>9.55a</td>
<td>8.63ab</td>
</tr>
<tr>
<td><strong>Turf collections</strong></td>
<td>9.37b</td>
<td>8.76a</td>
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<tr>
<td>Commercial cultivars</td>
<td>9.32b</td>
<td>8.55b</td>
</tr>
</tbody>
</table>

Turf types (golf fairways, golf roughs, cemeteries, home lawns, field lawns) did not differ from each other.
Differential natural selection and evolution in fence and sod.
Forage Yield of Fence vs. Sod Smooth Bromegrasses: Belleville, WI
Reed Canarygrass: An excellent pasture grass that is very difficult to establish.
Reed Canarygrass: Improving Establishment by Selection and Breeding

Ground cover: Fall seeding year.

Tiller production: 1 year after seeding.
Reed Canarygrass: Determining the Mechanism for Improved Establishment

Root weight: 16 days after emergence.

Shoot weight: 30 days after emergence.
“Local” Meadow Fescue

- Highly palatable, low fiber, high fiber digestibility.
- High levels of drought and cold tolerance.
- There are four subpopulations of meadow fescue within this unglaciated region of the north central USA.
  - Some geographic differentiation within the region.
  - Differential European origins.
  - Multiple introductions occurred over time.
Meadow Fescue Breeding

WMF1 selected for high forage yield and intake

<table>
<thead>
<tr>
<th></th>
<th>KY31</th>
<th>GA5</th>
<th>Malik</th>
<th>Johnstone</th>
<th>Elfina</th>
<th>Dovey</th>
<th>Barcel</th>
<th>Advance</th>
<th>WMF1</th>
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<tbody>
<tr>
<td><strong>Yield</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
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<td></td>
<td></td>
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<tr>
<td>Grazings</td>
<td>3.4</td>
<td>3.5</td>
<td>3.6</td>
<td>3.7</td>
<td>3.8</td>
<td>3.9</td>
<td>4</td>
<td>4.1</td>
<td>4.2</td>
</tr>
<tr>
<td>(Tons DM/acre)</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td><strong>Intake</strong></td>
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<tr>
<td>Grazings</td>
<td>0</td>
<td>0.2</td>
<td>0.4</td>
<td>0.6</td>
<td>0.8</td>
<td>1</td>
<td>1.2</td>
<td>1.4</td>
<td>1.6</td>
</tr>
<tr>
<td>(Tons DM/acre)</td>
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<td></td>
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<tr>
<td><strong>Preference</strong></td>
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<td></td>
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<td></td>
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<tr>
<td>(%)</td>
<td>0</td>
<td>0.5</td>
<td>1</td>
<td>1.5</td>
<td>2</td>
<td>2.5</td>
<td>3</td>
<td>3.5</td>
<td>4</td>
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<tr>
<td><strong>Crown rust</strong></td>
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<td></td>
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<tr>
<td>(0=none)</td>
<td>0.0</td>
<td>0.5</td>
<td>1</td>
<td>1.5</td>
<td>2</td>
<td>2.5</td>
<td>3</td>
<td>3.5</td>
<td>4</td>
</tr>
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</table>

*Note: The graphs illustrate the performance of different fescue varieties across various metrics such as yield, intake, preference, and crown rust resistance.*
‘Spring Green’ Festulolium

- Meadow fescue x Perennial ryegrass hybrid.
  - Quality & establishment similar to ryegrass.
  - Drought tolerance similar to fescue.
- Selected for winter survival on-farm.
- Tested in 8 states from Minnesota and Iowa to New York and Virginia.
  - 52 vs. 40% survival (31% increase)
  - 3.98 vs. 3.91 T/A (2% increase)
### Freezing Tolerance in Festulolium

<table>
<thead>
<tr>
<th>Variety</th>
<th>Survival at -11°C</th>
<th>Survival in Hardiness Zones 2-4 +</th>
<th>Survival in Hardiness Zones 5-7 *</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spring Green</td>
<td>55 %</td>
<td>52 %</td>
<td>77 %</td>
</tr>
<tr>
<td>Tandem (parent)</td>
<td>14 %</td>
<td>37 %</td>
<td>72 %</td>
</tr>
<tr>
<td>Kemal (parent)</td>
<td>3 %</td>
<td>43 %</td>
<td>76 %</td>
</tr>
</tbody>
</table>

+ Minnesota, Wisconsin, Iowa.

* Kentucky, Ohio, Pennsylvania, Virginia.
Non-heading Orchardgrass

- It flowers too early in the spring.
- Early flowering varieties are by far the most common.
Non-heading Orchardgrass

Arne Hovin, Clyde Berg, USDA-ARS, University Park, PA
Jerry Cherney, Cornell Univ.
Yousef Papadopolous, A&AFC, Prince Edward Is.
Reed Barker, Richard Johnson, Maria Jendarek, USDA-ARS

Non-heading plants (%)

Non-heading Orchardgrass

Orchardgrass varieties

Northern Wisconsin
Southern Wisconsin
Prince Edward Is.
Ithaca, NY
Oregon
Non-heading Orchardgrass

Stable non-heading plants (%)

- Phase I: Completed.
- Phase II: Seed production in Oregon (feasibility)
- Phase III: Forage production and grazing in eastern North America (validation)
Conclusions

• Although many forage breeding objectives require many years of effort, many species can be modified significantly to be adapted to defined management strategies.

• Genetic variation is the foundation of our ability to make significant changes to forage plants - development of an effective and efficient screening method is often the most important limitation to our ability to create these genetic modifications.