Factors Influencing N Accumulation in Maize Grain

Devin M. Nichols, Fred E. Below, George Singletary, and Stephen P. Moose
Introduction

- Moose Lab’s focus is Discovering Genes involved in Maize Nitrogen Response
- Approaches include Microarray Analysis, Metabolic Profiling, QTL Mapping

Regions containing QTL controlling N Response.
Agronomic Traits:
- N Use Efficiency (NUE) = Grain Yield/Nfert
- N Uptake Efficiency (NUpE)= Plant N/Nfert
- N Utilization Efficiency (NUtE)= Grain Yield/Plant N
- Grain Yield
- Kernel Number
- Kernel Composition
- Stover Biomass
- Stover N Content

N Metabolism traits:
- Nitrate
- Amino Acids
Questions

• Do the IBMRIL and IBMRIL×IHP1 Populations show Variation for Grain Traits?

• What are the Effects of Supplemental N on Grain Traits in the Populations?

• What are the Effects of the Pollen Source on Grain Traits in the Populations?
Germplasm

• IBMRIL Population
  – High Resolution Genetic Map (>3000 markers)
Germplasm

- IBMRIL × IHP1 Hybrids
- IHP1
  - Developed from Cycle 90 of ILTSE
  - 30% Protein, High N Uptake
  - Known to Alter NUE
Questions

- Do the IBMRIL and IBMRIL×IHP1 Populations show Variation for Grain Traits?
- What are the Effects of Supplemental N on Grain Traits in the Populations?
- What are the Effects of the Pollen Source on Grain Traits in the Populations?
Variation for Grain Traits: Field Experiments

• IBMRIL inbreds
  – 302 Genotypes, 1 N rate (100 kg/ha) in 2004
  – 3 ears Selfed
  – 10 Kernels per ear Analyzed by Single Seed NIR

• IBMRIL × IHP1 hybrids
  – ~280 Genotypes, 1 N (100 kg/ha) rate in 2005 and 2006
  – 5 ears Selfed
  – Bulked grain Analyzed by NIR
## Variation for Grain Traits: Results

<table>
<thead>
<tr>
<th>Trait</th>
<th>Mean</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>IBMRIL Inbreds</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Starch (%)</td>
<td>69.3</td>
<td>57.4-75.0</td>
</tr>
<tr>
<td>Protein (%)</td>
<td>11.4</td>
<td>6.1-17.7</td>
</tr>
<tr>
<td>Kernel Wt. (g)</td>
<td>0.273</td>
<td>0.165-0.406</td>
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<tr>
<td><strong>IBMRIL × IHP1 Hybrids</strong></td>
<td></td>
<td></td>
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<tr>
<td>Starch (%)</td>
<td>62.2</td>
<td>57.7-68.7</td>
</tr>
<tr>
<td>Protein (%)</td>
<td>15.4</td>
<td>9.9-19.7</td>
</tr>
<tr>
<td>Kernel Wt. (g)</td>
<td>0.237</td>
<td>0.126-0.424</td>
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</tbody>
</table>
Variation for Grain Traits: Results

Starch Concentration

Kernel Weight
Variation for Grain Traits: Conclusions

- Increased Protein Concentration in IBMRIL×IHP1 hybrids shows Increased N Uptake capacity

- Wide Range of Protein Concentration in hybrids demonstrates Variability in N Utilization Efficiency which will allow Identification of QTL
Questions

- Do the IBMRIL and IBMRIL×IHP1 Populations show Variation for Grain Traits?

- What are the Effects of Supplemental N on Grain Traits in the Populations?

- What are the Effects of the Pollen Source on Grain Traits in the Populations?
N Response: Field Experiments

• IBMRIL × IHP1 N Response Evaluation

  – 94 Hybrids grown in NRN at 3 N rates: 0, 84, 252 kg/ha

  – Open Pollinated grain Analyzed by NIR
### N Response of IBMRL×IHP1 Population

<table>
<thead>
<tr>
<th>Trait</th>
<th>N Rate 0</th>
<th>N Rate 84</th>
<th>N Rate 252</th>
</tr>
</thead>
<tbody>
<tr>
<td>Protein</td>
<td>9.2</td>
<td>11.0</td>
<td>12.9</td>
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<tr>
<td>Starch</td>
<td>69.0</td>
<td>66.9</td>
<td>64.8</td>
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</tbody>
</table>

N effect on both traits significant (P<0.0001) based on ANOVA
N Response of IBMRIL×IHP1 Population

Seed Protein Concentration

Number of genotypes

Protein Concentration (%)

0 kg N/ha
252 kg N/ha
Questions

• Do the IBMRIL and IBMRIL×IHP1 Populations show Variation for Grain Traits?

• What are the Effects of Supplemental N on Grain Traits in the Populations?

• What are the Effects of the Pollen Source on Grain Traits in the Populations?
Pollen Source Effects: Field Experiments

• IBMRIL Inbreds
  – 302 Genotypes, 1 N rate (100 kg/ha) in 2004
  – 3 ears Selfed, 3 ears Pollinated by IHP1
  – 10 Kernels per ear Analyzed by Single Seed NIR

• B73 × Mo17 Pollen Mixing Experiment
  – B73 × Mo17 Hybrid grown at single N Rate
  – Four Pollination Treatments (min. 3 ears each):
    • Self Pollinated
    • Pollinated with B73 pollen
    • Pollinated with IHP1 pollen
    • Pollinated with 50:50 Mixture of B73 and IHP1 pollen
  – Kernel N and Protein Analyzed by Combustion Analysis
Pollen Source Effects: Inbred Results

• Significant Effect of Pollen Source on Starch Concentration (P<0.0001) but Not on Kernel Weight in IBMRILs based on ANOVA

• T-tests performed on Individual Genotypes showed that Few IBMRILs had Differences in Starch Concentration or Kernel Weight between Self Pollinated ears and ears Pollinated by IHP1
Pollen Source Effects: Inbred Results

Kernel Weight

Starch Concentration
Pollen Source Effects: B73×Mo17 Results

B73×Mo17 ears pollinated with a 50:50 mixture of B73 and IHP1 pollen
Yellow kernels pollinated by B73, creamy light yellow kernels pollinated by IHP1
### Pollen Source Effects: B73×Mo17 Results

<table>
<thead>
<tr>
<th>Pollen Source</th>
<th>Mean Kernel Protein (%)</th>
<th>Range Kernel Protein (%)</th>
<th>Mean Kernel Weight (g K⁻¹)</th>
<th>Range Kernel Weight (g K⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td>B73×Mo17</td>
<td>11.18</td>
<td>9.09-12.85</td>
<td>0.223</td>
<td>0.212-0.235</td>
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<tr>
<td>B73</td>
<td>12.05</td>
<td>9.37-14.35</td>
<td>0.207</td>
<td>0.185-0.225</td>
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<tr>
<td>IHP1</td>
<td>12.80</td>
<td>10.9-14.52</td>
<td>0.197</td>
<td>0.160-0.213</td>
</tr>
<tr>
<td>Mix-IHP1</td>
<td>12.69</td>
<td>10.28-14.56</td>
<td>0.204</td>
<td>0.187-0.233</td>
</tr>
<tr>
<td>Mix-B73</td>
<td>12.48</td>
<td>10.16-14.0</td>
<td>0.214</td>
<td>0.201-0.232</td>
</tr>
</tbody>
</table>

No significant effect of pollen source on either protein or kernel weight (P=0.05) based on ANOVA
Pollen Source Effects: Conclusions

• No Effect of Pollen Source Observed in Pollen Mixing Experiment

• Significant Effects of Pollen Source seen in IBMRIL inbreds Pollinated with IHP1, Difference is Small Relative to other Sources of Variation

• Not Necessary to Control Pollination in Plants used to Measure NUE

• No Need to use Specialized Endosperm Mapping Model to Account for Triploid Endosperm
Environmental Effects on Grain Protein

Plant-to-plant variation is as large as that mediated by extreme differences in N.

Underscores the importance of replication and multiple plant sampling.
Acknowledgements

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  – Dr. Fred Below
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[Image: NitroGENES logo]