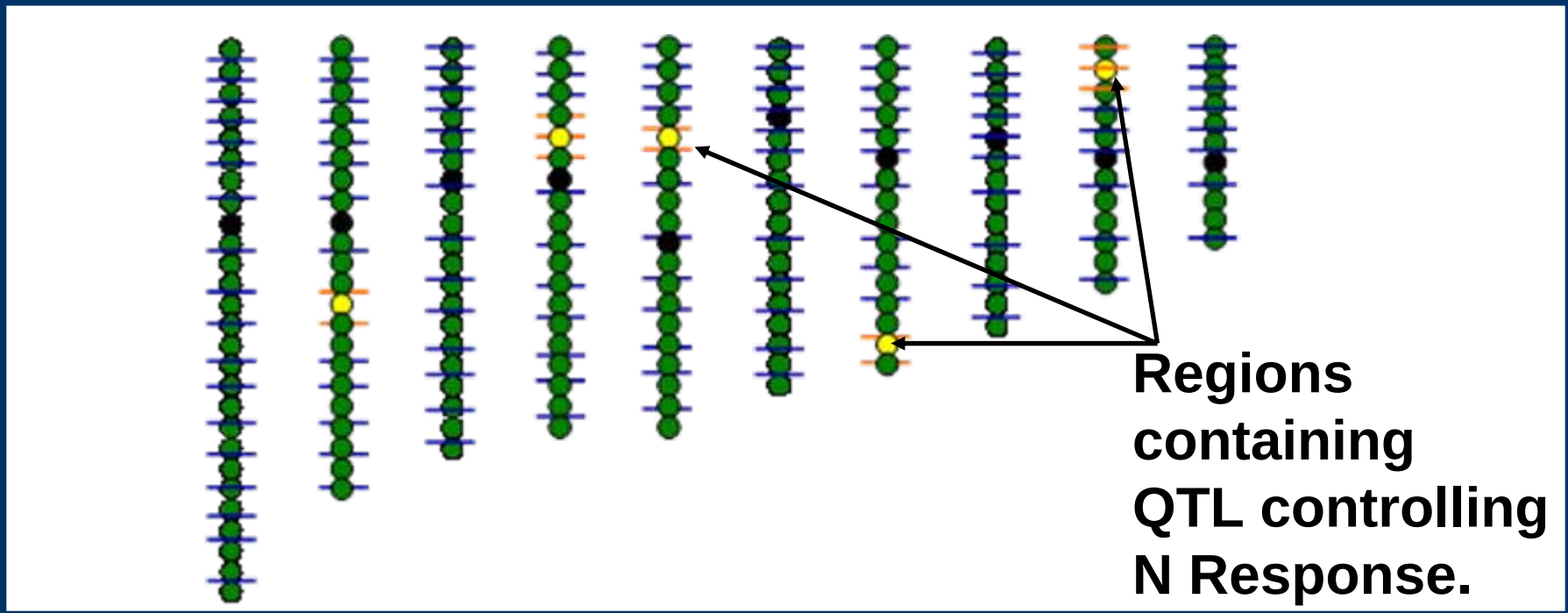
Factors Influencing N Accumulation in Maize Grain

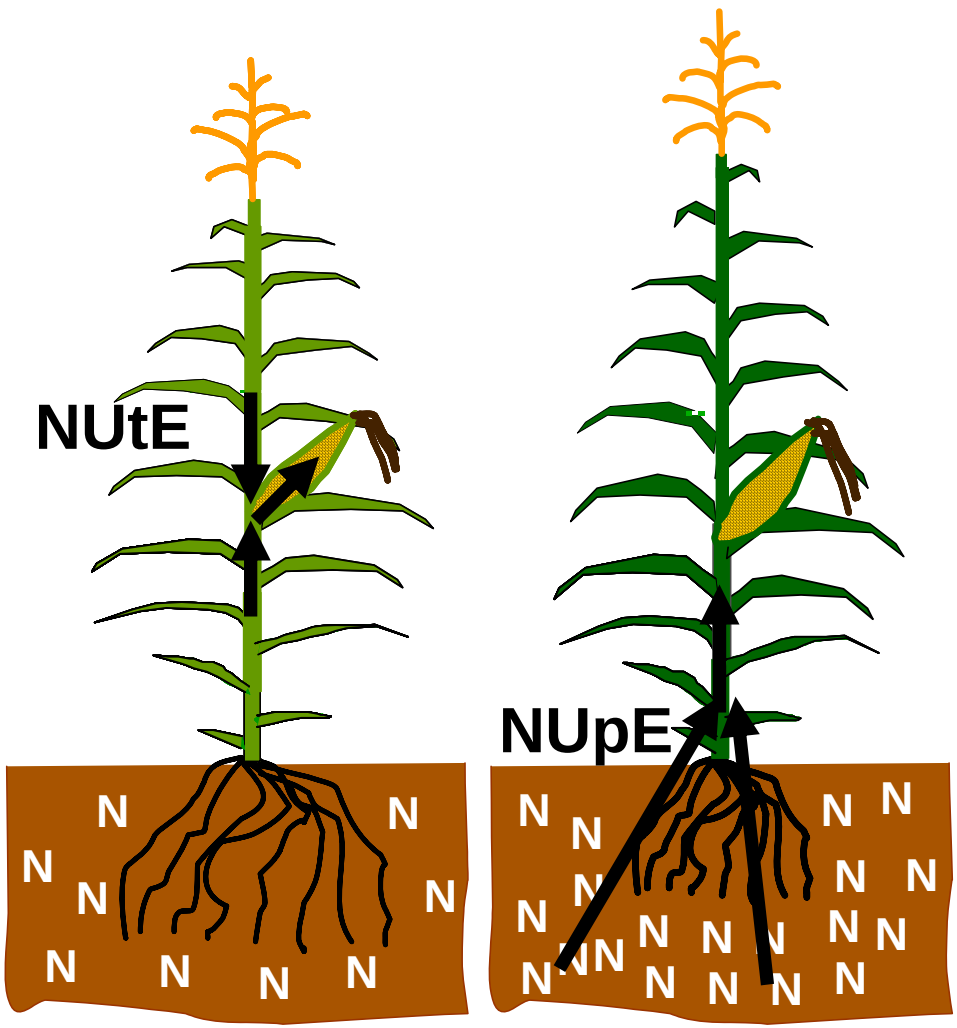
Devin M. Nichols, Fred E. Below, George Singletary, and Stephen P. Moose

Introduction

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



Traits for QTL Study



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:

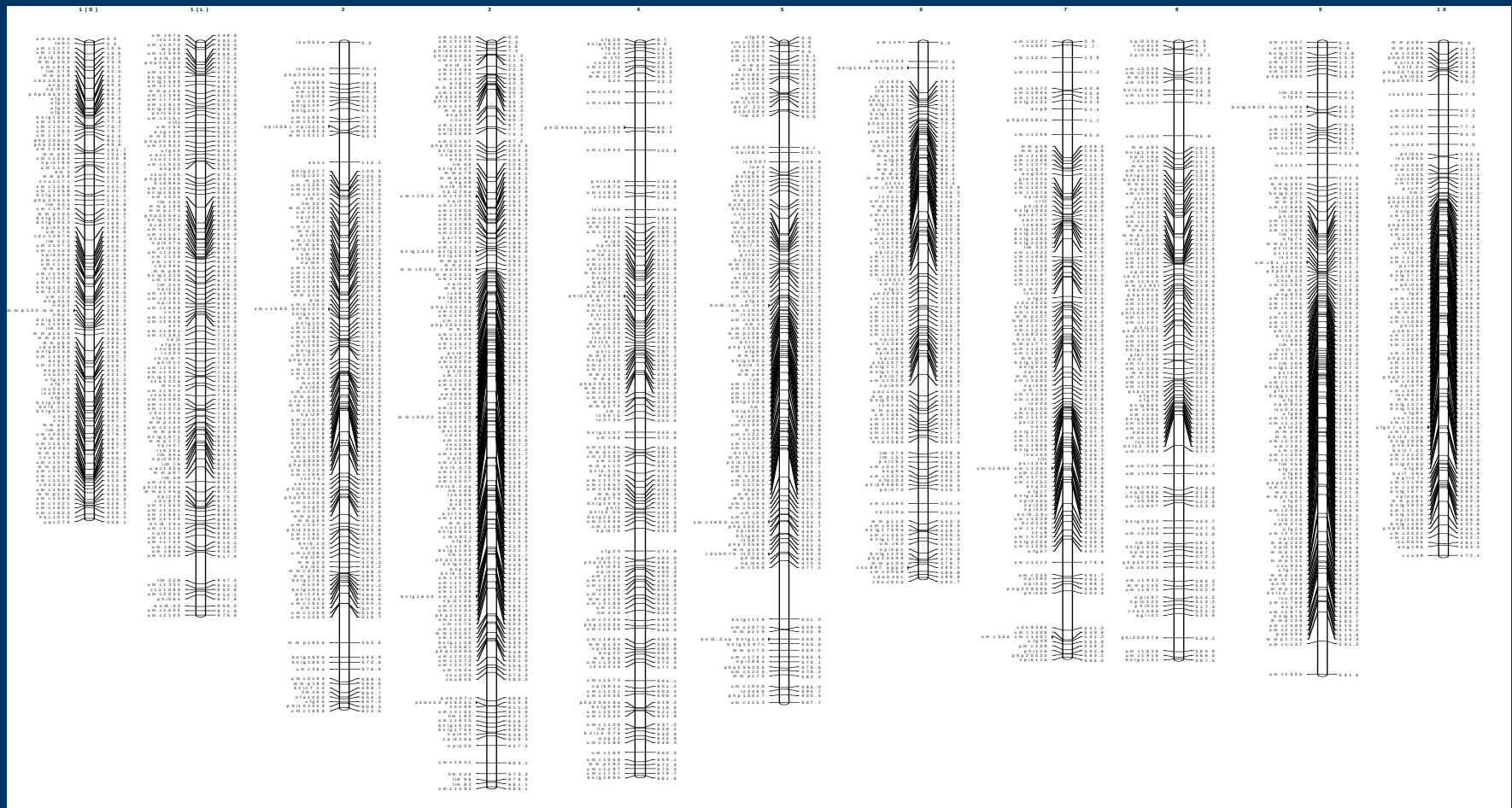
- **Nitrate**
- **Amino Acids**

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

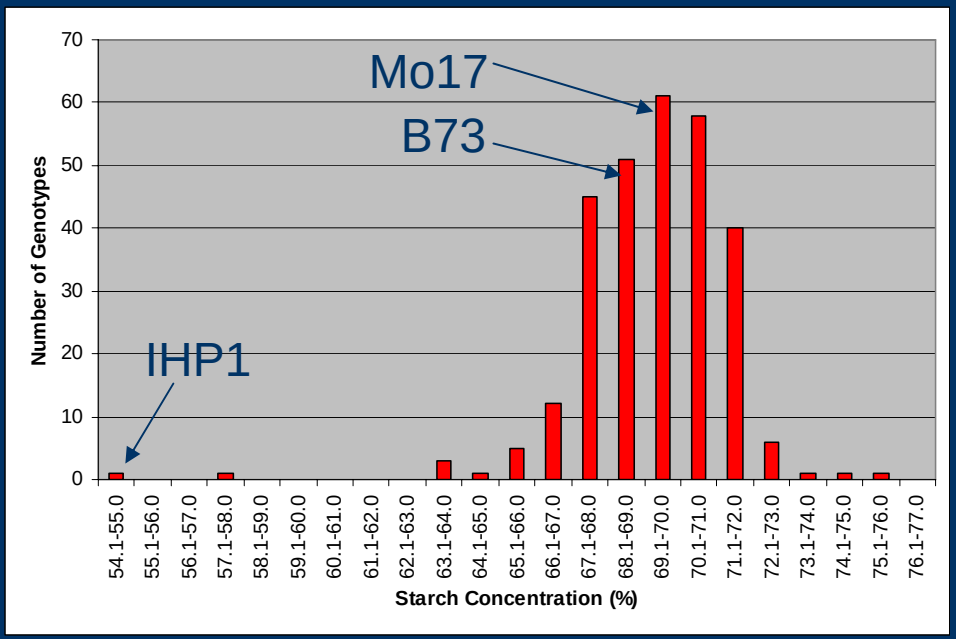
- IBMRIL inbreds
  - 302 Genotypes, 1 N rate (100 kg/ha) in 2004
  - 3 ears Selfed
  - 10 Kernels per ear Analyzed by Single Seed NIR
- IBMRIL × IHP1 hybrids
  - ~280 Genotypes, 1 N (100 kg/ha) rate in 2005 and 2006
  - 5 ears Selfed
  - Bulked grain Analyzed by NIR

Variation for Grain Traits: Results

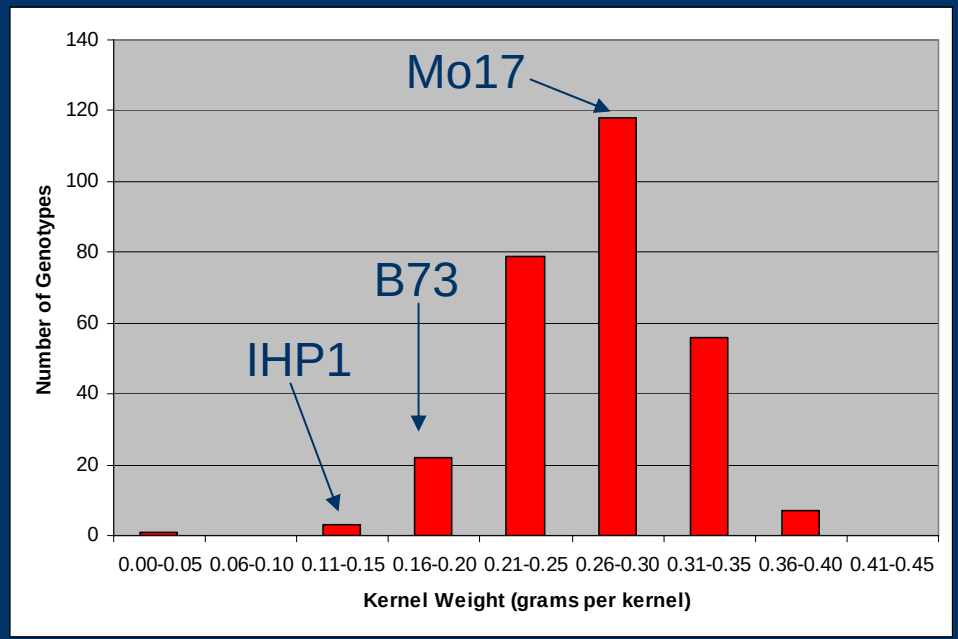
Trait	Mean	Range
IBMRIL Inbreds		
Starch (%)	69.3	57.4-75.0
Protein (%)	11.4	6.1-17.7
Kernel Wt. (g)	0.273	0.165-0.406
IBMRIL × IHP1 Hybrids		
Starch (%)	62.2	57.7-68.7
Protein (%)	15.4	9.9-19.7
Kernel Wt. (g)	0.237	0.126-0.424

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

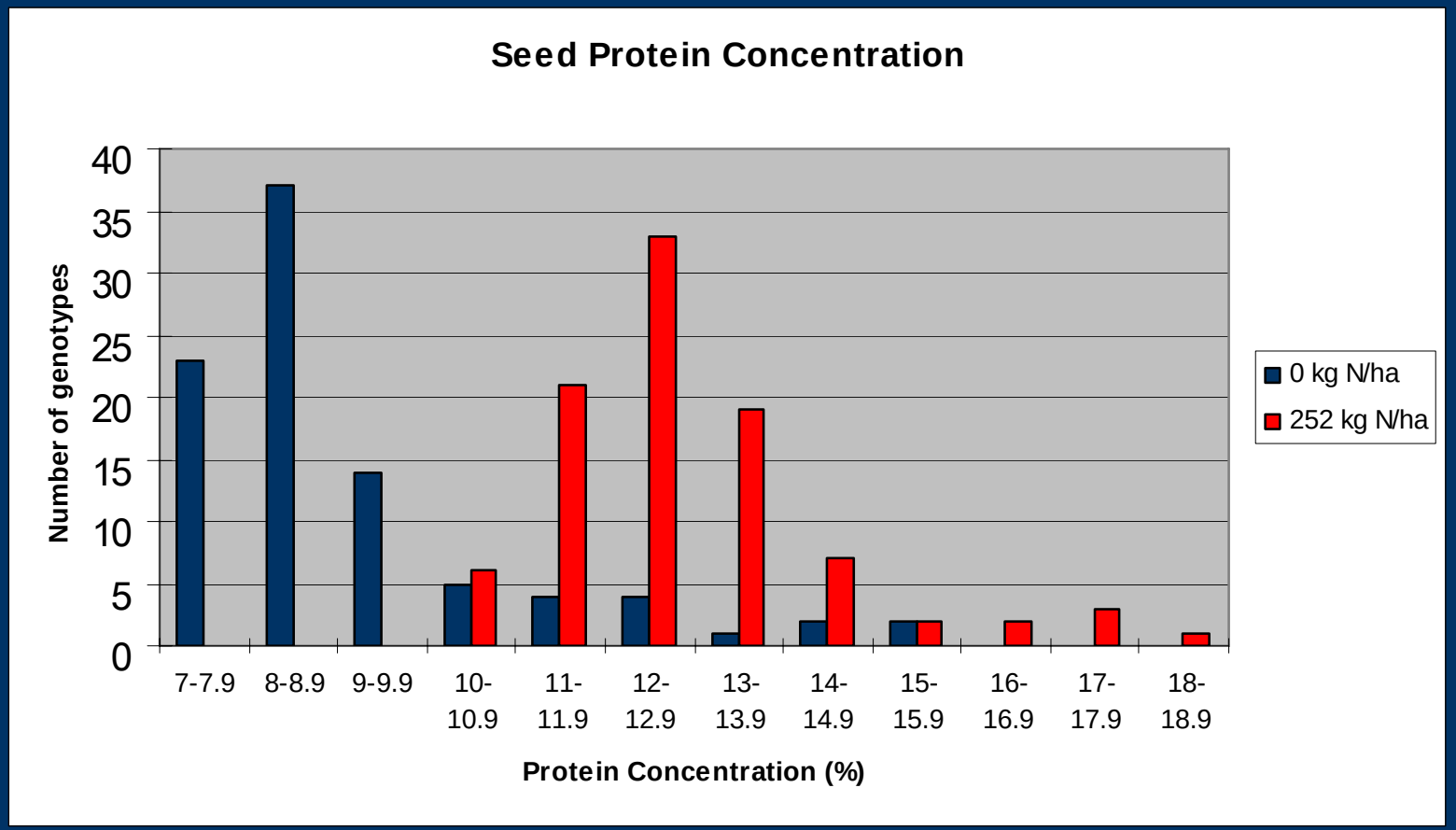
- IBMRIL × IHP1 N Response Evaluation
  - 94 Hybrids grown in NRN at 3 N rates:
    0, 84, 252 kg/ha
  - Open Pollinated grain Analyzed by NIR

N Response of IBMRIL×IHP1 Population

Trait	N Rate 0	84	252
Protein (%)	**9.2**	**11.0**	**12.9**
Starch (%)	**69.0**	**66.9**	**64.8**

N effect on both traits significant (P<0.0001) based on ANOVA

N Response of IBMRIL×IHP1 Population



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

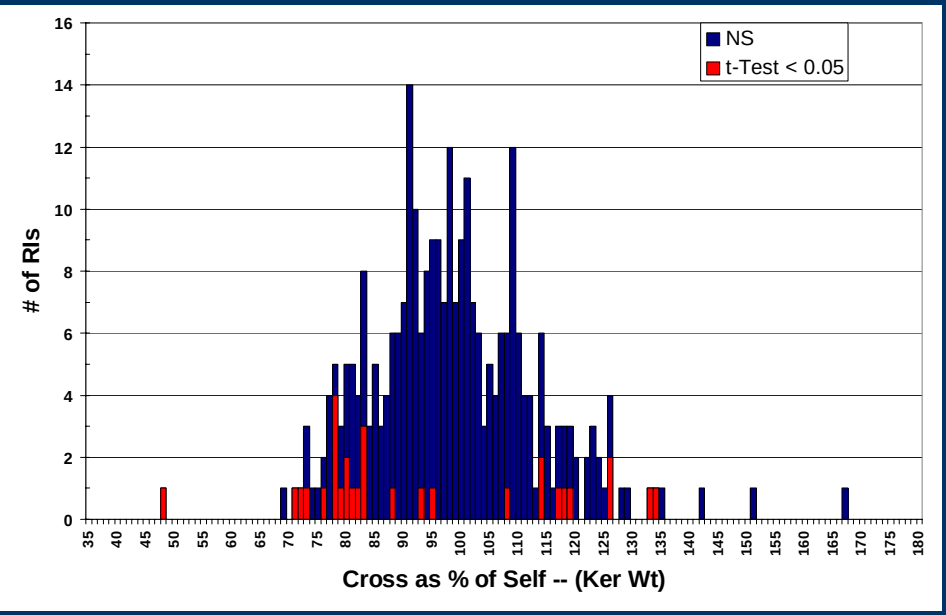
Pollen Source Effects: Inbred Results

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

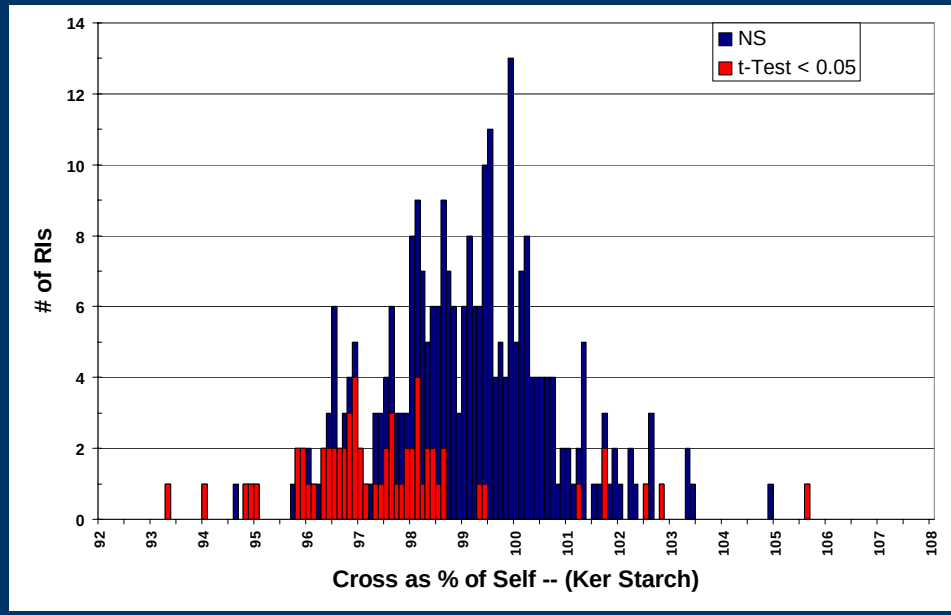
- T-tests performed on Individual Genotypes showed that Few IBMRILs had Differences in Starch Concentration or Kernel Weight between Self Pollinated ears and ears Pollinated by IHP1

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

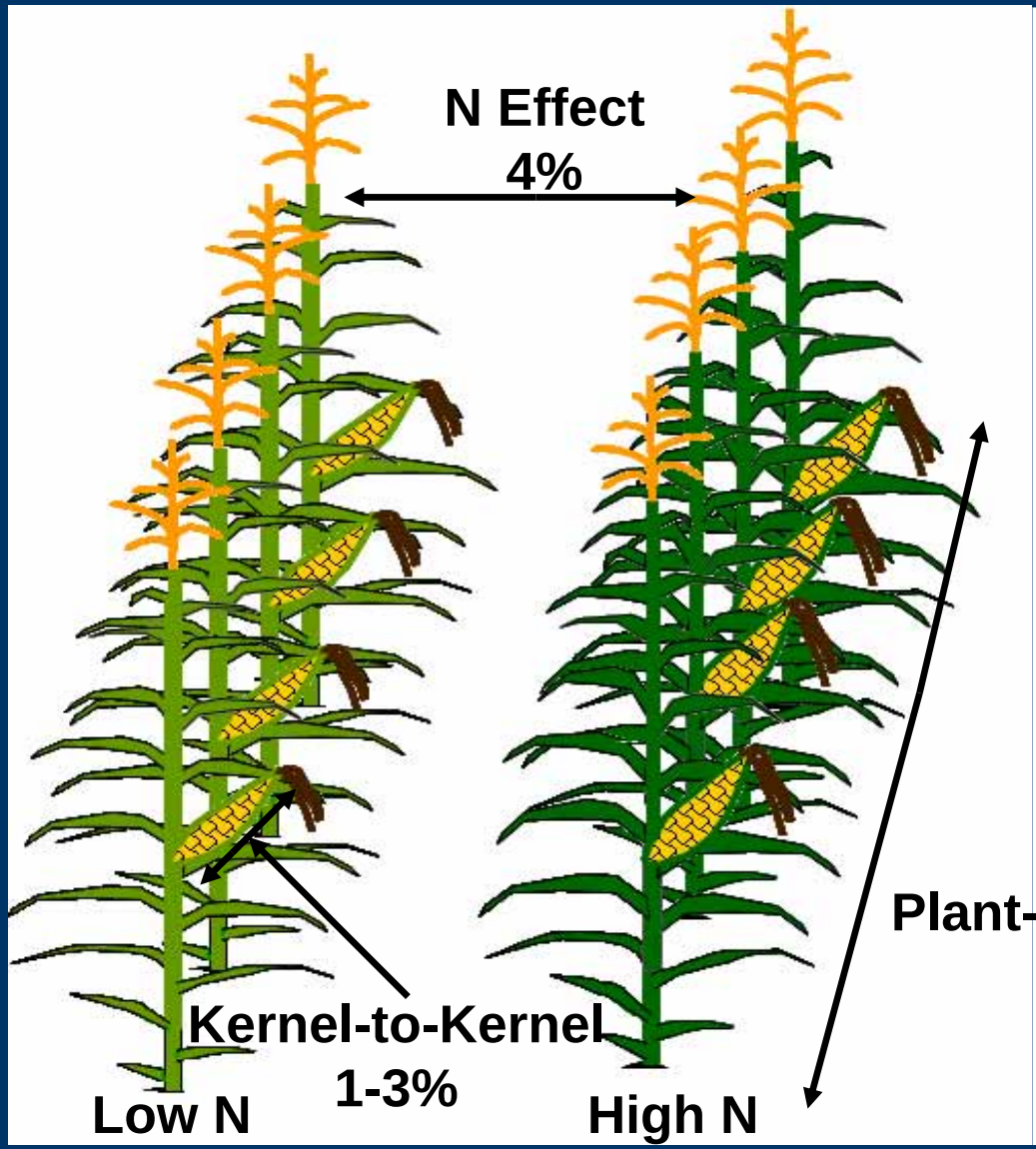
Pollen Source	Mean Kernel Protein (%)	Range Kernel Protein (%)	Mean Kernel Weight (g K^{-1})	Range Kernel Weight (g K^{-1})
B73×Mo17	11.18	9.09-12.85	0.223	0.212-0.235
B73	12.05	9.37-14.35	0.207	0.185-0.225
IHP1	12.80	10.9-14.52	0.197	0.160-0.213
Mix-IHP1	12.69	10.28-14.56	0.204	0.187-0.233
Mix-B73	12.48	10.16-14.0	0.214	0.201-0.232

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

- Coauthors
  - Dr. Steve Moose
  - Dr. Fred Below
  - Dr. George Singletary
- Members of Moose and Below Labs

- Funding
  - NSF