Multiple Pest Resistance in Elite Corn Inbreds and Hybrids

Xinzhi Ni\textsuperscript{1}, Wenwei Xu\textsuperscript{2}, Michael Blanco\textsuperscript{3}, Jeffrey P. Wilson\textsuperscript{1}, and G. David Buntin\textsuperscript{4}

1 USDA-ARS-CGBRU, Tifton, GA 31793
2 Texas A&M University, Lubbock, Texas 79403
3 USDA-ARS, Ames, IA 50011
4 Entomology, University of Georgia, Griffin, GA 30223
Goal of Program

To reduce insect damage and mycotoxin contaminations in corn by:

a) Screening for native insect and disease resistance;

b) Developing new corn germplasm;

c) Understanding the mechanisms.
Entomology Program

Approaches

Field

- New Inbreds/Hybrids
- Field Screening

Laboratory

- Mol./Biochem./Physiol. Bases
- Resis./Suscept. traits

Objectives

1) Field Screening
   - Single insect → Multiple pests

2) Insect Resistance/Susceptibility Bases
   - Biochem./Physiol. bases ↔ Phenotypic traits

3) Recombination
   - Multiple Innate resistant traits (Pathogens + Insects)
Experiment Objectives

1) To evaluate ear and kernel insect and disease resistance;

2) To assess correlation among the parameters;

3) To identify best inbred lines and hybrids conferring multiple pest resistance.
Experimental Protocols

• 20 elite GEM inbred lines and 20 hybrids from Iowa and Texas
• 2 controls for inbreds and hybrids
• 2 years: 2007 and 2008
• 6 or 7 damage-related parameters
Evaluation Parameters

- **Five pest damage:**
  - Corn earworm (artificial)
  - Stink bugs
  - Maize weevil
  - Kernel-chewing insects
  - Ear smut (and ear rot)

- **Two phenotypic Traits:**
  - Husk tightness
  - Husk extension
The corn earworm, *Helicoverpa zea* (Boddie)
The fall armyworm, *Spodoptera frugiperda* (J.E. Smith)
(Lepidoptera: Noctuidae)

Ear Damage Rating Scale:
1 = silk damage
2+ = 1 + centimeter(s) of penetration;
Brown stink bug, *Euschistus servus* (Say)
Southern green stink bug, *Nezara viridula* (L.)
(Hemiptera: Pentatomidae)
Stink Bug-Discolored Kernels

Discolored kernels (%) = \frac{\text{Number of discolored}}{\text{row column}}
The maize weevil, *Sitophilus zeamais* Motschulsky (Coleoptera: Curculionidae)

Percentage of weevil-damaged kernels
Kernel-Chewing Insect Damage (%)

1) Sap beetles, *Carpophilus* spp. (Coleoptera: Nitidulidae)

2) Pink scavenger caterpillar [*Sathrobrota (Pyroderces) rileyi* (Walsingham)] (Lepidoptera: Cosmopterygidae)

3) Chocolate milkworm, *Moodna* spp. (Lepidoptera: Pyralidae)

http://www.entsoc.org/Pubs/Books/Handbooks/corn_samples.htm
Common smut (*Ustilago maydis*)

Smut-infected ears (% per plot)
Phenotypic Traits

• **Husk coverage (or extension) (cm):**
  • Measured from tip of the cob to the tip of the husk;

• **Husk tightness (Rector et al. 2002):**
  (rated as loose-tight = 1 - 5):
  1 = very loose; 4 = tight;
  2 = loose; 5 = very tight;
  3 = moderately tight;
Experimental Design and Data Analyses

• Randomized complete block design with 4 replications each year for two years;

  a) Analysis of variance within a parameter: PROC MIXED
  b) Among the parameters:
     PROC CORR
     PROC CLUSTER
     PROC TREE
Results

A) Analysis of variance among the inbred lines:

• Pest damage ratings:
  Corn earworm \( (F = 3.26; \text{df} = 21, 1686; P < 0.0001) \)
  Stink bugs \( (F = 2.13; \text{df} = 21, 1690; P = 0.0021) \)
  Maize weevil \( (F = 2.91; \text{df} = 21, 1690; P < 0.0001) \)
  Kernel-chewing insects \( (F = 4.60; \text{df} = 21, 1688; P < 0.0001) \)
  Ear smut \( (F = 2.64; \text{df} = 21, 63; P = 0.0016) \)

• Phenotypic Traits:
  Husk tightness \( (F = 20.08; \text{df} = 21, 1646; P < 0.0001) \)
  Husk extension \( (F = 15.56; \text{df} = 21, 1684; P < 0.0001) \)
Results

B) Correlation among the parameters:

• Pest damage:
  • Corn earworm (CEWd)
  • Stink bugs (SBpct)
  • Maize weevil (MWpct)
  • Kernel-chewing insects (KCpct)
  • Earsmut

• Phenotypic traits:
  • Husk tightness (HTight)
  • Husk extension (HEextn)
### Correlation Among All Parameters

<table>
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<th>CEWd</th>
<th>kept</th>
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Results

C) Identification of the Best GEM Inbred Lines and Hybrids:

Dilemma:
Rankings of the parameters are not always agree;

Resolution:
Using principal component analysis and cluster analysis
Cluster Analysis

Original Data

Standardization

Principal Component Analysis

Cluster Analysis → Dendrogram
Principal Component Analysis
- All seven parameters for inbreds

Eigenvalues of the Covariance Matrix

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<th>Proportion</th>
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Inbred Dendrogram: 7 Parameters
Best Inbred Lines

- Nine entries:
  3, 4, 5, 6, 7, 8, 10, 14, and 20

- Sources:
  Iowa: 3, 4, 5, 6, 7, 8, and 10
  Texas: 14, and 20
# The Best GEM Inbreds

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<thead>
<tr>
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<th>Source</th>
<th>GEM Code</th>
<th>Pedigree</th>
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GEM Hybrid Categorization

- Cluster analysis
- Dendrogram
Hybrid Dendrogram: 6 Parameters
Best Hybrids

• Eight entries:
  1, 4, 5, 6, 7, 8, 10, and 15

• Sources:
  Iowa: 1, 4, 5, 6, 7, 8, and 10
  Texas: 15
## The Best GEM Hybrids

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Conclusions

1) Corn ear damage was positively correlated to kernel-chewing insect damage;

2) Stink bug damage was positively correlated to kernel-chewing insect and maize weevil damage; and negatively correlated to husk tightness;

3) Nine inbred lines and eight hybrids were identified as multiple pest resistant.
Next Step

• Screening for foliage-feeding fall armyworm resistance on these lines using artificial infestation;
• Screening for low aflatoxin contamination using artificial inoculation with *Aspergillus flavus*;
• Mechanisms for multiple pest resistance.
Entomology Program

Approaches

Field Screening

Mol./Biochem./Physiol. Bases

Resist./Suscept. traits

New Inbreds/Hybrids

Objectives

1) Field Screening

Single insect → Multiple pests

2) Insect Resistance/Susceptibility Bases

Biochem./Physiol. bases ↔ Phenotypic traits

3) Recombination

Multiple Innate resistant traits (Pathogens + Insects)