Use of Exotic Germplasm to Improve Abiotic Stress Tolerance

Wenwei Xu
Texas A&M University
Lubbock, Texas
we-xu@tamu.edu
Breeding Efforts of Corn Breeding Program at Texas A&M University-Lubbock Center

- Drought
- Heat
- Insects - CEW
- Insects - Mites
- Mycotoxins - Aflatoxins
Presentation Outline

• Evaluation of GEM and other exotic germplasm for drought tolerance.
• Progress in breeding for stress tolerant and high yielding germplasm.
Evaluation of GEM and other exotic germplasm for drought tolerance
Drought tolerance: an important trait for worldwide corn production

- Water: a precious natural resource.
- Agriculture accounts for 70% global fresh-water use.
- A major limiting factor for crop production.

Drought stress reduces:
- Yield stability ➔ Yield
- Grain/silage quality ➔ Profitability
Drought tolerance is especially important in the High Plains in the U.S.

- Low rainfall
- Increasing pumping costs
- Declining water level of the Ogallala Aquifer
Drought tolerance is a complex trait.

Accurate screening for drought tolerance depends on the timing, intensity and duration of drought stress.

It requires intensive and careful field management, and examination of a series of traits.

Greenhouse study is useful to identify biochemical, morphological, and physiological traits contributing to drought tolerance.

Field evaluation is critical for selecting drought tolerant genotypes and for validating the efficacy of transgenic drought tolerant plants.
How to Evaluate and Improve Drought Tolerance?

• Select for heat tolerance.

• Measure physiological and biochemical traits under controlled stress in a greenhouse and growth chambers.

• Subject plants to controlled drought stress in the fields.

• Integrate genomic and transgenic tools to transfer drought tolerance genes to elite germplasm.
Field Evaluation of Drought Tolerance

• Control soil moisture
  ➔ Rainout shelter + controlled irrigation
  ➔ Low rainfall + controlled irrigation

• Irrigation methods
  ➔ Furrow irrigation
  ➔ Center pivot irrigation
  ➔ Subsurface drip irrigation
Irrigation Efficiency

Furrow irrigation: 40-60%

Center pivot irrigation: LEPA 95-98%

Subsurface drip irrigation: 98-100%

IE = (Amount of water stored in the soil available for crop use after irrigation)/(amount of water pumped).
Breeding Drought Tolerant Corn In Texas

- Take advantage of low rainfall.
- Apply precise and uniform amount of irrigation water to impose drought stress at target growth stages.
- Use subsurface drip irrigation systems.
- Have two fields dedicated for drought study.
- Usually have 2-3 water treatments in a field.

Average Rainfall in Inches

- <8
- 8-20
- 21-32
- 33-44
- 45-56
Field Evaluation of Drought Tolerance
- Impose different types of drought stress

100% ET:
- 0.20 inch/day at V-6
- 0.35 inch/day at V-11

Daily ET depends on:
- Temperature
- RH
- Solar radiation

Project the ET:
- 10-day weather
  [www.weather.com](http://www.weather.com)

Drought intensity:
- Irrigation schedule
- Irrigation amount
- Pause drought?

http://txhighplainset.tamu.edu/
Drought Stress Symptoms In Corn

- Leaf rolling
- Shorter plant
- Early senescence
- Stalk lodging

Aspergillus flavus

Poor seed set, short ear, small kernel, molded kernels (high aflatoxins)

Yes, severe drought stress can cause total crop loss!
Drought and heat Tolerant maize
Stay green rating

1 = 100% green, 2 = 75%, 3 = 50%, 4 = 25%, 5 = 0% green leaves
Sources of Drought Tolerant Genes

• **Native genes:**
  ➔ Already existing in maize;
  ➔ Transfer them to elite lines with MAS.

• **Transgenes:**
  ➔ Seed companies use both approaches.
Native Drought Tolerance Genes

- Tropical and exotic germplasm:
  - GEM (Germplasm Enhancement of Maize) Project
  - CIMMYT

- Evaluate for drought and heat tolerance, insect resistance, grain mold resistance, yield and other agronomic traits.

- Develop multiple stress tolerant corn.
<table>
<thead>
<tr>
<th>Wenwei’s Favored GEM Breeding Crosses</th>
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<tr>
<td>ANTIGO01:N16</td>
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<td>AR01150:N0406</td>
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CK1 = BH8913RR/YGCB, CK2 = DKC 66-23, CK3 = DKC 67-87, CK4 = P31G96
Average grain yield (bu/a) in nine environments in 2010

CK1 = BH8914VT3, CK2 = DKC 66-23, CK3 = DKC 67-87, CK4 = P31G96
The hybrids of the GEM lines usually have tall and robust plants. Some of these hybrids have high grain yield, and therefore, they are suitable for high tonnage and high quality silage corn production.
Forage yield (tons/a) of the 2011 Texas State Silage Corn Performance Test at Etter, Texas. Red hybrids are our experimental hybrids. Entries 33, 35, 38, 39, and 40 have GEM germplasm.

Mean = 32.96, CV = 6.65, LSD = 3.66
Aflatoxins

Aspergillus flavus sporulating on corn

Aflatoxin B1 (C17 H12 O6)

Aspergillus flavus
Breeding Strategies For Aflatoxin Resistance

- Improve drought tolerance.
- Improve heat tolerance.
- Improve corn earworm resistance.
- Incorporate aflatoxin resistance QTLs from the resistance sources like Mp715.

⇒ Develop multiple stress tolerant corn hybrids that are adapted to the Southern environments.
Teosinte as a Potential Source of Rust Resistance?

Selfed ears of $F_1$ plants

$\rightarrow$

Ears of $BC_3F_1$ plants with 6.25% teosinte germplasm.

Teo-Lines
Southern Rust

College Station, TX

Weslaco, TX
Summary

• Exotic germplasm can be very useful to improve stress tolerance and disease resistance.

• Hybrids of the GEM lines have tall and robust plants, and they are suitable for high tonnage and high quality silage corn production.

• Hybrids of some GEM lines produced high grain yield and have low aflatoxin under wide range of environments.
Improving Life through Science and Technology.

Thank you

Mike Blanco       Junping Chen       Teresa Gaus
Seth Murray       Gary Odvody       Adam Vanous
Paul Williams     Yongtao Yu       Yingen Xue
Many others

Improving Life through Science and Technology.
Acknowledgement

We appreciate the financial support from:

- USDA GEM Project
- USDA-ARS Pre-harvest Control of Aflatoxin Program
- USDA-ARS Ogallala Aquifer Program
- The Texas Corn Producers Board
- The High Plains Underground Water Conservation District No.1
- Texas Water Development Board
- Industrial support