Increasing Grain Yield in Tropical Maize in a Changing Climate

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Presentation Overview

- Motivation for working on abiotic stress tolerance
- Site identification for abiotic stress phenotyping
- Novel methods used for abiotic stress phenotyping
- Best Germplasm for abiotic stress tolerance
- Effect of planting density on grain yield in tropical germplasm
Motivation for working on abiotic stress

- Climate change
- Yield reductions 10-30%
- Population growth of ~2-3 bio
Mexico site development

**Basis for site selection**

- Partner organizations?
- Climatic conditions
- Water availability
- General infrastructure?
Abiotic stress phenotyping network

Drought / Drought + heat

Drought

Low Nitrogen

Drought / Drought + heat/ Low nitrogen
Remote sensing: canopy temperature (CT) and NDVI

Canopy temperature is negatively associated with GY.

NDVI is positively associated with GY.

Selection for CT and NDVI increases genetic gains on GY

- CT, NDVI and ASI allow to identify high yielding germplasm under HS and HD+DS
- Selection for CT and NDVI increases genetic gain for GY

Future: hyperspectral camera

- GRE measurements will eventually replace visual senescence scores
- CWMI will facilitate germplasm identification under drought and heat
Hyperspectral data: Prediction of GY

- Use of BayesB models will facilitate yield prediction (BGLR R-package)

Abiotic stress evaluation at CIMMYT

- Line-by-tester trials
- -> selection based on BLUEs/BLUPs from multilocation trials and GCA under stress
  - CIMMYT maize line (CML)
  - Trait donor
- Evaluation of ~30-35k plots under abiotic stress at 6-9 sites/year
  - 50% drought (winter season)
  - 25% LN (winter + summer season)
  - 25% heat (summer season)
- Aiming for yield reductions of 60-70%
- Stress at flowering and during grain fill
Donors for abiotic stress tolerance

- 15 donors for drought
- 8 donors for nitrogen use efficiency

New Climate Resilient Hybrid

- Better than tropical hybrid under non-stress
- Better than donor under stress
GY as affected by planting density

- GY can be increased by higher planting density
- Water and nitrogen scarcity reduce density response
- Heat reduces GY level, but not the density response

Climate, fertilizer, water availability and market prices determine planting density

QTL and candidate genes

• **Drought**
  - Bin 3.06: Stay green; Zmm16/pbs1; Almeida and Trachsel, 2014
  - Bin 1.03: PhiPSII; hcf50; Trachsel et al. 2010
  - Bin 2.02; NDVI; *Nec*t
  - Bin 2.05; NDVI; hcf/spt1
  - Bin 2.07; NDVI; CBF3
  - Bin 5.04: NDVI; bv1/ N681A
  - Bin 8.04; GY; sps1

• **LN**
  - Bin 1.07: GY
  - Bin 5.05: GY
  - Bin 8.05: GY, hcf105?
  - Bin 4.05: stay green, spt2?, su1?

• **Heat**
  - Bin 1.08: GY, 8% PVE
  - Bin 5.07: GY, 20% PVE

**Growth under drought**
Trachsel et al., 2016

Use in genomic prediction of performance under drought?
Summary

• Development and management of an abiotic stress phenotyping network
• Discovery of new traits and indices facilitating the identification of drought and heat tolerant germplasm (CT, UAV-NDVI, GRE, CWMI)
• 8 donor lines for multiple abiotic stress tolerance available
• Increased GY in current germplasm by increasing planting density
• Identification of QTL and candidate genes that will speed up breeding in the future
Thank you!

Tlaxiaco, Oaxaca

Navolato, Sinaloa
Experimental design

**Germplasm** Grouping by:
- Adaptation zone (tropical, subtropical, highlands)
- Flowering/maturity/vigor

**Control/account for environmental factors:**
- Appropriate *site selection* (i.e. heat stress in desert)
- Appropriate *planting date* (i.e. drought in dry season)
- Irrigation system: *Uniform water distribution*
- Augmented *row column design* (mapping/GS training populations)
- *Alpha-lattice incomplete block* design (breeder’s trials)
Data analysis

- Mixed effect models (R; lme4) -> BLUEs/ BLUPs; GCA
- Spatial analysis (ASReml)
- Cofactors
  - Plant height in density trials/ for landraces
  - Anthesis/Soil moisture in drought trials
  - Use soil map as covariate in trial analysis?

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Heritability for GY