Breeding WEMA maize for the African Continent

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Maize in Africa

- Africa depends on maize for the income and livelihoods.
- Maize accounts for 73% and 64% of the total demand in ESA and WCA, respectively.
- Wide adaptation (from sea level to 2200 masl).
- Wide acceptability by farmers and consumers.
- African seed and grain sectors are mainly driven by maize.

Constraints to maize production in Africa
- Biotic stresses – Diseases (MLN, Leaf blights, stem and ear rots) & pests (FAW, stem borers and weevils).
WEMA Product Concept/Profile

- White hybrids (SC or 3-way)
- 25% yield improvement compared to 2008 hybrids under moderate drought conditions
  - Target 15% from breeding over 10 years
  - Additional 8-10% from DT transgene
  - Insect protection from \textit{Bt} transgene
- General Product Requirements
  - Drought tolerance
  - Maturity 125-135 days
  - Disease resistance: GLS, TLB, MSV and \textbf{MLN}
  - Agronomic traits: root lodging, prolificacy, maturity, husk cover
- Consumer requirements
  - Maintain required milling quality
  - Maintain meal yield
  - Grain Texture: flint to flinty-dent
# Breeding Technologies and approaches

## Technologies

- **Conventional breeding**
  - Pedigree breeding – line development through selfing
  - DH development and use
- **Molecular breeding**
  - Marker Assisted Recurrent Selection (MARS) / Genomic selection (GS)
  - Drought tolerant QTL mapping
- **Transgenic 4RD**
  - Drought tolerant transgene (MON87460)
  - Insect protected transgene (MON810)
  - Stack (MON87460+ MON810)
  - Insect protected transgene (MON89034)

## Approaches

**Accelerated forward breeding** – recycling elite germplasm from different projects and partners
- DT elite line x {DT elite line / Insect resistant elite line / MLN tolerant line / Off-PVP line
- CIMMYT x Monsanto / NARs

**Use of technologies that enhance genetic gains and breeding efficiency**
- Integration of DH technology
- Use of MARS and GS in breeding pipelines
- Use of project wide trial networking system
- Use of decision support tools (BMS, META-R, AGD-R, GEA-R)
- Following an advancement process (Stages 1-3 -> WWT -> NPT)
Partners worked together to create compelling products

Working together

- **Germplasm source**: CIMMYT, NARS & Monsanto
- **Germplasm exchange**: For breeding starts and hybrid make up
- **DH Facilities**: Monsanto and at CIMMYT (Kiboko)
- **MARS**: Genotyping at Monsanto and phenotyping at CIMMYT and NARs
- **Testing network**: Large; Developed / accessed from NARs, CIMMYT and Monsanto sites
- **Treatments**: Managed drought, random drought and optimum moisture CFT and open sites
- **Joint Site visits**: Held regularly for selection and cross learning
- **Germplasm advancement meetings**: Held regularly
- **Products /Ecologies**: Inbred / DH Lines & hybrids; for medium and early maturity ecologies
- **MLN Tolerance**: Rapid response
- **Trait Introgression**: To CIMMYT, NARS and Monsanto lines

### Summary of WEMA sites

<table>
<thead>
<tr>
<th>No</th>
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<th>No Sites</th>
<th>Elevation (masl)</th>
</tr>
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<td>1</td>
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<td>25</td>
<td>7 to 1900</td>
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<tr>
<td>2</td>
<td>Tanzania</td>
<td>15</td>
<td>252 to 1788</td>
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<tr>
<td>3</td>
<td>Uganda</td>
<td>9</td>
<td>1085 to 1790</td>
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<td>4</td>
<td>Mozambique</td>
<td>8</td>
<td>13 to 1356</td>
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<td>South Africa</td>
<td>7</td>
<td>1068 to 1180</td>
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<td>6</td>
<td>Zimbabwe</td>
<td>13</td>
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<td>7</td>
<td>Zambia</td>
<td>4</td>
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<td><strong>Total</strong></td>
<td><strong>81</strong></td>
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</table>
Lines & hybrids developed and hybrids released in WEMA countries from 2011-2018

DH lines developed and use

- 121 TEGO hybrids released in 5 countries
- Five TELA hybrids for South Africa

Hybrids developed and evaluated

- 101 TEGO hybrids released in 5 countries
- Five TELA hybrids for South Africa
Large scale implementation of GS/MARS in Africa

Leaf sampling

• 34 bi-parental populations (total = 6252 F_{2:3}, each with ca. 184 progenies)
• Each pop phenotyped in 2-4 managed water-stressed, 3-4 well-watered environments, and genotyped with 190-286 SNPs
• Genetic gain = 147 kg/year
Hybrids showed significant benefit of trait (MON87460) under drought stress in general and under severe, high and moderate drought stress.

The more severe the stress the higher the differences between positive and negative (up to 360 kg/ha).
Uganda and Kenya MON810 Field testing

- The gene has a positive and significant effect on yield across germplasm and trials. The yield increase was 52% on average.
- The gene significantly reduced numbers of exit holes and tunnel length across germplasm and trials.
Concluding Remarks

WEMA PDT Success = \{Product target * germplasm * Breeding approaches (Conv + Biotech) * teamwork * seed system\}

“Quick wins in conventional breeding are based on the alignment of research skills of the different partners, the choice of suitable technologies and approaches, an efficient and large scale testing network and access to diverse germplasm”

*External reviewer on WEMA Assessment of Key Lessons Learned*