Stress Tolerance for Food Security

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Converging challenges to Food Security
“In the next 50 years we will need to produce as much food as has been consumed over our entire human history.”
Megan Clark, CEO of the Commonwealth Scientific and Industrial Research Organization (CSIRO), Australia

Impacts of climate change
Current Wheat Mega-Environments

Impacts of climate change
Future Wheat Mega-Environments - 2020

Impacts of climate change
Future Wheat Mega-Environments - 2020

Impacts of climate change
1 billion people = 1/7 of the world population affected
Annual loss in 2025: USD 7.7 billion

- IPCC Climate Models
- increasing Heat Stress (wheat)
- 17-38% Reduction in High Potential Zone

Peak oil
Fertilizer prices

Water shortage
Land degradation
Challenges summarized: For food prices to remain constant, annual yield gains would have to increase

- From 1.2% to 1.7% for maize
- From 0.8% to 1.2% for rice
- From 1.1% to 1.7% for wheat
- On essentially the same land area, with less water, nutrients, fossil fuel, labor and as climates change

The more we delay investments, the steeper the challenge

We can change our future – Science provides us with tremendous opportunities

Regulators have opportunities and means to act

New drought tolerant varieties are available
However: Time to farmer 5-10 years

<table>
<thead>
<tr>
<th>DPV</th>
<th>Countries</th>
<th>Hybrid</th>
<th>Countries</th>
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<tbody>
<tr>
<td>ZM309</td>
<td>ZW, MW, SZ</td>
<td>FANES3</td>
<td>ZW, MW, ZM, GI, ZA, SZ</td>
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<tr>
<td>ZM401</td>
<td>ZW, TZ (Tan251)</td>
<td>Llige H7</td>
<td>ZG</td>
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<tr>
<td>ZM423</td>
<td>ZA, ZM, ZW</td>
<td>SM26</td>
<td>QM</td>
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<td>ZM523</td>
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<td>KE</td>
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<tr>
<td>AVS03</td>
<td>KE</td>
<td>TAN4003</td>
<td>ZG / KE</td>
</tr>
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</table>

Why are new varieties only slowly reaching farmers?

Bakir Luvarcic with ZM6251 seed production in Mozambique (Photo: Ken Rice)

Mr. Farias with pilot ZM401/00 hybrid seed production in Angola

Basis seed ready for dispatch from Ukolima Farm, SA, 2010

Community Seed Production of ZM430 in Zimbabwe, 2008

Agriseeds stock of ZM401 in Zimbabwe, 2010

Tanseed stock of ZM401 (Tan200) in Tanzania, 2008
### Accelerating time to farmers

**Action steps**
- Liberalize seed trade and price policies ⇒ larger markets
- Reduce overzealous barriers to variety release
- Facilitate access to business credits
- Invest in reliable seed production areas
- Increase seed quality control - combat fake seed

Source: CIMMYT, 2008

Variety descriptors ⇒ Fingerprints (LIC) + Sequences (HIC)

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### Accelerating breeding gains

<table>
<thead>
<tr>
<th>Year</th>
<th>System</th>
<th>No. data points</th>
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</thead>
<tbody>
<tr>
<td>2006</td>
<td>Illumina 1536</td>
<td>2.7M</td>
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<tr>
<td>2009</td>
<td>Illumina S5</td>
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<td>2011</td>
<td>Genotyping-by-sequencing</td>
<td>0.12M</td>
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</tbody>
</table>

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### What about transgenics?

Drought tolerance, nitrogen use efficiency ....

Collaboration with Monsanto, Pioneer, AATF, and several African countries

**Bottlenecks**
- Extent of single gene effect: 8-15%
- Translating lab results into consistent results in the field (GxG and GxE)
- Price of the technology ⇒ Humanitarian licenses

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### Seeds of Discovery

Exploring the untapped biodiversity for maize and wheat

- > 150,000 ancestral genotypes in 27,000 pop’s
- > 180,000 ancestral genotypes

*New technologies enable us to unlock the entire native genetic diversity of maize, rice or wheat for the price of commercializing 1-2 transgenics*

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### Seeds of Discovery

**Goals:**
- Fully characterize the untapped biodiversity of maize and wheat.
- Enable breeding programs worldwide to use maize and wheat biodiversity to meet tomorrow’s challenges.
- Public data release on a level playing field ⇒ Proactive IP strategy

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### Genotyping-by-sequencing (GBS)

- Differences in water-logging tolerance in maize

SNPs: Polymorphisms within the fragments

- ATGACATATCAG
- ATGAATATCAG
Making the data available as “Breeders’ digest”: visually intuitive genetic information

Sharing of germplasm and data
- Dissemination of data and information over web
  - Encourage a “level the playing field” approach focusing on tools and low hanging fruits
  - Pre-competitive domain: discourage IP protection on project products per se (sequences, markers) while allowing/encouraging IPR on downstream products (varieties)
- Potential to making benefit-sharing real:
  - Revenues from IP-protected downstream products to contribute to a fund for farmers in the center of origin

Seeds of Discovery will find heat tolerant wheat

Coordinated action plans are available

Conclusion
2010 - 2050: Food security will become an escalating concern

Science, policy makers, regulators must provide solutions