Breeding Climate-Smart Cowpeas for West Africa

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Rogério Chiulele, E. Mondlane U., Mozambique
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Cowpea in sub-Saharan Africa

Grain vitally important in human diet

Forage is highly valued for livestock feed

A Cowpea Forage Vendor

Kano, Northern Nigeria

‘Yacine’ grain, Senegal
Partners in semi-arid cowpea zones:
- INERA, Burkina Faso
- CSIR-SARI, Ghana
- IITA-Kano, Nigeria
- ISRA, Senegal
- Eduardo Mondlane University, Mozambique
Cowpea production zones relative to average annual rainfall in Burkina Faso
Drought events across cowpea growing stages

- **Seedling-stage drought**
  - Planting
  - Seedling

- **Mid-season drought**
  - Vegetative mid season
  - Flowering

- **Terminal drought**
  - Pod filling
  - Harvesting

QTLs for:
- **Early season delayed senescence**
- **Delayed senescence and stay-green**
Macrophomina phaseolina
Devastating under drought
Effective resistance available

Field symptoms in Senegal

Ashy stem blight or Charcoal rot
Delayed Senescence Phenotyping

Early Vegetative stage - Greenhouse

Sandbox seedling screen
SARI, Ghana

Muchero et al. (2008)
Crop science 48:541-552
Delayed Senescence Phenotyping

Early Vegetative stage - Greenhouse

SUS

Leaf senescence  Stem greenness  Recovery dry weight

TOL
Delayed Senescence Phenotyping

Vegetative stage field phenotyping
Coachella, CA
Ramping up genotyping capability

<table>
<thead>
<tr>
<th>Year</th>
<th>Platform</th>
<th>Assays/Platforms</th>
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<tbody>
<tr>
<td>2008</td>
<td>Illumina GoldenGate</td>
<td>1536 SNP assays</td>
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<tr>
<td></td>
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<td>Fixed Platform</td>
</tr>
<tr>
<td>2010/2011</td>
<td>LGC (Kbioscience)</td>
<td>~1100 mapped SNPs</td>
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<tr>
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<td>Customized sets of SNPs</td>
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<tr>
<td>2014/2015</td>
<td>Illumina iSelect</td>
<td>&gt;48,000 SNPs</td>
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<tr>
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<td>Fixed Platform</td>
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</table>
Drought tolerance QTL identified from both GWAS and Bi-parental mapping

Marker – Allele Effects: 189 Diverse Genotypes; LD mapping

LD decays between 1.5-2 cM
~10x QTL resolution LD mapping
383 diversity panel
Nigeria - 339; B Faso - 189; Senegal - 155; USA – 200

Muchero et al. 2013 PLoS ONE 8(7):1-10
Burkina Faso – MARS example

- Developed F2 from elite parents (Suvita 2, IT97K-499-35).
- Genotyped 300 F2s with 164 poly SNPs every 2 cM interval.
- Phenotyped F2:3 families
  - Pobe (low-yielding site)
  - Saria (high-yielding site)
QTL detection

Position in the whole genome

Yield
Grain size

Favorable alleles from Suvita 2
Favorable alleles from IT97K-499-35

QTL IciMapping: http://www.isbreeding.net/
QTL effects on yield and seed weight

**Yield-8 (1_0033)**

![Graph showing seed weight per plot (g) for Yield-8.]

- **A: Suvita-2 allele**
- **B: IT97K-499-35 allele**

**GDW-11 (1_0771)**

![Graph showing 100-seed weight (g) for GDW-11.]

- **A: Suvita-2 allele**
- **B: IT97K-499-35 allele**
Select best families with OptiMAS (IBP-BMS tool)

<table>
<thead>
<tr>
<th>F2:3 family</th>
<th>Molecular score</th>
<th>Yield QTLs</th>
<th>Kernel-size QTLs</th>
<th>Striga</th>
<th>Selected</th>
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<tbody>
<tr>
<td></td>
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<td>YLD-4</td>
<td>YLD-6</td>
<td>YLD-8</td>
<td>GDW-3</td>
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<tr>
<td>71</td>
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</table>

(Example list)

The Striga QTL is incorporated from prior publication
2002 Genome 45:787-793 (Ouédraogo et al.)
OptiMAS summary: Frequency of favorable alleles at different selection steps in Burkina Faso MARS (on average and for each QTL)
Yield performance of MARS lines under different rainfall conditions (Saria, Burkina Faso, 2015)

**Drought**
(Planted on 18 Aug 2015
Rainfall 372 mm)

**Normal rainfall**
(Planted on 03 Aug 2015
Rainfall 539 mm)
Seed size of MARS lines under different rainfall conditions
(Soria, Burkina Faso, 2015)

**Drought**
(Planted on 18 Aug 2015
Rainfall 372 mm)

**Normal rainfall**
(Planted on 03 Aug 2015
Rainfall 539 mm)

![Bar chart showing seed size under different conditions]

- **Parents**
- **MARS positive**
- **MARS negative**
- **Local checks**
Illumina BeadChip for Cowpea

- Reliably assays >48,000 SNPs
- 37,372 SNPs on current consensus map
- Available from Illumina since 8/2014

http://www.illumina.com/areas-of-interest/agrigenomics/consortia.html
350-line 8-parent MAGIC population - founder parents and traits relevant to sub-Saharan Africa

<table>
<thead>
<tr>
<th>Founders</th>
<th>High yielding under drought in:</th>
<th>Resistance traits</th>
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<tbody>
<tr>
<td></td>
<td>Senegal</td>
<td>Nigeria</td>
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<tr>
<td>A: IT89KD-288</td>
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<tr>
<td>B: IT84S-2049</td>
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<tr>
<td>C: CB27</td>
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<tr>
<td>D: IT82E-18</td>
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<tr>
<td>E: SuVita 2</td>
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<td>F: IT00K-1263</td>
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<td>G: IT84S-2246</td>
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<tr>
<td>H: IT93K-503-1</td>
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</table>
Cowpea MAGIC population in Coachella Valley, CA in 2015 (47 days after planting)
Cowpea MAGIC population in Coachella Valley, CA in 2015 (75 days after planting)

Restricted irrigation (Drought)  Normal irrigation
MAGIC parents in Coachella Valley, CA in 2015 (100 days after planting)

Normal irrigation

Restricted irrigation (Drought)
350-line 8-parent MAGIC population field phenotyping under drought S. California, 2015
Cowpea variation in N-fixation under drought

Should we target these as yet unmapped loci for breeding selection?

Sinclair et al., 2015, *Crop Science* 55: 2270-75
Opportunity to target favorable root traits with QTL mapping and MAS for drought tolerance breeding

Photos: J. Burridge
Summary

• Define the target(s) for drought tolerance
• Associated problems (e.g. diseases under drought)
• Enhanced genotyping technologies and tools
• Challenges of phenotyping in TPEs
• Importance of collaborative partnerships
Thank you!