Seeds of Discovery: A platform for enhanced use of genetic resources

Kevin Pixley, Sarah Hearne, Sukhwinder Singh & many colleagues
Converging Challenges to Global 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, CSIRO CEO
Vision of Success: the wealth contained in the world’s genetic resources is ‘unlocked’ for breeders globally to make new varieties

≈ 28,000 maize

≈ 150,000 wheat

Use of crop wild relatives in the past 20 years in released cultivars of 13 crops of international importance

(Euphytica 2007, 156:1-13)
Challenges of Use

Lack of relevant information
High-density genetic profiles

Genomic characterization using DArTseq
  • SNP and PAV markers

✓ 28,000 Maize
✓ 100,000 Wheat
# Field and laboratory phenotyping

**Maize**: >1.5m data points

<table>
<thead>
<tr>
<th>Traits</th>
<th>Experiments</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Abiotic stresses</strong></td>
<td>heat</td>
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<tr>
<td></td>
<td>drought</td>
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<td></td>
<td>low N</td>
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<tr>
<td><strong>Biotic stresses</strong></td>
<td>tar spot, ear rot, stalk rot, <em>Turcicum, Cercospora, MLN (MCMV &amp; SCMV)</em></td>
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<tr>
<td><strong>Grain quality</strong></td>
<td>hardness, starch, oil, amino acids, phenolics</td>
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Flowering
- Plant, ear height
- Stem, root lodging
Diversity panels for breeders

- 1000 entries, $200k USD
- 500 entries, $100k USD
- 100 entries, $20k USD
- ~5,000 entries, $1M USD
Core sets of wheat landraces

PCA of Iranian landraces (core entries circled)

PCA of Mexican landraces (core entries circled)

N=2404  N=361

N=8416  N=1261

7%  3%

Number of Iranian landraces with grain yield >150 grams m$^{-2}$ under heat stress (Cd. Obregón, México)

Number of Mexican landraces with grain yield >150 grams m$^{-2}$ under heat stress (Cd. Obregón, México)
Exploring genetic resources for heat-adaptive traits (wheat)

Elite lines:
ESWYT - Blue
SAWYT - Green

Tolerant Landraces:
Iranian : Red
Mexican : Yellow
GWAS: Flowering and broad adaptation (maize)

Romero et al. Nat Gen 2017
Can apply to many traits: Grain protein content (maize)

What’s next?

- DArTseq
- GWAS phen
- GS model, validated with FT, PH
- Predict Bank materials

Total number of markers: 611457

Image credits: CIMMYT
Environmental GWAS (maize)

Environmental GWAS using GBS 500k markers

Soil pH

6-month precipitation

What’s next?
- DArTseq
- GIS
- Env GWAS

Alberto Romero
A “greening agriculture” program

- Research portfolio focused on carbon footprint reducing, eco-friendly maize and wheat system technologies
  - Genetic Diversity: Nutrient use efficiency, GxM, nutrition, ?
  - Agronomy
- Participate in global discussions to define targets for sustainable agriculture
  - Representing the perspectives of farmers and societies in low and middle income countries
A “greening agriculture” program

• Define and pursue opportunities for poverty alleviation and food security in low and middle income countries, with realistic targets on resource conservation

• Social and economic analyses of options, e.g. participatory plant breeding, stress tolerance breeding, climate smart systems/villages, novel breeding technologies (e.g. transgenics, gene editing), etc.
Biodiversity – an untapped opportunity

• Hypothesis: synergies are possible between crop breeding and crop management to address challenges of environmental sustainability and climate change
  – Explore the biodiversity contained in our germplasm bank for novel, valuable traits that prioritize this goal
  – Aggressive discovery and pursuit of genetic traits that contribute to cropping system sustainability or “eco-friendliness” - both through G and GxE – is largely an untapped opportunity
Biodiversity for sustainable agriculture

• What do you – pioneers/advocates/architects of sustainable agriculture - wish for in maize and wheat varieties?
• Which are the traits to prioritize?
Thank you for your interest!

www.seedsofdiscovery.org