PL-1: Drought and Low P Tolerant Common Bean, Cowpeas, and Soybean

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With inputs from A. Alene, E. Birachi, N. Duarte, E. Katungi, M. Lungaho, O. Boukar, S. Prager, I. Rao, J.C. Rubyogo, R. Zulu, and many national partners

http://grainlegumes.cgiar.org

Leveraging legumes to combat poverty, hunger, malnutrition and environmental degradation
Product Line Description

- Background Issues and R4D Challenges

- Soil fertility...most widespread yield limitation across the tropics, but why P?
  - P deficiency is especially common
  - Fertilizer is expensive, and P reserves are limited
  - P efficiency in uptake and use is critical in short and long term

- Drought...the biggest RISK factor

- Combined stress can lead to interactions and far more reduction in yield

- An approach of genetics + agronomic management is required
Product Line Description

- Background Issues and R4D Challenges

Figure 1. Map of global soil phosphorus availability. The dominance of red and light-gray colors, indicating suboptimal phosphorus availability for the growth of many plant species, indicates the importance of phosphorus availability as a primary limitation to plant productivity in terrestrial environments (from Jaramillo-Velastegui, 2011).
Objectives 2012-16:

- **Overarching Goal:** Common bean, cowpea, and soybean cultivars having combined tolerance to drought and low P.

- **Outcomes:**

<table>
<thead>
<tr>
<th>Output targets</th>
<th>Outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quantitative data on degree of stress</td>
<td>More focused research agenda</td>
</tr>
<tr>
<td>Common screening methods for tolerance to drought and low P</td>
<td>More efficient selection</td>
</tr>
<tr>
<td>Field screening sites</td>
<td>Access to field sites</td>
</tr>
<tr>
<td>Sources of shoot and root traits</td>
<td>Breeders use trait selection</td>
</tr>
</tbody>
</table>
## Outcomes

<table>
<thead>
<tr>
<th>Output targets</th>
<th>Outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Key alleles and gene based markers identified</td>
<td>Breeders use favorable alleles</td>
</tr>
<tr>
<td>QTL for relevant traits</td>
<td>Breeders use molecular markers</td>
</tr>
<tr>
<td>Ideotypes with key traits developed</td>
<td>Breeders, physiologists and agronomists use trait approach</td>
</tr>
<tr>
<td>Cultivars developed &amp; disseminated</td>
<td>Farmers benefit from 30% higher yields</td>
</tr>
<tr>
<td>Processing technologies refined and disseminated</td>
<td>Benefits from less post-harvest losses and value added products</td>
</tr>
<tr>
<td>Capacity of NARS enhanced</td>
<td>Efficient NARS breeding programs</td>
</tr>
</tbody>
</table>
RESULTS:
SC-1: Analyzing demand and setting research priorities

- In response to the Science Council “must have” on demonstrating demand...COMMON BEAN

Per capita real bean expenditures (UGX) in the past 7 days, per wealth quintile, Rural and Urban Uganda

<table>
<thead>
<tr>
<th>Quintile</th>
<th>Rural</th>
<th>Urban</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quintile 1</td>
<td>408.23</td>
<td>462.57</td>
</tr>
<tr>
<td>Quintile 2</td>
<td>675.71</td>
<td>788.54</td>
</tr>
<tr>
<td>Quintile 3</td>
<td>917.63</td>
<td>818.07</td>
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<tr>
<td>Quintile 4</td>
<td>1087.3</td>
<td>686.00</td>
</tr>
<tr>
<td>Quintile 5</td>
<td>1237.1</td>
<td>832.87</td>
</tr>
</tbody>
</table>
RESULTS:
SC-1: Analyzing demand and setting research priorities

- In response to the Science Council “must have” on demonstrating demand...COWPEAS
RESULTS:
SC-2: Developing productive varieties & management practices

Is it feasible to develop multiple-stress tolerant legumes?

<table>
<thead>
<tr>
<th></th>
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</thead>
<tbody>
<tr>
<td>BFS 81</td>
<td>1014</td>
<td>1</td>
<td>1418</td>
<td>3</td>
<td>1216</td>
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<tr>
<td>INTA CENTRO SUR</td>
<td>851</td>
<td>5</td>
<td>1459</td>
<td>2</td>
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<tr>
<td>BFS 85</td>
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<td>1478</td>
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<td>14</td>
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<td>14</td>
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<td>BFS 10</td>
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<td>16</td>
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<tr>
<td>INTA ROJO</td>
<td>465</td>
<td>17</td>
<td>791</td>
<td>15</td>
<td>628</td>
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<tr>
<td>RECREO 1</td>
<td>380</td>
<td>19</td>
<td>526</td>
<td>19</td>
<td>453</td>
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<tr>
<td>Average</td>
<td>713</td>
<td></td>
<td>980</td>
<td></td>
<td>847</td>
</tr>
</tbody>
</table>
RESULTS:
SC-2: Developing productive varieties & management practices

Cowpeas: QTL analysis to back up MARS for drought

<table>
<thead>
<tr>
<th>Trait</th>
<th>Environment</th>
<th>Marker</th>
<th>Chr</th>
<th>% Var.</th>
<th>Additive</th>
<th>Positive parent</th>
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</thead>
<tbody>
<tr>
<td>Grain yield</td>
<td>Minjibir</td>
<td>1_1526</td>
<td>1</td>
<td>8.4</td>
<td>35.1</td>
<td>IT84S-2246-4</td>
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<tr>
<td></td>
<td>Minjibir</td>
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<td>4</td>
<td>9.1</td>
<td>40.8</td>
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<tr>
<td>Staygreen</td>
<td>Malamadori</td>
<td>1_0436</td>
<td>3</td>
<td>11.2</td>
<td>0.2</td>
<td>IT84S-2246-4</td>
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<tr>
<td></td>
<td>Malamadori</td>
<td>1_0684</td>
<td>5</td>
<td>14.1</td>
<td>0.2</td>
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<tr>
<td></td>
<td>Malamadori</td>
<td>1_0719</td>
<td>7</td>
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<tr>
<td></td>
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<tr>
<td></td>
<td>Malamadori</td>
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<td>9</td>
<td>10.0</td>
<td>-0.2</td>
<td>IT98K-1111-1</td>
</tr>
</tbody>
</table>
RESULTS:
SC-3. Facilitating legume seed & technology delivery systems

- Significant advances...

Policy change in ES Africa: Acceptance of QDS - *Quality Declared Seed*

- An option to certified seed
- Good seed produced by trained farmers
- Lower transport costs
- Option of availing locally preferred varieties
- Local entrepreneurship

Seed produced (MT):
- 96,000 of bean,
- 16,549 of cowpeas and soybean

*The Syngenta Foundation*

- Increasing the role of private companies including licensing of varieties
RESULTS:
SC-4. Post-harvest processing & market opportunities

Bean-based products for urban and rural markets
  • Convenience
  • Cooking time

Burundi:
  • Cottage industry of porridge
  • Expand, from 2 to 10 T/mo
RESULTS:
SC-4. Post-harvest processing & market opportunities

Documenting bean trade corridors permits defining the product...
- For which market...
- Produced where...
- Under what constraints...
- In what volume...
- And which varieties...
- And with what other service providers?
RESULTS:
SC-5. Fostering innovation and managing knowledge

An Innovation Platform for Nutrition

- **National School Feeding Program of Madagascar** using the bean-based flour.
- Key actors working together
  - PROFIT Company (food sector)
  - Ministry of Agriculture and Rural Development
  - Ministry of Health,
  - Ministry of National Education
  - Ministry of Trade
  - Ministry of Finance
  - Ministry of Population, Social Protection and Women Promotion
IMPACT

- Ex-ante evaluation: Drought tolerance of Bean under Global Futures:
  - Average increase of 24.7% across countries
Lessons Learned

- Systematic analysis demonstrates much unmet demand – a huge challenge, even to keep up with population growth and economic growth!
- Multiple stress breeding...possible and potentially very productive but many “red herrings” (false leads)
- In addition to QDS, there is increasing interest by private sector in bean seed.
- It is feasible to be creative and open new areas of impact with a modest investment in human resources to build bridges to other disciplines (e.g., food industry)
Areas suggested for continued R4D

- Crop physiology
  - What are the physiological TRIGGERS that control the plant’s commitment to yield production? (vegetative vs reproductive)

- Climate change
  - How severe? Where? Market dynamics?

- Markets
  - Dialog with private sector to predict future product type and demand

- Seed systems
  - How to respond to differentiated markets? How to add value to seed?

- Genomics
  - How can comparative genomics (Arabidopsis; Medicago; soybean) be employed as a complement to physiology?

- Breeding
  - How can interspecific crosses be exploited more efficiently for adaptation to extreme environments?
## Contributing Bilateral Projects

<table>
<thead>
<tr>
<th>Effecting change in seed security response: In crisis, chronic stress and developmental contexts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pathogen distribution, characterization and identification of resistance markers associated with root rot resistance in common beans</td>
</tr>
<tr>
<td>Africa rising - research in sustainable intensification for the next generation</td>
</tr>
<tr>
<td>Promoting business models for sustainable trading relationships among smallholder farmers in Eastern Africa</td>
</tr>
</tbody>
</table>

* An Integrated Program to Accelerate Breeding of Resilient, More Productive Beans for Smallholder Farmers

| Strengthening bean seed systems with focus on bio-fortified bean varieties to respond to bean farmers and market demand in Burundi, Kenya and Rwanda |
| Improving food security, nutrition, incomes, natural resource base and gender equity for better livelihoods of smallholder households in Sub-Saharan Africa |
| Feminization, agricultural transition and rural employment: social and political conditions of asset building in the context of export-led agriculture |

* Pre cooked Beans for improving Food and Nutrition Security and income generation in Kenya and Uganda

* Assessing Impacts of the Adoption of High Iron Bean Varieties on Bean and Iron Intake of Rural Vulnerable Populations in Rwanda

* Unlocking the Potential of Seed Companies to Reach Small Holders with Quality Seed of New Bean Varieties in Northern Tanzania

* Strengthening partnerships for innovation in Beans, groundnuts and sesame research and technology transfer in Mozambique

| Improving Livelihoods for Smallholder Farmers: Enhanced Grain Legume Productivity and Production in Sub-saharan Africa and South Asia |
Summary

- Progress in breeding for drought
- Variability in root traits. Root hairs seem to be an excellent option.
- Enough success in multiple stress breeding to validate potential
- Ex ante analysis suggests important gains from drought tolerance
- Seed policy and QDS has great potential to exploit local seed production
- Links to the food industry offer viable options for collaboration, often with a nutrition focus
List of Posters

• Back to our roots: Morphological variability in bean and cowpea roots that influence agronomic performance

• Water use in bean and cowpeas: efficiency or effective use of water?

• P response in bean and cowpea: traits and results
Leveraging legumes to combat poverty, hunger, malnutrition and environmental degradation

CIAT
- S. Beebe
- E. Birachi
- R. Chirwa
- D.G. Debouck
- C. Mukankusi
- R. Buruchara
- G. Mosquera
- J. Tohme

IITA
- B. Raatz
- I.M. Rao
- J.C. Rubyogo
- E. Katungi
- M. Lungaho
- E. Maereka
- R. Muthoni

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