Breeding beans for drought tolerance, multiple disease resistance, nutritional and canning quality in Kenya

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Bean for Climate Change Consortium
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Contents

• Drought tolerance
  • Mesoamerican
  • Andean
• Mechanisms of drought tolerance
  • Shoot traits
  • Root traits
• Participatory selection for drought tolerance
• Canning Quality
  • Water absorption
  • Cooking time
• Partnership for Seed production and Dissemination
• Conclusions and future directions
• Acknowledgements
Overview of Breeding Canning Beans Adapted to Biotic and Abiotic stresses

Rationale

- Current variety more than 50 years old, susceptible to biotic and abiotic stresses
- Processing industry not able to meet demand e.g. 300 t/year for Trufoods
- Erratic supply and poor quality raw materials
- Industry demand for better varieties
- Demand for fast cooking or pre-cooked products – high energy costs
- Changing eating habits - wider range of preferences with urbanization
- Focus on 7 market classes for canning industry
  - Fast cooking- for direct consumption
  - Pre-cooked products
  - Canned products

Process

445 lines
Agronomic potential - yield, diseases, vigour, growth habit

150 lines
Drought tolerance & farmer preferences

20-25 lines
Canning and Nutritional quality
Gene pools and Market Classes

**Andean**
- Red mottled
- Red kidney
- Speckled sugar

**Mesoamerican**
- Navy
- Small Red
- Pinto
- Carioca
- Tan
- Yellow
- BEIGE
- Green yellow
New drought tolerant Mesoamerican lines

New Drought tolerant Navy, Small Red and Mixed colour lines are better yielding than local and international checks in drought stressed and non-stressed conditions.
New drought tolerant Andean lines

- New Drought tolerant
- Red mottled,
- Red kidneys
- Speckled sugar lines are better yielding than local checks in drought stressed and non-stressed conditions at Kabete and Mwea

![Graph showing reduced and drought stress yields of various Andean lines with their respective codes and yields.](image-url)
## Mechanisms of Drought tolerance- Shoot traits

<table>
<thead>
<tr>
<th>Plant traits</th>
<th>Irrigated</th>
<th>Rainfed (Stress)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Canopy biomass (kg/ha)</td>
<td>0.64***</td>
<td>0.25**</td>
</tr>
<tr>
<td>Pod harvest index (%)</td>
<td>0.62***</td>
<td>0.40***</td>
</tr>
<tr>
<td>Grain harvest index (%)</td>
<td>0.50***</td>
<td>0.39***</td>
</tr>
<tr>
<td>Pod partitioning index (%)</td>
<td>0.57***</td>
<td>0.89***</td>
</tr>
<tr>
<td>Pod wall biomass proportion (%)</td>
<td>0.26**</td>
<td>0.19*</td>
</tr>
<tr>
<td>Stem biomass reduction (%)</td>
<td>-0.18*</td>
<td>0.32**</td>
</tr>
<tr>
<td>Total chlorophyll content (SPAD)</td>
<td>0.24**</td>
<td>0.18**</td>
</tr>
</tbody>
</table>

*, **, *** Significant at p<0.05, p<0.01 and p<0.001 probability levels respectively.
Mechanisms of Drought tolerance - Root traits

Framework for root studies at Kabete Field Station, January 2013

No Stress treatment

Drought stressed plants

Tagging a young spread leaf for measurements

A tagged young spread leaf for measurements

Measuring chlorophyll content on leaf using SPAD
Participatory selection for drought tolerance

- Mwea and Kabete for two seasons
- Gender disaggregated
- Selection under stress and no stress plots
- Ribbon method for preferred and non-preferred line

Key traits for farmers:
- Yield
- Drought tolerance
- Earliness
- Marketability
- Fast cooking
- Taste
- Plant type
- Non shattering
- Foliage
PVS for drought tolerant lines conducted at Mwea and Kabete in 2011 and 2012

Bean program staff explains objective and technique of selection

Farmers select at Kabete Field Station, March 2012

Preferred line

Rejected line

Refreshments
Selection for Multiple Disease Resistance

BCB 11-34 is a small white (navy canning bean) which showed high degree of resistance to ALS, anth, BCMV and CBB at Kabete during the LR 2012. Note that neighbouring lines were destroyed by the disease.

BCB 11-196, a small red showed high degree of resistance to anth, angular leafspot, BCMV and CBB at Kabete during the LR 2012-12-15 (picture taken 10 July 2012). Note adjacent lines were devastated by the disease.

BCB 11-162 is highly disease resistant red kidney line with good vigour at Kabete, LR 2012

Photo: 10 July 2012 at 7.26 PM

BCB 11-400 is disease resistant red mottled line. Note adjacent lines were severely damaged by diseases at Kabet LR 2012

Photo: 10 July 2012 at 4.23 PM

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Photo: 10 July 2012 at 4.23 PM
## Summary of Advanced lines with Multiple Disease resistance and high yield potential

<table>
<thead>
<tr>
<th>Market Class</th>
<th>Lines select for MDR</th>
<th>Resistances</th>
</tr>
</thead>
<tbody>
<tr>
<td>Red mottled</td>
<td>21</td>
<td>ALS, root rots, BCMV, anthracnose, CBB</td>
</tr>
<tr>
<td>Red kidney</td>
<td>23</td>
<td></td>
</tr>
<tr>
<td>Speckled sugar</td>
<td>17</td>
<td></td>
</tr>
<tr>
<td>Navy</td>
<td>24</td>
<td></td>
</tr>
<tr>
<td>Small Red</td>
<td>22</td>
<td></td>
</tr>
<tr>
<td>Pinto/carioca</td>
<td>19</td>
<td></td>
</tr>
<tr>
<td>Mixed colours</td>
<td>24</td>
<td></td>
</tr>
</tbody>
</table>

- Lines currently in AYT at Kabete, Thika, Meru, Nakuru and Tigoni
Fig 1. Water absorption by advanced navy bean canning bean lines over a 16 hour period.
Fig 2. Percent water absorption of advanced navy bean lines soaked for 16 hours
Fig 4. Water absorption of advanced small red lines over 16 hours.
Fig 5. Water absorption of advanced small red lines after soaking for 16 hours.
Fig 10. Water absorption trends of advanced red kidney bean lines soaked over 16 hours
Fig 12. Water uptake patterns of advanced red mottled lines over 16 hours
Fig 13. Water absorption of advanced Red Mottled lines soaked for 16 hours
Fig 14. Water absorption patterns of advanced speckled sugar lines soaked for 16 hours.

Percent water absorption

Genotype

Genotype

Genotype
Fig 15. Water absorption of advanced speckled sugar bean lines soaked for 16 hours
Cooking Time

Fig 1. Cooking time of advanced Red Mottled canning bean lines grown at Kabete Field Station, 2012
Fig 2. Cooking time of advanced Red Kidney canning bean lines
Fig 3. Cooking time of advanced Speckled Sugar canning bean lines
Fig 5. Cooking time of advanced Navy Bean lines grown at Kabete Field Station, 2012
Fig 4. Cooking time of advanced Small Red canning bean lines
## Certified Seed Production

<table>
<thead>
<tr>
<th>Season</th>
<th>Category of Seed</th>
<th>Quantity (kg)</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>LR 2011</td>
<td>Nucleus</td>
<td>350</td>
<td>Stage I, II</td>
</tr>
<tr>
<td>Breeder</td>
<td>4,129</td>
<td>Isiolo, Naivasha, Kabete</td>
<td></td>
</tr>
<tr>
<td>Basic</td>
<td>4,562</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>9,041</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SR 2011</td>
<td>Nucleus</td>
<td>800</td>
<td>Stage I, II and III</td>
</tr>
<tr>
<td>Breeder</td>
<td>8,000</td>
<td>Used by Simlaw Ltd as pre-basic and planting certified seed</td>
<td></td>
</tr>
<tr>
<td>Basic</td>
<td>12,667</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>21,467</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LR 2012</td>
<td>Nucleus</td>
<td>1.2 ha</td>
<td>Kabete (stages I, II and III)</td>
</tr>
<tr>
<td>Breeder</td>
<td>7 ha</td>
<td>Kabete (SEMI)</td>
<td></td>
</tr>
<tr>
<td>Basic</td>
<td>73 ha</td>
<td>Diverse areas (see semi-annul report)</td>
<td></td>
</tr>
<tr>
<td>Certified</td>
<td>100</td>
<td>Simlaw Production Dept</td>
<td></td>
</tr>
</tbody>
</table>
8 May 2012

Pilot food processing Plant-CAVS

Blanching

Seaming

Retort

Cooling system

Recorder

Steam generation and regulation
Future Directions

• Complete lab canning tests
• Industrial canning - grain production
• NPT
• Fe-Zn analysis
• Root studies
• Graduate students - complete work
• Bio-innovate conference
• Publications
Conclusions

• New dry bean varieties meant for canning should possess **good canning qualities while ensuring uniform and complete water uptake** in order to prevent further expansion of beans in the can.

• The **new advanced drought tolerant and disease resistant dry bean lines** possess the physical suitability for **direct consumption, pre-cooked and canned bean** products.

• **Water uptake, percent volume increase** and **cookability** after soaking are critical characteristics of dry beans destined for the canning industry.

• Most genotypes took up at least **90% water** and qualify for canning purposes, with seven lines in seven **market classes** picking up water and cooking **faster** than the control.

• The new lines compared well, some even better, with the control navy bean variety, the **Mexican 142** which is imported, and popular for its taste and short cooking time.

• These new drought and disease resistant varieties have a **clear potential for enhancing productivity, nutrition and food security** and livelihoods of smallholder farmers and **new products** for processing industry.
Acknowledgements

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PVS for drought tolerant canning beans in Mwea
THANK YOU