Soybean breeding in Africa

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Soybean in Africa

- Improve human nutrition
- Major animal feed source
- Improve soil fertility
- Increase farmers' income
Production area of the major field crops in hectares (ha)
World soybean production
Africa’s soybean area = 1.5 million ha and production = 1.8 million tones with an average 1186 kg ha\(^{-1}\)

The world average yield per ha = 2471 kg
Why soybean were considered by IITA

- Little effort in improving soybean in Africa
- Yield was extremely low
- Low seed viability
- Poor nodulation with native *Rhizobium*
- High shattering in the moist and dry savanna
Some characteristics of soybean breeding locations in sub-Saharan Africa

<table>
<thead>
<tr>
<th>Location</th>
<th>Coordinates</th>
<th>Elevation (masl)</th>
<th>Rainfall long-term average (mm)</th>
<th>Vegetation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mokwa, Nigeria</td>
<td>6°5’N, 9°48’E</td>
<td>308</td>
<td>1100</td>
<td>Southern Guinea savanna</td>
</tr>
<tr>
<td>Zaria, Nigeria</td>
<td>11°11’N, 7°38’E</td>
<td>685</td>
<td>900</td>
<td>Northern Guinea savanna</td>
</tr>
<tr>
<td>Kano, Nigeria</td>
<td>12°47N, 9°2E</td>
<td>700</td>
<td>600</td>
<td>Sudan savanna</td>
</tr>
<tr>
<td>Chitedze, Malawi</td>
<td>15° 55' S, 35° 04' E</td>
<td>1146</td>
<td>892</td>
<td>Plateau</td>
</tr>
</tbody>
</table>
Suitable Areas for Soybean Production in Africa

Annual rainfall (mm)

- < 150
- 151 - 500
- 501 - 750
- 751 - 1,000
- 1,001 - 1,200
- 1,201 - 1,400
- 1,401 - 1,800
- 1,801 - 2,000
- 2,001 - 2,500
- > 2,500

Suitability
- Not suited
- Very Marginal
- Marginal
- Suitable
- Very Suitable
- Excellent
Trend of soybean production in major countries in Africa

![Chart showing soybean production trends in Africa](chart.png)
World soybean yield
World soybean yield
Soybean production in Africa, 2011

<table>
<thead>
<tr>
<th>Country</th>
<th>Yield (kg ha(^{-1}))</th>
</tr>
</thead>
<tbody>
<tr>
<td>South Africa</td>
<td>1578</td>
</tr>
<tr>
<td>Zimbabwe</td>
<td>1574</td>
</tr>
<tr>
<td>Uganda</td>
<td>1202</td>
</tr>
<tr>
<td>Nigeria</td>
<td>946</td>
</tr>
<tr>
<td>Malawi</td>
<td>700</td>
</tr>
<tr>
<td>Rwanda</td>
<td>632</td>
</tr>
</tbody>
</table>

Country distribution:

- Nigeria: 32%
- South Africa: 40%
- Malawi: 4%
- Zimbabwe: 4%
- Uganda: 10%
- Rwanda: 2%

Total production: 1,787,270 tones
The State of Food Insecurity in the World 2012

870 million hungry people worldwide

1990-92 - 130 million
2010-12 - 870 million

There are 130 million fewer hungry people today than there were 20 years ago

Number of hungry declining in Asia and Latin America

FAO infographic SOFI 2012-en
Number of hungry people, sub-Saharan Africa

170 millions

234 millions

Asia and Latin America have reduced the number of hungry people, while the number is on the rise in sub-Saharan Africa.
The Millennium Development Goal 1 hunger target, halving the proportion of hungry people in developing countries by 2015, is still within reach.
Soybean yield improvement

Objectives

Constraints

Factors

Yield
Production constraints

- Lack of high yielding varieties tolerant to droughts
- Lack of varieties tolerant to diseases such as rust
- Lack of seed production and distribution systems
- Lack of organized market
- Lack of processing knowledge for home consumption
Objectives of program

- Breed for high grain and fodder yield
- Breed for early maturity
- Breed for disease/pest, shattering, lodging and drought tolerance
- Breed for promiscuity in nodulation
- Breed for good human consumption quality
How: Proposed Activities

The main goal of is to enhance the productivity of soybean in the farmers’ fields in target countries of SSA and demonstrate its processing for small-scale households and link them to markets.

This will be achieved through two general objectives:

• Develop improved soybean varieties, and
• Promote soybean processing and utilization at the household and community level and link them to soybean supply chain.
Breeding approach

Concentrate various traits into superior and adapted varieties

Selection (on-station & on-farm)

Crosses
Soybean varieties released in Africa

Soybean Variety Release

Number of varieties released

- IITA bred
- IITA parent
- Non-IITA
- total

- earlier
- 1981-1990
- 1991-2000
- 2001-2010
- unknown

- 18
- 56
- 109
- 176
- 204
### Development of soybean varieties/lines tolerant to drought and soybean rust with enhanced BNF

<table>
<thead>
<tr>
<th>Variety</th>
<th>Country/Year</th>
<th>Traits Improved</th>
</tr>
</thead>
<tbody>
<tr>
<td>TGx 1835-10E</td>
<td>Nigeria (2008)</td>
<td>Rust resistance</td>
</tr>
<tr>
<td><strong>Nyala, Hill, Black Hawk, Gazelle, EAI 3600</strong></td>
<td>Kenya (2009)</td>
<td>Grain yield, adaptation</td>
</tr>
<tr>
<td>TGx 1904-6F</td>
<td>Nigeria (2009)</td>
<td>Grain, biomass</td>
</tr>
<tr>
<td>TGx 1740-2F, TGx 1895-33F</td>
<td>Kenya (2010)</td>
<td>Yield, adaptation</td>
</tr>
<tr>
<td><strong>TGx 1740-2F (Tikolore)</strong></td>
<td>Malawi (2011)</td>
<td>Yield, earliness</td>
</tr>
<tr>
<td>TGx 1740-2F, TGx 1908-8F, TGx 1904-6F, TGx 1937-1F, TGx 1485-1D</td>
<td>Mozambique (2012)</td>
<td>Grain and biomass yield, adaptation</td>
</tr>
</tbody>
</table>
Breeding for improved soybean to the benefit of African farmers

Germplasm accessions trail

soybean preliminary variety trials (PVT)

Advanced variety trial (AVT)

Farmer participatory variety selection trials
List of Trials in Malawi in 2011/12

- Advanced variety trial: Early set
- Preliminary variety trials: Sets 1, 2, 3, 4 & 5
- Farmer participatory variety selection trials
- Germplasm accessions trial (screening for rust resistance and promiscuity in nodulation)
- Segregating populations
Segregating Populations

- 24 parental lines (grain and biomass yields, earliness, rust tolerance, drought tolerance, seed quality, farmer’s preference)
- $F_2$ generations from 24 crosses were grown in 2011/12
- $F_3$ generations from 38 families were grown in 2012
- $F_4$ generation from 20 crosses (669 single plants) in 2012
- $F_5$ generation from 20 crosses (536 families) in 2012
- $F_6$ generation from TGx 1987-14F x Nasoko (53 families) and Nasoko x TGx 1740-2F (91 families) in 2012
Germplasm accessions trail

Objectives
- Assess adaptation
- Select for resistance to soybean rust disease
- Select for promiscuity in nodulation
- Germplasm collection and their seed increase

Materials & Methods
- 260 genotypes planted at Bvumbwe in 3 reps
- 2m single row plot size used
- Late planted on 14 January 2012 for rust exposure
- No seed inoculants (rhizobia) applied

Results
- Severe rust attack recorded on most of the genotypes
  - 11 TGx genotypes scored 35% and below
- Highly promiscuous genotypes were identified
  - TGx 1988-12F and TGx 1989-52F gave largest nodule dry weights of 456mg and 358mg per plant respectively
Germplasm accessions trail

Phakopsora pachyrhizi

Rust at R6 (%)
Grain weight (g)

Rust at R6
Grain weight

Preliminary Variety Trial (PVT)

- The objective was to assess the adaptability and yielding ability of the IITA developed soybean lines
- From nursery and IITA-Nigeria; and Chitedze and Chitala, Malawi
Three sets (sets 1, 2 and 4) of PVT comprising of 25 genotypes each were evaluated at Chitedze Research Station.

Eight recommended varieties: Nasoko, Makwacha, Magoye, UG5, TGx 1448-2E, TGx 1440-1E, TGx 1485-1D and Tikolore.
Mean performance of 25 soybean genotypes tested in PVT set 1
Mean performance of 25 soybean genotypes tested in PVT set 3
Objective

to compare the field and yield performance of introduced IITA varieties with four recommended check varieties (Tikolore, Magoye, Nasoko and Magoye)

- The locations were Bvumbwe, Chitala, Chitedze, Makoka, Mbawa
- The entries (16 IITA varieties & 4 recommended varieties)
- The Design: RCBD with 3 replicates
- PS: 6m x 2m with 4 rows spaced at 50cm
Advanced variety trial

Mean grain yields (Kg ha\(^{-1}\))

TGx 1989.60F
TGx 1987.62F
TGX 1991.18F
TGX 1988.9F
TGX 1989.46F
TGX 1988.22F
TGX 1991.22F
TGX 1988.18F
TGX 1990.129F
TGX 1989.70F
TGX 1990.137F
Tikolore
TGX 1988.16F
TGX 1987.23F
Makwacha
Nasoko
Magoye
TGX 1989.51F
Participatory Variety Selection (PVS) Trials

Objective
To compare the adaptability and yield performance of promising genotypes with the checks and identify new superior genotypes that can be considered for release for commercial production

Materials & Methods
- Districts: Lilongwe (Chitekwere/Chigodi EPA) and Dowa (Nachisaka EPA)
- No. of farmers: 40 (20 per district)
- Genotypes: 8 (three checks & five tests)
On-farm PVS Trial

Grain yield of varieties tested in 2011/12 in Lilongwe and Dowa districts, Malawi

Grain Yield (kg/ha)

Tikolore 1800 1600 1400 1200 1000 800 600 400 200 0
TGx 1989-60F 1400 1200 1000 800 600 400 200 0
TGx 1987-62F 1600 1400 1200 1000 800 600 400 200 0
TGx 1987-11F 1800 1600 1400 1200 1000 800 600 400 200 0
TGx 1835-10E 2000 1800 1600 1400 1200 1000 800 600 400 200 0
Makwacha 1800 1600 1400 1200 1000 800 600 400 200 0
Magadye 1600 1400 1200 1000 800 600 400 200 0
TGx 1830-20E 1400 1200 1000 800 600 400 200 0

Lilongwe  Dowa  Mean
Advanced variety trials 2000-2011

Medium maturity trails

\[ y = 29.283x - 56882 \]

\[ R^2 = 0.0887 \]
Future considerations

Soybean is highly nutritious and adaptable, offering resources to address world food issues through current and future utilization practices.

Soybean production is expected to increase in proportion to increased demand.

Soybean has potential to improve with application of newer genomic technologies.
Production and national demand projections (1000 MT) for soybean in Sub-Saharan Africa

Source: IFPRI IMPACT model results for 2020 (Rosegrant et al. 2001)
Supply and demand projections of Soybean

Production and consumption of soybean in ESA

Area, demand and supply projections for soybean in ESA

Eastern and Southern Africa (ESA)
Supply and demand projections of Soybean Production and consumption of soybean in WCA

Area, demand and supply projections for soybean in WCA

Western and Central Africa (WCA)
Meeting the demand

Countries and the international community must do more to fight hunger: invest in farmers and agriculture and create jobs and safety nets for the poorest.
Tropical Legumes (I&II)

- Target regions: Sub-Saharan Africa and South Asia
- Objective 7: Enhancing soybean productivity and production in sub-Saharan Africa
TLII Objective 7

- Activity 1. Development of varieties/lines tolerant to drought with enhanced BNF
- Activity 2. Development of varieties/lines with tolerance to soybean rust and other diseases with enhanced BNF
- Activity 3. Soybeans with improved quality traits
- Activity 4: data management of breeding activities
- Activity 5. Facilitation of household and community level processing and utilization of soybean
Leveraging legumes to combat poverty, hunger, malnutrition and environmental degradation

CGIAR Grain Legumes
## Priority Crops and Regions

<table>
<thead>
<tr>
<th>Area</th>
<th>HIGH (&gt;750 million)</th>
<th>MEDIUM (250-750 million)</th>
<th>LOW (&lt;250 million)</th>
<th>Total Area (M hectares)</th>
</tr>
</thead>
</table>
|            | SSEA (1.3 billion)  | SSA (539 million)        | CWANA (64 million) | LAC (55 million)        | Groundnut (19.02)  
            |                     |                          |                    |                         | Chickpea (10.71)  
            | HIGH (>0.5M hectares) | Groundnut (10.8)         | Chickpea (1.2)     | Soybean, oil (4.4)     | Cowpea (10.62)    
            | Soybean, oil (11.4) | Cowpea (10.4)            | Lentil (0.6)       | Bean, common (2.7)      | Bean, common (8.75)|
            | Chickpea (9.0)     | Bean, common (5.8)       |                    |                         | Mung bean (5.00)    
            | Groundnut (7.9)    | Soybean (1.4)            |                    |                         | Pigeonpea (4.74)   
            | Mung bean (5.0)    | Faba bean (0.50)         |                    |                         | Lentil (2.43)      
            | Pigeonpea (4.2)    | Pigeonpea (0.50)         |                    |                         | Soybean (1.58)     
            | Lentil (1.7)       |                          |                    |                         | Pea (1.47)         
            | Pea (0.78)         |                          |                    |                         | Faba bean (1.04)   |
| LOW (<0.5M hectares) | Cowpea (0.17) | Pea (0.45)                | Faba bean (0.4)    | Groundnut (0.19)        |                         |
|            |                    | Chickpea (0.42)          | Bean, common (0.25)| Chickpea (0.14)         |                         |
|            |                    | Bambara nut (0.12)       | Soybean (0.18)     | Faba bean (0.19)        |                         |
|            |                    | Lentil (0.11)            | Groundnut (0.13)   | Chickpea (0.09)         |                         |
|            |                    | Pea (0.04)               | Pea (0.13)         | Pea (0.09)              |                         |
|            |                    |                            | Cowpea (<0.01)     | Groundnut (0.07)        |                         |
|            |                    |                            |                    | Cowpea (0.04)           |                         |
|            |                    |                            |                    | Pigeonpea (0.04)        |                         |
|            |                    |                            |                    | Lentil (0.02)           |                         |

### Priority Crops

- **Bean**
- **Chickpea**
- **Cowpea**
- **Faba bean**
- **Groundnut**
- **Lentil**
- **Pigeonpea**
- **Soybean**
Focused Product Lines: Soybean

- Abiotic stresses
  - PL1 – Drought and low-phosphorus tolerant
- Nitrogen fixation
  - PL4 – High nitrogen-fixing
Project Goals and CRPGL Vision

TL1 - contribute to the development of improved legume varieties in sub-Saharan Africa and South Asia by advancing molecular breeding for traits of importance in both regions.

TL2 - Improve the livelihoods of smallholder farmers in drought-prone areas of Sub-Saharan Africa and South Asia through enhanced grain legume production and productivity.

The CRPGL Vision is that in 10 years, increased production, sales and consumption of grain legumes will reduce poverty, hunger, malnutrition of smallholder farmers, while improving the health of mankind and the planet.
Synergies: TLII with CRP Grain Legumes

- TL1 and TL2 goals and objectives are consistent with CRP Grain Legumes
- Significant portion of CRP GL deliverables are likely to happen through TL
Together we can do it!

Thank you