Review Meeting
Grain Legumes Phase 1 and Extension Phase

Development and promotion of short duration, drought tolerant and aflatoxin free groundnuts

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Date 5 October, 2016

http://grainlegumes.cgiar.org

Leveraging legumes to combat poverty, hunger, malnutrition and environmental degradation
Groundnut yield

Source: FAOstat
Product Line Description

### Background Issues and R4D Challenges

<table>
<thead>
<tr>
<th>Production of oil crops (Millions of tons oil equivalents)</th>
<th>1969/71</th>
<th>1979/81</th>
<th>1989/91</th>
<th>1999/01</th>
<th>2030</th>
<th>2050</th>
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<tbody>
<tr>
<td>Soybean</td>
<td>8.1</td>
<td>15.9</td>
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<td>30.5</td>
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<td>5.2</td>
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<td>6.8</td>
<td>9.9</td>
<td>16.7</td>
<td>21.4</td>
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<td>5.7</td>
<td>13</td>
<td>25.6</td>
<td>54.2</td>
<td>77.2</td>
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<tr>
<td>Rape seed</td>
<td>2.6</td>
<td>4.4</td>
<td>9.7</td>
<td>15.3</td>
<td>29.8</td>
<td>41.4</td>
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<table>
<thead>
<tr>
<th>Growth rates, percent per annum</th>
<th></th>
<th></th>
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<tbody>
<tr>
<td>Soybean</td>
<td>4.7</td>
<td>4</td>
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<td>5.1</td>
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<td>1.8</td>
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<tr>
<td>Groundnut</td>
<td>2</td>
<td>2.5</td>
<td>3.3</td>
<td>4</td>
<td>1.8</td>
<td>1.3</td>
</tr>
<tr>
<td>Oil palm</td>
<td>5</td>
<td>8.1</td>
<td>7.6</td>
<td>7</td>
<td>2.5</td>
<td>1.8</td>
</tr>
<tr>
<td>Rape seed</td>
<td>6.7</td>
<td>6.6</td>
<td>5.6</td>
<td>4.4</td>
<td>2.2</td>
<td>1.3</td>
</tr>
</tbody>
</table>

- **Productivity and production:**
  - Growing demand at slower with reduced competitiveness

- **Demand**
  - Aflatoxin contamination and dysfunctional value chains reduce competitiveness
RUTF AND HOME THERAPY

What is RUTF?

From 2000–2004, Dr. Manary and colleague Dr. André Briend experimented with various ingredients until they created a formula that provides the specific, high quality nutrition that severely malnourished children need to recover. The food became known as Ready-to-Use Therapeutic Food (RUTF). RUTF is an energy-dense, peanut butter like paste, but it is more than just peanut butter. It consists of roasted ground peanuts (peanut paste), powdered milk, vegetable oil, sugar, and vitamins/minerals. Peanuts contain mono-unsaturated fats, which are easy to digest, and they are rich in protein and zinc, which is good for the immune system. RUTF’s intended use is for severely malnourished children ages 6 mo–to 5yrs.

RUTF Formula

Product Line Description

- Background issues and R4D Challenges

Biotic and abiotic stresses

Markets and Institutions

R4D through-put
Objectives 2012-16

Overarching Goal:

- Develop and deploy *short-duration, drought tolerant, nutrient dense and aflatoxin resistant cultivars* to catalyse *production, productivity and competitiveness of groundnut value chains*
Objectives 2012-16

Outcomes (output targets):

1. High priority target areas requiring short-duration, drought tolerant cultivars and aflatoxin management identified (SC1)
2. Precision phenotyping tools for drought tolerance traits developed (SC2)
3. Sources of traits related to drought tolerance, aflatoxin resistance and nutritional quality identified (SC2)
4. Transgenic events of groundnut with high levels of drought tolerance and resistance to aflatoxin contamination developed (SC2)
5. Better understanding of mechanisms and genetics of drought tolerance and aflatoxin contamination (SC2)
6. Genomic tools developed and integrated in breeding for drought tolerance (SC2) Short-duration, drought tolerant, nutrient dense and low aflatoxin breeding lines/varieties developed and shared with partners (SC2)
7. Enhanced adoption of short duration, high yielding cultivars and integrated crop management practices (SC3)
8. Formal and informal seed systems strengthened to ensure adequate seed supply (SC3)
9. Post-harvest processing technologies for reduced aflatoxin contamination and value added products refined and disseminated (SC4)
10. Capacity of stakeholders in R&D on short-duration, drought tolerance and aflatoxin management strengthened (SC5)
Conceptual framework

**Vision of Success**
- Improved production performance
- Sales performance of seed and grain
- Dietary performance at households
- Sustainable intensification + ecological performance

**IDO 4 + IDO 5**

**IDO 2 + 3**

**Increased and equitable income**

**IDO 4 + IDO 5**

**Functional input and output markets improve access, quality and utilization**

**Sustainable intensification & Productivity enhancement**

**R4D Process**

**Priority setting**

**CC 1**

**Product delivery**

**Capacity**
RESULTS: Target sites for drought (SC1)

Yield losses due to drought (g m$^{-2}$) groundnut)
RESULTS: Target areas requiring PL3 outputs (SC1)

- Adoption and impact studies in ESA using Malawi as a case

<table>
<thead>
<tr>
<th>Groundnut variety</th>
<th>2012/13</th>
<th>2013/14</th>
<th>Proportionate change (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CG7</td>
<td>0.48</td>
<td>0.54</td>
<td>12.5</td>
</tr>
<tr>
<td>Nsinjiro</td>
<td>0.46</td>
<td>0.47</td>
<td>2.2</td>
</tr>
<tr>
<td>Kakoma</td>
<td>0.40</td>
<td>0.28</td>
<td>-30.0</td>
</tr>
<tr>
<td>Chitala</td>
<td>0.56</td>
<td>0.27</td>
<td>-111.5</td>
</tr>
<tr>
<td>Baka</td>
<td>0.38</td>
<td>0.6</td>
<td>61.1</td>
</tr>
<tr>
<td>All local</td>
<td>0.46</td>
<td>0.52</td>
<td>13.0</td>
</tr>
</tbody>
</table>

- Impact of groundnut on smallholder economy
  - Smallholders earning a profit of USD 180 per acre.
  - Forms over 90% of total household income.
RESULTS: Target areas requiring PL3 outputs (SC1)

- Tracked adoption and impact studies in Asia using India- Tamil Nadu

<table>
<thead>
<tr>
<th>Cultivar</th>
<th>Sample area (ha)</th>
<th>Percentage share</th>
</tr>
</thead>
<tbody>
<tr>
<td>Co 6*</td>
<td>40.5</td>
<td>3.5</td>
</tr>
<tr>
<td>Co 7*</td>
<td>27.55</td>
<td>2.4</td>
</tr>
<tr>
<td>Co 2</td>
<td>236.9</td>
<td>20.2</td>
</tr>
<tr>
<td>POL 2</td>
<td>321.95</td>
<td>27.5</td>
</tr>
<tr>
<td>TMV 13</td>
<td>11.7</td>
<td>1.0</td>
</tr>
<tr>
<td>TMV 1</td>
<td>224.1</td>
<td>19.2</td>
</tr>
<tr>
<td>TMV 2</td>
<td>2.9</td>
<td>0.2</td>
</tr>
<tr>
<td>VRI 2</td>
<td>249.65</td>
<td>21.3</td>
</tr>
<tr>
<td>TMV 7</td>
<td>8.6</td>
<td>0.7</td>
</tr>
<tr>
<td>VRI 6</td>
<td>7.1</td>
<td>0.6</td>
</tr>
<tr>
<td>VRI 7</td>
<td>39.4</td>
<td>3.4</td>
</tr>
<tr>
<td>Total</td>
<td>1170</td>
<td>100.0</td>
</tr>
</tbody>
</table>

* TL II project introduced cultivars (PL3)

- Farmers are completely depended on retailers or local markets for groundnut seed.
- The extent of area covered by formal releases/improved cultivars is limited.
RESULTS: precision phenotyping tools for drought traits (SC2)
RESULTS: Transgenics for drought (SC2)

18-23% increase in pod yield

Yield evaluations under field conditions

Moving for Product translation
RESULTS: Transgenics for low aflatoxin (SC2)

Aflatoxin concentration (ppb) in groundnut transgenics (T7) with rice chitinase gene under micro-sick plots in preharvest screening

Aflatoxin concentration in groundnut transgenics (T3) carrying 13LOX gene under micro-sick plots (Rainy season 2013)
RESULTS: Genomic tools developed and integrated in breeding for drought (SC2)

- Genome sequence of *A. duranensis* and *A. ipaensis*, the diploid ancestors of cultivated groundnut
- Genes related to oil biosynthesis, aerial flowering and subterranean fructification, and allergy identified
- Genome-wide identification of SNPs/SSRs towards development of *Arachis* marker database
- Development of cost-effective high density SNP array

Genes for oil biosynthesis and allergy (PNAS 2016)
Genetic factors for aerial flower and subterranean fruit (PNAS 2016)
RESULTS: Genomic tools developed and integrated in breeding for drought (SC2)

- Improved genetic/consensus maps and diagnostic markers for foliar disease resistance and oil quality
- Improved consensus genetic map and meta-QTL analysis for drought tolerance related traits.
- Candidate genes for foliar diseases identified through RNA-seq.
- Genome-wide association studies for pre-harvest aflatoxin contamination in groundnut.
- Associated genetic markers for several key breeding traits including drought tolerance related traits and pre-harvest aflatoxin contamination
- Development of cost-effective high density SNP array
RESULTS: New varieties developed and shared with partners (SC2)

Harnessing genetic & genomic resources in breeding

- New sources- ICG 11651 & ICG 5445 for drought deployed
- **NIL trials** constituted for first time in India, with 16 lines combining early maturity and foliar fungal disease resistance – a key step towards release.
- For first time, **High Oleic groundnut lines** in the Spanish and Virginia Bunch types were developed and 65 lines were shared with NARS for Multi-location testing
- High oil lines identified for release – ICGV 03043, ICGV 051444, ICGV 06420, ICGV 06146
RESULTS: New varieties developed and shared with partners (SC2)

39-79% higher mean pod yield and 23-62% higher haulm yield (2014 trials)
RESULTS: New varieties developed and shared with partners (SC2) - New varieties released

7 in Malawi
Medium duration Virginia: ICGV-SM 08501, ICGV-SM 08503, ICGV-SM 01724, ICGV-SM 01731S
Short duration Spanish : ICGV-SM 99551, ICGV-SM 99556, ICGV-SM 01514

Summary of groundnut varieties released in Phase I of CRP

<table>
<thead>
<tr>
<th>Country</th>
<th>Number released</th>
<th>Year of release</th>
</tr>
</thead>
<tbody>
<tr>
<td>Malawi</td>
<td>7</td>
<td>2014</td>
</tr>
<tr>
<td>Tanzania</td>
<td>4</td>
<td>2015</td>
</tr>
<tr>
<td>Zambia</td>
<td>5</td>
<td>2015</td>
</tr>
<tr>
<td>Zimbabwe</td>
<td>1</td>
<td>2014</td>
</tr>
<tr>
<td>Haiti</td>
<td>1</td>
<td>2013</td>
</tr>
<tr>
<td>India</td>
<td>3</td>
<td>2012-14</td>
</tr>
<tr>
<td>Philippines</td>
<td>2</td>
<td>2013</td>
</tr>
<tr>
<td>Srilanka</td>
<td>1</td>
<td>2015</td>
</tr>
</tbody>
</table>

Foliar disease resistant varieties
• ICGV 99030, ICGV 05049

Drought tolerant varieties
• ICGV 00351 (Co 7), ICGV 95390

Confectionary
• ICGV 04168 (KDG 123), ICGV 05200

Medium-duration with high yield
• ICGV 01273
RESULTS: Sources of drought tolerance, aflatoxin resistance and nutritional quality identified (SC2)

New diversity for drought and disease resistance

- 15 new sources of tolerance to drought
- 5 new sources of resistance to GRD
- 2 new AB QTL populations (BC2F4)
- Multi-parent genetic populations such as MAGIC and NAM for drought tolerance and aflatoxin
- Promising results from CSSL evaluation for drought and disease.
RESULTS: Enhanced adoption of PL3 products and ICM deployment (SC3)

- On-farm participatory evaluation enhance adoption

- Annually 17-25 FPVS conducted in Gujarat, Andhra Pradesh and Tamil Nadu
- Annually 63 FPVS conducted in Malawi, Tanzania, Mozambique, Uganda and Zambia.
- Seed treatment
- Optimal plant population (seed rate)
- Strategic promotional events via W3 support
  - TLIII and scaling projects (ESA, WCA) x 5 projects
RESULTS: Enhanced adoption of PL3 products and ICM deployment (SC3)

- Promotional events increase adoption

![Groundnut Area in Malawi 2008-2014](chart)
RESULTS: Road-map for technology delivery

OT 3.5.1 Improved functionality of national seed systems generated for scaling up & out

1. National seed strategies & roadmaps developed & deployed

2. Strengthening of breeder & foundation seed production in selected regions

3. Alternative approaches tested to support informal seed systems

4. Formal outlet chains strengthened

5. IDO4 Improved system productivity

6. IDO 1 Food security

7. IDO 3 Increased & equitable income
RESULTS: Formal and informal seed systems strengthened (SC3)

Informal systems examples from Malawi

Community seed banks
- 15,000 Direct beneficiaries
- 33,000 Indirect beneficiaries
- 120 tons of quality declared seed (QDS) produced
- 10 tons of QDS available for new beneficiaries

Spread:
- Average distance of spread is 50 km
- Longest distance 120 km

Over 30 MT annually handled through informal systems in Tanzania
RESULTS: Formal and informal seed systems strengthened (SC3)

Formal systems: Examples from Malawi

Early generation of seed (EGS) production enhanced:

Catalytic effects of EGS on certified seed production
Results: Enhanced capacities (SC 5)

- MSc – 8 (Zambia, Uganda, Mozambique)
- PhD – 2
- Short-term training for seed quality assurance – 100 para seed inspectors
- Short-term training for NARS and extension staff on FPVS and demonstrations – 50
- Short-term training on aflatoxin mitigation techniques – 10 technicians
- Short term training to NARS staff on BMS – 20
- Lead farmers for extension – 810
IMPACTs: Key

1. Intensified productivity and profitability
   - 56% groundnut farmers in Malawi cultivate CG 7 a widely promoted improved varieties,
   - Increased productivity from 450 kg/ha in the 1990s to 800 kg/ha in 2014.
   - Improved return on improved seed adoption: 1 US$ returns 9 US$.

2. Improved nutrition and livelihoods
   - Malawi -76.6% of households attribute their high consumption to improved groundnut.

3. A low-cost ELISA diagnosis kit developed for aflatoxin mitigation

5. Cross-learning and sharing
   - GRD resistant varieties

4. Partnerships and genetic resources assembled for R4D
   - Seed systems – example Tanzania model
   - Complementary project exist and several R&D communities
   - Genetic, genomic and knowledge products assembled and shared.
   - Forward breeding is under way
   - Robust phenotyping tools– NIRS, disease nurseries, sick plots
Lessons Learned

1. Informal seed systems essential for scaling out. Seed banks are a basis for bulking of grain and seed and stronger bargaining power for prices with purchasers.

2. Scaling up and out. Groundnuts is a major investment vehicle to move out of poverty.

3. Community learning. Women based and or dominated self help groups are suitable R&D investment vehicles.

4. Strategic partnerships. Scope to grow legume based seed companies, exists when appropriate public / private sector partnerships are put in place.

5. Partnership and networking are essential in tackling regional to global important constraints.

6. Partnership with Industry is need of the hour.
Areas suggested for continued R4D

1. Improved targeting of groundnut varieties to meet changing farming systems
   Characterization of production environments

2. Improved breeding program efficiency
   * Deployment of forward breeding
   * Robust- and reliable- phenotyping tools
   * International Nurseries
   * Rapid generation advancement

3. Science of delivery for furthering seed systems
   * Agronomy for groundnut seed production

4. Addressing drudgery will improve profitability

5. Aflatoxins, nutrition and value addition
Contributing Bilateral Projects

- Tropical legumes I, II and III (TL I, TLII and TLIII)
- Malawi Improved seed systems sand Technologies (FtF MISST)
- Malawi Improved Seed Systems and Technologies (FtF MSIDP)
- Feed-the-Future Mozambique Improved Seeds for Better Agriculture (SEMEAR)
- Alliance for Green Revolution in Africa-Scaling Seeds and Technologies Partnership in Africa (AGRA-SSTP)
- Feed-the-Future West Africa Seed Programs (WASP)
- Feed-the-Future Kenya
- Improving groundnut farmer incomes and nutrition through innovation and technology enhancement (I-FINITE)
- Department of Agriculture and Cooperation & Farmer Welfare (DAC&FW), Government of India
- International Fund for Agricultural Development (IFAD)
- OPEC Fund for International Development (OFID)
- MARS Chocolate North America and Peanut Foundation
Indeed a team work!

Thank you!

http://grainlegumes.cgiar.org