Flagship on Variety and Hybrid Development of CRP-GLC

With contributions from Shiv K Agrawal & Safaa Kumari (ICARDA), Vincent Vadez (IRD), Godfree Chegeza (IITA), Gilles Trouche (CIRAD) (till March 2019), Ronnie Vernooy (Bioversity), and Jan Daebane & Chris Ojewo (ICRISAT)

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Leader of Flagship on “Variety and Hybrid Development” of CRP-GLDC
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Recognition to GLDC work on improved genetics, partnerships with private and public sector to deliver seeds to farms (Hybrid Parent Research Consortium)
What to expect from the FP4 presentation?

1. Milestones achieved
2. Progress towards milestones
3. Three key highlights from 2018 & 2019

Three key features of crop breeding programs of CG

- Product design to delivery (commercial breeding)
- Knowledge creation
- Knowledge sharing

Enhancing rate of genetic gain, and operational efficiencies of crop breeding program
1. Milestones achieved

2. Progress towards milestones

Milestone(s): Variety releases/NPTs from Phase I investment, delivery

- Breeding lines from Phase I enter the National performance trials (NPT) or release
- New varieties with enhanced nutrient levels (Fe, Zn, oil, protein, high oleic) developed
- New suite of resilient varieties released by NARS partners. (Phase 1 investments start being released)
- Seed systems
2018: 73 cultivars of nine GLDC crop in 16 target countries of Africa and Asia:

- **biofortified cultivars** - Parbhani Shakti sorghum (India), EUFM 403 pearl millet (Kenya), Barimasur 9 lentil (Bangladesh), and Khajuro Masuro 4 lentil (Nepal) for nutrition security.
- Machine harvestable chickpea and lentil & high protein soybean driving youth and women entrepreneurship,
- high oleic groundnut & grain sorghum suitable for brewing - market traits for industry.
- **Improved genetics for climate resilience** - heat tolerance in chickpea and pearl millet, low nutrient adaptation in cowpea, early maturity as escape to water deficit stress in eight of the GLDC crops, super-early pigeon pea and cowpea, high transpiration efficiency (TE) under high vapor pressure deficit (VPD) in sorghum.

In the backdrop of early maturing cowpea trails @ IITA, Ibadan, 2018

Mr. Alabi Abidini, Mr. Ibikunle Mumini A., Dr. Janila, Mr. Ukaukwu Ugochukwu, Mr. Ojo Joseph and Ms Ige Gbemisola
Milestone: Variety releases/NPTs from Phase I investment, delivery

1. First hybrid millet in WCA (2018)
2. First biofortified sorghum in India (2018)
3. First high Oleic groundnut in India (2019)

1. 3 biofortified lentil varieties in Bangladesh, India and Nepal (2018) + five varieties (2019)
2. New high yielding cowpea varieties in Nigeria
3. New soybean variety in Ghana (2019)
Milestone(s): Variety releases/NPTs from Phase I investment, delivery

2018 story

Impact of early maturing and high yielding lentils into rice-based systems Bangladesh:
- 27.7% higher yields, 29.5% higher net returns.
- The additional production saved ca. $25.8 m of foreign currency/year by replacing imports with domestic production.
- DNA fingerprinting revealed 98% of total lentil areas in Bangladesh covered by genetic material from ICARDA.

2019 story

Myanmar chickpea revolution during the past two decades
- production increased nearly eightfold due to 300% increase in area from 101,000 ha and doubling of productivity (660 to 1,400 kg/ha).
- 96% of the chickpea area in 2017-18 was under the five improved varieties developed through ICRISAT-DAR partnership research.
Maize is the giant of all food crops in Malawi. However, most smallholder farmers often intercrop maize with soybean, making it an equally important crop.

Builds narration on value proposition of grain legumes as inter-crops and/or crop rotation for sustainable soil nutrient management & environmental sustainability

Milestone: Variety releases/NPTs from Phase I investment, delivery

<table>
<thead>
<tr>
<th>Variable</th>
<th>Groundnut</th>
<th>Chickpea</th>
<th>Common bean</th>
<th>Cowpea</th>
<th>Sorghum</th>
<th>Pearl millet</th>
<th>Finger millet</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amount of seed produced (thousand MT)</td>
<td>32.28</td>
<td>12.43</td>
<td>41.03</td>
<td>16.68</td>
<td>2.74</td>
<td>0.21</td>
<td>0.04</td>
<td>105.40</td>
</tr>
<tr>
<td>Area covered (thousand Ha)</td>
<td>322.82</td>
<td>103.62</td>
<td>586.08</td>
<td>834.10</td>
<td>342.18</td>
<td>34.43</td>
<td>7.25</td>
<td>2,230.49</td>
</tr>
<tr>
<td>Grain produced (thousand MT)</td>
<td>325.40</td>
<td>136.78</td>
<td>750.18</td>
<td>650.60</td>
<td>418.15</td>
<td>32.05</td>
<td>10.05</td>
<td>2,323.22</td>
</tr>
<tr>
<td>Value of grain produced (million US$)</td>
<td>161.92</td>
<td>68.92</td>
<td>451.39</td>
<td>302.66</td>
<td>120.84</td>
<td>9.78</td>
<td>4.31</td>
<td>1,119.82</td>
</tr>
<tr>
<td># households reached (millions)</td>
<td>1.61</td>
<td>0.52</td>
<td>2.93</td>
<td>4.17</td>
<td>0.86</td>
<td>0.09</td>
<td>0.02</td>
<td>10.19</td>
</tr>
</tbody>
</table>

Source: Two bilateral projects, TL III & HOPE II mapped to GLDC; covers the target countries mostly in Africa and chickpea in Asia.

Varieties being popularized in Sudan-Sahel agro-ecology

Sorghum variety SAMSORG-45

Fe >50ppm + early maturing (85-95 days) + drought tolerant

Pearl millet variety LCIC MV-3

Early maturing (80-90 days) + high yield + bold golden grain
Milestone: Variety releases/NPTs from Phase I investment, delivery

Working towards building sustainable public-private business-oriented sorghum and groundnut seed systems in Uganda and Tanzania

• Critical bottlenecks along seed value chain identified
  ✓ low public funding for early generation seed
  ✓ limited demand forecasting due to stochastic procurement by NGOs and inconsistency of farmers
  ✓ limited land with irrigation and capacity for year-round production for EGS

• Current interventions
  ✓ Variety business case studies focusing on demonstrating profitability of seed and grain of sorghum and groundnut
  ✓ developing a sustainable early generation seed revolving fund (SRF) in Tanzania, linking public and private sector stakeholders (variety licensing)
  ✓ Building the technical capacity of sorghum and groundnut seed producers in Tanzania and Uganda on innovation platforms; seed business management; digital seed roadmap and seed catalogue; aligning seed roadmap with product profiles.

The handbook includes a new module on seed production and distribution and incorporates several of more recent useful ideas, examples of good practices and the latest references.

Working closely with EiB Platform GLDC team developed crop Product Profiles with NARS partners
Characterizing Target Population of Environments (TPEs) to design testing sites for MLTs

Drought effects on groundnuts in India (not published)

The size of the circles is equivalent to the simulated yield potential ($Y_p$) and the blue proportion of the circles reflects the water-limited yield potential ($Y_w$). The magnitude of yield loss accountable to water deficit is reflected in the size of the red proportion of the circles within each district. Green-highlighted districts encompass 80% of groundnut production area in India.
Adopting best practices from Industry: Seed Inventory Management System

- Global inventory! Transparent! Online!
- Breeding team and BMS teams of ICARDA, IITA, ICRISAT are supported from FP4.
- Integrated with electronic weighing balances for withdrawing seeds
- To adopt SIMS crop wise standardization is on the way

![Seed inventory](image1.png)

**Improved Soybean Seed Store in Lusaka, Zambia**

**ICARDA**
Early generation selection using SNP genotyping, NIRS, XRF, & imaging technologies for phenotyping

Imaging technologies for phenotyping being developed in partnership with a private sector company and with engagement with EiB platform.

<table>
<thead>
<tr>
<th>Cross identify</th>
<th>F2 seeds</th>
<th>Homozygous (A:A)</th>
<th>Heterozygous (A:-)</th>
<th>Wilde type (:-)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ICGX 191003</td>
<td>656</td>
<td>138</td>
<td>340</td>
<td>162</td>
</tr>
<tr>
<td>ICGX 191004</td>
<td>470</td>
<td>93</td>
<td>207</td>
<td>160</td>
</tr>
<tr>
<td>ICGX 191005</td>
<td>374</td>
<td>103</td>
<td>174</td>
<td>88</td>
</tr>
<tr>
<td>ICGX 191006</td>
<td>564</td>
<td>96</td>
<td>209</td>
<td>258</td>
</tr>
<tr>
<td>ICGX 191007</td>
<td>575</td>
<td>85</td>
<td>227</td>
<td>256</td>
</tr>
<tr>
<td>ICGX 191008</td>
<td>361</td>
<td>78</td>
<td>170</td>
<td>104</td>
</tr>
</tbody>
</table>
Knowledge sharing:
2nd International Training Course on “Breeding approaches for enhancing genetic gains in grain legumes and dryland cereals”

Feedback form the participants:
“I learned about product profile development for delivering profitable products to farmers and how speed breeding techniques reduce the breeding cycle.”
---Dr Dramane Sako, Mali

“This training has provided a platform for collaboration, networking and sharing best practices on crop breeding.”
---Prof Anthony Mshandete,

Trainees: 12 women and 14 men from 14 countries – Ethiopia, Myanmar, Tanzania, India, Tunisia, Burkina Faso, Malawi, Uganda, Ghana, Mali, Nigeria, Sudan, Zimbabwe, and Egypt.

Resource persons: 7 CGIAR centers: CIMMYT, ICARDA, ICRISAT, IITA, CIAT, ICRAF; Excellence in Breeding (EiB); and Integrated Breeding Platform (IBP); (NM-AIST); ADVANTA and Neilsen Seeds.

Unique as it leverages key capacities of NARS:
1. Indian Agricultural Research Institute (IARI), New Delhi, India
2. Nelson Mandela-African Institute of Science and Technology (NM-AIST), Arusha, Tanzania

Dr Prasanna, CIMMYT talking on genetic gains assessment at NM-AIST, Arusha at the 2nd training course in 2019

1st training at New Delhi in 2018 that motivates the FP team to continue as the training module met the expectations of the ‘practicing crop breeders’
Capacity building

Student’s research at IITA, ICARDA and ICRISAT contributes to CRP-GLDC’s deliverables

ICRISAT, Patancheru (2018)

ICARDA, Lebanon (2019)
3. Three key highlights from 2018 & 2019

|---------------------------------------------|----------------------------------------|-----------------------------------------------|

i. Biofortification: product commercialization

ii. Process innovations: Speed breeding

iii. Partnerships: delivery, build ecosystem for multi-stakeholder engagement, capacity building
1. Mainstreaming biofortification in crop breeding pipelines

- Africa’s first biofortified pearl millet variety aims to combat anaemia – June 4 2018
- High protein soybean variety, Favour
- Early maturing – best fit to the cropping systems with rotation

India gets its first biofortified sorghum, July 5 2018

Alleviating Malnutrition with Biofortified Lentil

http://www.icarda.org/project/alleviating-malnutrition-biofortified-lentil
http://gldc.cgiar.org/media-releases
1. CGIAR Science Forum 2018: case studies around nutrition and market traits

What kinds of partnerships were critical?

➢ Multi-stakeholder partnerships with diverse competencies are very critical to carry forward the research and development initiatives.
➢ Mahabeej (one of the largest public sector seed production bodies in the world) for large-scale sorghum seed production which helped the outreach, reaching 300,000 farmers per year and increasing every year.

➢ Partnership with NARS in the design, testing and delivery
➢ Partnership with industry (MARS) to get the right product
➢ Partnership with public and private seed sector to scale-up
➢ Donor engagement (GOI, S) for financial assistance from 2011 to 2018. MAR
2. Process innovations: Speed breeding

Maximum 1 or 2 generations per year

Lentil: 7 generations from 5 to 2-3 years

First high oleic groundnut variety released in India (2019) in a 8-years on contrary to 12-15 years required normally. Over 100 high oleic lines shared with collaborators in 9 countries.
3. Partnerships, public and private sector

Crop Network Groups (CNG’s)

➢ Crop Network Group (CNG) is a multi-stakeholder platform of NARS, Private sector, NGOs, CG etc. to engage along crop Product Profile design, development, testing, advancements and delivery.

➢ It is a knowledge sharing platform enabling continuous learning.

➢ It builds an ecosystem to modernize the crop breeding programs.

➢ It’s a platform to engage with private sector, both seed sector and food processing industries.
3. Partnerships

- Public and private partnership around **improved genetics** in consortium model was recognized by CGIAR.

- **Private sector partnerships** – ADVANTA, Seed Co., HPRC members in Africa & Asia, ZamSeed, Syngenta, food processing industry (MARS, ITC), Intertek (SNP, wet chemistry), CT-XRF (development of tools)

- Partnerships with **food processors** and value chain actors key to get feedback on market value traits and market needs for future

For 2020 & 2021

FP4
✓ International nurseries
✓ Phenotyping platform – collaborations, service providers and private partnerships

With FP1
✓ Market survey to design Product Profiles
✓ Adoption studies.
✓ Evidence for narration on contribution of GLDC crops to nutrient diets
✓ Risk analysis of private sector business model for low endowed environments

With FP5
✓ Quality Control (QC)
International nurseries

ICARDA’s Terbol research station, Zahle, Lebanon (May 2019)
Phenotyping platform – collaboration with ARI’s, service providers, private partnership

INRA, Dijon, France (May, 2019)
Agricultural researchers now have tools that allow them to **create seeds resistant to various stresses**, said Mr. Gates, offering the example of ICRISAT’s development of dryland cereals and legumes which are more tolerant to drought.

“This is a case where the seeds are in the lab, but we have a lot of work to do to get them out into the farmers’ hands, especially smallholder farmers,” he said, adding that private sector involvement in such innovation was also critical.