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

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Leveraging legumes to combat poverty, hunger, malnutrition and environmental degradation
Background Issues and R4D Challenges

- Crop specific
- Ecological
- Productivity
- ICM technologies
- Seed systems
- Stresses
- Seed production
- Genomic resources

Large Yield Gap
Overarching Goal: Enhance adoption

10 Years Target: 500,000 ha

Outcomes:

- Different CMS systems.
- Resistance to key biotic and abiotic stresses
- 25% higher yield
- Seed production systems
- ICM technologies
- Commercial hybrids and varieties (ESA)
- Enhanced capacity of stakeholders
Varietal improvement Traits

**Super Early:** Stabilized DT and NDT  
Agronomy  
Rice Fallows  
Seed Size  
Wilt and SMD

**Early, Medium and Late:**  
Plant Type  
Protein content  
Vegetable types

**Cleistogamous flower:**  
Elite lines  
Seed size  
Plant type

Wide hybridization Lines
Varietal improvement Traits in ESA

- Intercropping compatibility
- Photo-thermo insensitivity
- Ratoonability with high yield
- Grain quality for dry & fresh grains
- *Fusarium* wilt tolerance
- Pest tolerance esp. Pod borers

ICPL 86022
Cream large seeded
traits for hybrid breeding

*Cajanus reticulatus* A 8

- Obcordate leaf shape ‘A’ lines
  - ICPA 2203 X ICPL 20116
  - ICPA 2204 X ICPL 20116
Current status of hybrids Released

**ICPH 2740 in 570 OFTs**

- Maharashtra: 1643, 1646, Mean: 1646
- Andhra Pradesh: 1224, 1194, Mean: 1224
- Madhya Pradesh: 1063, 1194, Mean: 1093

Yield (kg/ha)

**Performance of ICPH 2671 in 1370 OFTs**

- Maharashtra: 969, 1411, Mean: 1201
- Andhra Pradesh: 717, 907, Mean: 817
- Karnataka: 951, 1460, Mean: 1255.5
- Jharkhand: 864, 1326, Mean: 1095
- Madhya Pradesh: 1940, 1396, Mean: 1718

Yield (kg/ha)

**ICPH 3762 in OFTs’ at Odisha, 2013**

- Kalahandi: 2000, 2290, Mean: 2090
- Bosh (3): 803, 803, Mean: 803
- Rayagada: 803, 803, Mean: 803
- Bolangir (11): 803, 1804, Mean: 998.5
- Naupartha (21): 1734, 1801, Mean: 1762.5

Yield (kg/ha)

**ICPH 2671**

**ICPH 3762**

**ICPH 2740**

**ICPH 4503**

**BIO 1001**
Hybrids parents & elite lines

<table>
<thead>
<tr>
<th>Maturity group</th>
<th>No. of R lines</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extra Early</td>
<td>15</td>
</tr>
<tr>
<td>Early</td>
<td>17</td>
</tr>
<tr>
<td>Medium</td>
<td>45</td>
</tr>
<tr>
<td>Long</td>
<td>14</td>
</tr>
</tbody>
</table>

- A and B lines available
- Maturity group
- Seed Size
- Seed color
- Disease resistance

- Dt X NDT enhance heterosis
- Open flowered structure types.
- Agronomic interventions
- Heterotic gene pools
- Super early hybrids
- Early hybrids for p’ pea-wheat system
- Mid-early hybrids for red soils
- Medium hybrids for black soils
- Long duration hybrids for north
- Hybrids for high input conditions
Phytophthora Blight: An Emerging Threat to Pigeonpea Expansion & Production

- PB incidence up to 80% recorded in farmer’s fields (in surveys 2013/14 to 2015/16).
- PB incidence observed irrespective of soil types and cultivars grown
- Rainfall positively correlated with PB incidence

Standardized Resistance Screening Techniques for PB

Published in: Sharma et al., 2015 BMC Plant Biology; Sharma & Ghosh, 2016 Bio Protocol

Identification of resistant sources to PB

Promising lines (R-MR):
ICPLs 99009, 99008, 99004, 20135, 99048, 99099, AL 1836, KPL 43, few local selection
Fusarium wilt

- **Field**: 9 locations
- **Controlled environment conditions**: ICRISAT, Patancheru
- **Genotypes**: ICPLs 20109, 20096, 20115, 20116, 20102, 20106, 20094
- **12 resistant genotypes identified in ESA**

Sterility Mosaic Disease

- **Field**: 8 locations
- **Controlled environment conditions**: ICRISAT, Patancheru
- **Genotypes**: ICPLs 20094, 20106, 20098, 20115, 20096, 20107, 20110
• Transgenic events for insect resistance derived pigeonpea hybrid maintainer parent ICPB 2048 developed with stacked (cry1Ac and cry2Aa) and (cry1Ac and cry1F) for use in hybrid breeding programs.

• Selected transgenic events characterized for presence and inheritance of transgenes and advanced to further generations. Insect feeding studies ongoing under containment conditions.

• The causative gene responsible for male sterility phenotype in the CMS line of pigeonpea identified and molecular mechanisms identified.
<table>
<thead>
<tr>
<th>Country</th>
<th>Production (000’ t)</th>
<th>% increase</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2001</td>
<td>2014</td>
</tr>
<tr>
<td>Tanzania</td>
<td>87.1</td>
<td>249.3</td>
</tr>
<tr>
<td>Mozambique*</td>
<td>31.6</td>
<td>120.9</td>
</tr>
<tr>
<td>Malawi</td>
<td>105.8</td>
<td>301.0</td>
</tr>
<tr>
<td>Kenya</td>
<td>73.46</td>
<td>274.5</td>
</tr>
<tr>
<td>Uganda</td>
<td>80.0</td>
<td>93.6</td>
</tr>
<tr>
<td>E. S. Africa</td>
<td>380.6</td>
<td>1047.3</td>
</tr>
</tbody>
</table>

* Mozambique data is for 2012

- About 6 million farmers grow pigeonpea in Eastern and Southern Africa
- ESA exports about 290,000 t of grain to India worth approx. 200 M$
- PM of India signed MoU with Govt. of Mozambique to import 100,000 t/year during next 5 years.
- Similar agreements are in preparation with Tanzania, Kenya, Malawi
Pigeonpea growth rates in Tanzania

<table>
<thead>
<tr>
<th>Year</th>
<th>Area (000’ ha)</th>
<th>Production (000’ t)</th>
<th>Productivity (kg/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2006</td>
<td>162.4</td>
<td>118.5</td>
<td>729</td>
</tr>
<tr>
<td>2014</td>
<td>276.4</td>
<td>249.3</td>
<td>902</td>
</tr>
<tr>
<td>% increase</td>
<td>70.2</td>
<td>110.4</td>
<td>23.5</td>
</tr>
</tbody>
</table>

Drivers of change:

- 4 new varieties released with Fusarium resistance to replace susceptible Babati white
- Exports about 82,500 t per year worth about 80 million USD
- Local and regional consumption is 67% of production
- Innovative Community seed systems including QDS
- Sustainable intensification with maize and other legumes
- Strong support from BMGF, EC-IFAD, AGRA, Feed the Future and governments (Kilimo Kwanza, MoU with GOI)
- Value addition and use in domestic markets and export to regional markets
### Pigeonpea success story in Malawi

<table>
<thead>
<tr>
<th>Year</th>
<th>Area (000’ ha)</th>
<th>Production (000’ t)</th>
<th>Productivity (kg/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2006</td>
<td>150.2</td>
<td>130.9</td>
<td>872</td>
</tr>
<tr>
<td>2014</td>
<td>229.8</td>
<td>301.0</td>
<td>1309</td>
</tr>
<tr>
<td>% increase</td>
<td>53.0</td>
<td>129.9</td>
<td>50.1</td>
</tr>
</tbody>
</table>

### Drivers of change:

- 3 new MD and photo period insensitive varieties were released resulted in area expansion in to central and northern regions
- Exports about 80,000 t per year worth about 78 million USD
- Local and regional consumption is 73% of production
- Innovative Revolving seed scheme
- Sustainable intensification with maize, groundnut and other legumes
- Strong support from BMGF, Irish aid, EC-IFAD, AGRA, Feed the Future and governments (Input subsidy scheme)
- Value addition through 9 processing mills and use in domestic markets and export to regional markets (Malaw Dhal in Nairobi fetches premium)
Expansion in Mozambique

<table>
<thead>
<tr>
<th>Year</th>
<th>Area (000' ha)</th>
<th>Production (000' t)</th>
<th>Productivity (kg/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2006</td>
<td>170.2</td>
<td>77.8</td>
<td>457</td>
</tr>
<tr>
<td>2012</td>
<td>248.9</td>
<td>120.9</td>
<td>486</td>
</tr>
<tr>
<td>% increase</td>
<td>46.2</td>
<td>55.4</td>
<td>6.3</td>
</tr>
</tbody>
</table>

Drivers of change:

- 2 new MD and 2 LD varieties released that resulted in area expansion and increased production
- More than 1 million growers grow and market pull from India
- Exports about 65,000 t per year worth about 63 million USD
- Local and regional consumption is 50% of production
- Huge expansion in Zambezia and Nampula provinces
- Strong support from Feed the Future, DNEA and governments
- Value addition through 2 processing mills and use in domestic markets and export to regional markets
Myanmar

Table 2. Pigeonpea released varieties

<table>
<thead>
<tr>
<th>Genotype</th>
<th>Released name</th>
</tr>
</thead>
<tbody>
<tr>
<td>HPA-1</td>
<td>Yezin-1</td>
</tr>
<tr>
<td>BR-172</td>
<td>Yezin-2</td>
</tr>
<tr>
<td>ICPL 87</td>
<td>Yezin-3</td>
</tr>
<tr>
<td>ICPL 93003</td>
<td>Yezin-4</td>
</tr>
<tr>
<td>ICPL 87119</td>
<td>Yezin-5</td>
</tr>
<tr>
<td>ICPL 96061</td>
<td>Yezin-6</td>
</tr>
</tbody>
</table>

18 to 40 % yield advantage
2000 kg/ha hybrid seed
Niches for seed production
Seed Production and Delivery in ESA

- 4250 t of seed produced and disseminated to cover 0.5 Mha

Production strategies:
- Breeder seed: ICRISAT, NARS, ASA
- Foundation seed and certified: Private seed companies (Zenobia, Krishna, Miombo estate, Tanseed international)
- QDS(1 & 2) - Farmers field schools, Farmers’ associations, Progressive small scale farmers

Seed Delivery strategies:
- Revolving seed system in Malawi
- Small seed packs
- Farmer marketing groups
- Seed fairs
Seed Production of hybrids

1. Niches
2. Honey bee units
3. Staggering
4. Row ratios
5. Procurement price
6. Subsidy
7. Pvt sector

1. 657 tones -2013
2. 507 tons in 2014
3. 705 tons in 2015
4. Standards
5. Researchable issues

Off Season
## Hybrid seed production (yield kg/Acre) data from seven states

<table>
<thead>
<tr>
<th>State</th>
<th>Years</th>
<th>Locs</th>
<th>Yield (range)</th>
<th>Yield/acre</th>
</tr>
</thead>
<tbody>
<tr>
<td>Andhra Pradesh</td>
<td>6</td>
<td>34</td>
<td>625-1750</td>
<td>998</td>
</tr>
<tr>
<td>Jharkhand</td>
<td>2</td>
<td>2</td>
<td>450-550</td>
<td>500</td>
</tr>
<tr>
<td>Karnataka</td>
<td>2</td>
<td>2</td>
<td>375-1900</td>
<td>1138</td>
</tr>
<tr>
<td>Madhya Pradesh</td>
<td>3</td>
<td>9</td>
<td>700-2267</td>
<td>1674</td>
</tr>
<tr>
<td>Gujarat</td>
<td>2</td>
<td>4</td>
<td>750-1669</td>
<td>1179</td>
</tr>
<tr>
<td>Odisha</td>
<td>3</td>
<td>40</td>
<td>200-1040</td>
<td>523</td>
</tr>
<tr>
<td>Maharashtra</td>
<td>4</td>
<td>5</td>
<td>200-1017</td>
<td>603</td>
</tr>
</tbody>
</table>
On-farm demonstrations of Hybrids in 2014
Hybrid ICPH 2740

Raver, Jalgaon, Maharashtra

2012

Best Farmer Award in AP State
A line production in 2016

18000 T in 3.6 M Ha
1.4 Million T of Additional Grain
14400 Crores (212 M$)

60000 kgs of female For 2017 kharif

12000ha hybrid seed Production 2017

18000 tons of hybrid seed for 2018

40 ha
Transplanting Technology

- Seedling age
- Choice of varieties
- Spacing
- Irrigation
- High yield potential (5 t/ha)
### Maize-pigeonpea intercropping with micro P-fertilization in Tanzania

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Total VC (US $)</th>
<th>Net Income (US $)</th>
<th>B-C Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>DAP</td>
<td>518</td>
<td>1137</td>
<td>2.2</td>
</tr>
<tr>
<td>Minjingu phosphate granules</td>
<td>493</td>
<td>991</td>
<td>2.0</td>
</tr>
<tr>
<td>Minjingu Mazao</td>
<td>541</td>
<td>994</td>
<td>1.8</td>
</tr>
<tr>
<td>Sole maize with Minjingu Mazao</td>
<td>432</td>
<td>478</td>
<td>1.1</td>
</tr>
<tr>
<td>Farmers’ practice</td>
<td>345</td>
<td>496</td>
<td>1.4</td>
</tr>
</tbody>
</table>

**Graph:**
- **Y-axis:** Treatment categories: Farmer Practice, DAP, Minjingu Phosphate Granular, Minjingu Mazao, Sole Maize
- **X-axis:** Yield (US $)
- **Legend:**
  - Maize
  - Pigeonpea

**LSD values:**
- LSD 0.3
- LSD 0.6

**Notes:**
- October 2016
- Data collection and analysis conducted by the Crop Science Institute of Tanzania (CSIT)
Genomic approaches

- NAM and MAGIC
- Hybrid Purity Assessment Kits
- Two Line breeding
<table>
<thead>
<tr>
<th></th>
<th>Number of new varieties released (OPVs)</th>
<th>Tanzania: 4, Kenya: 1; Malawi: 1, Zambia: 1, India: 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>Number of new varieties released (Hybrids)</td>
<td>India: 4</td>
</tr>
<tr>
<td>3</td>
<td>Seed produced (metric tons)</td>
<td>17950</td>
</tr>
<tr>
<td>4</td>
<td>Seed distributed (metric tons)</td>
<td>17950</td>
</tr>
<tr>
<td>5</td>
<td>Number of farmers growing improved varieties released during the CRP period</td>
<td>897500</td>
</tr>
<tr>
<td>6</td>
<td>Area covered by improved varieties released during the CRP period</td>
<td>1795000 ha.</td>
</tr>
<tr>
<td>7</td>
<td>Number of management practices demonstrated (also name the practice, eg - micro dosing)</td>
<td>13700 (Transplanted technology, IPM, INM, P Micro dosing, Intercropping with maize, Legumes)</td>
</tr>
<tr>
<td>8</td>
<td>Total number of publications during the CRP period</td>
<td>88</td>
</tr>
<tr>
<td>9</td>
<td>Number of publications in ISI journals during the CRP period</td>
<td>73</td>
</tr>
<tr>
<td>10</td>
<td>Number of farmers at farmer field days</td>
<td>10700 (8900 Male and 1800 Female)</td>
</tr>
<tr>
<td>11</td>
<td>Number of trainees in short-duration training programs</td>
<td>176 (102 Male and 74 Female)</td>
</tr>
<tr>
<td>12</td>
<td>Number of students who completed Masters training</td>
<td>12 (4 Male and 8 Female)</td>
</tr>
<tr>
<td>13</td>
<td>Number of students who completed PhD training</td>
<td>7 (3 male and 4 Female)</td>
</tr>
</tbody>
</table>

**Impacts**
Lessons Learned

- Stability & restoration
- Establishment of seed systems
- Standardization
- Mind set of the farmers
- Maintainers for African germplasm
- Continued development of varieties for ESA
- Policy interventions
Areas suggested for continued R4D

- Diversification of CMS sources
- Identification of maintainers for Eastern and Southern Africa
- Development of pest tolerant genotypes (stem borer, pod fly, pod bugs)
- Development of Asia and ESA regions specific cultivars
- Development of dual purpose varieties (green & dry grain)
- Development of photoperiod insensitive and stable varieties
- Identification of heterotic gene pools
- Multiple disease resistance
- Scaling up of the technologies on large scale
- Development of seed road maps & strengthen seed systems
- Capacitating NARES, DOA, MoA and Farmers
Contributing Bilateral Projects

- Tropical Legumes II - Phase 1 and Phase 2
- Introduction and expansion of improved pigeonpea (Arhar) production technology in rain-fed upland ecosystems Odisha (RKVY, GoI of Odisha)
- Center of Excellence on climate change research for plant protection (Donor: DST-Climate Change Programme-SPLICE) PI-Mamta Sharma
- Addressing Phytophthora Blight Disease: An Emerging Threat to Pigeonpea Expansion and Production (Donor: DAC-NFSM, GoI) PI-Mamta Sharma
- Identification of superior alleles and lines from wild Cajanus species for pigeonpea (Cajanus cajan) improvement (Donor: GCDT)
- Scaling up and popularization of high yielding pigeonpea hybrids for enhancing productivity of small and marginal farmers of Maharashtra, Karnataka and Odisha states of India. NFSM, GoI
- Enhancing livelihoods of resource-poor farmers of Rajasthan through introduction of eco-friendly pigeonpea varieties. Department of Agriculture, Government of Rajasthan
- Development of hybrid pigeonpea technology suitable for Rajasthan. Department of Agriculture, Government of Rajasthan
- USAID-Feed the Future in Tanzania, Kenya, Malawi, Mozambique, Zambia and India
- ACIAR funded SIMLESA project in Kenya, Tanzania, Malawi, Mozambique, Ethiopia, Uganda
- Irish aid Project in Malawi
- Austria funded grain legumes project in Uganda
- AGRA funded soil health enrichment projects in Tanzania and Uganda
- BIIP
List of Posters

- Medium duration and Fusarium wilt tolerant pigeonpea cultivars for Eastern and Southern Africa: their development and adoption

- Hybrid pigeonpea-current status

- Advances in host plant resistance to Fusarium wilt, sterility mosaic disease and Phytophthora blight diseases of pigeonpea

- Genomics interventions towards fast-track development of pigeonpea hybrids
Sprouted Pigeonpea Meal as Feed for Broilers

Carcass & Sensory characteristics of broilers.

Utilization as feed for Broilers and tilapia

Potential as Anticalastogenic and anti diabetic

Packaged foods

Value Addition
Leveraging legumes to combat poverty, hunger, malnutrition and environmental degradation

http://grainlegumes.cgiar.org

and public and private institutes and organizations, governments, and farmers worldwide

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