Review Meeting
Dryland Cereals Phase 1 and Extension Phase

Sorghum  ESA 2012-2016

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A global alliance for improving food security, nutrition and economic growth for the world’s most vulnerable poor
Drought tolerant, highly productive multi-use sorghum varieties for food and processing uses in the dry lowlands of East Africa

- **Background**
  - 4% increase in sorghum production in East Africa in the last 30 years
    - increases in area cultivated,
    - a 1% yield increase per year.

- **Aim:**
  - 30-50% grain yield increase over the next 10 years
  - Improve yield stability of sorghum varieties
  - Develop and promote intensified, and profitable crop management options
  - Grain processing and product diversification - main drivers for sorghum market demand.
Challenges

• Resistance to key constraints
  ✓ Drought
  ✓ *Striga*.
  ✓ *Leaf diseases*
• Grain quality traits, especially for the processing industries
• Mechanization – production/processing
• Seed quality, availability and accessibility
• Market linkages
Objectives

- **Overarching Goal**
  - Achieve farm-level impacts, primarily through higher and more stable sorghum productivity on smallholder farms in ESA that will increase incomes and reduce rural poverty, increase food security, improve nutrition, and help reduce adverse environmental impacts.

- **Outcomes**
  - reduced rural poverty;
  - improved food security;
  - improved nutrition and health.
  - Enhanced cereal/legume systems to optimize crop production
  - increased production with minimized risks of environmental degradation
RESULTS PRESENTED

- Mapping Returns to Sorghum breeding in ESA countries
- Sorghum Hybrids Development in ESA
- Varieties/hybrids released
- Prevalence of Sorghum Diseases in Tanzania and Uganda
- Integrated climate change-ready cereal and legume technologies for food security in Wote District, Makueni County-Kenya
- Enabling Farmers access quality seed.
- Post-harvest handling Value addition and Marketing
Mapping Returns to Sorghum breeding in ESA countries

- Objectives: Assess the ex-post and ex-ante returns to research of improved sorghum varieties, for Uganda, Tanzania and Ethiopia
- Method: GIS based country level analysis, crop economics assessed by NARS experts, differentiation by variety, AEZ and regional market setup (supply, demand and prices)

<table>
<thead>
<tr>
<th>Setup</th>
<th>Crop</th>
<th>No. of improved varieties</th>
<th>No. of Subdivisions</th>
<th>Market size (production in mt)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Uganda</td>
<td>Sorghum</td>
<td>10</td>
<td>5 sub-regions</td>
<td>400,000</td>
</tr>
<tr>
<td>Tanzania</td>
<td>Sorghum</td>
<td>14</td>
<td>10 districts+1 group of districts</td>
<td>800,000</td>
</tr>
<tr>
<td>Ethiopia</td>
<td>Sorghum</td>
<td>23</td>
<td>4 AEZ</td>
<td>3,800,000</td>
</tr>
</tbody>
</table>
Table 2. Dream model study results 2

<table>
<thead>
<tr>
<th>Impacts</th>
<th>Modelling Period</th>
<th>Internal rates of return</th>
<th>Economic gains (USD million)</th>
<th>Economic gains/year (USD million)</th>
<th>How much goes to producers?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Uganda</td>
<td>1980-2030 (S)</td>
<td>28-59%</td>
<td>125</td>
<td>3.6</td>
<td>61%</td>
</tr>
<tr>
<td>Tanzania</td>
<td>1980-2030</td>
<td>31-180%</td>
<td>1,203</td>
<td>5.7</td>
<td>29%</td>
</tr>
<tr>
<td>Ethiopia</td>
<td>1971-2040</td>
<td>8-104%</td>
<td>760</td>
<td>3.6</td>
<td>81%</td>
</tr>
</tbody>
</table>

Returns to research on improved sorghum varieties are economically sound with IRR >20%. However, many of 1st generation varieties underperform (IRR < 20 %) as national breeding programs incurred long breeding cycles, high research costs and sub-standard varietal performance in farmers’ fields.

Fig 1. Mapping economic returns from improved sorghum varieties (million USD, Ethiopia and Tanzania)

Fig 2. Linking poverty hot spots and sorghum production (Uganda)
Sorghum Hybrids Development in ESA

- Hybrids development based on adapted introduced and local restorers have been successful
  - Tanzania: 2 hybrids IESH 28002 (Fig 3) and IESH 22012 released in 2013 - partnership with NACO Seed Company.
  - Kenya: IESH 211001 released in July 2016 - partnership with Egerton University (*seed production underway-EAML*); 3 hybrids in DUS - collaboration with Kenya Seed Company.
  - Ethiopia: ESH 1 and 2 released in 2012; ESH 3 – 2014; ESH 4/5-2016
  - All hybrids have 30-40% yield advantage over farmer/improved OPVs and good for food and feed

Fig 3: Hybrid IESH 28002 released in Tanzania and selected in Malawi and Zimbabwe
Sorghum Hybrids Development in ESA

- New hybrids
  - 25 hybrids (KE, TZ and ZM) and 16 hybrids (MW) evaluated (Table 3)
    - Highest grain yield at Chitedze (7.196 t/ha)
    - Mean yield at Matopos (4.514 t/ha)
    - Lowest mean at Miwaleni (2.287)
    - Most stable hybrids IESH 28001(G10), IESH 22012 G1) and ICSA 276 x ICSR 162 (G6) (Fig 3)
  - SeedCo and East African Seed, NileSun, Hytec testing the hybrids
  - Hybrids parents dev at Kiboko >1000 BC₃
  - HPC initiative on-going
Table 3. Performance of sorghum hybrids across 5 locations in ESA

<table>
<thead>
<tr>
<th>Hybrid</th>
<th>Grain yield t ha(^{-1})</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Across</td>
</tr>
<tr>
<td>IESH 22023</td>
<td>3.961</td>
</tr>
<tr>
<td>ICSA 15 X ICSR 93001</td>
<td>3.845</td>
</tr>
<tr>
<td>ATX 623 X KARI MTAMA 1</td>
<td>3.706</td>
</tr>
<tr>
<td>ATX 623 X MACIA</td>
<td>3.595</td>
</tr>
<tr>
<td>ICSA 11004 X ICSR 89058</td>
<td>3.572</td>
</tr>
<tr>
<td>IESH 22002</td>
<td>3.462</td>
</tr>
<tr>
<td>ICSA 88001 X ICSR 160</td>
<td>3.434</td>
</tr>
<tr>
<td>ICSA 12 X IESV 91104 DL</td>
<td>3.431</td>
</tr>
<tr>
<td>ICSA 11003 X IESV 92172 DL</td>
<td>3.422</td>
</tr>
<tr>
<td>ATX 623 X IESV 91104 DL</td>
<td>3.418</td>
</tr>
<tr>
<td>ICSA 90001 X ICSR 172</td>
<td>3.337</td>
</tr>
<tr>
<td>SE(\pm)</td>
<td>1.317</td>
</tr>
<tr>
<td>CV%</td>
<td>27.1</td>
</tr>
</tbody>
</table>
Fig 3. Biplot analysis based on grain yield
Table 4. Variety Releases 2012-2016

<table>
<thead>
<tr>
<th>Country</th>
<th>Year</th>
<th>Varieties released</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eritrea</td>
<td>2012</td>
<td>IESV 92029 DL</td>
</tr>
<tr>
<td>Ethiopia</td>
<td>2012</td>
<td>Macia and ICSR24004/Dekeba</td>
</tr>
<tr>
<td></td>
<td>2015</td>
<td>Dibaba</td>
</tr>
<tr>
<td></td>
<td>2016</td>
<td>Jiru and Adele</td>
</tr>
<tr>
<td>South Sudan</td>
<td>2013</td>
<td>KARI Mtama 1 and Macia</td>
</tr>
<tr>
<td>Tanzania</td>
<td>2012</td>
<td>KARI Mtama 1</td>
</tr>
<tr>
<td>Kenya</td>
<td>2013</td>
<td>IESV 92001 DL (Sweetsorg 4), SPV 422 (Sweetsorg 14)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>ICSR 93034 (Sweetsorg 17) and IS 35 (Sweetsorg 21)</td>
</tr>
<tr>
<td>Zimbabwe</td>
<td>2013</td>
<td>IESV 92043 DL (Shirikure)</td>
</tr>
</tbody>
</table>
Prevalence of Sorghum Diseases in Tanzania and Uganda

Survey 2014

- To determine the prevalence of sorghum diseases in major sorghum production areas in TZ and UG and Uganda.
  - Samples analysed at Chitedze to confirm diseases observed.

Tanzania:

- 16 diseases were identified
- Most prevalent (% of fields): Leaf blight (76%), Anthracnose (56%) and rust (43%)
Prevalence of Sorghum Diseases in Tanzania and Uganda

- **Uganda:**
  - 15 diseases were identified
  - Leaf blight (55%), anthracnose (43%) and ladder leaf spot (20%).

- **Disease prevalence differed significantly between countries**
  - More prevalent in Tanzania than Uganda: leaf blight ($P = 0.0007$), covered smut ($P = 0.0002$), rust ($P < 0.0001$), bacterial leaf blight ($P = 0.0007$), head mold ($P < 0.0001$) and long smut ($P < 0.0001$).
  - More prevalent in Uganda than in Tanzania were anthracnose ($P = 0.032$), ladder leaf spot ($P = 0.0018$), loose smut ($P = 0.015$), gray leaf spot ($P = 0.0098$), oval leaf spot ($P = 0.001$), and downy mildew ($P = 0.001$).
Integrated climate change-ready cereal and legume technologies for food security - Kenya

- Sorghum: 3 varieties
- Legumes: Green gram-1; Cowpea-1; Maize-1; Bean-1
- 235 mother-baby trials hosted by 235 households
  - Sorghum-cowpea or sorghum-green gram intercropping systems are most productive in Makueni
- Farmers received 35-60% more value for their resources in sorghum legumes systems than in maize bean systems
- Sorghum-cowpea or sorghum-green gram systems - better chance of enhancing food security in Makueni County than Maize & beans (Table 5.)
Table 5. Gross value of cereal and legume grain yield using farm gate and Wote market prices

<table>
<thead>
<tr>
<th>Sorghum-legumes systems</th>
<th>Cereal yield (ton/ha)</th>
<th>Legume yield (ton/ha)</th>
<th>Gross value (Kes/ha): Farm gate price (rank)</th>
<th>Gross value (Kes/ha) Wote market prices(rank)</th>
</tr>
</thead>
<tbody>
<tr>
<td>KARI Mtama 1 &amp; Cowpea K80</td>
<td>1.366</td>
<td>1.042</td>
<td>66776 (4)</td>
<td>84744 (4)</td>
</tr>
<tr>
<td>Gadam &amp; Cowpea K80</td>
<td>1.474</td>
<td>1.128</td>
<td>72164 (2)</td>
<td>91596 (3)</td>
</tr>
<tr>
<td>Seredo &amp; Cowpea K80</td>
<td>1.741</td>
<td>1.001</td>
<td>75296 (1)</td>
<td>94272 (1)</td>
</tr>
<tr>
<td>KARI Mtama 1 &amp; greengram N26</td>
<td>1.455</td>
<td>0.454</td>
<td>60530 (6)</td>
<td>79062 (6)</td>
</tr>
<tr>
<td>Gadam &amp; greengram N26</td>
<td>1.576</td>
<td>0.474</td>
<td>64676 (5)</td>
<td>84252 (5)</td>
</tr>
<tr>
<td>Seredo &amp; greengram N26</td>
<td>1.881</td>
<td>0.453</td>
<td>71556 (3)</td>
<td>91764 (2)</td>
</tr>
<tr>
<td>Maize KDV1 &amp; Beans Katex56</td>
<td>1.087</td>
<td>0.298</td>
<td>48404 (7)</td>
<td>56521 (7)</td>
</tr>
</tbody>
</table>
Enabling Farmers access quality seed

- Improved incentives for farmers to access seed
  - Awareness
    - On-farm
      - Variety selection suitable varieties
      - Demonstration of the agronomic and economic benefits of using improved varieties and associated packages
  - Use of affordable mini-seed packs
  - Promotion of QDS (1/2 the price of certified Tanzania)
Enabling farmers access quality seed

- Strengthened PPPs in supply of high quality seed to farmers
  - Seed supply stakeholders mapped
  - Linked research to private seed companies
    - capacity building
    - provision of breeders and foundation seed
  - Encouraged private seed companies to market mini-seed packs of new varieties
  - >1700t foundation/QDS/certified seed accessed by seed producers and farmers

10 October 2016
Post-harvest handling Value addition and Marketing

- Farmers enabled to access threshers
- Working with fabricators to develop threshers for small scale farmers
- 25 women groups trained/year in Value addition and product diversification for household use and commercialization
- 17 Low energy use charcoal ovens availed to groups in Kenya and Tanzania
- Farmers linked to grain markets through aggregator model
  - >8000 farmers marketing grain to malting industry per
  - grain prize improvement of about 40%.
- New uses of sorghum grain explored
  - Fish feed
  - Grain quality analysis (Table 6)
Post-harvest handling, Value addition and Marketing
### Table 6. Grain analysis for feed quality (Unga Feeds Ltd-Kenya)

<table>
<thead>
<tr>
<th>Variety</th>
<th>Protein (%)</th>
<th>Oil (%)</th>
<th>Fibre (%)</th>
<th>Tannin (%)</th>
<th>Grain colour</th>
</tr>
</thead>
<tbody>
<tr>
<td>KARI Matam 1</td>
<td>7.89</td>
<td>2.78</td>
<td>2</td>
<td>1</td>
<td>White</td>
</tr>
<tr>
<td>KAT 487</td>
<td>8.32</td>
<td>2.96</td>
<td>1.6</td>
<td>0</td>
<td>White</td>
</tr>
<tr>
<td>Tegemeo</td>
<td>7.89</td>
<td>3.66</td>
<td>2.3</td>
<td>0</td>
<td>White</td>
</tr>
<tr>
<td>Sila</td>
<td>7.45</td>
<td>2.68</td>
<td>1.8</td>
<td>1</td>
<td>White</td>
</tr>
<tr>
<td>Tegemeo</td>
<td>7.01</td>
<td>2.54</td>
<td>1.2</td>
<td>1</td>
<td>White</td>
</tr>
<tr>
<td>IESH 22012</td>
<td>7.45</td>
<td>3.1</td>
<td>2.1</td>
<td>0</td>
<td>White</td>
</tr>
<tr>
<td>ATX 623 x Macia</td>
<td>8.10</td>
<td>3.52</td>
<td>1.5</td>
<td>1</td>
<td>White</td>
</tr>
<tr>
<td>IESH 22009</td>
<td>7.89</td>
<td>3.54</td>
<td>1.3</td>
<td>0</td>
<td>White</td>
</tr>
<tr>
<td>IESH 22010</td>
<td>8.76</td>
<td>3.92</td>
<td>1.9</td>
<td>0</td>
<td>White</td>
</tr>
<tr>
<td>IESH 22002</td>
<td>7.01</td>
<td>2.8</td>
<td>1.3</td>
<td>0</td>
<td>White</td>
</tr>
<tr>
<td>Specification</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>&lt;5%</td>
<td></td>
</tr>
</tbody>
</table>
IMPACT

- Increased access to affordable quality seed
- Increased productivity – from 0.8 to 2.0 t/ha in target areas
- In eastern Kenya 49,000 MT of Sorghum grain (surplus after HH needs are satisfied) from the project area sold
- Income - valued at KES 16.2 billion or USD 16 Million with USD 10.8 Million of that total value (67%) remaining with producers as gross earnings
- 35-60% more value for resources in sorghum legumes systems than in maize bean systems
- Food security (*Farmer’s comment next slide*)
Statement from Mr Mutisya-farmer Wote, Kenya

“Using the early maturing sorghum and legume seed varieties on my 2 acres of land, I was able to harvest about 15 bags of sorghum grain, 3 bags of cowpea, and 1 bag of green grams,” says a triumphant Charles Wambua Mutisya of Kona Baridi Village, Kikumini in Kenya. This 45 year old father of eight believes his harvest will feed his family until the next harvest in Aug and ensure surplus grain for sale. “Had I planted maize and beans on the 2 acres, I would have harvested no more than 3 and 0.5 bags, respectively, which would have lasted only up to the end April, and with no surplus to sell”, he says
Cross cutting

- **Capacity building**
  - 30 extension agents/year trained as TOTs
  - >4000 farmers trained – crop mgt
  - 20 scientists/technicians in field breeding techniques/seed production
  - 25 women groups/year trained in value addition
  - 4 MSc and 4 PhD

- **Gender**
  - Women involved in decision making along the value chain
    - Data disaggregated
  - Crop management and post harvest handling options that reduce drudgery
  - Extension/research partners trained in mainstreaming gender
Lessons Learned

- Value chain approach with PPPs – impact on adoption
- Hybrid seed production and delivery to farmers still requires engagement and partnership with private sector
- Overcoming constraints on seed availability and knowledge are key to increasing adoption.
- Right choice of crop management options increases returns to investment and reduces risks associated with climate change
Areas suggested for continued R4D

- Germplasm screening – identify material with desired traits (Classic + Mol)
- Targeted variety/hybrids development (Conven + MAB)
  - Biotic and abiotic stresses
  - End use qualities
- Mechanization (production and post-harvest)
- Nutrient profiling – better targeting of varieties
- Enhance efficiency of existing farming systems by incorporating improved practices.
- Capacity building in nutritional benefits of sorghum and promotion of new and nutritious products
- PPPs to develop alternative markets for sorghum utilization; including animal feed as well as human consumption,
Contributing Bilateral Projects

- HOPE 1 (BMGF)
- SMU (IFAD/EU)
- CCAFs
- FTF-AVCD DTC (USAID)
Summary

- Returns to research on improved sorghum varieties are economically sound
- Potential for sorghum hybrids to improve grain productivity – private seed sector and grain market interest emerging
- PPPs across Value chain increased productivity, production and profitability
  - promotion and uptake of new sorghum cultivars and management options,
  - Availability, accessibility and affordability of seed
  - Access to input and grain markets
- Disease surveillance necessary to develop appropriate management and research strategies
- Training in nutrition, value addition and product diversification will increase sorghum consumption
List of Posters

- Improving Sorghum Productivity, Utilization and Marketing in Kenya and Tanzania - *A Value Chain Approach*
- Sorghum Hybrids Evaluation in ESA: *Increasing productivity for food security and income*
- Yield stability, heterosis and performance of sorghum hybrids in the semi-arid areas of Kenya
- Prevalence of Sorghum (*Sorghum bicolor* L.) Diseases in Tanzania
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