Breeding for Resilience for Different Food Systems in Tanzania & Implications for the East African region.

By

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Outline

• Introduction:
  • Importance and Crop Use

• Crop improvement

• Product target

• Research focus

• Breeding approaches

• Objectives

• Seed systems

• Examples in seed systems and collaborations
Food systems

• A food system includes all processes and infrastructure involved in feeding a population: growing, harvesting, processing, packaging, transporting, marketing, consumption, and disposal of food and food-related items. It also includes the inputs needed and outputs generated at each of these steps.
Sweet potatoes, production quantity (tons)

Top 10 countries for 2014

United States
Vietnam
Uganda
Angola
Indonesia
Mozambique
Ethiopia
Tanzania
Nigeria

71,539,950 Sweet potatoes, production quantity (tons)
2014 China

Source: FAOSTAT 2014
Sweetpotato Production in Top 10 African countries
Importance and crop uses

• Sweetpotato is grown for its storage roots and leaves:
  • for food and nutrition security
  • income generation
  • for feed in many developing countries.

• It remains an attractive crop in the rural communities in developing countries.

• In Tanzania, sweetpotato is an important crop grown by subsistence farmers mostly women for food security

• Sweet potato leaves are grown widely in the peri-urbans and in rural areas as a source of income for women and youths
Crop uses

• Sweet potato leaves are consumed as a leafy vegetable by the majority of the people in Tanzania,

• It is a good source of micro-nutrients: Vit A, B, C, K, calcium, iron, magnesium, phosphorus, Potassium

• Roots are nutrient dense especially the orange fleshed-rich in beta carotene content
Narrow leaf varieties

Broad leaf varieties
Roots can be processed into products: cakes, noodles, Jam, Juice, crisps, sliced-dried chips.
Health benefits of sweetpotatoes

1. Massive Amounts of Beta-carotene (an important antioxidant and precursor to vitamin A)
2. Contain Twice The Fibre of Normal Potatoes (which aids satiety and digestive health)
3. Rich in Vitamin C and E (which act as antioxidants in the body and improve immune and cardiovascular health)
4. Potent Source of Manganese (that helps stabilise blood glucose levels and appetite for hours)
5. High Levels of B6 and Potassium (important for heart health and electrolyte balance)
6. The Tubers also Contain Iron, Magnesium and Vitamin D (while the edible leaves contain even more iron, vitamin C and potassium as well as folate and vitamin K)

Bake it. Mash it. Soup it. Salad it.
http://OmNomAlly.com
## Nutritional Value

### Raw Sweet Potato

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Value per 100 g (3.5 oz)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Energy</strong></td>
<td>359 kJ (86 kcal)</td>
</tr>
<tr>
<td><strong>Carbohydrates</strong></td>
<td></td>
</tr>
<tr>
<td>- Starch</td>
<td>12.7 g</td>
</tr>
<tr>
<td>- Sugars</td>
<td>4.2 g</td>
</tr>
<tr>
<td>- Dietary fibre</td>
<td>3 g</td>
</tr>
<tr>
<td><strong>Fat</strong></td>
<td>0.1 g</td>
</tr>
<tr>
<td><strong>Protein</strong></td>
<td>1.6 g</td>
</tr>
<tr>
<td>Vitamin A equiv.</td>
<td>709 µg (89%)</td>
</tr>
<tr>
<td>- beta-carotene</td>
<td>8509 µg (79%)</td>
</tr>
<tr>
<td>Thiamine (vit. B₁)</td>
<td>0.078 mg (7%)</td>
</tr>
<tr>
<td>Riboflavin (vit. B₂)</td>
<td>0.061 mg (5%)</td>
</tr>
<tr>
<td>Niacin (vit. B₃)</td>
<td>0.557 mg (4%)</td>
</tr>
<tr>
<td>Pantothenic acid (B₅)</td>
<td>0.8 mg (16%)</td>
</tr>
<tr>
<td>Vitamin B₆</td>
<td>0.209 mg (16%)</td>
</tr>
<tr>
<td>Folate (vit. B₉)</td>
<td>11 µg (3%)</td>
</tr>
<tr>
<td>Vitamin C</td>
<td>2.4 mg (3%)</td>
</tr>
<tr>
<td>Vitamin E</td>
<td>0.26 mg (2%)</td>
</tr>
<tr>
<td>Calcium</td>
<td>30 mg (3%)</td>
</tr>
<tr>
<td>Iron</td>
<td>0.61 mg (5%)</td>
</tr>
<tr>
<td>Magnesium</td>
<td>25 mg (7%)</td>
</tr>
<tr>
<td>Manganese</td>
<td>0.258 mg (12%)</td>
</tr>
<tr>
<td>Phosphorus</td>
<td>47 mg (7%)</td>
</tr>
<tr>
<td>Potassium</td>
<td>337 mg (7%)</td>
</tr>
<tr>
<td>Sodium</td>
<td>55 mg (4%)</td>
</tr>
<tr>
<td>Zinc</td>
<td>0.3 mg (3%)</td>
</tr>
</tbody>
</table>

### Sweet Potato Leaves, raw

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Value per 100 g (3.5 oz)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Energy</strong></td>
<td>175 kJ (42 kcal)</td>
</tr>
<tr>
<td><strong>Carbohydrates</strong></td>
<td></td>
</tr>
<tr>
<td>- Dietary fiber</td>
<td>5.3 g</td>
</tr>
<tr>
<td><strong>Fat</strong></td>
<td>0.51 g</td>
</tr>
<tr>
<td><strong>Protein</strong></td>
<td>2.49 g</td>
</tr>
<tr>
<td>Vitamin A equiv.</td>
<td>189 µg (24%)</td>
</tr>
<tr>
<td>- beta-carotene</td>
<td>2217 µg (21%)</td>
</tr>
<tr>
<td>- Lutein and zeaxanthin</td>
<td>14720 µg</td>
</tr>
<tr>
<td>Thiamine (vit. B₁)</td>
<td>0.156 mg (14%)</td>
</tr>
<tr>
<td>Riboflavin (vit. B₂)</td>
<td>0.345 mg (29%)</td>
</tr>
<tr>
<td>Niacin (vit. B₃)</td>
<td>1.13 mg (8%)</td>
</tr>
<tr>
<td>Pantothenic acid (B₅)</td>
<td>0.225 mg (5%)</td>
</tr>
<tr>
<td>Vitamin B₆</td>
<td>0.19 mg (15%)</td>
</tr>
<tr>
<td>Vitamin C</td>
<td>11 mg (13%)</td>
</tr>
<tr>
<td>Vitamin K</td>
<td>302.2 µg (288%)</td>
</tr>
<tr>
<td>Calcium</td>
<td>78 mg (8%)</td>
</tr>
<tr>
<td>Iron</td>
<td>0.97 mg (7%)</td>
</tr>
<tr>
<td>Magnesium</td>
<td>70 mg (20%)</td>
</tr>
<tr>
<td>Phosphorus</td>
<td>81 mg (12%)</td>
</tr>
<tr>
<td>Potassium</td>
<td>508 mg (11%)</td>
</tr>
</tbody>
</table>

Source: USDA Nutrient Database [4]

Direct link to database entry

Percentages are relative to US recommendations for adults.
Sweetpotato used as Ornamental plants
Important constraints in E.A. Region

- **Tanzania**: Low yield, SP weevils and SPVD, drought, and low DM of OFSP
- **Uganda**: SPVD, Alternaria, weevils
- **Ethiopia**: SPVD, SP weevil, low yield and low dry matter content of OFSP
- **Kenya**: SPVD, Alternaria and weevils, Drought, low yield, low dry matter in OFSP, in-adequate research funds, and few breeders.
- **Rwanda**: Low yield, dual purpose varieties, low DM, low β-carotene, SPVD, Weevil
Crop improvement

- Yield (10-25%)
- Dry matter content (20-38%)
  - Low, medium, high
- Virus resistance/tolerance
  - Select 2 in (1-5 scale)
- Pest tolerance
- Increased micronutrients (beta carotene positive correlated with zinc, iron)
- Mealyness for fresh use
- Drought tolerance-
- Good storability
- Seed systems-virus free
Crop Improvement

• To develop improved varieties, plant breeders require:
  • a diverse pool of genetic resources, not entirely available in the case of sweetpotato.

• Crop wild relatives: the undomesticated “cousins” - can be used to introduce greater tolerance to heat and other stresses to the crop.

• Collection and conservation: CIP Lima, Peru maintain >6,500 wild, traditional and improved varieties
Product target:

• Root yield: >15t/ha
• Maturity: 4 month after planting
• Tolerate important virus diseases (SPVD) score 2 (1-5 scale)
• High beta carotene content-roots and leaves
• High iron and zinc content-leaves
• Sugar content: low, moderate and high
• Dry matter content : 20-38%
• Dual purpose sweetpotato-leaf and root production
Breeding approaches

• Germplasm collection, introduction, conservation and utilization

• Morphologic characterization-IBPGR-1980, CIP descriptors
  • Agronomic characterization
  • Micronutrient determination (beta carotene, iron and zinc)-HPLC in advanced laboratory

• Genetic characterization- use of Markers

• Hybrization, evaluation and selection
Markers in sweetpotato

- Simple sequence repeat markers are of particularly interest to study: (Ngailo et al., 2016; Yada et al., 2010; Rodriguez-Bonilla et al., 2014)
  - because they are abundant in plants,
  - have high level of polymorphism and the codominance nature and high numbers of alleles per locus
  - are adaptable to automation (Donini and Stephenson, 1998).

- Efficiency of SSR markers has been demonstrated in identifying and characterizing the genetic diversity and relationships

- These markers are powerful and have the ability to discriminate genotypes including those related by pedigree
Hybridization, Evaluation and Selection:

- About 10 parental lines selected based on genetic background, performance
- Crossing block – made at SRI-Kibaha and LZARDI ukiriguru
- $F_1$ - about 2000 botanical seeds (a seed is a potential genotype)
  - Unreplicated trial – local check plots
- Preliminary evaluation - 200 genotype selected, planted in 2 sites;
- Advanced evaluation: 20 or more
- On-farm Trials- farmers assessment
- National Performance Trials and DUS
- Apply for official release
Nutritional analysis for micronutrients

• Root and leaf samples collected and prepared for micronutrients determination using HPLC
• Other nutrients: Proximate analysis - water, ash and fibre according to AOAC, 1984
Research focus

- To improve root yield of SP varieties adapted to broad and specific Agro ecological zones
- To increase SP resistance to SPVD and weevil
- To screen for drought resistance
- To improve beta carotene and dry matter content of OFSP
- To promote technical and training support to CBOs, NGOs, and farmers seed producers
- To improve sweetpotato quality planting material production and seed system in the country
- To promote diversified utilization, i.e. food/processing
- To promote linkages, and distribution of breeder seed to seed entrepreneurs
Sweetpotato seed systems

• Use of virus free planting materials - Collaborate with different laboratories: both public-MARI, KEPHIS and private- CBS-Arusha and KILIMORGANO-Dar

• Research: Responsible with **Pre-basic seed production** and Basic seed category:
  • Inspection and Certification by Tanzania Seed Certification Institute (TOSCI)

• **Basic seed, Certified (C1&C2)- Private sector and Seed enterpreneurs**- Seed regulations of 2017 in place -January 2017
  • Inspection and Certification by Tanzania Seed Certification Institute (TOSCI)

• **Quality Declared Planting Materials (QDPM)- seed enterpreneurs and farmers groups**- We continue advocating for sweetpotato seed systems
  • Quality Declared planting materials- Legislation tabled to the Ministry for endorsement
SP Action for Security and Health (SASHA II)- Pre-Basic seed

• Objectives
  ✓ Strengthen tech. & institutional capacity to produce pre-basic seeds
  • To create awareness of clean planting materials, and coordinate demand for increased sustainability

✓ Achievements
  ✓ 8500 cutting of 9 varieties (Kabode, mlezi, Naspot-13, Naspot-12, Naspot-11, Kakamega, Ejumula, Kiegeya and Mataya) procured from Crop Bioscience Solution - Arusha

✓ Workshops: Two workshops were conducted
  ✓ 96 multipliers trained by the three team: SRI-Kibaha, ARI-Ukiriguru and ARI-Uyole
  ✓ 787,647 cuttings produced and 80% were sold between to date

✓ to compare vine and root yield btn seed sourced from farmers' fields versus seed sourced from screen house.
FAST TRACKING THE ACCESS TO IMPROVED VARIETIES OF SWEETPOTATO BY SMALL HOLDER FARMERS:

- Disseminated >7,000,000 cuttings of SP
- Reached 16 districts in Tanzania and Uganda
- Reached 153 schools in both Tz and UG
- Include OFSP in Primary school curriculum-in Uganda
Achievements...

✓ Table 2: The comparison of 3 demo plots using planting material from (screen house and farmers fields in Misungwi district.

<table>
<thead>
<tr>
<th>Varieties</th>
<th>Farmer Source</th>
<th>Screen House Source</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Root yield (t/ha)</td>
<td>Foliage yield</td>
</tr>
<tr>
<td>Polista</td>
<td>13.01</td>
<td>23.93</td>
</tr>
<tr>
<td>Kabode</td>
<td>9.00</td>
<td>21.08</td>
</tr>
<tr>
<td>Naspot 11</td>
<td>14.44</td>
<td>22.35</td>
</tr>
<tr>
<td>Umeme</td>
<td>13.51</td>
<td>17.86</td>
</tr>
<tr>
<td>Mean</td>
<td><strong>12.49</strong></td>
<td><strong>21.31</strong></td>
</tr>
<tr>
<td>LSD</td>
<td><strong>3.804</strong></td>
<td><strong>8.419</strong></td>
</tr>
<tr>
<td>CV</td>
<td><strong>15.24</strong></td>
<td><strong>19.78</strong></td>
</tr>
</tbody>
</table>
Fast Track Project on SP variety dissemination

- More than 7,000,000 cuttings disseminated
- Primary schools
- 153 primary schools piloted in Tanzania and Uganda
- 15 districts intervened
- More than 200 extension officers trained on SP technologies
- OFSP incorporated in Primary school curriculum in Uganda with 4 exemplar books to be tested
- Nutrition education book approved by the Tanzania Institute of Education

Dr Everina Lukonge with farmers and district leaders
VISTA and BNFB Projects

• Trained 24 vine multipliers in the Central zone of Tanzania: Dodoma ad Singida BNFB

• Training of extension staff on 'Everything you ever wanted to Know about Sweetpotato'- SUA for VISTA and BNFB

• Pre-basic seeds for VISTA and BNFB projects
  • SRI-Kibaha, ARI-Hombolo, ARI-Uyole

• Evaluated 16 OFSP varieties in 10 districts in Central and Southern Highlands zones-

• Conducted Mother Baby Trials-17 mother trials and 152 baby trials to determine the performance and adaptability of varieties
  • Identified about 3 superior OFSP varieties for release in 2 years.
Basic seed production at SUGECO-SUA, Morogoro
Conducted 3 training session to 131 lead farmers/seed multipliers and extension staff from 5 districts in Central and Lake zones: Topics: Agronomy, Postharvest and values addition
SRI-KIBAHA AND LZARDI UKIRIGURU-TRAINING FARMERS AND EXTENSION OFFICERS
Achievements

- National Program – officially released 17 SP varieties among those 6 are OFSP
- Seed Regulations of 2017-(G.N. 37-2007) includes Cassava, Sweetpotato and Potato
- Provision of pre-basic seed-inspected and certified by TOSCI
- Nutrition enhanced through OFSP – reached 48 districts out of 169 in Tanzania (29%)
- Promotion of OFSP: Good collaboration with the Media houses-Radio, TV, Newspapers, etc
- Noted Increased demand for OFSP planting materials
Achievements

• Established strong Collaboration with different partners in the region: CIP, IFPRI-HarvestPlus, World Vision, AGRA,

• Locally: Commission for Science and Technology, Sokoine University of Agriculture-SUGECO, UDSM, LGA, Seed Multipliers and farmers, CBOs, Private sector-processors, TAHA, etc

• Supporting District programs- dissemination of OFSP varieties and awareness creation: Ilindi ward, Bahi district, Dodoma, Tanzania- BNFB

• Harmonized seed Regulations in East African Countries and Now SADC countries (May 2017)
Collaboration with Private sector

• Matoborwa company in Dodoma Tanzania
• AFCO company in Dar es salaam
• TAHA, CBS
Challenges

• Drought-climate change
• Inadequate funding for breeding
• Succession plan of scientist
• Inadequate clean planting materials – more efforts needed
• Lack of equipment in the National program for micronutrient analysis-NIRS,HPLC
Future plans

• Continue with the conventional breeding- incorporating end-users preferences around market segments
  • Sugar levels for processing and value addition (high vs. Low)
  • Dry matter content (low, medium and high)
• Maintainance of breeder seeds
• Use of molecular markers- complement breeding
• Nutritional analysis-NIRS technology or HPLC (out source)
• Genomic selection- need for capacity building
• Try GBS -high throughput, next generation sequencing- in collaboration with Beca
Acknowledgement

FARMERS, SEED MULTIPLIERS, PROCESSORS
Asanteni sana; Thank you for listening