The Sweetpotato Breeding Community of Practice: Breeding in Africa for Africa (2009-2019)

- A vibrant community of practice consisting of sweetpotato breeders from 16 African countries has been strengthened during the past 10 years, adopting modern breeding methods and releasing user-preferred varieties having an impact on health and wealth.
- Since 2009, sweetpotato breeders in 16 countries have released 143 varieties, with 93 having orange-flesh color, indicative of beta-carotene content, which the body turns into vitamin A.
- Sixteen varieties were released in more than one country, having broad adaptation and user acceptance.
- Of the released varieties since 2009, 112 were bred by 12 African programs, and 19 were superior African landrace selections.

SASHA Sweetpotato Action for Security and Health in Africa

AUGUST 2019

Fig 1. Participants at the 18th annual meeting of the Speedbreeders and Genomics Community of Practice meeting held in Maputo, Mozambique, June 2019. Participants came from 13 national programs, the regional Sweetpotato Support Platforms, CIP headquarters, North Carolina State University, and the Boyce Thompson Institute. 4th from the right is the Minister of Agriculture and Food Security of Mozambique, who opened the meetig.

What was the problem?

The problem was to modernize conventional breeding in sub-Saharan Africa (SSA). For many years sweetpotato was essentially an orphan crop. Indeed, prior to 2005, most countries in SSA had no real breeding program and relied on testing of materials imported from elsewhere, or the identification of superior local landrace varieties. This changed in 2009, with the inception of the Sweetpotato Action for Security and Health in Africa (SASHA) project, and complementary support from Alliance for a Green Revolution in Africa (AGRA) in a number of countries for Ph.D. training in sweetpotato breeding followed by support for variety development. Key regional requirements were identified by stakeholders:

- the need for sweetpotato virus disease resistant varieties in eastern and Central Africa,
- the need for drought tolerant varieties in southern Africa, and
- the need for less sweet varieties to meet consumer preferences in West Africa
- the need for standardized tools for collecting and analyzing breeding data

What objectives did we set?

The major objective was to strengthen sweetpotato breeding capacity and modernize methods in SSA. We sought to work with breeding programs to enhance the capacity for sweetpotato breeding in Africa to deliver user preferred varieties to delivery systems capable of reaching large numbers of national and regional producers and consumers. The focus was primarily, but not exclusively on orange-fleshed sweetpotato varieties, and we aimed for genetic gains for yield and other key traits, both in our breeding trials and on farmers' fields. We have sought consistently to develop and use, with partners, tools and techniques for trial design, data collection analysis and management, that will allow us to become more efficient through the use of the best and most appropriate modern practices.

Where and how did we work?

To address needs and opportunities on a regional basis, sub-regional Sweetpotato Support Platforms (SSPs) were established at National research institutes in Uganda, Mozambique and Ghana. A CIP breeder was based at each platform to provide technical backstopping and collaboration at the sub-regional level to breeders from 17 countries: Angola, Madagascar, Malawi, Mozambique, South Africa, and Zambia in Southern Africa; Burundi, Ethiopia, Kenya, Rwanda, Tanzania, and Uganda, in East and Central Africa; and Burkina Faso, Cote d'Ivoire, Ghana, Nigeria and Sierra Leone in West Africa. Partner countries exchanged germplasm in the form of clones and seed for selection from improved breeding populations, and other countries received varieties for testing in response to requests.

An annual meeting of breeders provided opportunities for capacity development and information exchange and has served as a forum for the introduction of new breeding methods and, in collaboration with the Genomic Tools for Sweetpotato Project from 2015 onwards, the tools of modern genomic approaches (Fig. 1).

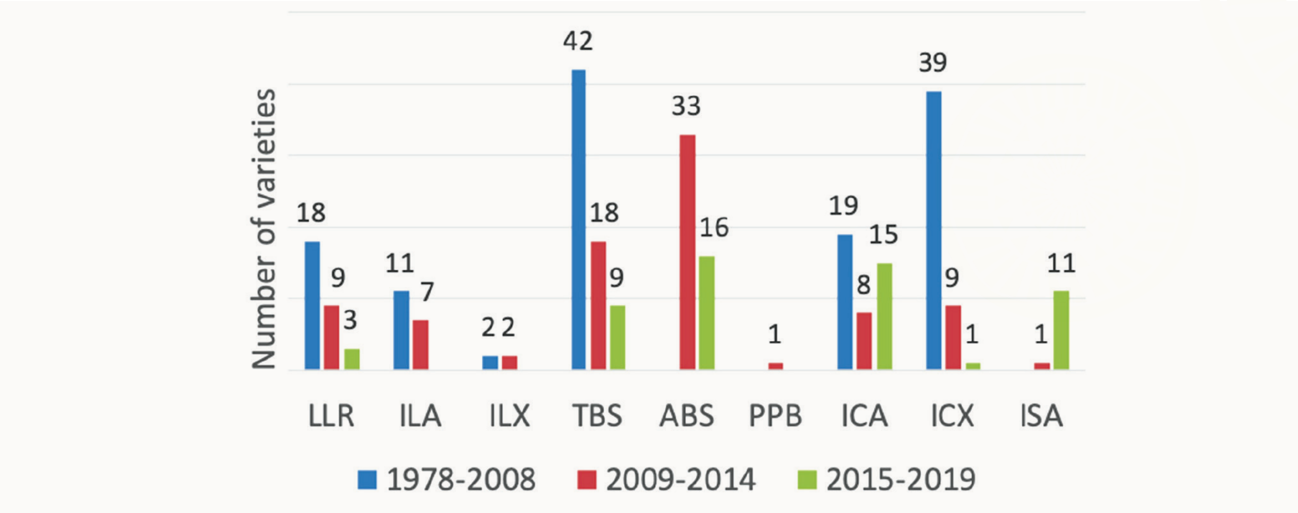

Fig 2. Numbers and sources of varieties released by 16 sweetpotato breeding programs in sub-Saharan Africa over three time periods. Abbreviations: Local landrace (LLR), Introduced African landrace (ILA), Introduced exotic landrace (ILX), Traditional breeding scheme (TBS), Accelerated breeding scheme (ABS), Participatory plant breeding (PPB), Introduced clone from African breeding program (ICA), Introduced clone from non-African breeding program (ICX), Varieties selected from introduced seed from African breeding program (ISA).

What did we achieve during SASHA Phases 1 and 2?

There can be no scaling without adapted varieties that consumers want to eat. During SASHA Phase 1, the Alliance for a Green Revolution in Africa (AGRA) supported 10 national sweetpotato programs with breeding grants, four with seed systems grants, and sponsored 10 sweetpotato breeders for PhD training and four for Masters. This critical joint investment enabled the growth of a vibrant Speedbreeders Community of Practice, which expanded to 16 countries by 2019[1]. During the past decade, 13 SSA countries[2] had crossing blocks at some point in time, which were used to create new varieties adapted to local agro-ecologies and preferences, generating a sense of pride and ownership among national breeders. Since 2009, sweetpotato breeders in 16 countries have released 143 varieties, with 93 having orange-flesh color. Among the released varieties, 112 were bred by 12 African programs, with 74 having orange-flesh and 3 purple-flesh color[3]. Sixteen of these varieties were released in more than one country, having broad adaptation and user acceptance. Trends in types of materials being released during the periods prior to 2009 and from 2009 through 2014, and 2015 to date are presented in Fig. 2. Increases in numbers of varieties bred in Africa, and in selections from seed or clones from other African programs are evident, as are declines in the release of landrace germplasm, which was important prior to 2009.

A Catalogue of Orange-fleshed Sweetpotato for Africa published in 2014 described 60 varieties. The easily accessible 2019 on-line (and downloadable) Sweetpotato Catalogue for SSA (www.sweetpotatoknowledge.org) describes 80 varieties and includes important white and yellow fleshed varieties, as well as the recently released purple-fleshed varieties.

In 2014, recognizing the high prevalence of vitamin A deficiency among young children in SSA (48%), 14 national sweetpotato breeders committed to *mainstreaming* the beta-carotene trait, which they defined as assuring that at least 50% of all varieties submitted for release would be orange-fleshed. Evidence is clear that the commitment has been met.

The SASHA-supported breeding programs at CIP-HQ and at the SSPs in SSA evaluated genetic gains in storage root yield of released varieties over the years and found relatively consistent gains of about 0.3 t/ha/year across programs in Ghana, Mozambique, Uganda and Peru.

Other key achievements under SASHA included:

- Introduction and validation of an accelerated breeding scheme (ABS), which reduced time to variety release from 7 or 8 years (traditional breeding scheme or TBS) to 4 or 5, through multi-environment testing at the earliest stages of selection. The first sets of 15 drought tolerant varieties selected using the accelerated breeding scheme were released in Mozambique in 2011, and others followed across the region. The second set of 7 varieties in Mozambique were released in 2016 and a third set of 7 including two purple-fleshed varieties is in the pipeline for release in 2019.
- Demonstration of systematic exploitation of heterosis in Peru can lead to dramatic increases in storage root and biomass yield, with its introduction to population improvement efforts in the SSPs in Africa
- The use of trial design and data management tools, field plot techniques, including the use of the Westcott row-column design, and standard checks significantly reduced experimental error and allowed us and our partners to make rapid progress.
- We have worked continuously to develop, adapt and encourage the use of tools by the breeding community of practice to improve trial design, data collection, analysis and management. Our suite of tools includes HIDAP (for

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[1] Angola, Burkina Faso, Burundi, Cote d'Ivoire, Ethiopia, Kenya, Ghana, Madagascar, Malawi, Mozambique, Nigeria, Rwanda, South Africa, Tanzania, Zambia, and Uganda.

[2] Burkina Faso, Burundi, Ethiopia, Kenya, Ghana, Malawi, Mozambique, Nigeria, Rwanda, South Africa, Tanzania, Zambia, and Uganda.

[3] Purple-fleshed varieties contain anthocyanins, which are anti-oxidants. The high dry matter texture of these new varieties is well-liked among adult Mozambican consumers, the country in which they have been released.

Fig 3. Environmental conditions in in Mozambique and Uganda are conducive to the production of large quantities of seed from open pollinated and controlled crosses. Here seed collection is underway at Umbeluzi, Mozambique (Credit: A. Naico)

efficient trial design, data curation and analysis), fieldbook app (for data collection), barcode labels (for plot and sample tracking), and Sweetpotatobase to ensure data integrity.

- The use of near infrared spectroscopy (NIRS) for proximate analysis and key micronutrient screening at the SSPs. From 2013, the Southern African SSP used NIRS for initial screening of top 300 OFSP clones with higher iron content; these were then analyzed using X-Ray Florescence (XRF) for more precise iron measurements; with Inductively Coupled Plasmas (ICP) used on the top candidates to ensure samples were contamination free. The Mozambican program produced a clone (MUSGI 5052-2) with 44 ppm iron (dwb), over twice as high as typical values around 18 ppm. A multi-meal trial to assess bioavailable of iron in OFSP is underway in 2019.
- To date, during phase 2, the population development program in Uganda has provided 399,986 seeds to 8 NARIs; the one in Mozambique distributed 229,263 seeds to 18 NARIs based in SSA, South America, and Asia (Fig. 3). In Ghana, we used a range of techniques to improve seed production - a perennial problem in West Africa - with successful production of over 41,000 seeds from paired crosses (Fig. 4), and distribution of seed to 9 NARS.
- At CIP-HQ, four potential testers (materials with positive, medium to high general combining ability to the complementary gene pool) were identified that will be used to evaluate more parents for their value in population improvement.

What are the key challenges and lessons learned?

The critical importance of the "seed system traits". When examining 4 OFSP varieties that have been widely adopted (Kabode (Uganda); Olympia (Zambia); Kadyaubwerere (Malawi) and Irene (Mozambique) by smallholders, the ability of the variety to establish easily, to have a high multiplication rate for vines, and to be able to sprout after the dry season, are considered essential traits that to date have not been integrated and evaluated systematically in breeding programs.

The challenge of developing convenient tools for data entry and analysis and getting widespread use across programs. During Phase 1, we developed an Excel-based data entry and analysis program named CloneSelector that integrated the statistical program R into its structure. In-country trainings led to widespread use of the program. However, CloneSelector was not linked to a database, needed to ensure the data integrity and consistency needed of a collaborative international effort, and we and partners moved and adopted the use of HIDAP, fieldbook app, and Sweetpotatobase. This transition to new tools and systems has been challenging, requiring dedicated data management resources. In-country trainings, and partner buy-in are essential to assure that technicians and breeders are conversant with and supported to use new tools.

The balance between breeding for today and the needs of tomorrow. Attention to preferences of men and women processors, producers and consumers through the use of appropriate tools will allow for refinement and targeting of key traits and market segments. Product profiles have emerged as a useful tool to help define key attributes for breeding programs to improve on current leading varieties, but it will be important to use this and other tools carefully, bearing in mind the needs and opportunities arising from climate uncertainty, changing markets and urbanizing populations.

Accelerated breeding schemes need to be matched with accelerated seed delivery – the bottleneck. Released superior sweetpotato varieties require efficient seed systems for maximum benefits, but the current system is developing slowly. There must be tight linkages between

Fig 4. The use of the bouquet method where flowering cuttings are brought into the screenhouse from field plots for crossing and seed maturation, has allowed us to produce high quantities of seed from crosses in Ghana (Credit, E. Carey)

seed producers and breeders, working together at the national level to deliver highly demanded varieties to producers.

The lack of consistent government support for breeding in general, and sweetpotato in particular, is a threat to continued progress. Sweetpotato breeding programs and capacity need to be sustained to gain from the investments made to date by AGRA and other partners. Without consistent support, breeding efforts will wither and the potential for future contributions to global food systems by this resilient, nutritious crop may stagnate.

What's next?

Some of the population development work in SASHA Phase 2 (2014-2019) will continue under a new project called SweetGains, with further efforts to exploit heterosis under drought and high SPVD pressure in Mozambique and Uganda. To continue, the West Africa platform will need to identify new sources of funding to support the development of regionally-adapted, less-sweet genotypes with other desirable traits, including reduced perishability. Breeders will increasingly engage with a diverse range of end users in the varietal selection process. Results of on-going experiments with ETH Zurich may open a new vista in the breeding of biofortified iron-rich sweetpotato.

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Partners • The Sweetpotato Support Platform (SSP) for Eastern and Central Africa is based at the National Crops Resources Research Institute (NaCRRI) in Uganda and the Kenyan Plant Health Inspection Service (KEPHIS). For Southern Africa, the SSP is based at the Agrarian Research Institute of Mozambique (IIAM) in Maputo. The West Africa platform is located at the Council for Scientific and Industrial Research-Crops Research Institute and CSIR-Savanna Agricultural Research Institutes in Ghana

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