Yam breeding at IITA: achievements, challenges, and prospects

Antonio Lopez-Montes (a.lopez-montes@cgiar.org), Ranjana Bhattacharjee, and Gezahegn Tessema

Yam—an integral part of the West African food system

Yam (*Dioscorea* spp.) is a multi-species, clonally propagated crop cultivated for its starchy tubers. About 10 species are widely cultivated around the world, but only *D. rotundata*, *D. alata*, and *D. cayenensis* are the most widely cultivated species in West Africa, accounting for 93% of the global yam production. Since inception, IITA R4D efforts have focused on developing new varieties of yam with desired agronomic and quality traits and to improve yam-based cropping systems.

Largest collection of yam genetic resources

IITA maintains the largest world collection of yam, accounting for over 3,000 accessions mainly of West African origin. The collection represents eight species: *D. rotundata* (67%), *D. alata* (25%), *D. dumetorum* (1.6%), *D. cayenensis* (2%), *D. bulbifera* (2%), *D. mangenotiana* (0.25%), *D. esculenta* (0.7%), and *D. praehensilis* (0.3%). The passport data and characterization information on these accessions are maintained in databases accessible at http://genebank.iita.org/. On request, these germplasm

Novel vertical sacs method for seed yam production using vine cuttings.
Photo by L. Kumar.

A. Lopez-Montes, Yam Breeder; R. Bhattacharjee, Molecular Geneticist; G. Tessema, Associate Professional Officer, IITA, Ibadan, Nigeria.

accessions are distributed following Standard Material Transfer Agreements (SMTA). As in many other crops, the request for gene bank accessions has been low for use in national and international yam improvement programs. Of a total of 3170 accessions, only 1077 accessions have been distributed in the last 10 years.

To increase the use of yam germplasm, which are a wealth of rare alleles for target traits, a core collection (391 accessions) was established in 2006 representing 75% of genetic diversity of the entire collection using data on 99 morphological descriptors and country of origin. The germplasm collection is being genotyped using 18 DNA-based markers. Presently, research efforts are under way in collaboration with CIRAD for cryopreservation, using liquid nitrogen, to reduce the cost of maintenance of such a large collection. Efforts to improve yam germplasm conservation and use will be continued under the framework of the CGIAR Research Program (CRP) on Roots, Tubers and Bananas (RTB) for Food Security and Income. As part of this program efforts will be made to (a) optimize *ex situ* and *in situ* yam conservation methodologies; (b) increase coverage of yam gene pools; (c) evaluate, genotype, and phenotype yam collections for important traits; (d) enrich databases with information on yam collections and make it freely accessible to users; and (e) improve procedures for safe exchange of RTB genetic resources.

Making the difference

IITA's yam breeding program has mainly focused on clonal selection from landraces and hybridization of elite clones of *D. alata* and *D. rotundata*. Conventional breeding efforts in yam have resulted in substantial achievements leading to release of high-yielding and disease-resistant cultivars. For instance, through collaborative evaluation of IITA-derived breeding lines with national research institutes (National Root Crop Research Institute, Umudike, Nigeria, and the Crops Research Institute, Ghana), 10 varieties of *D. rotundata* (10 during 2001–2009 in Nigeria and 1 in 2007 in Ghana) and 5 varieties of *D. alata* (during 2008–2009 in Nigeria) were released. More lines are in the pipeline to be released by these institutions in Nigeria and Ghana, and also in Benin, Burkina Faso, Côte d'Ivoire, Sierra Leone, Togo, and Liberia. The released varieties have multiple pest and disease resistance, wide adaptability, and good organoleptic attributes.

Some work has also been carried out in interspecific hybridization, but it is faced with a lot of challenges, including cross-compatibility and synchronization of flowering. For instance, *D. rotundata* can be crossed to *D. cayenensis*, but crossing either of the two to *D. alata* has not been successful. Research effort in interspecific hybridization has been geared towards the genetic improvement of yam, primarily on *D. rotundata, D. cayenensis*, and *D. alata* by transferring complementary traits from one to the other, e.g., higher carotenoid in *D. cayenensis* transferred to *D. rotundata* by interspecific hybridization.

Besides success in hybridization, efforts of the breeding program

Researchers in accelerated yam breeding trial plot. Photo by L. Kumar.

resulted in identification of resistance to nematodes (*D. dumetorum*), fungi and viruses (*D. alata* and *D. rotundata*); selection of germplasm for their response to soil nutrients and nutrients use efficiency; physicochemical characterization of *D. alata* for food quality, sensory evaluation of '*amala*' (yam flour paste) and pasting characteristics of fresh yam as indicators of textural quality in major food products. Studies are ongoing to determine the variation in nutrient retention during processing of yam into food products; characterization of tuber micronutrient density, specifically for iron, zinc, total carotenoids, ascorbic acid (vitamin C), phytate, and tannin content. Traits, such as photoperiod response, flowering, and dormancy are also being studied in *D. rotundata*.

The future thrust will be on reducing the breeding period required to develop improved varieties with consumer-preferred traits, as well as increased participation of stakeholders for improved efficiency and impact of the yam breeding program. Developing participatory value chain strategy will set priorities not only for research and development but also for a consistent value chain articulation and low risk models to link farmers to markets. Yam for food security, food industry (flour, pasta, noodles, pancakes etc.), and pharmacology (drugs, cosmetics) needs prioritized by stakeholders will drive the development of new varieties, that are high yielding, resistant to diseases and pests, and with good adaptability to specific production systems, low fertility soils, and dry environments. GIS-based characterization of yam production systems, yam growth models and genome sequencing will provide strategic knowledge for the success of the yam breeding program.

Rapid and high-ratio seed yam propagation systems will support the variety development and dissemination efforts to breeders and other stakeholders. The implementation of the new scheme is expected to reduce the time to develop and recommend new varieties from 9 to 3.5 years and facilitate rapid release of consumer-preferred varieties by the national programs.

Genomic resources for yam improvement

Research on biotechnology of yam includes tissue culture, genetic transformation, and development and use of molecular markers. However, no genetically modified yam has been produced so far although this approach could be used to transfer resistance to virus and anthracnose diseases into popular commercial varieties. Progress on yam genomics and transformation is covered in Bhattacharjee et al. (next page).

Future prospects

Review of constraints in yam production in West Africa identified the high cost of planting material, high labor costs, poor soil fertility, low yield potential of local varieties, pests and diseases (on-farm and in storage), and shortage of quality seed yam of popular landraces and released varieties as major limitations. To overcome these challenges, in the next five years under the CRP-RTB framework, yam breeding efforts will focus on (a) development of new breeding tools and strategies, (b) trait capture and gene discovery, (c) pre-breeding for new traits, (d) development of new varieties incorporating consumer-preferred characters, and (e) aligning research with farmer and end-user priorities.

These efforts will be supported by the ongoing R4D programs on developing efficient phenotyping protocols for nutrient use efficiency, moisture stress tolerance and biotic stresses in different yam species; regeneration protocol for transformation of various species (*D. rotundata*, *D. alata*, and *D. cayenensis*); methods for efficient interspecific hybridization among *D. alata*, *D. rotundata*, *D. bulbifera*, *D. cayenensis*, and *D. dumetorum*; establishment of marker-assisted breeding platform; techniques for rapid propagation of high quality seed yam; protocol for double haploids from yam microspores; and adoption of stakeholder participatory approaches in development and release of new varieties. Ongoing efforts to strengthen seed yam systems for ensuring sustainable production and supply of quality seed yam in West Africa, and communication and promotional strategies for the dissemination of breeding materials and improved varieties underpin the success of these efforts.