Primary Outcome 3*. Improved yam genotypes adapted to production systems and suited to market preferences nominated for release*

The complete development of standardized operating procedures for regional germplasm exchange, standardized operating procedures for trial management and phenotyping, including digital data collection and integration in a database and environments for varietal testing and selection redefined by soil type, land use for yam, farmer types and climate will therefore be an essential preliminary condition to be fulfilled.

Through several years of yam research in West Africa, a broad set of constraints for delivering developed varieties for ware and seed yam production have been identified. Delivering a good variety will be easy if the clients participate in the development; however this is not the case in Ghana and Nigeria. Additionally, once the variety has been released, there is no operative strategy to disseminate and put it in farmers' fields. That is why through this project, two key outputs are the harmonized yam breeding schemes, practices and procedures and the establishment of a breeding community of practices.

A lack of a formal seed system is also constraining the process despite the adaptation by ECOWAS of the Regulation c/reg.4/05/2008 on harmonization of the rules governing quality control, certification and marketing of plant seeds and seedlings in ECOWAS Region for eleven crops including yam. These problems are contributing enormously to low adoption rate of the developed and released varieties, constraining also yam productivity.

The conventional approach in yam breeding has been developing yam varieties based on good performance on mega environments and therefore low GxE interaction. However, there is increasing concern about changes in soil fertility, expansion of cultivated area, and climate change with severe effects at local level. A lack of standardized procedures for germplasm exchange and for trial management within the yam breeding programs increases the magnitude of the constraints.

This situation is also reflected in the performance of the research institution itself. Results of a BMGF funded project to determine institutional capacities to carry out yam research in West Africa, indicated that there is not an institutional research agenda for yam, no operative funds are assigned by the governments, the main stakeholders of the research carried out are students and the main source of funds has been IITA through collaborative projects. The same study found that at the international research institution level, the situation is quite similar in terms of priorities for budget allocation relegating yam research to constrained personnel, equipment and operative expenses.

The system will have two components:

In the first component a participatory review of germplasm exchange, including methods for planting material production, and health testing will be implemented. A review of data collection, at different stage of the crop cycle and procedures and strategies for stakeholder participation in the process will also be revised.

In the second component, protocols for field lay out and maintenance, experimental designs, data collection, and common checks, as well as methods for planting material production, and phenotyping protocols (e.g. for quality, diseases and nematodes) using the updated yam ontology (developed in the Generation Challenge Program) will be harmonized and discussed with national breeders.

In all the participating countries there are government legislations, regulations and procedures mainly phytosanitary measures that regulate, restrict or prevent the regional exchange of germplasm of certain plant species or plant products including yam. These measures aim to prevent the introduction and spread of plant pests across boundaries or to limit the economic impact of regulated non-quarantine pests.

Because of the importance of the yearly germplasm exchange in this project (two ways between IITA and NARS and between NARS themselves) it is key to partner with the National quarantine services, the plant protection and regulatory services/directorate and the national research Institute of all the 4 countries at the beginning of the project to have a special agreement to ease the germplasm exchange. Representative of these organizations/institutions will be invited to attend the project launch, yearly progress review and planning meeting as well as the in-country workshops of community of practice.

A direct consultation with the yam breeders in the national programs of Nigeria, Benin, Ghana and Ivory Coast indicated not only that screening protocols need to be harmonized but also the equipment for screening will need to be installed.

Current phenotyping strategies in the field mainly rely on hard-copy field books. Use of such books is prone to transcription errors, which is a major challenge with respect to downstream data analysis. Tablet computers with capacitive touchscreens are inexpensive yet powerful computing devices that can be used for field data collection either using spread-sheets or specially apps.

Field Book is one of the apps developed as part of the One Handheld Per Breeder initiative by Jesse Poland of USDA-ARS and Kansas State University through a grant by McKnight Foundation. It is a fast and flexible data entry app created using open source software that is freely downloadable at http://www.wheatgenetics.org/bioinformatics/22-android-field-book.html. With the open-source software and relatively inexpensive tablet computers, the Field Book is designed to input various types of data such as numeric, percentage, categorical, date, and Boolean. These data types can be used for a variety of traits. Once data is collected, it can be directly sent to a database for storage and analysis. In this project, each breeding program will be required to adopt this data collection tool.

Workshop will be conducted including representatives of various value chain actors from different regions where yam is being grown by state or district per country. Participants will be briefed about the objectives of the project, expectations will be clarified and then working groups by regions within each state/district will be organized to generate the draft of the analogue map. There will be a facilitator per group who will guide the group to identify the areas where yam is growing, drawn the boundaries in the map and also listing characteristic of the yam production systems for each area. The map obtained will then be digitized in the GIS system as yam land use map.

The maps generated in the above activity will be further classified using soil and weather data. Soil types in conventional soil studies are characterized for physical and chemical properties, associated with soil management; however a more generic classification in terms of fertility could facilitate the combination of these with other components. Environments for varietal testing and selection will be re-defined following a three stages process each of which will produce mapped units and is described in turn below.

1. Soil fertility class assignment to soil's attributes to generate soil fertility map.
2. The generated new map will then be superimposed with the yam land use map and weather (rainfall) map to generate biophysical zone map. Data from viruses and anthracnose surveys will be added to this map.
3. The biophysical zone map will then be superimposed with poverty level map to generate the yam production system map

YIIFSWA baseline using a close question survey identified pest and diseases, followed by high cost of labor as the main constraint in production and postharvest activities in yams. Additional data obtained during field evaluations indicated that viruses in both *D. alata* and *D. rotundata* and antrachnose in *D. alata* are the major diseases; however the impact of these has not yet been quantified. More recently, Shatu Asala, et al (2012) reported YMV and CMV and the mixture of YMMV + badnavirus+ YMV as the most common mixed infections in 2009 and 2010 respectively.

The most recent surveys about nematodes incidence has been reported from 2002-2003 reported (Coyne et al 2005). The distribution, population density and incidence of plant parasitic nematodes and associated damage to yam tubers obtained from market stalls in the West African countries of Benin, Burkina Faso, Cote d'Ivoire, Ghana, Mali, Nigeria and Togo was determined during the tuber storage periods in 2002 and 2003.

In summary, considering the update on yam value chain strategies in Ghana and Nigeria, the base lines developed by research projects and priority setting exercises, high yielding varieties fitting specific markets demands is the first traits to consider, viruses in *D. alata* and *D. rotundata*, and anthracnose disease in *D. alata* is considered as important diseases, and nematodes are considered as a growing problem; however it is also clear that this problem can be controlled with good management practices.

Food quality in the yam tuber is significant in determining its utilization (both at subsistence and industrial level) and acceptability of yam's food products by farmers, processors and consumers to ensure sustainable food security.

Food quality attributes include nutritional value (protein, minerals, and vitamins) and anti-nutritional factors (phytates, tannins, saponins and oxalates), microbiological safety, convenience, stability, cost and sensory (texture, appearance, flavor and aroma) (Waldron et al., 2003). Information on these characteristics can be used in a breeding program in developing new varieties with acceptable end user characteristics. The objective of this study is to evaluate collections of yam germplasm *(Dioscorea alata and D. rotundata)* for tuber quality characteristics. A total of 200 yam varieties will be characterized for nutritional value (protein, minerals, and vitamins) and anti-nutritional factors (phytates, tannins, saponins and oxalates) using standard laboratory procedures (AOAC, 2000

Breeders working collections short listed in each national program and IITA will be propagated within country using a suite of rapid propagation technologies to generate clean planting materials. Plants will be indexed for major viruses (YMV, YMMV, CMV and yam badnaviruses) as per the procedures established in the YIIFSWA project.

Evaluations of the working collections will be carried out in two contrasting redefined environments in partner countries.

It has been indicated (Otegbayo et al., 2010) that farmers do not have definite food quality indicators of yam tubers that can determine or predict the quality of the processed product. Indigenous knowledge such as pattern of leaf foliage, smoothness and shape of the tubers are used to identify species and varieties rather than for predicting food quality. Farmers' perception of food quality of yams is mainly determined by the sustainable income derived from cultivating particular species or varieties and also, on the textural quality of the product. Therefore, there is need to involve farmers in developing food quality criteria that can be utilized in breeding programs and product development.

Food quality in yam can be defined as those quality attributes such as physico-chemical characteristics (granule morphology, pasting properties, swelling, water binding capacity of yam starch), nutrient composition (proximate, minerals, vitamins), and anti-nutritional factors (phytates, tannins, saponins and oxalates) in the yam tuber. These parameters are significant in determining utilization and acceptability of yam food product by all stakeholders (farmers, processors and consumers) to ensure sustainable food security. According to Otoo and Asiedu (2009) in variety development, sensory evaluation is not only the most important hurdle after all the necessary agronomic characteristics have been developed but also a major determinant of acceptability of the variety, as well as a major determinant in the subsequent adoption and use of the variety.

Implementing a new approach to evaluate and release varieties based on re-defined environment complemented with a systematic implementation and institutionalization of the participatory variety selection approach, will improve the impact of breeding programs. Breeding programs applying genomic selection, will significantly contribute to reduce the time to adopt a new variety.