Progress on Root and Tuber Improvement at IITA

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Introduction

Root and tuber improvement work at IITA since 1971 has been to develop improved varieties and populations of cassava, sweet potato, yams, and cocoyams with high stable yield, resistance to major diseases and insect pests and nematodes, wide adaptability, good storage ability, and high consumer acceptance in the tropics.

Initial research and priority were directed towards stabilizing root crop production through varietal improvement by incorporating into locally adapted varieties the resistance to diseases and insect pests which cause severe damage to root and tuber crops in the tropics, particularly tropical Africa. Among the root and tuber crops, cassava had been given highest research priority followed by sweet potato, yams and cocoyams. However, yams are now given second priority.

Constraints to production

In Africa, major biological constraints to stable production of cassava are diseases such as cassava mosaic (CMD) and bacterial blight (CBB) diseases, and more recently, insect pests such as cassava mealybug (CMB) and green spider mite (CGM), which were accidentally introduced from Latin America and are now causing severe damage.

For sweet potato in the tropics, weevils, nematodes and viruses are prevalent pests and diseases cause severe damage to the crop. Storage has also been a problem.

In yams, nematodes and tuber rots are serious during the pre- and post-harvest period causing extensive storage loss and reduction of quality and market value. Virus is also a problem. High production inputs for seed yams, such as staking and harvesting are required.

In cocoyams, blight complex has been serious in many countries and storage is another problem.

In addition to these constraints, traditional unimproved agronomic practices have seriously limited root and tuber production in the tropics.

This paper reports on approaches to overcome these constraints and on achievements made, particularly through genetic improvement, at IITA in the past 10 years.

Approaches to overcome constraints

Cassava: Local germplasm collected, evaluated and used as base material for breeding. Several thousand examples of exotic germplasm were introduced from outside, entirely in seed form for quarantine and phytosanitary reasons. Germplasm introduction was facilitated with less risk by this approach.

Both intra-specific and inter-specific crosses were made to obtain breeding source populations. Breeding populations have been improved through continuous, cyclic evaluation, selection and recombination using a half-sib family selection scheme. This also enabled incorporating many different genetic sources from many countries and institutions in Africa, Latin America, and Asia into a large breeding population with a large genetic variation of important agronomic characters. Seeds were planted directly and 100,000 seedlings have been raised and selected in the field each year. It has been most fortunate that the Institute is located at an ideal site for efficient screening of the breeding material for resistance to major diseases, insect pests and nematodes and with environmental conditions representing major root and tuber growing areas in tropical Africa. When environmental conditions in the field are not favorable for disease infection, artificial epiphytotic presence has been provided to magnify the differences between genotypes in the manifestation of the symptoms. The resistance is then re-confirmed in the laboratory by positive screening.

Dry matter content has been tested for each clone using a large drying oven from the preliminary yield trials stage. Consumer acceptance quality has been assessed at an advanced stage of breeding. A large number of genotypes have been screened for low cyanide content using the picrate leaf test method. The selections have been re-confirmed for low leaf and root cyanide content using Cooke's enzymatic assay method. Through continuous selection and recombination of the low cyanide genotypes, an improved low cyanide population with high yield potential and disease resistance has been developed from which many improved low cyanide clones have been selected. Recently an automated enzymatic assay method has been developed adopting Cooke's manual method. The method was used for more accurate testing of cyanide levels. With this method about 300 samples a day can be analyzed under better controlled conditions.

Sources of resistance to CMB and CGM have been identified and incorporated into susceptible but high yielding and disease resistant clones and populations. Results so far indicate that pubescence on young apical leaves is an important factor responsible for resistance to both insect pests. An antibiosis of resistance to CMB has also been reported.

All performance tests have been without fertilization at several locations with a wide range of environmental conditions, including high rainfall, sandy soil and dry savannah conditions under which cassava is grown.

The IITA improved breeding material has been sent to national programs in seed form for their evaluation and selection under local conditions.

Biological control of CMB at IITA has used several natural enemies introduced from Latin America where CMB originates.

Sweet potato: Germplasm has been introduced in seed form from many different countries in Africa, the Americas and Asia and evaluated for resistance to weevils and viruses and for other important agronomic characters. Sources of resistance to insects and diseases have been identified and incorporated into breeding populations. The populations have been improved using a half-sib family selection scheme. The scheme is aimed at increasing population means, and retaining a high degree of genetic variability through continuous, cyclic evaluation, selection and recombination.

The short-range improvement program has focused on developing clones and populations with resistance to viruses, weevils and nematodes; the long-range program aims at developing improved populations with other important agronomic characters in addition to resistance to diseases, insect pests and nematodes. This two-pronged improvement approach is appropriate for IITA because it permits serving many national programs, providing them with genetically diverse and improved seed for selection under local conditions. In addition, the conventional intervarietal crossing program has also been used to meet specific needs.

The most promising clones have been tested without fertilization at several different locations covering a wide range of environmental conditions.

Tissue culture techniques have been introduced to produce disease-free material and to preserve germplasm in vitro. The most promising clones have been cultured in vitro and indexed for viruses for distribution to national programs.

Screening for large source potentials and sink capacities are being incorporated into breeding populations.

Recently, interspecific crosses were made to introduce resistance to diseases, pests and nematodes and other desirable characters into breeding populations.

Yams: White yams have been given highest priority among the economic yam species because of its relative importance in the region where IITA is situated.

Genetic improvement of yams previously was not possible because of the lack of knowledge about flowering, seed behavior and physiology. Now, techniques of hybridization, seed germination and establishment of seedlings have been developed. Techniques to obtain large tubers (1,000 to 1,200 g) from seeds and to increase multiplication ratio of tubers have been developed and applied for making up the planting material sufficient enough for subsequent clonal evaluation. Efforts are being made to obtain more seeds from *D. alata*.

Cocoyams: GA at the concentration of 1,500 ppm gave the best results of flower induction for both *Colocasia* and *Xanthosoma*. GA-promoted flowers have been hand-pollinated, resulting in about 2% of *Colocasia* and 38% of *Xanthosoma* inflorescenses setting viable seed. A large number of viable hybrid seeds have been produced, seedlings established and selections made. The hybrids have been evaluated for resistance to cocoyam blight and promising results are being obtained.

More than a hundred germplasm accessions of *Xanthosoma* have been introduced and evaluated. Cytogenetics and crossability of cocoyams have been studied, with encouraging results for developing future improvement strategies.

Accomplishments

Cassava: The IITA improved high yielding and disease resistant varieties are popular and mass adopted by farmers in Nigeria. It is estimated that the varieties are now grown on more than 80,000 ha in Nigeria. They give farmers these advantages over local unimproved varieties: 50% to 300% higher yields, stable production due to resistance to CMB and CBB, better and quicker canopy development which speeds recovery from CMB and CGM attack with the onset of the rainy season, reduced weeding by one-third or more, and better processing quality. Demand by farmers for planting material of the IITA improved varieties is continuously high and expected to increase in the years ahead.

Among other national programs receiving improved cassava breeding material from IITA several have developed and released varieties in their countries. They include Sierra Leone, Zaire, Gabon, Tanzania, Seychelles, and Liberia.

Biological control of CMB has been successful using two natural enemies. They are being mass reared and distributed to national programs for release.

Sweet potato: Sources of resistance to African weevils, viruses and nematodes have been identified and incorporated into breeding populations. Clones with yields of about 20 tons/ha under no fertilization have been produced and some yielded up to 50 tons/ha under good soil conditions.

Countries that released varieties selected from IITA breeding material are Sierra Leone, Nigeria, Cameroon, Gabon, and Seychelles. Other countries receiving IITA material are also reporting promising results.

IITA-improved varieties indexed to be negative for viruses have been sent in vitro to more than 30 countries. A total of 600 germplasm accessions are preserved in vitro.

Yams: Breeding technologies for white and water yams have been sufficiently developed and populations with uniform and large tubers from seeds have been produced. Several white yam clones that can produce yields of 20 tons/ha without staking under no fertilization have been identified. Improved healthy seed yam production systems requiring less inputs have been developed.

Cocoyams: Breeding technologies have been developed. Sources of resistance to cocoyam blight complex have been identified and are being incorporated into breeding populations. Triploid *Colocasia* clones and a tetraploid *Xanthosoma* clone were identified.

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