IITA Research to Nourish Africa

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Vision

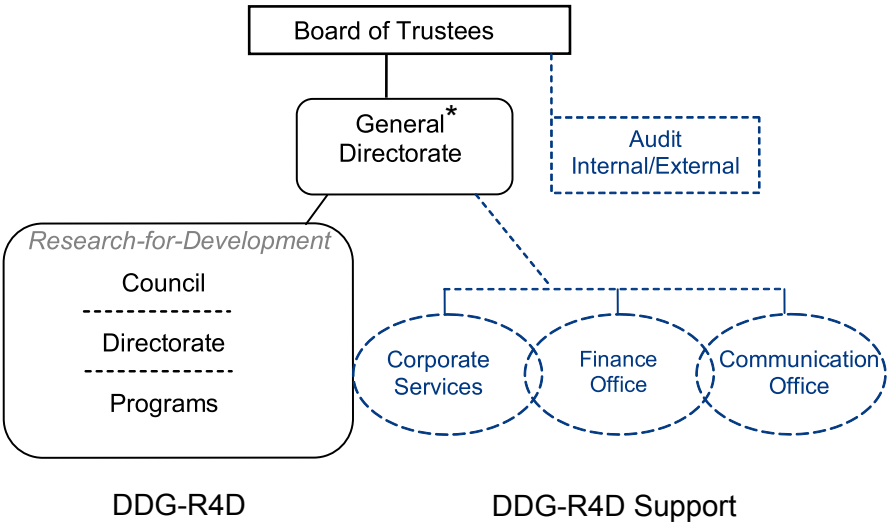
To be one of Africa's leading research partners in finding solutions for hunger and poverty

Who we are

About IITA

The International Institute of Tropical Agriculture (IITA) is an Africa-based international research-for-development organization, established in 1967, and governed by a Board of Trustees. We have more than 100 international scientists based in various IITA stations across Africa. This network of scientists is dedicated to the development of technologies that reduce producer and consumer risk, increase local production, and generate wealth. We are supported by over 30 donors, primarily members of the Consultative Group for International Agricultural Research (CGIAR, www.cgiar.org).

Organization Chart



* DG, DDG R4D, DDG R4D Support

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Introduction

IITA's research-for-development activities will impact wealth, health, and food security from agricultural production systems, consider equity across gender and social strata and the sustainable management of natural resources. The expected outcomes of its seven programs outlined below, relate to increases in investment, productivity, availability, quality, and the processing and marketing of products. They will enhance the use of genetic resources and improve knowledge of the different social, economic, and ecological systems. Meta-analysis of the research-for-development approaches will translate into additional International Public Goods (IPG)s to improve future science.

Agriculture and Health

Agriculture and health are related in many ways. Malnutrition, often caused by the lack of micronutrients affects vulnerable groups. Poor food quality and safety, caused, for example, by mycotoxins, endanger consumers and impose barriers to trade between Africa and important export markets. Widespread diseases affect the labor force, agricultural productivity, and therefore, food security and livelihoods.

Objectives

- To improve nutrition quality by providing a higher diversity and density of micronutrients in human diets and reducing food toxins
- To increase the knowledge on nutrition patterns and distribution of food and nutrients within social systems
- To research ways to overcome labor force shortages in farms and households through appropriate technologies
- The specific impacts this project is aiming at are primarily healthier people in sub-Saharan Africa, equity across gender and social strata, as well as better science-based development.

Agrobiodiversity

The genetic base of the world's food crops is shrinking as genetic resources are being lost to changing tastes, industrialization, urbanization, mechanization and commercialization of agriculture. Conservation and use of biodiversity are central to research on the improvement of food crops and the development of sustainable systems of farming for increased production. Genetic and functional diversity of plants are the building blocks of improved agricultural performance and production. Genetic diversity can introduce useful new traits and

create new heterotic combinations. These in turn can contribute to better crop yields and enhance adaptability of finished varieties by providing appropriate and useful genetic stocks for breeding programs. The wild relatives of crop plants are a reservoir of potentially important genes for crop improvement, especially for tolerance or resistance to biotic and abiotic stresses, but also for other important adaptive traits. However, wild relatives are underrepresented in IITA collections. There is a need to collect, conserve, evaluate, characterize, document, and distribute plant genetic resources of a wide range of crops and their wild relatives, conserve and improve the contribution of neglected underutilized genetic resources to enhance the future income, health, and nutrition of the poor. In the short term, germplasm of vegetatively propagated crops is usually maintained as tubers, roots, bulbils, cuttings, and in the field. Maintaining germplasm collections in the field is expensive in labor, land, and space, with the risk of losing valuable material to pest attack and unforeseen problems. In vitro reduced-growth storage methods are used routinely at IITA for short- to medium-term storage of germplasm of yams, cassava, plantain, and banana risking contamination, accidental loss or reduced genetic stability.

The key objectives of this project are the efficient long-term conservation and use of genetic resources of staple and underutilized crop species, and increased efficiency and effectiveness of research aimed at exploiting their potential.

IITA collects and preserves several hundred accessions of food crops in trust for the international community using the best

Children need to be assured of adequate nutrition for healthy growth and development

practices available. These accessions are characterized, evaluated, documented, systematically cleaned of pests, and certified for international distribution. Core sets are identified for even more detailed characterization to maximize the use of the collections.

The collections are the basis for genetic diversity analyses to elucidate relationships among genomes and offer opportunities for gene mining. Additional genetic variation in wild relatives of food crops and unadapted crop germplasm is identified and made available to interested breeders. Studies are conducted to develop more efficient procedures for medium- to long-term storage, the maintenance of germplasm health, and safe movement for a range of species.

Banana and Plantain systems

Grown by smallholder farmers, bananas and plantains are major food staples and two of the leading cash crops, in East, Central and West Africa. Because of its cash crop status, farmers are more likely to adopt high-level management technologies to intensify production and yet sustain the natural resource base in the systems. Much progress can be realized with more profitable and sustainable banana systems. Since the 1970s, widespread reports of low and declining banana yields have been attributed to soil degradation, pests, poor crop husbandry, and drought. In this project, the hypothesis is that these constraints are, to a large extent, interlinked. The overall purpose of the banana and plantain project is to enhance the performance of banana and plantain systems within smallholder farms in SSA.

Objectives

The main project objectives are:

- To increase knowledge on ecosystems, social systems, and commodity chains
- To research ways to improve profitability
- To improve the quality of banana- and plantain-based food products

The most prominent impacts expected are wealth for banana-based smallholder systems as well as better science-based technologies. Increased wealth is based on research results that yield improved profitability and improved food quality. Better science-based technologies originate from better knowledge on ecosystems, social systems, and commodity chains.

In this project, international public goods will be obtained through research that covers a large and representative range of smallholder

farming systems in Africa. The project, operating across most SSA, covers most geographical zones. It is therefore expected that research results can easily be scaled out across sites, since the test sites have been selected according to their representativity and potential for scaling out.

Cereal and Legume Systems

The savanna is characterized by a growing period of 4–6 months with annual precipitation of 300–1300 mm. Farming systems here have high potential for cereal and legume production and livestock. Demographic pressure and the demand for more food are driving agriculture towards greater intensification. Most crops are produced in a continuous monoculture that steadily depletes the soil's natural resources and lead to lowered soil organic matter content, soil biological diversity, and enhance erosion risk

The problems of soil degradation interact with many biophysical and socioeconomic constraints. that prevent agricultural intensification, lower farm productivity, and encourage unsustainable farming practices with a negative impact on the rural poor, food security, and the environment.

In this project, we hypothesize that the high productivity of cereal and legume systems can be sustained by an integrated use of soil amendments, improved seeds, crop protection products, novel agronomic practices, better postharvest techniques, and the use of laborsaving methods.

Better production and postharvest systems will result in more benefits from the use of higher yielding crop varieties, external soil inputs, and improved agronomic practices. Improving the postharvest system will facilitate processing and marketing of quality crop products, expand their utilization potential, and be a key to greater. Greater support and strengthened institutional capacity will be required to overcome constraints. The project will help by promoting the use of resilient crop varieties, balanced nutrient management practices, integrated pest management practices, improved postharvest technologies, and markets access, and by facilitating technology transfer through strengthening the capacity of service providers.

Objectives

- Develop and facilitate the dissemination of natural resource management technologies that increase productivity in a sustainable manner.

- Facilitate the development of postharvest technologies and market systems that increase the availability of high quality and safe agricultural products.
- Generate knowledge to facilitate the effective management of ecosystems, social systems, and commodity chains.
- Increase research efficiency and effectiveness by enhancing the capacity of national programs to generate and promote improved technologies.
- Develop technologies to improve labor-use efficiency and to reduce drudgery
- Reduce variability in productivity of cereal and legume systems.

The impacts will include improved wealth, better nutrition and food security, and sustainable natural resource management resulting from better science-based development in the savannas. The outputs will benefit all key actors along selected value chains. Farmers benefit from increased access to yield-enhancing and resource-conserving innovations. Processors benefit from the availability of regular supplies of high quality raw materials at competitive prices. Traders benefit from increased trade in diversified crop products. Consumers benefit from the greater availability of a range of higher quality food at affordable prices.

Soybean and maize mixed and processed as a nutritious food drink

High-Value Products

In Africa, tree crops and vegetables play key roles in the poverty reduction strategies. In rural areas, smallholder tree crop systems stimulate export-oriented economic growth through new investment and public–private sector partnerships and contribute significantly to enhancing livelihoods and sustaining biodiversity. In urban and peri-urban areas, indigenous and exotic leafy vegetables (e.g., cabbage, amaranth, African nightshade, and lettuce), fruit vegetables (e.g., tomato, peppers, garden eggs, and aubergine) and root vegetables (e.g., carrot) play key roles in food and nutritional security and poverty reduction. The economic potential and sustainability of high-value agricultural production and marketing systems are severely undermined by diverse constraints. The key challenges in both systems are similar and include the following:

- Maximizing use of biological assets:
- Building national capacity:
- Advocating a development vision for high value products:

This project sets out to address these challenges through research and effective public-private partnerships.

Objectives

- Develop and facilitate dissemination of natural resource management technologies that increase the productivity of high value cropping systems in a sustainable manner.

An urban market

- Facilitate the development of postharvest technologies and market systems that increase the availability of high quality agricultural products.
- Generate knowledge to facilitate effective management of ecosystems.
- Facilitate development of local agroenterprises for cost-effective seed systems and biological plant health management products.
- Explore and develop innovative institutional arrangements to facilitate the dissemination of research processes, methods, and emerging in selected value chains.
- Advise upstream decision-makers on a conducive institutional and policy environment for environmentally sound and socially acceptable high value production systems.

The impacts will include improved wealth from high value agricultural products and sustainability of natural resources resulting from better science-based development. The impacts will be achieved through increased research efficiency and effectiveness, increased availability of high quality agricultural products, informed agroenterprise and research investments, improved mknowledge about commodity chains, and increased productivity of high value systems. conditions.

Opportunities and Threats

Agricultural production and research take place in an ever changing environment. Numerous opportunities are arising from economic growth and increasing trade relationships. Income increases drive the demand for high quality raw and processed products. However, pests, diseases and drought impose a continuous threat to food security and livelihoods.

As a research institute operating in this dynamic and volatile environment, IITA has to determine its strategies with the maximum available knowledge on these dynamics. This project aims at identifying and quantifying opportunities and threats beyond research planning in the commodity systems-based projects. It views and analyzes a broad range of environmental, social and economic dynamics, feeds it back for strategic planning within IITA.

Objectives

- To increase knowledge about ecosystems, social systems and commodity chains
- To increase research efficiency and effectiveness

The most significant impact of this project is better science-based development, increased wealth from agricultural products, both primary and processed, and increased food security. These impacts will be achieved through increased research efficiency and effectiveness across all the outputs.

Root and Tuber Systems

Root and tuber crops are the major subsistence staples in large parts of humid, subhumid SSA, and the midaltitudes. In many areas productivity and yields of root and tuber crops are considerably lower than population growth. Production relies largely on smallholder, slash and burn or other traditional practices. Soil fertility is restored during fallow periods, if possible. All root and tuber crops suffer severe yield losses from a wide range of different pests and diseases, low nutrient availability, inappropriate germplasm, and postharvest technologies. Production practices still lack appropriate levels of mechanization.

Cassava provides affordable foods for the growing urban populations and raw material for starch and livestock feed industry but production costs are comparatively high. Yam is a traditional African crop. Due to consumers' preference of yam over other roots there will be greater demand for yam with increasing incomes in WCA but it has high labor and high soil fertility demands.

Cocoyam and taro play a vital role for women in family food supply and income generation but they have not received sufficient research attention. Large-scale production, mainly of cassava, stimulated by high demand and conducive policies, requires postharvest technologies capable of processing large quantities into quality products. The entire sector then shifts from small-scale household processing to large-scale agro-enterprises.This requires solid knowledge of the commodity chain and the technical equipment. Significant improvements of germplasm for greater yield and disease resistance have been made, and major breakthrough biological control measures have secured future production, especially of cassava. Greater yield will lead to soil nutrient depletion if not accompanied by soil and nutrient management strategies.

The low yields and high production costs are in stark contrast to the economic opportunities. Activities conducted in this project aim at increased productivity, informed agro-enterprise investments and increased efficiency and effectiveness of research to generate additional novel technologies.

The overall impact on farmers, consumers and agro-enterprises of this project is wealth created from root and tuber systems, accompanied by increased food security and improved equity across gender and social strata.

Sun dried yam tubers to make flour for a local food 'amala'

Research highlights

Agriculture and Health

Fusarium ear rot caused by *Fusarium verticilliodes* and fumonisin contamination are major in maize. Field trials in Ikenne and Ibadan (Nigeria) 2003 and 2004 evaluated 103 maize inbred lines for Fusarium ear rot. Two lines (02C14624 and 02C14585) had fumonisin level < 5.0 µg/g across years. These lines can be used directly to develop hybrids, with good levels of resistance to Fusarium ear rot adapted to Central and West Africa and as sources of resistance genes in breeding.

Biological control is one management option to reduce aflatoxin contamination in maize where atoxigenic strains of the fungus *A. flavus* competitively exclude toxigenic strains under field conditions. About 4000 strains of *A. flavus* were screened to identify atoxigenic strains and 14 were selected. Results showed strain La3279 can move effectively from soil to cobs and is an excellent candidate as a biocontrol agent against aflatoxin.

Late and early maturing elite open-pollinated varieties adapted to the lowlands have been converted to Quality Protein Maize (QPM). The partially converted populations had significantly higher protein content than the improved version of a popular QPM variety, Obatanpa. A synthetic variety, SYNIDFO, had a significantly higher tryptophan level than the improved version of Obatanpa but the partially converted varieties had a significantly lower level. S_1 plants will be extracted from each population in 2007 for further screening under the light box to enhance the tryptophan content in the partially converted materials.

IITA is committed to breeding maize varieties and hybrids with enhanced levels of iron, zinc and pro-vitamin A to contribute to improved nutrition, health, and quality of life of rural people. In 2006, 37 hybrids formed from inbred lines selected for ß-carotene content, high or low were evaluated for agronomic performance and micronutrient content. Results indicated that hybrids from inbred lines selected for high ß-carotene content had higher levels of ß-carotene in multiple locations. Some were also agronomically competitive with a commercial hybrid check. Considering the prevailing high genetic variability for ß-carotene and pro-vitamin A content in maize, combining complementary carotenoid profiles through breeding will be expected to increase these nutrients to levels significant for human nutrition.

Twenty-two yellow-fleshed and three white-fleshed cassava genotypes were grown in a randomized complete block design with two replications in Nigeria to determine the qualitative and quantitative variability of carotenoids in cassava. The result revealed that 90%

of the carotenoids in cassava are β-carotene. The mean Retinol Activity Equivalent for the genotypes across locations was 0.409, and the genotype 01/1371 had Retinol Activity Equivalent of 0.639. The result from this study has provided information that may be used in determining the amount needed to have a nutritional impact.

The results from 325 accessions of *D. rotundata* screened for tuber ascorbic acid content showed a range of 3.56 to 16.87 mg/100g (fresh weight basis) and an average of 8.3 ± 2.26 (std. dev.); 79 accessions of *D. cayenensis* showed a range of 4.19 to 11.34 mg/100g with an average of 7.85 ± 1.29 (std. dev.); 31 accessions of *D. dumetorum* showed a range of 15.42 to 39.43 mg/100g with an average of 25.83 ± 6.29 (std. dev.); and 25 accessions *D. bulbifera* showed a range of 10.81 to 21.86 mg/100g with an average of 13.28 ± 2.52 (std. dev.). In another study, ascorbic acid and phytate contents were determined in tubers from genotypes of *D. rotundata* and *D. alata* planted at four sites in Nigeria. In *D. rotundata* mean ascorbic acid contents ranged from 7.56 mg/100g at Abuja to 10.22 at Ibadan and mean phytate contents ranged from 5.48 mg/100g at Onne to 12.49 at Ubiaja. Values for *D. alata* ranged from 8.98 mg/100g (fresh basis) at Abuja to 15.31 at Ibadan.

Three yellow-fleshed cassava genotypes were grown in a randomized complete block design with two replications at Ibadan, Nigeria to evaluate the effects of processing on total carotenoids, ß-carotene, iron, and zinc retention. µβµThe concentration after processing varied depending on the product. Results indicated that boiled cassava retained the highest amount of total carotenoids (73.5%), followed by *gari* (44.9%), raw *fufu* (40.8%), and chips (32.3%); cooked *fufu* (21.5%). Boiled cassava also retained the highest amount of β-carotene (59.9%) followed by *gari* (33.6%), raw *fufu* (32.2%), and chips (15.1%); and least in cooked *fufu* (14.6%) retained least. Boiled cassava also retained the highest amount of iron and zinc. Processing cassava storage roots resulted in a significant reduction in nutrient retention that is depended on the genotype and processing method.

An in vitro digestion/Caco-2 cell model may predict iron bioavailability to humans but direct comparisons are lacking. The objective of the study was to test in vitro differences in iron bioavailability between two maize varieties, directly comparing human and Caco-2 cell results. Results obtained indicated that based on meal analyses, the ACR maize variety had nearly 20% more iron than TZB (P<0.0001). ACR also contained ~25% more zinc (P<0.01) and 7% more phytate (P<0.001) than TZB. Fractional iron absorption from maize meal without

ascorbic acid (AA) was low at approximately 2%. The maize varieties did not differ significantly in either the percentage or total amount of iron absorbed. Adding AA to the meal significantly enhanced iron absorption from approximately 2 to 7% (P<0.0001). Human iron absorption results confirmed Caco-2 cell predictions of AA enhancement with maize.

Colonized maize cobs

Agrobiodiversity

This project seeks to contribute to the assurance of food security and sustainability of natural resources through efficient long-term conservation and use of genetic resources of staple and underutilized crop species. The following specific outputs are targeted:

- Germplasm of clonally propagated species collected, preserved, documented and distributed
- Germplasm of seed crop species collected, preserved, documented, and distributed
- Genetic diversity of conserved germplasm described
- Traits transferred to breeding populations from wild species/ unadapted germplasm

The genebank holds over 29 000 accessions comprising cowpea, soybean, bambara groundnut, wild *Vigna* ssp, maize, cassava, yam, banana/plantain, African yam bean, and miscellaneous legumes. The collections are stored in seed-, field- or in vitro-banks, depending on the reproductive biology and agronomic dissemination of the species

For the past two years, efforts have been focused on duplicating clonal germplasm from the field to the *in vitro* collection, with the overall objective of reducing both the maintenance cost and the potential loss of germplasm and of facilitating germplasm distribution (through improved

Germplasm conservation through multiplication

sanitation). During this period, 2 017 accessions of cassava, 623 of yam, and 250 of *Musa* spp. were introduced in vitro. In addition, yam and cassava in vitro collections were duplicated for safety in the IITA-Bénin genebank facility, Cotonou. The use of cryopreservation is being considered in an effort to further reduce maintenance costs.

During the past three years, 7 000 accessions of cowpea, 1 000 of Bambara groundnut, 600 of wild *Vigna,* and 1 070 of soybean have been regenerated and processed for storage.

Also, 500 accessions of cowpea, wild *Vigna,* and soybean; and 139 accessions of cassava were certified healthy for international distribution. A total of 2 117 accessions were delivered to requestors. This comprised 1 988 accessions of cowpea, 56 of other *Vigna* species, and 73 of maize.

As part of the assessment of diversity of the cowpea collection, 2 000 accessions were characterized for 14 microsatellite (SSR) markers. In addition, 10 individuals of 100 accessions were screened for variation at 14 SSR loci for a study of variation within accessions. For the collection of *Musa* spp., diversity analysis was carried out on 192 genebank accessions using 25 SSR markers. Similar genotyping was conducted of a core set of yam germplasm (354 accessions) using 23 SSR markers. Ploidy levels of 158 accessions from the yam collection were determined based on DNA flow cytometry.

As part of efforts to introduce desired attributes from various *Dioscorea* species to the key cultivated species, 19 hybrids have been produced between clones of Dioscorea rotundata and D. cayenensis . Research is continuing to generate hybrids between *D. rotundata* and *D. alata* as a basis for exchanging complementary attributes.

Banana and Plaintain Systems

Banana *Xanthomonas* wilt control

Xanthomonas wilt disease (BXW) is the most serious threat to banana production in East and Central Africa. The disease is principally spread by insect vectors and contaminated tools, and through infected planting materials. It started in Uganda in 2001, and has spread to Rwanda, Tanzania, Kenya, and D.R. Congo. Germplasm screening trials have identified some cultivars that did not succumb to infection through moist flower cushions. Once a field is infected it cannot be replanted immediately due to bacteria in the soil. In 2006, efforts were made to

explore the underlying mechanisms of tolerance. Some of the factors were identified, including sap deficiency, which makes cushions dry and unreceptive infection sites low sap pH that is hostile to the bacteria, and viscous nectar that was inaccessible to insects. Activities were carried out in developing protocols for diagnosing the pandemic phase and describing the corresponding response measures. Research was initiated in management of postepidemic phase through community action and appropriate management of infected plants and rehabilitation of banana fields destroyed by BXW infection. Various technologies based on cultural practices were developed that reduce the infection of replanted suckers. Curing corms for at least 3 days after paring or dislodging from the mother mat is now recommended as the most beneficial practice in reducing infection.

Worldwide *Beauveria bassiana* is the most commonly used biopestide against a variety of insect pests. However, when used as a conventional biopesticide, it tends to be slow-acting, cumbersome, erratic, and expensive at practical application rates in the field. At IITA, we have been investigating whether or not *B. bassiana* can be formulated as an artificial endophyte in banana tissue culture plants. We not only demonstrated, for the first time, that *B. bassiana* can be so used, but also that persistence rates can be very high for prolonged periods of time. More excitingly, various screenhouse experiments have demonstrated that tissue culture plants enhanced with *B. bassiana* consistently reduce banana weevil damage >50%. These amazing results are encouraging as the novel technique is highly cost-effective, targets the most damaging pest stages inside the plant, and removes the problem of having to apply the biological control product themselves. At present, studies are underway to test this technology in farmers' fields.

Induced resistance is the activation of plant defense mechanisms after contact with biotic or abiotic elicitors. Induced resistance can be considered a phenomenon whereby a microorganism applied to the plant elicits a response in those plants that result in a disease-resistant phenotype. Research at IITA has demonstrated induction of phenol production and other plant defense mechanisms upon enhancement of banana with endophytic *Fusarium oxysporum*. Through induction of systemic resistance, *Fusarium oxysporum* protects the banana plant in a way that is similar to mechanisms currently present in resistant banana cultivars. As such, "vaccination" of plants with endophytes can be seen as a complement to current breeding programs, and a highly

flexible tool to tackle the diversity of existing pathotypes and counter emergence of new pathotypes. Collaboration with the University of Pretoria is underway to mine the novel banana genes responsible for induced resistance.

IITA has engaged in a public–private partnership with Agro-Genetic Technologies (AGT), Uganda's biggest tissue culture producer. IITA provides technical backstopping to tissue culture production and fully exposes endophyte-enhanced technology to AGT; AGT in turn provides IITA with plants at a reduced cost while providing space and human resources to fully integrate the technology in their operation. This partnership has proven to be very effective, and has been a strong impetus for obtaining the necessary quota for on-station and on-farm trials promoting endophyte-enhanced tissue culture technology in Uganda.

A banana market

Cereal and Legume Systems

- Seed treatment with low doses of ALS-inhibiting herbicides, such as imazapyr is one option to control *S. hermonthica*. Inbred lines and experimental hybrids with the herbicide resistance gene and *Striga* resistance have been developed. These hybrids were tested with and without seed treatment under artificial *Striga* infestation at Abuja and Mokwa in Nigeria. Most of the herbicide-resistant hybrids were comparable to a commercial hybrid, Oba Super I, in yield potential in *Striga*-free plots. Promising hybrids were selected for extensive testing in 2007.
- Under severe drought at the reproductive stage, two cultivars were selected as potential drought-resistant cowpea lines which could maintain grain and fodder yields more than 80% of control, though two others were reduced to 20-30%. Two drought resistant lines showed high leaf stomatal conductance when surface soil (0-40 cm) moisture was very low.
- Results of trials at Mokwa and Abuja showed five new QPM varieties, EV DT-Y 2000 STR QPM C0, TZEE-W Pop STR QPM C0, TZE-Y Pop STR QPM C0, TZE-W Pop STR QPM C0, and EV DT-W 99 STR QPM C0 as outstanding in grain yield and *Striga* damage ratings under *Striga*-infested and non-infested conditions.

Brown and white cowpea for sale

- The popular but *Striga* susceptible variety DMR ESR-W QPM was the lowest yielding variety under *Striga* infestation but the highest yielding when *Striga*-free.
- Analyses of the radionuclides ^{137}Cs, ^{210}Pb and ^{7}Be in soils were done for the first time in Nigeria. ^{7}Be is accumulated in the upper 5 cm and ^{137}Cs in the upper 10 cm of undisturbed soils. Sediments contain much higher concentrations of these fallout nuclides which are useful tracers for measuring soil redistribution in the savanna.
- A participatory evaluation of improved cowpea varieties with 159 farmers in 25 villages was conducted in Maradi and Zinder Regions of Niger Republic. Several of the improved exra-early maturing varieties yielded over 800 kg grain/ha even in areas of complete crop failure due to drought.
- The Nigeria Agriculture and Biotechnology Project assisted the Federal Ministry of Environment to prepare the National Biosafety Policy and Biosafety Bill to be made into the biosafety law for the country. The bill will facilitate the approval procedures for testing and commercialization of bioengineered crop varieties in Nigeria.
- Reducing ant colonies in pineapple fields by trapping and killing the ants will allow a classical biological control against the pineapple mealybug, the vector and cause of Pineapple Mealybug Wilt. Ants in the field disrupt the search behavior of the natural enemy.
- A method for screening soybean germplasm for rust resistance using detached leaves was developed and validated. The assay will accelerate breeding efforts since large populations of genotypes can be screened against different pathogen populations simultaneously.
- A bio-economic farm household production model together with a Multi-Attribute Utility Theory was used to determine differences in farmers' production strategies in the Nigerian NGS. Small groups of generally "richer" farmers were found to follow market production strategies associated with positive soil nutrient balances. The majority of "poorer" farmers have a subsistence production objective with moderate to strong risk-aversion and negative soil nutrient balances.
- A livelihood baseline study on a sample of 800 households indicated widespread poverty (58% of households) and food insecurity in western Kenya. *Striga* inflicted almost equally high damage on maize yields across households, but its impact on poverty is the greatest among households which depend heavily on maize for their livelihoods.

- Aqueous extracts of *Tephrosia vogelii*, *Hyptis suaveolens*, oils of *Azadirachta indica* and *Jatropha curcas*, and Furadan 5G were evaluated for their efficacy in reducing *Mussidia nigrivenella* infestation and its damages under field conditions and their oviposition deterrent effect in cages in Bénin. Most eggs were found on untreated ears showing the oviposition deterrent of the extracts and oils. Under field conditions, Furadan and the oils reduced the number of larvae compared to the extracts, which were similar to the control. The oils therefore act as persistent oviposition deterrents and insecticides.
- ^{13}C isotope discrimination in maize was validated under field conditions as a tool to identify water supply and it revealed a reduction of water stress at critical development stage due to incorporation of *Senna* residues.
- Grain yield of maize increased by 10% after 20 kg P/ha was applied to soybean and by 35% after 40 kg P/ha. Maize grown after late maturing soybean varieties gave higher grain yield than after early maturing varieties. The differences between the soybean varieties were more pronounced at 40 kg P/ha level.
- A Participatory Impact Assessment to evaluate the adoption of improved crop technologies on participating farmers in the savannas of Borno State, Nigeria, revealed that improved maize and soybean varieties had the highest adoption rates. Women farmers have adopted at higher rates than men (maize, 83% and soybean, 68%).
- Al-stress and P deficiency interact to reduce P accumulation in cowpea genotypes. Al-resistant cowpea genotypes release high quantities of malate and citrate from roots for enhanced P accumulation in Al-toxic and P deficient soils.

High Value Products

Across four States in Nigeria, the aflatoxin content in cocoa bean ranged from 0–5400 ppb with more contamination in samples from Cross River and Edo and less in Taraba. The incidence of toxigenic strains of *Aspergillus flavus* (40%) was lower than that of atoxigenic strains (60%), across all States. These results indicate the need to devise management options to reduce possible aflatoxin contamination in cocoa beans.

Five mango fruit fly species of economic interest in the north of Bénin have been identified for the development of the mango chain

in Bénin and other West African countries. Ecological studies aim to reduce mango fruit flies with IPM tools.

A database of the diversity, distribution, and economic importance of vegetable pests in Bénin was produced.

Three local strains of *Beauveria bassiana* were identified as effective alternatives to toxic pesticides against *Plutella xylostella*, *Hymenia recurvalis*, and *Psara basalis* on leafy vegetables.

Plant parasitic nematodes are important soil-borne pests in Bénin. In 2006, a survey identified not only species of the main nematode group (*Meloidogyne*) but also species never before identified in West Africa or on vegetables but known for high potential damage in Central and North America. Results question current distribution, diagnosis and distribution, and challenge pest management options.

A cocoa pod ready for harvest

Opportunities and Threats

A bio-economic farm household simulation model was developed to analyze farmers' production decision-making and its impact on the use of soil fertility resources. It is based on a non-separable farm household model extended with a soil nutrient balance for the three major soil macronutrients N, P, and K. This allows for a detailed analysis of the effect on soil fertility of various production strategies for different types of farmers. At the same time, various household indicators are quantified and trade-offs between various production targets and soil fertility use can be determined. The model has been applied recently in Northern Nigeria (see highlights under Cereals and Legumes).

For the second time in succession, IITA's social scientists organized a mini symposium after the paramount international conference of agricultural economists.

The symposium was organized on four major topics: (1) the broadening agricultural research agenda and resulting scope of agricultural research evaluation, (2) the current situation with respect to practices followed by academic economists and other practitioners in impact assessment, (3) gaps that needed to be filled in our assessment approaches, and (4) some suggested options for meeting current impact assessment needs.

The proceedings of the mini-symposium will be published in the IITA Impact series. Within the framework of the "Crop Crisis Control Project" (C3P), IITA and its collaborators, in particular the Catholic Relief Services (CRS), undertook food security surveys in five East African countries— Burundi, Kenya, Rwanda, Tanzania, and Uganda. The results showed that although households in Western Kenya and large parts of Uganda were food secure, the situation was worse in northern Tanzania, where households lived at the edge of food security, and worse still in Rwanda and Burundi, where food security was permanently at risk due to small-scale farming, biotic and abiotic stresses, and civil unrest.

The results are to be fed into a GIS mapping system and further applied to target measures by the project partner, CRS, that aims at fighting banana bacterial wilt and cassava mosaic disease. CRS informs the rural communities about management measures to counter banana bacterial wilt.

The Plant Pathogen Diagnostic Clinic at IITA Benin was created and resulted in the identification of over 150 pathogens from diseased plant samples from both the public and private sector in the last year

(NARS, SPS regulatory authorities, private growers of various sizes). Its database of live microorganisms has been revised into a format that could be uploaded onto an IITA linked website.

Establishment of West African Pathogen Diagnostic Network. This is linked to the National Plant Diagnostic Service of USA and networks in Central America and East Africa. The network comprises regional experts responsible for research, extension, University teaching, policy and phytosanitary regulation linked though databases and real time IT links. The aim is to perform rapid and accurate diagnoses that will help farmers throughout West Africa target best control options while also reducing use of unnecessary pesticides.

IITA and Global Plant Clinic (CABI-CSL-Rothamsted-UK) have created a network of mobile plant clinics in West Africa and confirmation of pathogen diagnoses and storage in UK. Mobile plant clinics are a cheap and effective method of providing surveillance of pathogens.

First identification of *Ralstonia solanaearum* on tomato in Benin. This has potentially severe consequences for export trade to USA as race 3 biovar 2 of this bacterium is classified as a bioterrorist threat. A series of surveys have been performed to determine its distribution across the AEZ's of Benin. The isolates recovered are being tested for virulence against tomato in glasshouse studies and characterised using developed ELISA tools and through carbon nutrition studies.

Habitus picture of Ceratitis cosyra *(Diptera: Tephritidae) a pest of mango, annona, and citrus widely distributed in tropical Africa*

Root and Tuber Systems

The project aims at increasing productivity of root and tuber systems, improving knowledge about commodity chains, as well as facilitating agro-enterprise and research investments through the following six outputs:

- Prioritization of policy, input/output market, postharvest and production constraints
- Description of biotic and abiotic processes and interactions
- Improved root and tuber germplasm
- Integration of improved component technologies
- Assessment of the commercial viability of agro-enterprises
- Strategies for enhancing technology adoption potential

Surveys during 2006 revealed a continued expansion of the Cassava Mosaic Disease (CMD) pandemic through Burundi and north-western Tanzania but had not reached the southern part of Sud Kivu in eastern DRC. An assessment of the occurrence and distribution of cassava mosaic viruses in Zambia showed both ACMV and EACMV alone and in mixtures, but the pandemic-associated EACMV-UG was not found and there was no evidence of rapid CMD spread. Maps have been developed on the distribution of cassava mosaic geminiviruses, including EACMV-UG, in East and Central Africa., , The incidence and severity of CMD and abundances of the whitefly vector have been mapped for northern Zambia.

A Brazilian isolate of *Neozygites tanajoae* was released in the Geita and Bunda areas of Tanzania for biological control of the cassava green mite. Follow-up surveys found the fungus in the Geita area but not in the Bunda area. In a cassava pest and disease survey in Bénin the fungus was found in more than 50% of the fields visited. Over 50 native and exotic isolates of *N. tanajoae* were multiplied to conserve their viability. Trials in 12 farmers' fields in two villages in Cameroon showed that the removal of host plants of the African Root and Tuber Scale (ARTS) from the fallow in the immediate vicinity of the field before planting could reduce ARTS densities by about 40% and increase cassava yield by about 35%. This approach will be expanded to other pilot sites in Cameroon and DR Congo.

Resistance to root rot was confirmed in five clones of cassava following three years of intensive evaluation under artificial inoculation and in naturally infected plots. Based on on-farm trials with farmer-participation over the past two seasons, five new cassava genotypes

which combine tolerance/resistance to Cassava Brown Streak Disease with other farmer/end-user preferred traits were selected by farmers for official release in Zanzibar.

An efficient and reproducible in vitro regeneration procedure via somatic embryogenesis has been developed for two farmer-preferred cassava landraces that are susceptible to Cassava Brown Streak Disease (CBSD). This opens up a realistic option for engineering resistance against this disease.

Development of techniques for producing clean or healthy seed yams and their promotion in target areas of Nigeria have been highly successful and well appreciated by farmers.

Evaluation of four yam cropping systems (*Mucuna* improved fallow, *Aeschynomene*/*Gliricidia*/yam association, *Pueraria* as live or dead mulch) in Togo, Burkina Faso, and Bénin (depending on the system) showed the advantages of the *Pueraria* and *Aeschynomene* systems. Compared to the traditional system in Bénin, previous experiments also concluded that planting into Pueraria mulch leads to higher total yield of marketable yam. Technologies for producing high quality cassava flour, chips, and starch are operational in 8 cassava processing pilot plants in 5 countries in East and Southern Africa. Data collected from these plants were used for the economic/profitability analysis for small-scale processing of cassava into high value products. The results and the lessons learnt in the implementation of these pilot plants have been documented.

A community processing center for cassava. Tubs for fermentation are seen in the background

Graduate research

completed at IITA in 2006

Mphil

Agbaje, Samuel; Male; Nigeria
University: University of Ife
Sponsor: Self
Research topic: Evaluation of heterotic patterns of tropical early maize Inbred lines

MSc Fellows

Abila, Nelson O.; Male; Nigeria
University: University of Agriculture, Abeokuta
Sponsor: Self
Research topic: Labour contracts and labour productivity in cassava and yam production in South Western Nigeria

Afolabi, Oluwatosin; Female; Nigeria
University: University of Lagos
Sponsor: Self
Research topic: Eliminating viruses from yam by meristem culture and thermotherapy

Anagbogu, Chinyere; Female; Nigeria
University: University of Ibadan
Sponsor: Self
Research topic: Assessing the genomic and somaclonal variation between mother plant and succers in Musa Germplasm

Chijioke, Ugo; Female; Nigeria
University: Michael Okpara University of Agriculture, Umudike
Sponsor: Self
Research topic: The evaluation of starch and rheological properties of cassava mosaic disease (CMD) resistant varieties and development of an extruded product from enriched cassava flour

Chumboh, Godlove; Male; Cameroon
University: University of Nigeria, Nsukka
Sponsor: Self
Research topic: Virus eradication from cassava for safe conservation and exchange

Gnonlonfin, Benoit; Male; Benin
University: University of Botswana
Sponsor: DANIDA
Research topic: Natural occurrence of fungi and subsequent mycotoxines contamination in cassava and yam chips in Benin

Ilogu, C.F; Male; Nigeria
University: University of Ibadan
Sponsor: Self
Research topic: Comparative study of large seeded grain legume transformation methods

Muamba, Kabeya; Male; Nigeria
University: University of Ibadan
Sponsor: Self
Research topic: Studies on development of new methods for rapid and mass propagation on yams (*Dioscorea* spp.)

Olayide, Olawale; Male; Nigeria
University: University of Ibadan
Sponsor: Self
Research topic: Manure marketing in the Northern Guinea Savanna of Nigeria

PhD Fellows

Adesanwo, Olusola; Female; Nigeria
University: University of Agriculture, Abeokuta
Sponsor: PTDP (WARDA)
Research topic: Legume/phosphate rock combination for sustainable rice production in South West Nigeria

Aigbe, Sylvester; Male; Nigeria
University: Ambrose Alli University, Ekpoma
Sponsor: Self
Research topic: Host-pathogen relationships in the development of root and tuberous root rot of cassava

Athman, Shashasi Y; Female; Kenya
University: University of Pretoria, South Africa
Sponsor: BMZ
Research topic: Biological control of banana nematodes using fungal endophytes and study of plant-endophytes-pest interactions

Ala, Adeola; Female; Nigeria
University: University of Ibadan
Sponsor: Self
Research topic: Production of monoclonal antibodies to effectively detect and differentiate geminiviruses in Africa and virus-vector relationships

Bah, Sanoussy; Male; Guinea
University: University of Sierra Leone
Sponsor: Self
Research topic: Trait association and genetic relationships among cassava germplasm and genotype x environmental interaction of cassava germplasm in Guinea

Baimey, Kossi H.; Male; Benin
University: University of Pretoria, South Africa
Sponsor: IITA
Research topic: Biology and epidemiology of yam nematodes in Benin

Banful, Ben; Male; Ghana
University: University of Ghana
Sponsor: IITA
Research topic: Contribution of legume cover crops to growth and yield of plantain

Odedara, Olusola; Female; Nigeria
University: University of Ibadan
Sponsor: Self
Research topic: Identification and characterization of viruses of herbaceous forage legumes in the derived and Northern Guinea Savanna Zones of Nigeria

Kapindu, Sinnia J.; Female; Malawi
University: University of Pretoria, South Africa
Sponsor: BMZ
Research topic: Biololgical control of banana nematodes using fungal endophytes and study of plant-endophytes-pest interaction

Maboudou Alidou, G; Male; Benin
University: University of Pretoria, South Africa
Sponsor: DANIDA
Research topic: Adoption and impact of chip production and storage technologies in the Northern Benin

Maiga, Idrissa H.; Male; Niger
University: Ecole Nationale Superieur Agronomique de Montpellier
Sponsor: IPM Grasshopper
Research topic: L'impact de la mortalite des eufs diapausants du criquet senegalais Oedaleus senegalensis (Krauss 1877) en saison seche sur la dynamique de la population dans le region de Zinder au Niger

Obeng-Antwi, Kwadwo; Male; Ghana
University: University of Reading
Sponsor: CSIR-AgSSIP (World Bank)
Research topic: Genetic diversity among local maize (Zea mays L.) accessions in Ghana

Ogunkanmi Liasu A.; Male; Nigeria
University: University of Lagos
Sponsor: Self
Research topic: Genetic diversity in cowpea and its wild relatives

Onitilo, Mojisola; Female; Nigeria
University: University of Agriculture, Abeokuta
Sponsor: Self
Research topic: Effect of processing methods on the physicochemical, functional and sensory properties of sour cassava starch bread

Tedihou, Ekanao; Male; Togo
University: Hannover University
Sponsor: DANIDA
Research topic: The factors that influence Aspergillus flavus strains and toxin expression in different agro-ecozones

Tounou, Agbeko K.; Male; Togo
University: Hannover University
Sponsor: IPM Grasshopper
Research topic: Grasshopper control with Nosema locustae

A technician recording physiological data in a cowpea plot

Financial information

Funding overview

Funding for 2006 was US$46.342 million, of which 96.9% came from CGIAR investors and 3.1% from other sources. Expenditure was US$45.218 million (net of indirect costs recovery of US$4.638 million), of which 85.0% was used for program expenses and 15.0% for management and general expenses.

The governments and agencies that provided the largest share of our funding in 2005 and 2006 are shown in Figure 1 (top 10 donors).

IITA`s 2006 research agenda expenditure by CGIAR System Priorities is shown in Figure 2.

Figure 1. Funding: top 10 donors, 2005 and 2006

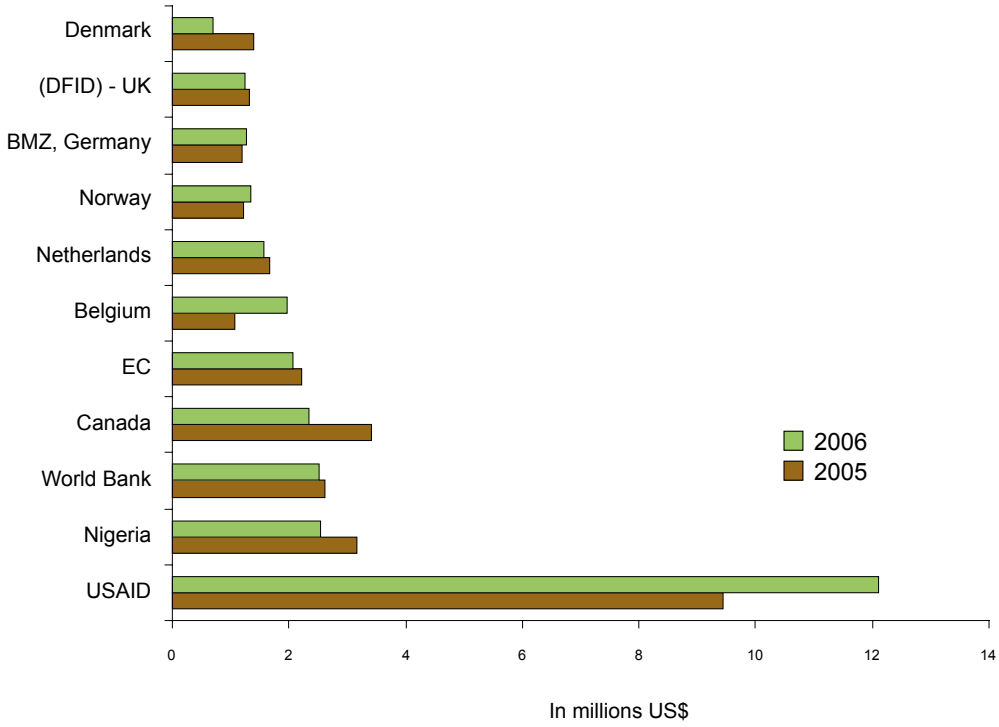
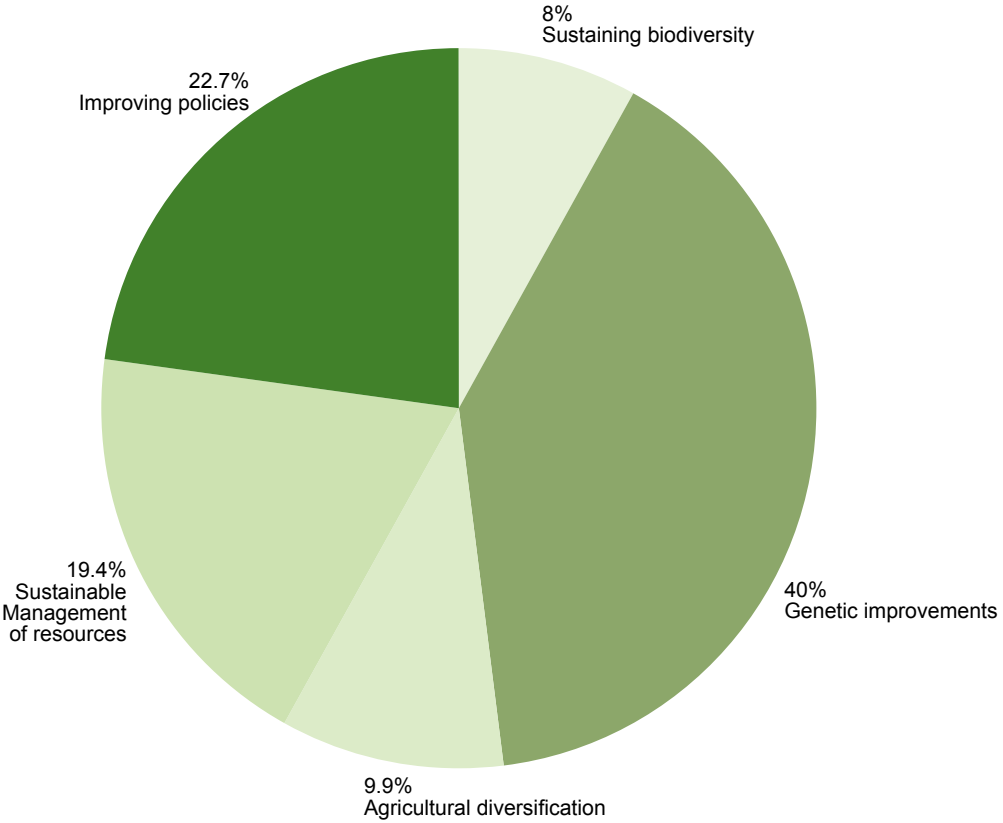


Figure 2. Core research expenditure by CGIAR System priorities, 2006



IITA supporters (expressed in US$ Thousands)

Austria	463
Belgium	1,970
BMZ, Germany	1,277
Canada	2,351
Catholic Relief Service	372
Commission of the European Communities	2,059
Common Fund	330
Denmark	692
Department for Int'l Development (DFID) - UK	1,237
FDPCC	131
Food and Agriculture Organization	20
France	198
Gatsby Charitable Foundation	289
Global Issues Group (GIG)	549
International Fund for Agricultural Development	980
Ireland	435
Italy	84
Japan	239
Korea, Republic of	50
Netherlands	1,575
Nigeria	2,545
Norway	1,352
NRI	11
Rockefeller Foundation	602
Shell Petroleum Development Company of Nig. Ltd.	3,423
South Africa	20
Sweden	439
Switzerland	677
United States Agency for International Development	12,100
United States Department of Agriculture	1,022
World Bank	2,511
Mozambique (Pro Agric.)	220
Nippon Foundation	130
Miscellaneous Projects	1,858
Closed Projects	44
TOTAL	42,255

Publications

Journal articles

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Drying cocoa beans on a concrete floor

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Ajala, Oyewole
Maize Breeder

Ajeigbe, Hakeem
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Akoroda, Malachy Oghenovo
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Amaza, Paul Sambo
Agricultural Economist

Asiedu, Robert
Yam Breeder

Ayodele, Awo Marie
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Baah, Faustina Dufie
Food Technologist

Badu-Apraku, Baffour
Maize Breeder

Baiyeri, Paul K.
Crop Management Specialist

Bandyopadhyay, Ranajit
Pathologist

Beed, Fen Douglas
Weed Pathologist

Berkhout, Ezra David
Production Economist

Boons, Peter
Entomologist

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Ghanaian NPP Manager
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Hearne, Sarah Jane
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Postharvest Biologist
Helsen, Jan
PROSAB Manager
Herron, Caroline Mary
Virologist
Hofs, Susann
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Entomologist/Coord. SP-IPM
Jonas, MVA MVA
Cameroonian NPP Manager
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Soil Conservation Specialist
Kamara, Alpha Yaya
Agronomist
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Legg, James
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Manyong, Victor A.W.
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WASNET Coordinator
Maziya-Dixon, Bussie
Maize Food Technologist
Menkir, Abebe
Maize Breeder

Mkumbira, Jonathan
Cassava Breeder

Muranaka, Satoru
Cowpea Breeder

Mwangi, Francis Maina
Plant Pathologist

Nankinga, Caroline Mary
Insect Pathologist

Neuenschwander, Peter
Emeritus Scientist

Nkamleu, Blaise Guy
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Ntawuruhunga, Pheneas
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Abbreviations used in this report

CBO	community-based organization
CBSD	cassava brown streak disease
CIDA	Canadian International Developement Agency
CGM	cassava green mite
CMD	cassava mosaic disease
DFID	Department for International Development (UK)
EACMV-Ug	East Africa Cassava Mosaic Virus-Uganda variant
EAHB	East African highland banana
ESARC	Eastern and Southern Africa Regional Center
FAO	Food and Agriculture Organization of the United Nations
GIS	geographic information system
IBC	IITA's Institutional Biosafety Committee
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
IIBC	International Institute of Biological Control
ILRI	International Livestock Research Institute
LEXSYS	Legume Expert System
MAS	Marker assisted selection
MDG	Millenium Development Goals
NARO	National Agricultural Research Organization
NARS	national agricultural research systems
NGO	nongovernmental organizations
NGN	Nigerian Naira
NGS	northern Guinea savanna
NRI	Natural Resources Institute (UK)
QPM	quantity protein maize
QTL	quantitative trait loci
PROSAB	Promoting sustainable agriculture in Borno State
RUVT	regional uniform variety trials
SARRNET	Southern Africa Root Crops Research Network
SP-IPM	Systemwide Program on Integrated Pest Management
SS	Sudan savanna
WECAMAN	West and Central Africa Maize Network

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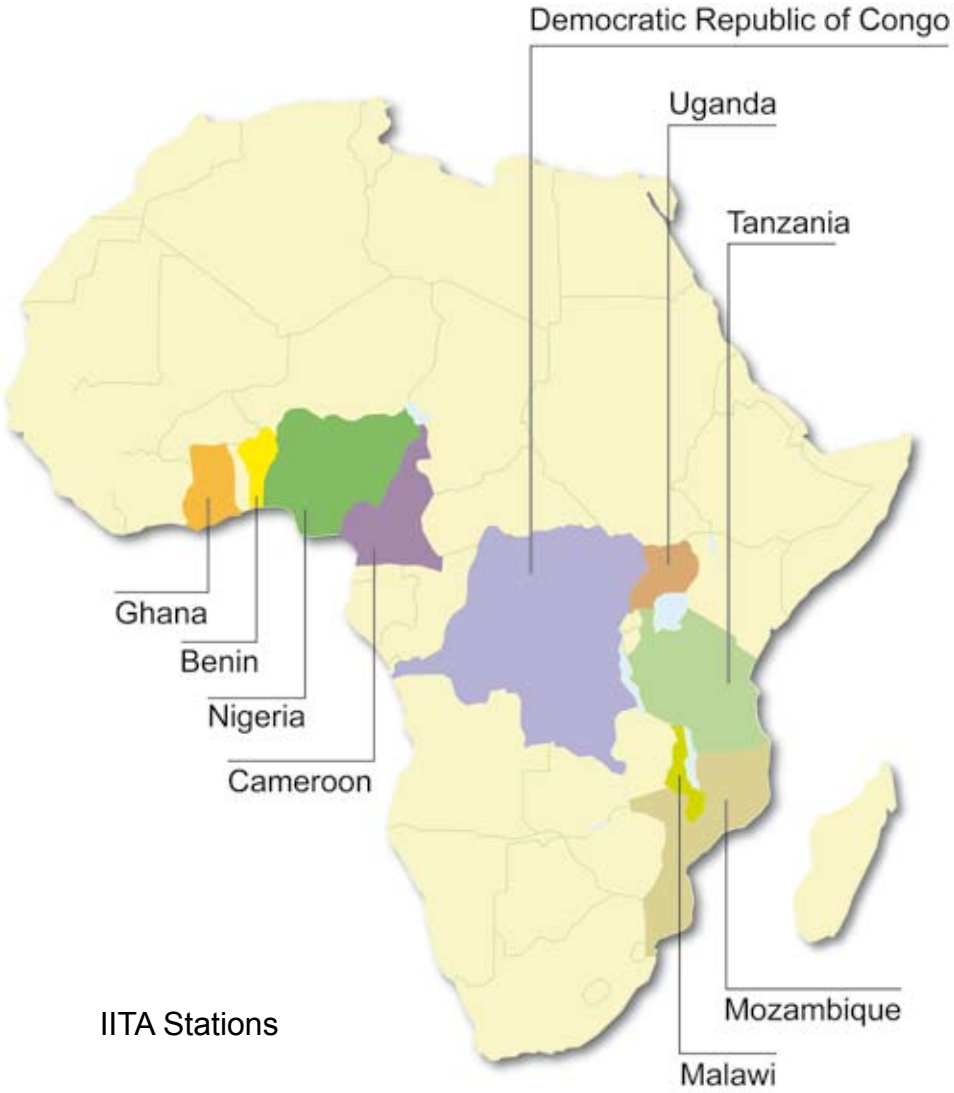

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