IITA

*Research to Nourish Africa*

# annual report 2012

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IITA
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ISSN 0331 4340

Cover photo: Burundi women farmer-beneficiaries welcoming guests to a field day. Photo by IITA

# Contents

# From the **Director General**

Eighteen months ago, I came back to IITA to start a new journey with a new management team and a refreshed strategy. Upon assumption as the Director General on 1 November 2011, I promised to implement the IITA strategy in the face of development challenges, such as poverty, food insecurity, malnutrition and natural resource degradation in Africa and globally.

The year 2012 was a challenging period for IITA. The resilience of staff in the face of changes in governance and the new way of doing business in the CGIAR system, the advent of the CGIAR Research Programs, and the unpleasant consequences from a failed Investment made in 2007-2008 was worthy of commendation. The Institute met its objectives and commitments, rising like the proverbial phoenix over the challenges and even made some gains. During the year, we put efforts in repositioning IITA for the tasks ahead, making sure that our vision of success is aligned with that of the new CGIAR. In so doing, we were able to:

- develop a stronger organizational structure with a redefined focus on research, partnership, and capacity development;
- strengthen the hubs and stations, making them more responsive to the needs in the regions;
- align our research programs with the CGIAR Research Programs;
- mobilize resources by tapping nontraditional funding sources to ensure that the Institute is prepared to take on more challenges;
- develop improved crop varieties to tackle present and emerging challenges to African food security. For instance, we developed pro-vitamin A maize and cassava in collaboration with HarvestPlus, and Nigeria's National Root Crop Research Institute and Institute of Agricultural Research and Training to tackle vitamin A deficiency;
- build capacities of partners/students in the regions.

All these have resulted in a stronger organization with a more relevant and focused science platform, responsive staff, and more effective institutional mechanisms to ensure effectiveness and efficiency in operations, proactive and more strategic relationships and networks, and an increase in resources that would facilitate the success of its research-for-development programs, i.e., a 38% increase in budget this year and the recruitment of more staff for new and emerging programs and projects.

The path ahead will continue to be fraught with even more challenges, but the new IITA will be able to overcome these difficulties.

I would like to thank the staff for their hard work and commitment. I encourage all to work even harder to make sure that IITA succeeds in its goal of being the leading partner in Africa facilitating solutions to hunger and poverty.

My thanks go to all our donors that have supported us during the course of the year.

**Dr Nteranya Sanginga**
Director General

*L-R: Omoshalewa Sholola, Director of Finance; Kenton Dashiell, Deputy Director General (DDG), Partnerships and Capacity Development; Nteranya Sanginga, Director General; Ylva Hillbur, DDG, Research for Development; Kwame Akuffo-Akuto, DDG, Corporate Services.* Photo by IITA

# From the Board Chair

In 2012, IITA underwent a major transition in its management and organization of research programs. This was Dr Nteranya Sanginga's first full year as Director General and during the year he hired a new senior management team: Dr Kenton Dashiell, Deputy Director General (DDG) Partnerships and Capacity Development, Dr Ylva Hillbur, DDG Research for Development, and Mr Kwame Akuffo-Akoto, DDG Corporate Services.

IITA's programs were brought into alignment with the CGIAR global research program portfolio. The CGIAR Research Program on Integrated Systems for the Humid Tropics, for which IITA is the lead center, received approval in 2012. This program will progressively become the focal point of the Institute's R4D programs. IITA is involved as a collaborating partner in eight other CGIAR Research Programs, with major research activities in the CGIAR Research Program on Maize, CGIAR Research Program on Roots, Tubers and Bananas, and CGIAR Research Program on Grain Legumes.

In addition, IITA's strategic plan was refreshed to reflect the changes in management and the alignment with the CGIAR research portfolio. Even though this was a year of major change, IITA went through a significant expansion in its research capacity, attracting many new partners and funding. New scientists and support staff were recruited and plans were elaborated to improve facilities at the four regional hubs and other IITA sites in Africa. Of particular note was the construction of the state-of-the-art science building in Tanzania which will be opened in May 2013.

The mission of IITA is to be the leading research partner facilitating agricultural solutions to overcome hunger, poverty, and natural resource degradation throughout the tropics. Feeding nine billion people in 2050 will require significant increases in agricultural production and Africa is expected to be a major contributor to this increase. The research programs of IITA will become even more important in meeting this challenge. The changes made over the past year, and the ambitious strategy set for the next ten years, will ensure that the Institute will achieve its mission.

**Dr Bruce Coulman**
Chair, Board of Trustees

The Board of Directors expresses its appreciation to Dr Sanginga for his major efforts in changing and expanding IITA in 2012, and for setting the course for the future. We congratulate the scientists and support staff for the excellent research being conducted. Finally, we thank IITA's investors who recognize the importance of the work being done and have confidence in the Institute's ability to do it.

Photo by IITA

## Our Mission

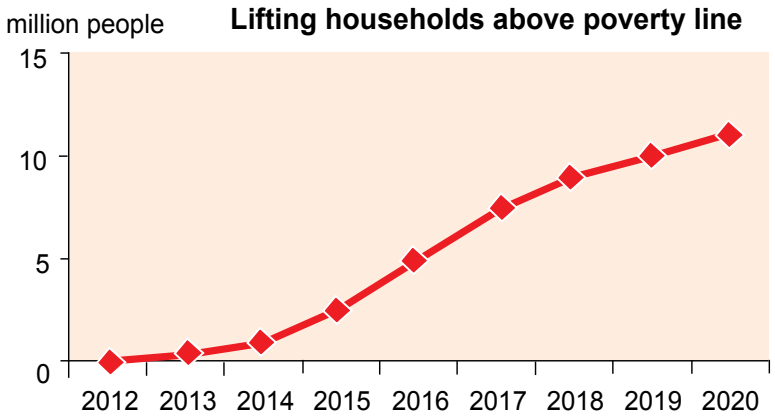
To offer a leading research partnership that facilitates agricultural solutions for hunger, poverty, and natural resource degradation throughout the tropics.

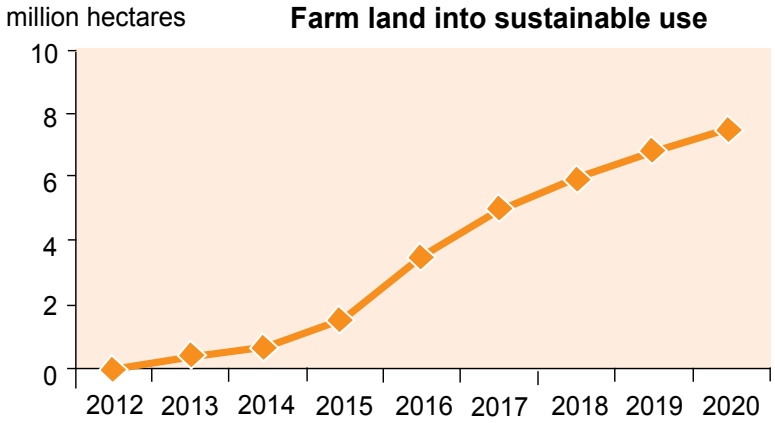
## Our Vision

IITA's revised mission is in line with that of the new CGIAR and focuses on the four system-level outcomes (SLO) described in CGIAR's Strategic Results Framework (SRF), namely, (1) increase in food security, (2) reduction of rural poverty, (3) reduction of undernutrition, and (4) more sustainable management of natural resources.

IITA will advance these SLOs by increasing the yields of major staple food crops, such as cassava, yam, maize, banana/plantain, soybean, and cowpea, by 60%; increasing average farm income by 50%; lifting 15% of poor households—over 11 million Africans—above the poverty line; reducing the number of malnourished children by 30%; and restoring and revitalizing 40% of degrading farmlands to sustainable resource management—equivalent to about 7.5 million hectares.

IITA will operate through decentralized but integrated regional research programs working on major agricultural constraints in Africa, specifically on crops, farming systems, and their natural resource base, and the CGIAR Research Programs that will also foster innovative partnerships and the outscaling of technologies developed in sub-Saharan Africa to the global tropics.




*Women project beneficiaries.* Photo by IITA

Photo by IITA

# **IITA's** Refreshed Strategy

## IITA's Refreshed Strategy for 2012-2020

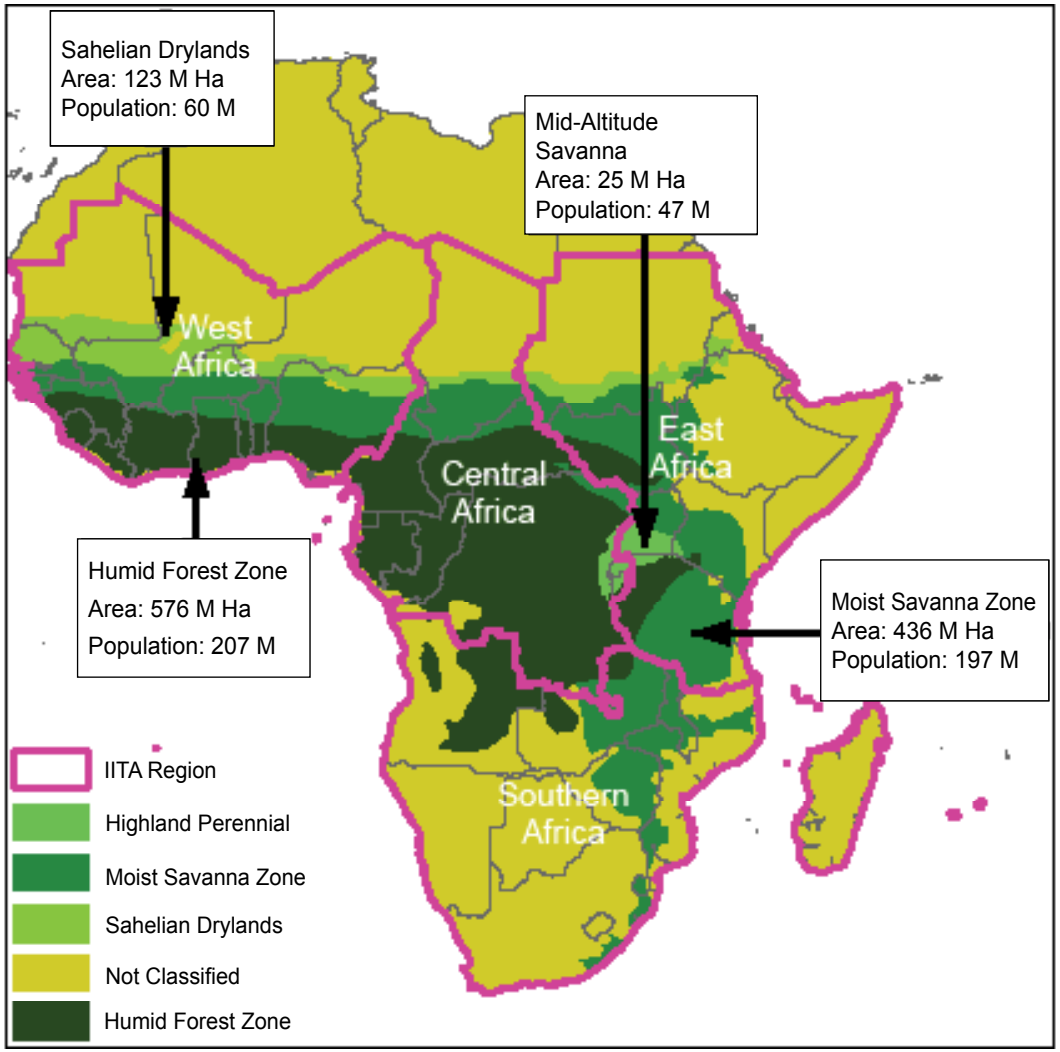
In its refreshed strategy, IITA will operate through decentralized and well-integrated research programs based among key farming systems located in major agroecological impact zones in sub-Saharan Africa. These programs will (1) consolidate the gains for cassava in lowland areas in West and Central Africa and extend IITA root and tuber cropping systems into East and Southern Africa; (2) enhance and diversify maize-legume farming systems integration in the dry savannas of West Africa; (3) intensify banana-based systems in the mid-altitudes of East and Central Africa; (4) promote cereal, cowpea, and livestock integration in the dry savannas of West Africa; and (5) develop high-value crops and enterprises suited to the different impact zones.

Two important features of the strategy are the profitability of the farm enterprises and employment generation particularly for the youth. IITA will continue to foster innovative partnerships and play catalytic and brokerage roles among advanced research institutes (ARIs), national, regional, and pan-African entities, the private sector, and farmers' organizations.

IITA's impact both within sub-Saharan Africa and in other tropical areas will be mediated through active engagement in the CGIAR Research Programs. The CGIAR Research Program on Integrated Systems for the Humid Tropics (Humidtropics), led by IITA, is the focal point for the integration of all R4D at IITA.

Meanwhile, our historical focus on the genetic improvement and plant health of our mandate crops, cassava, yam, plantain, banana, cocoa, cowpea, soybean, and maize, will be strengthened and will contribute to the CGIAR Research Programs on Maize, on Roots, Tubers and Bananas, and on Grain Legumes. IITA also has an important role in terms of the conservation and distribution of genetic resources for our mandate species through our participation in the CGIAR Research Program on Managing and Sustaining Crop Collections—Genebanks—led by the Global Trust Fund.

*Selecting cowpea seeds in Niger.* Photo by IITA




*IITA's impact zones and major cropping systems of four agroecological zones across sub-Saharan Africa.*

IITA will also renew its research on natural resource and crop management, and contribute to the CGIAR Research Program on Water, Land and Ecosystems. Maximum benefits from these research areas can be obtained only within an enabling socioeconomic environment, where factors such as viable farm input supply and produce markets, functional institutions, gender equity, and supportive policies are in place. The CGIAR Research Program on Policies, Institutions and Markets provides an opportunity for collaboration and impact throughout sub-Saharan Africa.

To address emerging challenges in agricultural development, research competencies will be strengthened in CGIAR Research Programs on Climate Change and Agricultural Food Security (CCAFS) and Agriculture for Nutrition and Health (A4NH).

Critical areas that cut across the CGIAR Research Programs, such as gender inequality, capacity strengthening, learning, and knowledge sharing, are also an integral part of the strategy.

**Impact through Hubs**

ITA will focus and integrate its R4D around farming system-based outcomes. IITA's primary focus will continue to be sub-Saharan Africa, but the products of its research will be relevant for tropical Asia and America. The R4D agenda will be implemented within four impact zones, representing major agroecological zones and farming systems.

*Humid Forest Impact Zone:* Gains will be consolidated for root, tuber, and banana crops (cassava, yam, and banana/plantain) in lowland areas in West and Central Africa and IITA's work will be expanded on cassava cropping systems into East and Southern Africa. The humid forest zone of West and Central Africa occupies 5.8 million km$^2$ and supports a population of 207 million.

*Moist Savanna and Woodland Zone:* Enhanced and diversified maize-legume farming systems in the moist savannas of West, East, and Southern Africa. Improved productivity within maize-legume intercrops and rotations offers particular promise in terms of food and nutritional security and income generation. Several technical breakthroughs in field crop traits and management developed by IITA and its partners will be extended to approximately 20 million households cultivating 31.7 million ha of cereal cropland.

*Sahelian Drylands Zone:* Cereal, cowpea, and livestock integration in the dry savannas of West Africa. The Sahelian drylands occupy 1.2 million km$^2$ and have a population of 60 million. This zone presents a particular challenge for agricultural investment, given its low rainfall, frequent and extended droughts, fragile soils, and competition for resources between cropping and livestock. Nonetheless, available crop cultivars and innovations in water management stand to benefit about 4.9 million households on 23.2 million ha cropped with millet and sorghum, resulting in additional 5.2 million tonnes of food worth $851 million and improving per capita food production by 137 kg millet/year.

*Mid-altitude Savannas and Forests:* Banana cropping systems in upland East and Central Africa. Banana and plantain are the staple crops for approximately 30 million people farming 6 million ha in the humid and subhumid uplands of East and Central Africa.

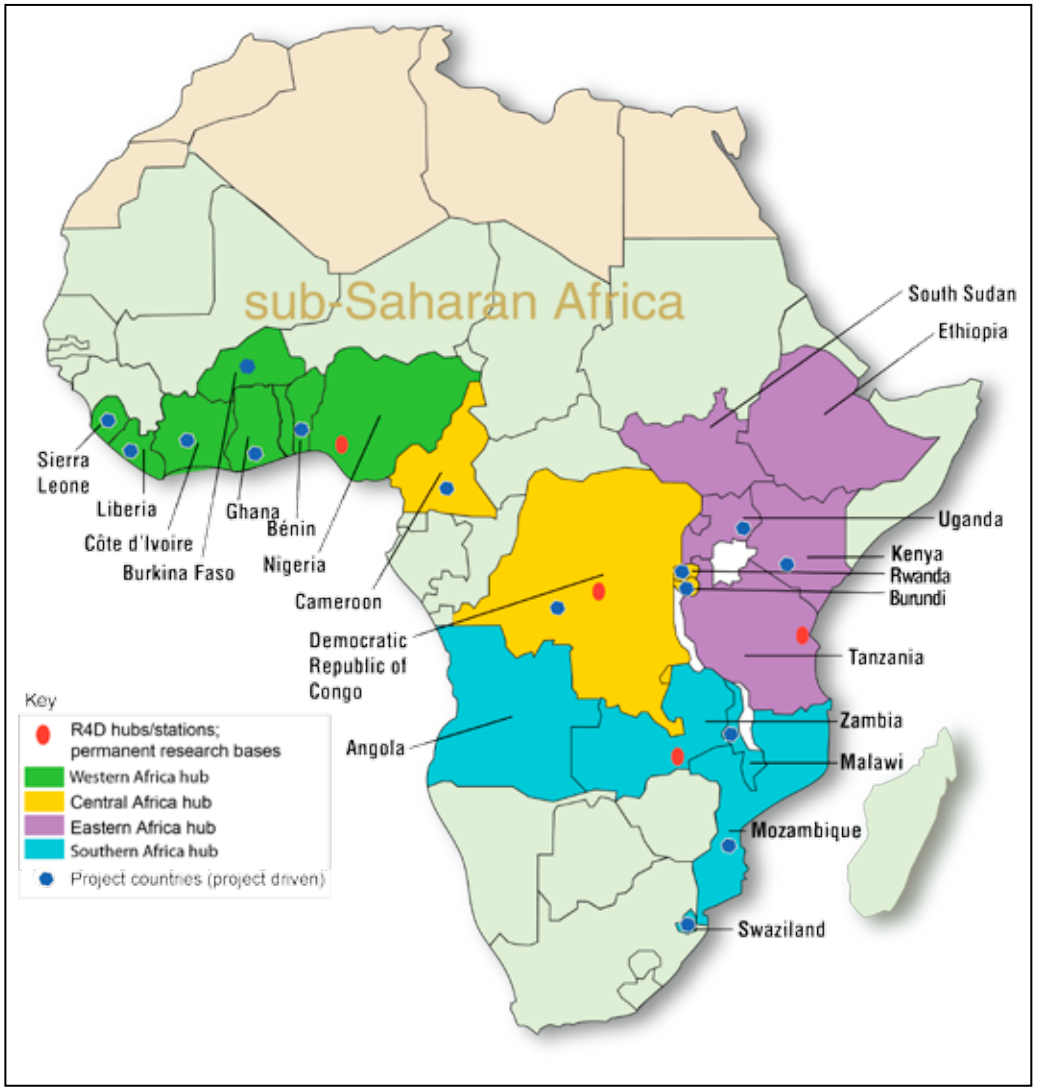
*Cross-cutting Agroecological Impact Zone:* High-value crops with potential across different impact zones. A focus on diversification and high-value crops is consistent with the CGIAR Research Program on Policies, Institutions and Markets and the CGIAR Research Program on Agriculture for Nutrition and Health, and offers IITA the possibility of establishing research expertise in new crops and cropping systems.

**Administrative Hubs**

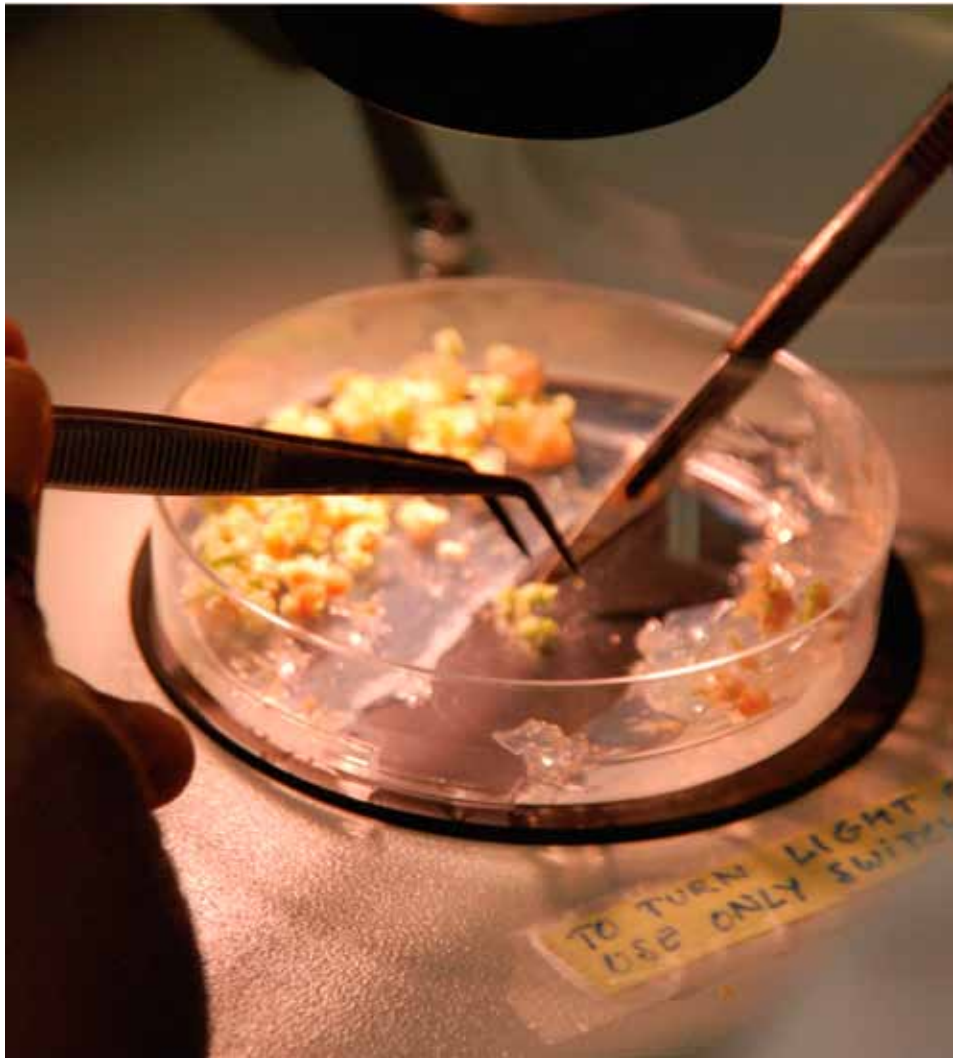
IITA is consolidating research sites, operational facilities, and administrative services in its major impact zones, which serve as Regional Hubs. IITA operates from Ibadan (headquarters) that serves the Western Africa hub, Dar es Salaam for East Africa, and Lusaka for Southern Africa. Activities in Central Africa will be administered by the hub in Kinshasa.

More than decentralized research programs, these regional offices represent important strategic assets to remain engaged in local and regional contexts, establishing partnerships and mobilizing resources, implementing R4D programs, and managing risks.

Two science platforms will be initiated. The soil and plant health platform will be based at *icipe*, Nairobi, Kenya, as a formal alliance is made between IITA, *icipe*, CIAT, IFDC, and IPNI. At its main campus in Ibadan, IITA will house the projected biotechnology platform for West Africa.




*The four IITA hubs in sub-Saharan Africa.*




*Multiplying cassava somatic embryos under sterile in vitro conditiions.* Photo by IITA

**Alignment with CRPs**

The CGIAR Research Program concept is intended as an instrument to achieve greater alignment as it becomes the main organizational structure of CGIAR research. Our programs are now aligned with and are part of the CGIAR Research Programs grouped into four major competencies: biotechnology and genetic improvement, plant production and health management, natural resources and crop management, and social science and agribusiness; these will contribute to the SLOs through the CGIAR Research Program on Integrated Systems for the Humid Tropics led by IITA. IITA will consolidate our operations with other key CGIAR centers working in sub-Saharan Africa, based on complementarities of strategic advantage.

**Core competencies and the CGIAR Research Programs**

Achieving our vision and impact on the four SLOs requires exploiting core competencies and better aligning CGIAR Research Programs and key research strategic interventions (specific IITA contribution).

*Genetic Improvement and Biotechnology*

Advances in biological sciences, particularly genomics, transgenic and nontransgenic breeding methods, cloning, plant tissue culture, apomixis, somatic embryogenesis, and integrated pest management (IPM) based on biological control will be linked to the CGIAR Research Programs dealing with crops. Interfaces between biology and information and communication technologies, ecology, biodiversity, even nanotechnology, are transforming both the processes and products of agricultural research, as well as the institutional and economic environment of agricultural technology development, and innovation systems. IITA's historical expertise on the genetic improvement and plant health of key crops grown in Africa (cassava, yam, cowpea, plantain, banana, soybean, and maize) will provide a fundamental resource.

*Plant Production and Health Management*

IITA recognizes that bridging the yield gap will involve the integrated management of several factors that limit production of a given crop in a particular environment. Hence, IITA will strengthen its activities that will bring together better genotypes and improved crop management options that minimize biotic and abiotic stresses through contributions to the CGIAR Research Programs on MAIZE, Grain Legumes, and Roots, Tubers and Bananas.

*Natural Resource Management*

IITA will renew its research on natural resource management (NRM), particularly in relation to the sustainable intensification of farming systems. Much of this work will be conducted through participation in two CGIAR Research Programs: Land, Water and Ecosystems and Climate Change, Agriculture and Food Security.

*Social Science and Agribusiness*

Impacts from the research outputs resulting from the cpre competencies Genetic Improvement and Biotechnology, and Plant Production and Health Management can best be obtained within an enabling context, where factors such as viable farm input supply and commodity markets, functional social, civil and political institutions, and good policy are in place. The CGIAR Research Program on Policies, Institutions and Markets offers a great opportunity for collaboration and impact within sub-Saharan Africa. IITA will also contribute to improving the nutition security and health of poor farm households through the CGIAR Research Program on Agriculture for Nutrition and Health.

*Well-managed Rwandan hillside.* Photo by IITA

Photo by IITA

# **The IITA** CGIAR Research Program **Portfolio**

Poverty and hunger remain enormous problems. Nearly 1 billion people in the world go hungry, and more than 1 billion live on just $1.25 a day. Seventy-five percent of the poor live in rural areas, and the majority of them depend on agriculture for their livelihoods. Food prices are high and rising—a situation that points to continued challenges in food security in the coming years. Evidence shows that agricultural growth reduces poverty by twice the rate of growth in non-agricultural sectors, but this growth has been held back by failures related to policies, institutions, and markets and will be further challenged by emerging trends, such as climate change and natural resource scarcity. Furthermore, agriculture plays a key role in the interplay between nutrition and health.

It is projected that food production will need to increase by 70% globally and by 100% in developing countries to ensure adequate food for the world's population by the year 2050. It is in this mixed context of need, challenge, and uncertainty that the CGIAR Research Programs have been developed to address the four System Level Outcomes: (1) Increase in food security, (2) Reduction of rural poverty, (3) Reduction of under-nutrition, (4) Sustainable management of natural resources.

Of the 15 CGIAR Research Programs, IITA hosts and leads one, Humidtropics, and participates in eight others. Briefs on IITA's contributions during 2012 are provided below.

*Assessing disease symptoms in the field.* Photo by IITA

*Humidtropics Director Kwesi Atta-Krah (left) and IITA Deputy Director General (R4D) Ylva Hillbur (right) during the program launch at IITA.* Photo by IITA

**Hunidtropics Launched**

The CGIAR Research Program on Integrated Systems for the Humid Tropics or Humidtropics was launched last year in a low-key ceremony in IITA, Ibadan.

Humidtropics, a major new research-for-development program, aims at increasing average farm income by 50% with 15% of poor households in the humid tropics lifted above the poverty line in the next 15 years. Research leading to production system intensification is expected to boost yields of staple crops and help to reduce the number of malnourished children by 30%.

## Humidtropics

Humidtropics, led by IITA, is one of three system research programs within the portfolio of CGIAR. It was designed from the outset to be a research-for-development (R4D) program, which is clearly expressed in its overall goal:

"To strengthen research and stimulate institutional innovation that increases economic and social returns among rural households adopting enhanced and sustained agricultural production and marketing strategies, while improving the biological and ecological integrity of their natural resource base."

The program seeks to transform the lives of the rural poor in the humid lowlands, moist savannas, and highlands in the tropical Americas, Asia, and Africa. It provides a new integrated agricultural systems approach and unique partnership platforms for better impact on livelihoods, productivity, poverty, and ecosystems integrity. The research will include the analysis of interactions and trade-offs between commodities, land, labor, and capital allocation to farm operations or enterprises. This innovative integrated systems research in the humid tropics will help poor farm families, most of whom are led by women, and boost their income from agriculture while preserving the land for future generations. The humid and subhumid tropics, with 2.9 billion people on about 3 billion ha of land, are critical to global food supplies, central to the maintenance of global biodiversity, and vital to the mitigation of greenhouse gases. Intensification of agricultural systems in these areas offers the best potential for poverty reduction, especially for women and other vulnerable groups, as well as contributing towards meeting world food demand.

The research program is structured into three main Strategic Research Themes (SRTs), which operate in an integrated systems-oriented fashion. The first focuses on situation analysis and global synthesis, which involve a holistic analysis and characterization of Action Areas and their component Action Sites, to identify entry points for research and coordinate the development of tools, to monitor agricultural system change, and to provide analytical support in research synthesis. The second is an integrated research component, organized

around three pillars of institutional and market development, system productivity, and natural resource management. The third research theme involves research on scaling and institutional innovation, as well as impacts on rural poverty and gender equity in a manner that raises the institutional effectiveness of program partners.

Over the next 15 years, Humidtropics will advance the CGIAR SLOs within the action areas by increasing staple food yields by 60%, increasing average farm income by 50%, lifting 15% of poor households above the poverty line, reducing the number of malnourished children by 30%, and restoring 40% of the farms to sustainable resource management. All these targets are within the action areas, but with a potential for expansion beyond these areas. In this way, Humidtropics will serve as a model to other agencies seeking to link agricultural systems research to developmental impact.

**Activities in 2012**

Most of the first half of 2012 was used in further developing the Humidtropics proposal. This also included addressing specific review comments and questions of the CGIAR Independent Science and Partnership Council (ISPC), that helped shape the proposal and make it more focused towards realizing the system-level outcomes of the CGIAR. The second half of the year started with workshops on proposal completion, that also included developing specific components to be addressed in the action areas.

The revised proposal was submitted to the CGIAR Consortium Board on 15 August and approved by the Fund Council on 1 October. Following the approval, a management team, including the Director and Chief Officer Management, was recruited and the inception workshop for the program was held in November, at IITA, Ibadan. This workshop was attended by representatives from several of Humidtropics key partners.

Humidtropics as a research program is of central relevance and interest for IITA. Currently, 43 IITA-led projects are contributing to the research portfolio of Humidtropics, covering most of sub-Saharan Africa. The research process will include the conduct of baseline Situation Analysis leading to identified entry points for integrated production systems research; assemblying, testing, and refining systems interventions through participatory processes and R4D platforms; and championing both technological and institutional innovation arising from the platforms as pathways to adoptability and impacts. Such programs and platforms will be linked to partner development initiatives and government agricultural development programs for maximizing impact at scale.

Humidtropics is place-based, and will work in selected sites of high relevance for a larger region. In its first phase, the program will be implemented in four action areas: West African humid lowlands, East and Central African highlands, Central America and the Caribbean, and Central Mekong. Co-location of research activities of related CGIAR Research Programs will be important to exploit synergies and allow for faster progress.

*Sustainable resource management is one of the goals of Humidtropics.* Photo by IITA

*IITA's research looks at reducing drudgery in agricultural work for women and the marginalized.* Photo by IITA

Collaboration and partnership are fundamental to the operation of Humidtropics. The program involves a number of CGIAR centers but also other partners, e.g., AVRDC, Wageningen University, *icipe*, and FARA. It also involves national research institutions, as well as development organizations, private sector organizations, and farmers' groups. The R4D platforms will be an essential instrument for managing the partnership's contributions and ensuring that synergies are maximized.

## Policies, Institutions and Markets

Policies, Institutions and Markets will provide knowledge and tools to support a policy and institutional environment in which markets function effectively and competitively and agriculture and related sectors fully contribute to poverty reduction, sustainable rural development, and income growth. The program is implemented by 12 CGIAR centers (IFPRI (lead center), Bioversity, CIAT, CIMMYT, CIP, ICARDA, ICRAF, ICRISAT, IITA, ILRI, IWMI, and World Fish), strategic partners who jointly design the research objectives, and boundary partners with the direct goal of changing their behavior or positions. IITA is involved in two of the program's research themes: (1) Policies and Investments that Enable Pro-Poor Growth and (2) Value Chains Linking Small Farmers to Markets.

**Research highlights**

*Potential economic and environmental impact of cowpea and soybean research*

Under a conservative assumption of expected adoption and yield gains in the range of 15–20%, economic benefits of cowpea research in sub-Saharan Africa over the period 2011-2020 were estimated at US$192 million. Over the same period, cowpea research is projected to contribute environmental benefits through biological nitrogen fixation that translate to a fertilizer cost saving of US$21 million. Cowpea research will have the greatest economic impacts in Nigeria, which accounts for over 70% of the projected economic benefits in sub-Saharan Africa. On the other hand, economic benefits of soybean research in sub-Saharan Africa over the period 2011–2020 were estimated at US$69 million. Over the same period, soybean research is also projected to generate environmental benefits through biological nitrogen fixation equalling a fertilizer cost saving of US$12 million. Soybean research will also have the greatest economic impacts in Nigeria. Overall, investments in cowpea and soybean research will generate economic benefits worth US$306 million.

Trend analysis and extrapolation into the future based on past trends of the world cowpea situation showed that, if past trends in cowpea area expansion and yields continue into the future, cowpea demand in West and Central Africa will grow at a faster rate/year than supply over the period 2010–2030. The projections suggest that increased investments in cowpea research and extension will be crucial for achieving increased productivity and a marketed surplus whereas commercialization and regional trade will be instrumental in achieving food security through the redistribution of any surplus among countries in West and Central Africa.

*Commodity database for IITA core crops*

IITA has established an internal online technology database (IITAAgriSTAT) based on a recent survey of national crop improvement programs working on IITA core crops. The activity involved the collection, processing, validation, and archiving of a range of national and subnational time series data for over 20 countries in sub-Saharan Africa. The databases include the following: (1) Crop production, harvested area, and yield/hectare; (2) Prices of crops and crop products; (3) Modern varieties of IITA core crops; (4) Rainfall; and (5) a number of development indicators. While all datasets needed for 2012 were successfully assembled, this activity involves a continuous process of data collection, and efforts will be made in 2013 and beyond to undertake further data collection to assemble a more complete dataset for the ex-ante analysis of technology-specific impacts as well as for the later projections of food supply under alternative research scenarios.

*Performance of crop improvement programs in sub-Saharan Africa—output and adoption*

As part of a larger effort to assess scientific strength, variety release, and adoption, a survey of national crop improvement programs was carried out in 2010 in over 20 target countries in sub-Saharan Africa. Analysis of the performance of several national crop improvement programs in sub-Saharan Africa over the period 1970-2012 showed

*Cowpea vendors in northern Nigeria.* Photo by IITA

(a) a ratio of 2.64 varieties released for each full-time researcher for cassava and 2.61 for cowpea. Results for the three other IITA core crops were 2.31 for maize, 3.5 for soybean, and 1.45 for yam. During the period, 79% of released cassava varieties and 67% of the released cowpea varieties were IITA related. Results for other crops are 70% for maize, 42% for soybean, and 85% for yam. The rates of adoption of new varieties, as estimated by an expert-panel in 2009, were highest for soybean (79%) and lowest for yam (15%). IITA remains the major contributor to those adoption rates (ranging from 65 to 87%).

*Ex-post impact assessment of cassava processing R4D programs—implications for upgrading cassava value chains*

IITA researchers and national agricultural research systems (NARS) scientists in Nigeria implemented a cassava postharvest engineering and processing program starting in 1988. The program developed, tested, and identified a package of improved machinery and equipment prototypes appropriate for different scales of operations. The program also developed several value-added products for the preparation of home meals, and process and institutional innovations for industrial manufacturing for domestic and export markets. The machinery and equipment prototypes and recipes were disseminated through extension services in many African countries.

In an ex-post impact assessment of the program, analysis of the survey data of a sample of R4D and non-R4D fabricators (58), processors (143), and households (952) collected in 2010/2011 showed that adoption of cassava processing machinery and equipment follows a stepwise adoption pattern. R4D increases the adoption of new machinery and equipment innovations and increases investments in cassava processing by processors and households as well as the adoption of improved varieties by households. R4D has no statistically significant effect on household food sufficiency and caloric consumption. These findings imply that policymakers can increase benefits through initially targeting research investments to small-scale general purpose machinery and equipment, ergonomic product quality, and process standardization innovations and then shifting research investments over time to large-scale machinery and equipment and institutional innovations for niche markets as market demand increases and economies of scale are generated and exploited.

*Loading agricultural produce for the market in urban centers.* Photo by IITA

## MAIZE

The objective of MAIZE, developed and run by CIMMYT (lead center) and IITA, is to double the productivity of maize-based farming systems by making them resilient through sustainable intensification. The goal is to significantly improve income and livelihoods of farmers, without encroaching into new areas as climate changes and fertilizer, water, and labor costs rise. To contribute to this goal, nine strategic initiatives have been identified based on analyses of the current and future external environments, the experience of the centers in collaborative work with an extensive network of partners, and their feedback. The research focus includes socioeconomics and policies for maize, sustainable intensification of maize production, smallholder-targeted precision farming, development of stress tolerant maize, research for doubling the productivity of maize, integrated postharvest management, development of nutritious maize, and use of diverse genetic resources and new tools and methods to strengthen the capacity of national institutions and entrepreneurs to develop and deliver better products to farmers. The program will also work with new institutions and individuals worldwide that are committed to the improvement of the crop to reduce poverty, enhance global food security, and ensure sustainable use of the maize production environment.

MAIZE's activities under the different strategic initiatives are implemented in Asia and Central and West Asia and North Africa, Latin America and the Caribbean, East and Southern Africa, and West and Central Africa. IITA has the responsibility for implementing program activities in West and Central Africa. Selected highlights of the progress that has been made so far at IITA are presented here.

**Seeds**

To facilitate access of improved maize varieties by small and medium-size seed companies and subsequent multiplication of the new varieties for marketing, 43 tonnes of foundation seeds of recently released open-pollinated maize varieties were produced and supplied to the National

Photo by IITA

**Vitamin A Maize**

The Nigerian Government released two new maize hybrids that can provide more vitamin A in the diets of millions.

The first generation vitamin A-rich maize hybrids were released by the National Variety Release Committee of Nigeria as Ife maizehyb 3 and Ife maizehyb 4. They are recognized as IITA hybrids A0905-28 and A0905-32, respectively. They outperformed local checks with yields ranging from 6 to 9 t/ha compared with 2 t/ha recorded on most farmers' fields.

The hybrids are a product of nearly a decade of breeding for enhanced levels of pro-vitamin A. The development of the new maize hybrids was led by Dr Abebe Menkir, maize breeder.

The vitamin A hybrids were developed by IITA in partnership with the Institute of Agricultural Research & Training (IAR&T) using conventional breeding in a project funded by HarvestPlus—a Challenge Program of CGIAR as part of strategies to address the prevalence of vitamin A deficiency. Other collaborating partners include the Institute for Agricultural Research (IAR), Zaria; University of Maiduguri; International Maize and Wheat Center (CIMMYT), University of Illinois, and University of Wisconsin.

In Nigeria, vitamin A deficiency afflicts about 30% of children below five years of age, almost 20% of pregnant women, and 13% of nursing mothers. Vitamin A deficiency lowers immunity and impairs vision, which can lead to blindness and even death.

Agricultural Seed Council in Nigeria for distribution to seed companies. The objective was to help the seed companies produce 4000 tonnes of certified seeds in 2013 for marketing to farmers in different states in 2014.

**Drought tolerance**

*Risk perception and coping mechanisms*

Assessments of farmers' perception of drought-related risks in West Africa demonstrated that 54% of the respondents in Mali, 43% in Benin Republic, 32% in Nigeria, and 27% in Ghana considered drought as a major factor limiting production. Due to differences in resource endowments, a broad range of coping mechanisms has been employed by the various categories of farmers to mitigate production risks associated with drought in these countries. For instance, the poorly-endowed households in Nigeria and Bénin adopted agricultural diversification as a major strategy to cope with the adverse effect of drought. The differences in farmers' perception about drought and coping strategies based on asset endowments will form the basis for deployment and dissemination of appropriate drought tolerant maize varieties of varying maturity in different areas in the four target countries. Additional surveys conducted in four countries in West Africa showed that drought tolerant varieties represent 25% of the current maize varieties cultivated in Nigeria, 5% of those cultivated in Ghana, 66% of those grown in Mali, and 44% of those grown in Benin Republic.

*Women carrying maize to the market.* Photo by IITA

*Breeding*

During the year, breeding efforts to develop new, drought tolerant, and high yielding varieties have generated promising results. Fifty early maturing maize varieties developed from 1988 to 2010, were evaluated for two years under controlled drought stress at one location and in 24 test environments in Benin Republic, Ghana, and Nigeria. The more recent drought tolerant varieties (developed between 2007 and 2010) gave on average 22% and 13% higher yields under controlled drought stress and diverse test environments, respectively, than the varieties developed before 2007. The observed increase in grain yield in the newer varieties was not associated with significant changes in anthesis and silking dates, plant height, and ear height, but was related with improvements in husk cover as well as plant and ear aspect scores. In another trial, four late maturing three-way cross hybrids developed in 2007 and 31 three-way cross hybrids developed in 2011 were evaluated under controlled drought stress as well as under stressful and favorable test locations in Benin Republic, Ghana, Mali, and Nigeria. The best 10 hybrids developed in 2011 outyielded those developed in 2007 by an average of 58% under drought stress, 26% in stressful locations, and 10% in favorable growing environments. The best hybrids also outyielded eight commercial hybrid checks by 139% under drought stress, 45% in stressful locations, and 19% in favorable growing environments.

In another approach to develop drought tolerant material, a diallel study was conducted under drought stress, *Striga* infestation, and optimal environments at three locations in Nigeria for two years.

Based on the results, 17 extra-early maturing white maize inbred lines were separated into four heterotic groups, similar to groups that were defined by molecular markers. Two of the lines, TZEEI 14 and TZEI 13, were selected as the best testers used to assess the capacity of the new generation of inbred lines to make productive hybrids.

**Effects of soil nutrients—crop rotation with legumes**

In a two-year field trial in the Sudan savanna of Nigeria, testing different rates of nitrogen fertilizer, maize varieties with tolerance for drought and resistance to *Striga* produced higher grain yields, accumulated a higher level of nitrogen, and had higher nitrogen-uptake or nitrogen-utilization efficiency under suboptimal nitrogen application than the variety that was not drought tolerant. It thus appears that varieties developed for drought tolerance may be tolerant to suboptimal soil nitrogen.

In a rotation study conducted in Mozambique, the maize crop planted after soybean produced 21% (690 kg/ha) more grain yield whereas maize planted after cowpea generated a yield increase of 16% (534 kg/ha). The soybean-maize and cowpea-maize systems left more maize residue on the field after harvesting the grains compared to the maize-maize system.

In another rotation experiment conducted in Nigeria, maize planted after soybean produced a higher grain yield than maize planted after maize in the same plot with or without Rhizobium bacteria inoculation. Application of phosphorus to soybean significantly increased the subsequent maize crop yield, probably due to increased soybean biomass and high nitrogen fixation by the preceding soybean. Results indicate that a preceding soybean crop fertilized with phosphorus provides benefits to the subsequent maize crop.

*Gender-biased trait preference*

To be able to incorporate gender-biased trait preferences in the breeding programs, an assessment was made where male and female farmers were involved in assessing trait preferences of new maize varieties included in regional and on-station trials conducted at different locations in Benin Republic, Ghana, Mali, and Nigeria. In each test location, male and female farmers separately assessed varieties included in these trials, and discussions were held with each group to carry out in-depth analyses of reasons for their choices.

*A healthy crop of maize.* Photo by IITA

**Management of pests, weeds, and diseases**

*Striga*

Laboratory studies conducted to determine the compatibility of a biological control agent (*F. oxysporum* f.sp. *strigae*), herbicides, and fungicides for coating maize seeds to control *Striga hermonthica* showed that the three components can be combined and delivered through seed treatment. Further laboratory, screenhouse, and field studies will be carried out to determine appropriate doses and complementary seed coating protocols for these compatible technologies to control *Striga* effectively in farmers' fields. In an effort to incorporate high pro-vitamin A into *Striga* resistant yellow and orange maize inbred lines, 270 lines

Photo by IITA

**Fighting the Violet Vampire**

In 2011, a private public partnership coordinated by IITA launched the Integrated Striga Management in Africa (ISMA) project to develop a package of *Striga* control options for smallholder farmers in Kenya and Nigeria. The project is funded by the Bill & Melinda Gates Foundation and is being implemented with the International Maize and Wheat Improvement Center (CIMMYT), International Centre of Insect Physiology and Ecology (*icipe*), African Agricultural Technology Foundation (AATF), BASF Crop Protection, and national agricultural research and extension services and private sector players in Kenya and Nigeria.

The initial outputs of ISMA have been encouraging. In Kenya, almost 6000 farmers in the western region now have access to new *Striga* and the Imazapyr-resistant (IR) variety and maize-legume intercrop *Striga* control technologies. Over 35 tonnes of seeds that use Imazapyr herbicide-resistant maize coating technology produced by partner seed companies had been disseminated to more than 23,000 smallholder farmers through participating agro-dealer networks. Likewise, community seed producers and partner seed companies have produced and disseminated some 2.1 tonnes of *Desmodium* seeds to farmers as part of the push-pull *Striga* management technology. The project has trained more than 8000 farmers on the push-pull technology. The project is also working with the Ministry of Agriculture to integrate the use of *Striga* control technologies into the extension program.

In Nigeria, the project worked with 100 communities in *Striga* hotspots in Kano and Bauchi States and established 500 on-farm demonstrations of improved cowpea, maize, and soybean varieties along with *Striga* management technologies. About 500 tonnes of certified seeds of *Striga*-resistant maize varieties were produced by participating seed companies and community-based seed producers and distributed to project beneficiaries. Partner seed companies and community seed producers have also produced some 142 tonnes of certified seeds of *Striga*-resistant cowpea varieties. The project has trained some 3500 farmers on group dynamics, participatory approaches, modern crop management, and *Striga* control practices in Northern Nigeria. The project has also disseminated *Striga* management technologies to about 38,000 Nigerian farmers through farmer-to-farmer knowledge transfer, on-farm demonstrations, field days, and radio.

The successful models in the two countries will be scaled out to other sub-Saharan African countries with similar ecologies and where *Striga* is also a major concern in maize and cowpea production systems.

derived from crosses of *Striga* resistant lines and high pro-vitamin A line were evaluated under artificial *Striga* infestation at two test locations in 2012. Among these, 99 promising lines with high levels of resistance to *Striga* were selected for further evaluation under *Striga* infestation, inbreeding, and carotenoid analysis.

*Maize streak virus disease*

Phenotyping of 130 maize lines developed at IITA for maize streak virus disease (MSV) resistance under viral inoculation revealed 75 lines with good recovery resistance to MSV infection six weeks after inoculation, whereas the remaining 55 lines showed no recovery resistance to the virus. Such polygenetic resistance can provide effective and durable control of MSV. A trial consisting of 250 lines derived from a cross between a drought tolerant inbred line and an MSV tolerant line was evaluated under artificial inoculation. The lines showed significant differences in incidence and severity of MSV. Linkage analysis using 230 SNP markers found a QTL with a major effect on chromosome 3 that accounted for more than 60% of phenotypic variance in disease severity. This QTL was considered to be a major gene with additive and dominance effects.

*Stem borers*

The egg parasitoids *Telenomus* and *Trichogrammatoidea eldanae* were recovered from parasitized egg batches of the maize stem borer *Sesamia calamistis* in southern Bénin and cultured in the laboratory. A device for releasing the eggs in the field was constructed and then tested in the laboratory and in the screenhouse. Preliminary results from a field trial conducted in Bénin showed up to 56% egg parasitism of sentinel egg batches of *S. calamistis*, which compared favorably with results obtained with commercially available trichogrammatids.

*Aflatoxin—combined biocontrol and resistance approach*

Field efficacy trials have demonstrated that the use of aflasafe™—atoxigenic fungal strains that outcompete the toxic *Aspergillus* fungi—can reduce aflatoxin in maize by up to 100%. Carryover effect of the

application of aflasafe™ reduced aflatoxin contamination by 92% in farmers' fields treated for three years. Even under poor storage conditions, aflatoxin reductions recorded in maize grains harvested from fields treated with aflasafe™ for three consecutive years, two consecutive years, two alternate years, and for one year were 98%, 95%, 90%, and 96%, respectively. The method builds on the use of local atoxigenic strains as biocontrol agents. From maize and soil samples collected in eastern Zambia, over 3000 isolates were characterized as toxigenic or atoxigenic strains of *A. flavus*. A total of 38 atoxigenic isolates with deletions in aflatoxin biosynthesis gene sequences were identified as potential candidates for biocontrol and were further screened at the University of Arizona using SSR markers and PCR detection. Three isolates were found to be potential biocontrol strains. Isolates obtained from maize samples collected in Kenya were also characterized following the same procedures described above and promising strains were selected to form mixtures for biocontrol.

In a trial composed of 72 maize hybrids evaluated for resistance to aflatoxin production at four locations, the best six hybrids with less than 50 ppb aflatoxin were identified at a location that had the highest levels of aflatoxin contamination. In addition, six inbred lines with consistently less than 20 ppb aflatoxin were identified from two inbred trials evaluated at two locations in 2012. The selected promising hybrids and inbred lines will be tested further under both artificial inoculation and natural infection to confirm the consistency of resistance to aflatoxin contamination.

In an attempt to combine the two approaches—resistance and biocontrol—three maize synthetics formed from aflatoxin-resistant lines and a susceptible check in combination with aflasafe™ were evaluated in on-farm trials in Nigeria. Application of aflasafe™ decreased aflatoxin accumulation in the susceptible variety by 80% whereas the aflatoxin resistant synthetics decreased aflatoxin accumulation by 53 to 67%. The combined effect of aflasafe™ application and resistant varieties was significantly higher than the individual effect of the synthetic varieties in decreasing aflatoxin accumulation.

*A harvest of yellow maize.* Photo by IITA

More information on the health aspects of aflatoxins is presented under Agriculture for Nutrition and Health.

**Nutritional quality**

An assessment of chemical and end-use quality traits showed significant differences among the orange pro-vitamin A-enriched varieties and hybrids only for protein and starch content, meaning that the chemical and end-use qualities of the new pro-vitamin A-enriched varieties and hybrids were similar to the yellow cultivars most commonly grown by farmers in Nigeria.

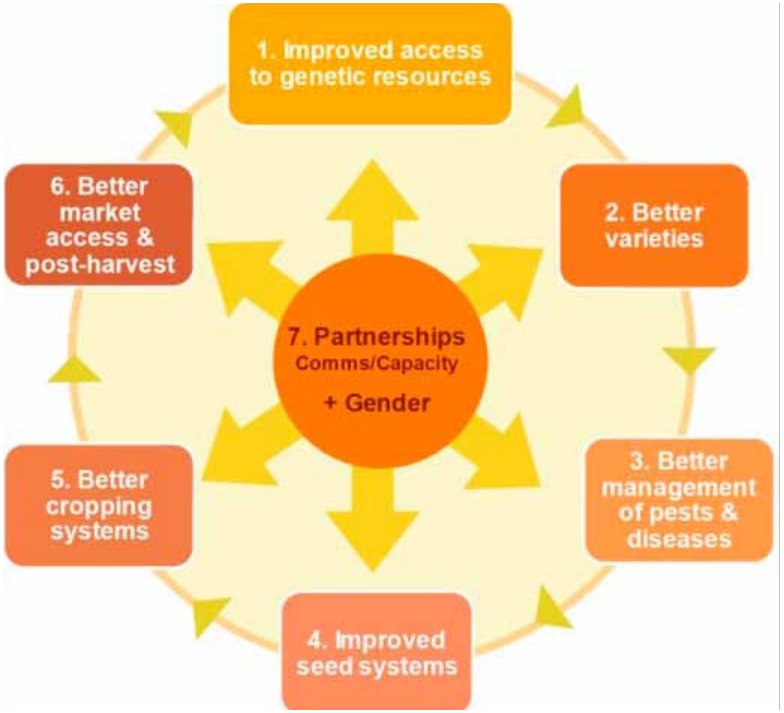
More information on the nutritional quality aspects of maize is presented under Agriculture for Nutrition and Health.

## Roots, Tubers and Bananas

During 2012, the Roots, Tubers and Bananas CRP resulted in unprecedented interaction among participating CGIAR centers IITA, CIP, CIAT, and Bioversity to produce an integrated research program that benefits from the synergies of joint collaboration on vegetatively propagated crops that form a foundation for food security and income generation in sub-Saharan Africa and elsewhere. In the first year of the program research was organized around seven themes (see figure) with each theme divided into 3-4 product lines supported by research products.

This organization provided a good starting point, bringing together research on five primary crops (banana/plantain, cassava, yam, potato, and sweet potato) and several minor tubers. The organizational framework resulted in the creation of new cross-cutting initiatives involving multiple crops and multiple centers. An example of these cross-cutting initiatives is 'Enhancing Global RTB Productivity' through more targeted use of global genetic diversity. To improve efficiency, accelerate the breeding process, and improve yields in farmers' fields, RTB is establishing a platform to harness the potential of next-generation sequencing technologies and plant metabolite profiling. The goal is to create comprehensive maps of genes and metabolic processes underlying traits of interest in the main RTB crops. This approach combines three strategic research areas—genomics (the use of DNA sequencing to uncover and map thousands of single nucleotide polymorphisms or SNP markers), metabolomics (the study of metabolites or the chemical fingerprints of cellular processes), and phenomics (evaluating how genes and the metabolic processes they control determine phenotypes).

RTB features three IITA mandate crops: banana/plantain, cassava, and yam. Research highlights from 2012 built on many ongoing IITA research projects and new initiatives. IITA is at the forefront of developing genetic transformation solutions for problems encountered by farmers in Africa. Banana bacterial wilt resistant varieties of banana have been developed through genetic transformation at the IITA/BecA




*Seven RTB themes interact to produce research and development outcomes that will increase productivity and improve livelihoods in farmers' fields.*

Hub, Nairobi, through constitutive expression of the sweet pepper *Hrap* or *Pflp* gene. Also, 12 varieties of nematode-resistant plantain are being tested in a confined field trial in collaboration with national partners in Uganda using the best transgenic lines (with maize cystatin peptide) showing >67% resistance against nematodes. Establishment of an efficient transformation system for local cassava cultivars using protocols for the regeneration of cassava plants through somatic embryogenesis is also encouraging.

**Next Generation Cassava Breeding**

In 2012, the NEXTGEN Cassava project was launched to improve cassava's productivity and build human and technical capacity for plant breeding in sub-Saharan Africa. The project aims to use the latest advances in breeding methodology to improve productivity and yield in cassava production, incorporate cassava germplasm diversity from South America into African breeding programs, train the next generation of plant breeders, and improve infrastructure at African institutions. NEXTGEN Cassava is supported by a $25.2M grant from the Bill & Melinda Gates Foundation and the Department for International Development of the United Kingdom until 2017.

The five-year project is hosted by Cornell University with five partner institutions: the National Crops Resources Research Institute (NaCRRI) in Uganda, National Root Crops Research Institute (NRCRI) in Nigeria, IITA, Boyce Thompson Institute (BTI) for Plant Research in New York, and US Department of Energy Joint Genome Institute of the Lawrence Berkeley National Laboratory, in California.

One output from the project is Cassavabase (http://www.cassavabase.org/), developed by scientists at the Boyce Thompson Institute. It is an open access database that features phenotypic and genotypic data generated by cassava breeding programs involved in the NEXTGEN. IITA is a major contributor of data to Cassavabase. Cassavabase will be hosted at IITA-Nigeria by the NEXTGEN Cassava project.

IITA and CIAT have increased collaborative work on cassava including initiation of a joint activity to use next-generation DNA sequencing methods to study over 1000 germplasm accessions (700 from Latin American countries and 300 from African landraces). This will facilitate the comparison of African and American germplasm and accelerate the identification of genes for breeding. Jointly we are developing partially inbred genetic stocks of cassava especially emphasizing resistance

*A huge cassava root brings a smile to this farmer.* Photo by IITA

Photos by Missionary Sisters of the Holy Rosary

**Yam for livelihoods**

The Yam Improvement for Income Generation and Food Security in West Africa (YIIFSWA) project, funded by the Bill & Melinda Gates Foundation, promotes clean seed yam production in Nigeria and Ghana using a range of approaches, including adapted yam minisett technology or AYMT.

When floods hit Idah, a major town in the Igalaland area adjacent to Niger in South East Nigeria, yam were among the most precious belongings saved and salvaged by residents. Residents contributed seed yam from their diminished harvest to share with flood victims who lost everything.

to pests and diseases such as white flies and cassava mosaic disease. Also as part of joint activities, IITA and CIAT are working to increase the pro-vitamin A content of cassava roots using fast-tracked selection procedures to shorten the breeding cycle. This includes the use of several rapid screening technologies, e.g., near-infrared spectroscopy, NIRS, colorimeter, and iCheck.

Yam breeding has made major strides in 2012 to shorten the breeding cycle, increase multiplication rates of seed yam, and evaluate potential varieties in participatory breeding schemes implemented in Ghana and Nigeria, with public sector NARS partners (CSIR and NRCRI) and private sector partners, including farmers and processors. Use of yam vine propagation and vertical sack technology in the screenhouse is enabling rapid multiplication of clean planting material for the accelerated yam breeding scheme. National yam breeding strategies are under development in Ghana and Nigeria using broad stakeholder participation to rapidly release improved yam varieties.

IITA is collaborating closely with other centers in RTB to study pests and diseases, to predict future threats to RTB crops, and to reduce seed degeneration that is common in vegetatively propagated crops. To advance the integrated management of whiteflies CIAT and IITA found differences in the COI gene on mitochondrial DNA of 10 whitefly species which could be used to develop chemical tests to identify whitefly species, even from damaged specimens.

RTB supported the publication of two training manuals to teach smallholders in East Africa how to produce banana plantlets using tissue culture. The first manual covers tissue culture technology, whereas the second explains how to use tissue culture to turn banana nurseries into profitable businesses. During the project, over 700 farmers were trained during more than 250 training sessions, and 150 nursery operators during 20 training sessions in Burundi and Uganda. In Kenya, farmers and nursery operators were trained together, and 75 training sessions were organized. Individual farmers or nursery operators attended up to 40 training events over 1–2 years.

## Grain Legumes

The CGIAR Research Program on Grain Legumes was approved in October 2012, but activities had already started in January 2012 on transition financing. The program is led by ICRISAT and other participating CGIAR centers include IITA, CIAT, and ICARDA. The major collaborators in Africa are the NARS in Senegal, Mali, Burkina Faso, Ghana, Bénin, Niger, Nigeria, Cameroon, Zambia, Malawi, Mozambique, and Tanzania. The activities in Grain Legumes build on and encompass a number of earlier and ongoing projects and programs, e.g., the Dry Grain Pulses Collaborative Research Program (now Legume Innovation Lab) (USAID), Tropical Legumes 1 and 2 (Bill & Melinda Gates Foundation), N2Africa (Bill & Melinda Gates Foundation and The Howard Buffet Foundation), and Feed the Future (USAID).

The objectives of Grain Legumes are to improve the production, sales, and consumption of grain legumes. The research activities are focused on five strategic components: (1) Analyzing demand and setting research priorities, (2) Developing productive varieties and management practices, (3) Facilitating legume seed and technology delivery systems, (4) Enhancing postharvest processing and market opportunities, and (5) Fostering innovation and managing knowledge. The research activities support the development, delivery, performance, and impact of several product lines. The product lines advance research on high-priority challenges and new opportunities, and are built on past breeding successes, germplasm collections, and recent progress in science. IITA contributes primarily to three components focusing on the IITA mandate crops cowpea and soybean: (1) Drought and low-phosphorus tolerant common bean, cowpea, and soybean, (2) High nitrogen-fixing chickpea, common bean, faba bean, and soybean, and (3) Insect-smart chickpea, cowpea, and pigeonpea production systems.

Photo by IITA

**The Benefits of Legumes**

Cowpea is important to the livelihoods of millions of people in Nigeria. From its production, rural families derive food, animal feed, and cash income.

About 8 million ha of cowpea are grown in West and Central Africa, where the most important producers are Nigeria (4 million ha), and Niger (3 million ha). In Nigeria, cowpea area has increased by about 441% and yield by 410% from 1961 to 1995.

IITA has improved the productivity of cowpea, with about 17 varieties released with combined diverse plant types, different maturity periods, and resistance to several diseases, insect pests, and parasitic weeds (*Striga* and *Orobanche*), and possessing other good agronomic traits.

Dual purpose varieties had also been developed for farmers in Nigeria, providing grains for human consumption and fodder for animals. IITA promoted the double planting relay cropping system, whereby cowpea is relayed twice with maize to generate more grain and fodder for s sustainable crop-livestock interaction system.

IITA has also developed high-yielding, early maturing soybean varieties capable of nodulating in association with local rhizobia, and possessing other good agronomic traits. Improved soybean varieties released in Nigeria include TGx 849-313D, TGx 1019-2EN, TGx 1019-2EB, TGx 1448-2E, TGx 536-02D, TGx 306-036C, TGx 1485-1D, and TGx 1440-1E. More recently, IITA developed rust-resistant soybean to tackle the problem of rust in Nigeria.

In addition, IITA also worked on developing a variety of food products from soybean that can contribute to enhanced health and nutrition, especially among women and young children.

**Drought and low-phosphorus tolerant cowpea and soybean**

*Breeding and selection for drought tolerance and high yield in cowpea*

To develop cowpea lines with enhanced drought tolerance and high yield potential through marker-assisted recurrent selection (MARS), two populations were phenotyped. Following genotyping, 30 families were selected for further evaluation. The genotypic data from those families showed that 182 plants are fixed for favorable alleles affecting yield (2 markers) and 'stay green' (5 markers). Phenotypic selection will be conducted on these plants to develop advanced breeding lines. The plants that do not have all the favorable alleles will undergo a second recombination cycle.

*Early morning dew on soybean.* Photo by IITA

Through the Tropical Legumes 2 project, more than 2000 farmers participated actively in the selection of cowpea lines in Ethiopia, Kenya, Malawi, Mali, Mozambique, Niger, Nigeria, Tanzania, and Zimbabwe. In addition, more than 4000 kg of seeds of several selected varieties were produced for the establishment of demonstration plots to be conducted next cropping season, i.e., in 2013. For the 2012 cropping season, 845 demonstration plots were established and more than 1000 farmers visited these demonstrations plots for observation and selection. Farmer-selected lines that perform well in two-year multilocation trials have been proposed for release in participating countries. Those that do not have a good performance but are still preferred by the farmers will be integrated into the breeding program for improving their yield performance. Two of the lines, IT99K-7-21-2-2 and IT99K-573-1-1, were released officially in Tanzania during 2012.

*Drought tolerant soybean*

In soybean, characters such as rooting depth, water use efficiency, and nitrogen fixation help to select varieties that can withstand drought. Screening for genotypes that are drought tolerant and produce good yields when subjected to different drought treatments was initiated in the 2012 off-season in Malawi. The results showed that TGx 1988-22F, TGx 1989-60F, and TGx 1988-18F are good performing genotypes in terms of grain yield, fodder yield, and ability to self-nodulate under drought stress from flowering and pod filling, to physiological maturity. These genotypes have also been found to take fewer days to reach physiological maturity. This is a characteristic that sustains the genotypes under mid-season drought. The trials will be revised and repeated in 2013.

*Evaluation of soybean varieties in several agroecologies*

Soybean evaluation trials involving 30 promising soybean genotypes were conducted across five locations in Mozambique. The soybean genotypes were selected over several years for good agronomic performance including high and stable yields, drought tolerance,

disease tolerance, promiscuous nodulation, and adaptability across agroecologies. The varieties formed nodules adequately with existing indigenous rhizobium. Nodule dry weight of the top 10 yielding genotypes ranged from 135 to 313 mg/plant. Averaged across locations, the genotypes reached 50% flowering 42 to 52 days after emergence and physiological maturity from 99 to 109 days after emergence. Five soybean genotypes selected in previous seasons for rust tolerance—TGx 1835-10E, TGx 1987-20F, TGx 1987-38F, 1987-57F, and TGx 1987-62F—outperformed most of the other genotypes, producing between 1.9 and 3.9 t/ha in high potential soybean-growing areas.

*Effects of phosphorus and nitrogen on soybean growth and yield*

The genetic variation of early maturing soybean genotypes in phosphorus utilization efficiency was evaluated in low phosphorus soils of the Guinea savanna of Nigeria. The results revealed that variability in the utilization of phosphorus was significant. Three early maturing genotypes were identified as having high phosphorus utilization index and low phosphorus uptake efficiency, indicating that they could be a potential source for breeding for phosphorus use efficiency in early maturing soybean genotypes.

More information on studies on soil nutrient impact in various rotational cropping systems including soybean is presented under MAIZE and Water, Land and Ecosystems.

*Soybean rust disease*

Soybean rust disease (*Phakopsora pachyrhizi*) exhibits a rapid global spread and can cause yield losses of up to 90%. In response to this, IITA carried out surveys in Kenya, Uganda, and Tanzania that helped identify some of the tolerant varieties in the region bred by Seed Co, Zimbabwe. Disease severity was assessed to identify areas infected and the risk of spreading to new regions. This information will be used to advise growers on the use of tolerant varieties available to control the disease. A soybean rust disease fact sheet has also been developed to inform growers on the common symptoms and the control measures.

**Insect-smart cowpea production systems**

*Breeding for multiple virus resistance*

Breeding for developing multiple virus resistant cowpea varieties was initiated in 2008. Over 150 cowpea genotypes were phenotyped, and several lines with resistance to more than one virus were identified. The two best lines were used to determine the inheritance of multiple virus resistance. They were crossed with two highly susceptible lines and the F2 generation of these crosses are being advanced to establish recombinant inbred lines to develop DNA markers linked to multiple virus resistance.

*Biopesticides and biological control*

Following the successful control of the pod borer *Maruca vitrata* in cowpea fields by a combination of neem oil and the pod borer-specific virus *MaviMNPV*, more detailed laboratory studies have been carried out to investigate the effect of the compounds, alone or in combination, on aphids, *Aphis craccivora*, and thrips, *Megalurothrips sjostedti*—also key pests of cowpea. A combined treatment resulted in a significantly higher—and faster—larval mortality extended larval and pupal development, and reduced adult emergence than was obtained with either virus or botanical insecticide alone.

A new method for producing the virus was developed, using cowpea sprouts infested with eggs of *M. vitrata*. After 4 days, *M. vitrata* caterpillars were inoculated with the virus and after another 3-4 days the virus infested larvae were harvested. With this method, approximately 200 larvae can produce enough virus inoculum to treat 1000 $m^2$. Furthermore, a system was developed for laboratory mass production of the wasp *Trichogrammatoidae eldanae*, a major egg parasitoid of *M. vitrata* using eggs of an alternative host.

*Sprouting cowpea grains ready for infestation.* Photo by IITA

*Moribund* Maruca vitrata *larvae ready to be harvested.* Photo by IITA

**Gender, adoption, and value chain studies**

*Gender adoption of climate-smart cowpea innovations in Ghana and Bénin*

The objective of this study was to assess the gender-related adoption of climate-smart technologies for addressing the negative effects of climate change on cowpea productivity. A survey conducted in 120 households in Ghana and 150 households in Bénin showed that land degradation, low soil fertility, low rainfall level, and increased biotic pressure, in the field as well as in storage, were perceived as the main climate change-related challenges.

Cowpea producers, including women, cited eight improved technologies and four traditional technologies as strategies for climate change adaptation in Ghana and Bénin. Improved technologies cited include short and long cycle improved varieties, and improved varieties tolerant of drought and insects; traditional technologies mentioned include use of biological fertilizer, essential oils, and botanical extracts. The survey also revealed that women have limited access, compared with men, to agrometeorological information and training—both important for adaptation to climate change.

*Multistakeholders' platforms and agricultural inputs market access*

A survey was conducted with 200 cowpea farmers in Burkina Faso and Niger to assess multistakeholders' platforms (aiming at improving the effectiveness and efficiency of cowpea value chains by decreasing transaction costs) and access to agricultural inputs markets by stakeholders in cowpea value chains.

Results show that farmers' access to inputs is hampered by several factors including lack of contact with the extension service, distance from house to farm, surface under cultivation, income generated from the last campaign, and the total distance traveled by farmer to purchase inputs. In both countries, platform concepts remain confused and mixed up with cooperative notions or value chain segments. Despite the rapid backstopping undertaken with all value chain actors, they expressed the need for an in-depth capacity building on the innovation platforms concept in the value chain framework. Local cowpea seeds and organic fertilizers

were the most common inputs used by cowpea farmers in Burkina Faso and Niger. Heads of households from the two countries perceive climate change and pest pressure as the top two constraints to production.

*Socioeconomic characterization of cowpea and soybean producers in southern Africa*

Analysis of constraints to technology adoption showed that over 85% of the non-adopters of improved cowpea and soybean in Malawi, Mozambique, and Zambia indicated lack of improved seeds as the main reason for non-adoption. By contrast, lack of access to capital (i.e., cash, credit, etc.) was the main reason for non-adoption of improved varieties of maize. Soybean, for example, is a non-traditional crop and farmers have to rely on outside suppliers to acquire quality seeds of improved varieties. A number of constraints have led to the diminished interest of the existing seed systems in providing small-scale farmers with access to cowpea and soybean seeds. First, public-sector seed production has not been able to meet the demand for seeds of new varieties and for initial quantities of high-quality seeds because priority for foundation seed stocks is generally given to more commercial crops, such as hybrid maize. The private sector has also shown little interest in entering the legume seed industry due to low profitability (as farmers recycle varieties multiple times once they receive the initial germplasm). Furthermore, soybean's high protein and oil content means that the maintenance of seed viability over a long period of time is difficult. The seed-demand side also has a number of constraints. At the most fundamental level, many farmers simply do not know about new varieties (i.e., their potential advantages, where to access them, or how to manage them). Seed production often takes place in areas of higher potential, with seed stores being concentrated in zones of higher population density or those with better infrastructure. Furthermore, when the seeds of promising varieties are made available locally, they tend to be too expensive and/or sold in large packages suitable only for larger-scale farmers.

Community analysis of access to infrastructure and services showed very limited access to credit and input markets, especially improved seeds. Given increased trader penetration into the rural areas for product assembly, most farmers sell at the farm gate and thus farmers have better access to output markets than to input markets.

*Soybean value chain*

During 2012, the soybean value chain project that is being implemented in Malawi and Mozambique contributed to the enhancement of the soybean seed system in the two countries. In collaboration with our development partners, over 50 tonnes of seeds of the recently released TGx varieties were produced. The seeds have been distributed to both private and community based seed producers for further production of certified seeds during the 2012/2013 season. Together with partners, the project reached over 4000 households with training on the household utilization of soybean. The aim was mainly to enhance the protein and energy quality of commonly eaten foods. In addition, promotional events have been conducted to create awareness of the contribution of soybean utilization to the overall value chain of soybean.

*His Excellency, the President of Mozambique, appreciates soybean-based foods during a farmers' day in Nampula province, Mozambique.* Photo by IITA

Photo by IITA

**Making African Foods Safe**

Scientists at IITA, in collaboration with the United States Department of Agriculture – Agricultural Research Service (USDA-ARS) and the African Agriculture Technology Foundation (AATF), have developed a natural, safe, and cost-effective biocontrol product that drastically cuts aflatoxin contamination in African food crops.

The product—aflasafe™—uses native strains of *Aspergillus flavus* that do not produce aflatoxins (called atoxigenic strains) to 'push out' their toxic cousins so that crops become less contaminated with aflatoxins in a process called 'competitive exclusion'. When appropriately applied prior to plant flowering, these native atoxigenic strains completely exclude aflatoxin producers.

The success of the aflasafe™ project has led to expansion of biocontrol research in Burkina Faso, Ghana, Kenya, Mali, Mozambique, Senegal, Tanzania, and Zambia.

Scientists from IITA and the University of Ibadan, Nigeria, found that poultry fed with maize that had been treated with aflasafe™ experienced reduced mortality in addition to other benefits. Mortality rate was reduced by 43.9%, feed intake dropped by 10.4%, and there was an increase of 3.3% in feed conversion ratio. The impact of aflasafe™ on the poultry industry—one of the major consumers of maize—could result in economic gains that translates into an estimated increase in profitability of over $3200 for every 10,000 birds.

## Agriculture for Nutrition and Health (A4NH)

The CGIAR Research Program on Agriculture for Nutrition and Health, led by IFPRI, started in January 2012. The program pursues two overarching strategies, to proactively influence agricultural research to focus its contributions on improving health and nutrition outputs and outcomes and to enhance collaborative research among the agriculture, nutrition, and health research communities. A4NH is organized around five components: (1) Nutrition-sensitive value chain, (2) Biofortification, (3) Control of agriculture-associated diseases, (4) Integrated agriculture, health, and nutrition programs, and (5) Policy and decision-making across agriculture, health, and nutrition.

A4NH activities are implemented in Southeast Asia and sub-Saharan Africa. Selected highlights of the progress that has been made so far at IITA are presented below.

**Nutrition sensitive value chain**

One in four children under five in the developing world—approximately 148 million children—suffers from undernutrition. Still, limited information is available on the current nutrition status, type, and amounts of foods consumed, and nutrient intakes of children under five and women of childbearing age in countries of sub-Saharan Africa. Surveys were therefore conducted in Malawi, Mozambique, Zambia, Swaziland, and Sierra Leone on children under five and women of childbearing age (15-49 years). The information will allow for effective targeting, monitoring, and evaluation of interventions.

To standardize the conduct of the surveys and improve data quality, 25 interviewers/country were trained on the methodology for food consumption and nutrition surveys. Data on anthropometric indicators to provide outcome measures of nutritional status, foods consumed, socioeconomic and demographic characteristics were collected using a structured questionnaire. Stunting (height-for-age), underweight (weight-for-age), and wasting (weight-for-height) were determined using the software WHOAnthro. Severe stunting is a reflection of long-

standing deprivation of food. For women of childbearing age, Body Mass Index (BMI) was calculated. Presented here are the results on nutrition status for Sierra Leone and Zambia—the analysis for the other countries is in progress.

In Sierra Leone, the survey encompassed 1615 children and showed that 50% of children under five are stunted. Stunting is significantly higher in Northern province (59%) than in the Western area (29%). When the data were disaggregated by sex, there were significantly more stunted boys compared with girls.

Only 6% of the investigated women of childbearing age (N=1728) were undernourished, 20% were overweight, and 8% were obese. In general, the number of undernourished women was far lower compared with those that were overweight and obese combined.

A similar study was conducted in Chipata, Katete, and Lundazi districts in Eastern Zambia. Overall, 49% of the 759 children under five investigated in the survey were stunted. The prevalence of stunting was similar among the districts. Here stunting was also significantly higher in boys compared with girls.

For women of childbearing age, the patterns were also similar between Sierra Leone and Zambia. Of the 798 women included in the survey, 16% were overweight, 4% obese, and only 4% were undernourished. When the data were disaggregated by district, there were significantly more malnourished women in Chipata compared with Lundazi. Women residing in Chipata district were significantly more overweight and obese compared with those residing in Katete and Lundazi districts.

The pattern in both countries shows that the number of undernourished women is lower compared with the number of overweight and obese combined. This represents the double burden on malnutrition that may result in a higher incidence of non-communicable diseases, such as hypertension, stroke, and diabetes.

**20-40% Cassava Flour**

Photo by IITA

IITA researchers continue to look at incorporating 20-40% of cassava flour in bread. Government officials in Nigeria, including President Goodluck Jonathan, have set in place policies to encourage the production of cassava bread in the country and the use of cassava flour for manufacturing processes. Nigeria is the highest cassava producer in the world, producing 34 million tonnes of the produce annually, but accounting for zero percent in terms of added value. Under the agriculture transformation strategy, the Nigerian government will be working actively to create new markets for cassava-growing farmers.

*Biofortification*

The nutritional value of selected maize varieties will depend not only on the micronutrient levels in the kernels but to a great extent on the bioavailability of the micronutrients, e.g., iron and zinc, to humans after consumption. This study aimed to identify maize inbred lines that combine high pro-vitamin A with high sulfur-containing amino acids, namely methionine and cysteine, which are considered to be promoters of iron and zinc bioavailability in humans. Twenty-five inbred lines were analyzed in 2012. The best inbred lines with high methionine and cysteine content from this study will be reanalyzed in 2013. The most promising lines will then be used as parents of biparental crosses to develop new inbred lines with much higher levels of pro-vitamin A and the two amino acids with a potential to promote iron and zinc uptake in humans.

In a similar study, with the same objective, a total of 64 cassava genotypes have been analyzed for total nitrogen using standard laboratory methods. Among the investigated genotypes, TMS 08/8691 and TMS 08/8693 had the highest total nitrogen, 3.8% and 3.4%, respectively.

**Control of agriculture-associated diseases**

*Aflatoxin*

Aflatoxins are extremely toxic substances produced by highly prevalent and common *Aspergillus* fungi, particularly *A. flavus* and *A. parasiticus*. Aflatoxins lower food quality, are barriers to trade, pose serious risks to health, and have caused several deaths in Africa and Asia. Recurrence of drought, further induced by climate change, might accentuate the aflatoxin problem. Aflatoxin contamination is pervasive in the food production system in Africa, leading to unknown but significant social and economic costs with respect to impaired health and productivity of people, increased food spoilage, and inability to market agricultural products internationally. A4NH supports the management of aflatoxin through a combination of technical, policy, and institutional measures to significantly reduce the impact of aflatoxin and improve the health of populations and their income in sub-Saharan Africa.

Photo by IITA

**A Miracle in Southern Africa**

Farmer Blessing (middle, in green skirt), a victim of HIV/AIDS, from Zambia, is now back on her feet. She received seeds, training, knowledge, and skills, and above all the opportunity to start over after joining an IITA project called MIRACLE. MIRACLE is an agriculture-based initiative aimed at improving the livelihoods, food security, and nutrition of people living with HIV/AIDS in southern Africa. It is implemented by IITA and funded by the Swedish International Development Agency (Sida). A "miracle" is slowly but surely happening in the communities participating in the project.

Farmers were trained on management practices as well as sensitized on the dangers of aflatoxins, using presentations, printed training materials, and practical demonstrations. Training materials distributed to farmers included leaflets containing basic information on aflatoxins, instructions for aflasafe™ application in the field, and soil and grain sampling protocols to evaluate the efficacy of biocontrol. A total of 100 extension agents working in public and private agricultural establishments and 35,000 farmers in Nigeria were trained.

In addition, maize grains and groundnut kernels were collected from farmers' stores and analyzed for aflatoxin concentration. More than 67% of the groundnut and 98% of the maize samples had detectable levels of aflatoxin. Concentration ranged from 0 to 925 ng/g in groundnut and from 0 to 517 ng/g in maize, with a mean occurrence of 46 and 49 ng/g in groundnut and maize, respectively. The threshold value allowed by CODEX is 10 ppm.

More information on the use of atoxigenic *Aspergillus* strains for biocontrol as aflasafe™ is presented under MAIZE.

*Buruli ulcer*

Buruli ulcer (BU) is a neglected tropical disease exacerbated by poor agricultural practices for which the mode of transmission remains unknown. The disease is a regional priority, associated with wetland areas, in West and Central African countries. A workshop of experts on BU led to the establishment of the Agro-Eco-Health Platform, led by IITA for controlling Buruli ulcer in wet agroecosystems and identification of important research gaps on BU transmission. Another workshop focused on harmonization of protocols for research on BU transmission with emphasis on description of standard operational procedures for collecting soil, water, and other environmental samples for isolating the causative agent of BU, *Mycobacterium ulcerans*. A total of 25 participants from Benin Republic, Ghana, Cameroon, Côte d'Ivoire, and Nigeria attended the workshop.

## Water, Land and Ecosystems (WLE)

The CGIAR Research Program for Water, Land and Ecosystems (WLE) is managed by the International Water Management Institute and has five research portfolios: Irrigated Systems, Rainfed Systems, Resource Recovery and Reuse, River Basins, and Information Systems.

IITA contributes to the rainfed systems portfolio that targets 80% of the world's farmland that is largely rainfed. The program seeks to better understand the risks that households face in rainfed settings. It also seeks to explore the reasons why many methods for enhancing soil and water management are not adopted, while learning more about livestock production in water-scarce environments. The rainfed system focuses on five problem sets. In 2012, IITA contributed largely to two of those: Recapitalizing African soils and reducing land degradation and Revitalizing productivity on responsive soils.

Several experiments were focused on the response of different crops to different rates of nutrient addition and soil amendments, either in the form of inoculants, chemical fertilizers, or other types of fertilizers and substrates.

Field trials were established in the Democratic Republic of Congo to assess the impact of rhizobium and fertilizer on the growth and performance of seven soybean varieties intercropped with maize or cassava in comparison with the traditional monocropping systems. The average soybean yield increased by about 300 kg/ha for rhizobium-inoculated soils as compared with non-inoculated soils, with a similar increase for soils amended with manure and microdoses of chemical fertilizers. This yield increase is estimated to account for about US$900/ha/year. In Nigeria, several commercial rhizobium inoculants were screened under field conditions for effectiveness in promoting growth in soybean and maize. The rhizobium inoculums strain RACA 6 and the formulation Legumefix produced higher nodulation, growth, and grain yield in soybean than the other strains. The application of Agroleaf high-nitrogen, Agroleaf high-phosphorus, and Agroleaf general significantly increased the shoot dry weight, and phosphorus and nitrogen uptake at 8 weeks after planting compared with the other products. In addition,

*Pastoralists in Tanzania digging deep into the earth to get water for their livestock.* Photo by IITA

Turbotop and Vitazyme significantly increased shoot dry weight, and phosphorus and nitrogen uptake of maize.

A series of inoculation trials were conducted in Mozambique. In the first one, two promiscuous soybean genotypes (TGx 1740-2F and TGx 1904-6F) and two non-promiscuous (Storm and Serenade) soybean varieties were tested with three peat-based inoculants. The inoculants were applied to the seeds prior to planting. Inoculation improved nodulation in all four varieties across the sites but there were interactions between varieties and inoculant strains. The non-promiscuous varieties produced more nodules than the promiscuous varieties when inoculated. Although there were clear trends in yield enhancement due to inoculation, the increases were not significant. Nevertheless, applying inoculants when available is recommended, since the cost of the inoculants is low compared with the gain generated by the increase in yield and in total biomass. An additional advantage is that well-inoculated plants are likely to fix more nitrogen into the soil. Furthermore, the relatively high nitrogen content in the residues adds to the soil nitrogen reserves.

*Left: Soybean Storm, Chimoio, Mozambique. Right: TGx soybean material.*
Photos by IITA

The soybean varieties Storm and TGx 1904-6F were also used in a study comparing 0 and 40 kg phosphorus/ha as the two main treatments/plots. Within these plots, 40 kg nitrogen/ha, a peat-based inoculant applied at planting, and a combination of 40 kg nitrogen/ha and inoculants, were added to individual subplots. Significant interaction occurred between phosphorus and inoculants indicating that the application of phosphorus enhanced nodulation in relatively low phosphorus soils. Interactions also occurred between variety and phosphorus, suggesting that the application of phosphorus improved nodulation of the non-promiscuous variety Storm more than that of the promiscuous variety. Inoculation alone improved nodulation at all sites compared with all the other treatments. It was also clear that the addition of nitrogen inhibited nodulation, evidenced in both nitrogen treatment alone and the combination of nitrogen and inoculation treatment.

Finally, in a broad screening of different nutrient sources, including biochar, a trial was set up at IITA-Ibadan with a local yam cultivar to test yield responses to biochar, chicken manure, and wood chip applications, compared with different ratios of fertilizer (N, P, K, S, Mg, Zn, and B). The number of marketable tubers and the tuber yield were unaffected by the treatments, and it appears that combinations of biochar with other inputs may be required to increase yields to profitable levels.

## Climate Change, Agriculture and Food Security (CCAFS)

CCAFS was officially approved in January 2011 but has been active since mid-2009. CIAT is leading this global, joint collaborative effort among all 15 CGIAR centers. IITA is involved in activities in Africa and the main collaborators there are NARS partners in the West and East African humid zones, as well as the CGIAR partners CIAT and ILRI. CCAFS' vision is to reduce poverty and hunger, improve human health and nutrition, and enhance ecosystem resilience through high-quality international agricultural research, partnership, and leadership. The program is organized into four closely interlinked themes: (1) Adaptation to Progressive Climate Change, (2) Adaptation through Managing Climate Risk, (3) Pro-poor Climate Change Mitigation, and (4) Integration for Decision-Making.

IITA is concentrating its efforts on themes 1 (adaptation) and 3 (mitigation) with some smaller contributions to theme 4 (integration for decision-making).

**Adaptation**

IITA has uploaded over 150 cassava trials into Agtrials and has set up a cassava catalog (in partnership with other research bodies - see Cassavabase.org). The aim is to provide cassava end-users with an overview of cassava germplasm traits in terms of yields, pest and disease resistance, and adaptation potential to cope with environmental stresses (e.g., drought). Furthermore, it aims to provide insight into the eco-physiological diversity of cassava germplasm for national (breeding) cassava programs, and to function as a parameter basis for cassava suitability modeling/mapping for current and future climates. In addition to this work, IITA has initiated research to explore the impact of climate parameters (and variability) on the bitterness (and cyanide content) of cassava varieties. This also includes an analysis of farmers' perceptions.

Photos by IITA

**Growing Coffee-Banana Together Results in More Gains**

Growing coffee and banana together not only generates more income for smallholder farmers, compared to growing either crop alone, but it can also help coffee production to better cope with the effects of climate change, an IITA study has shown.

The study, which sought to understand the potential impact of climate change on coffee-based livelihoods in the East African highlands, found that the areas suitable for growing Arabica coffee will drastically decrease in the future leading to losses in the region that may exceed US$100 million annually.

Researchers from IITA and the Colombian-based International Center for Tropical Agriculture (CIAT) used climate models and climate analogues to predict the impact of climate change on coffee production.

Shade provided by shade trees or banana can help coffee to cope with the warmer climate and with drought shocks. Research has shown that shade can reduce the temperature in the understorey plants by up to 2° C or more. Past research by IITA also showed that growing coffee and banana together increased the farmers' income—the coffee yield remained the same despite creating room for the banana and the farmer gained additional income from selling the banana. This study strengthens the case for growing coffee and banana together as it provides both short- and long-term benefits to farmers.

Besides the work on cassava, IITA has initiated work on yam, another IITA mandate crop. A catalog was started and parameters have been captured in trials to develop and calibrate a yam model to be built into ECOCROP (http://ecocrop.fao.org) and DSSAT (www.dssat.net). On the issue of plant health and climate change, IITA has engaged with CIP and partners in developing models that can be adapted and calibrated for various pests/vectors. Using field survey data and controlled lab experiments, risk assessment and strategy development have been done for adaptation to significant crop biotic threats due to climate change. Excellent insights have thus been gained concerning some major pests in Africa (nematodes, whitefly, coffee pests/diseases, banana weevil) and some of this work is about to be published.

*Banana and coffee intercropping is one climate-smart system that contributes to adaptation and mitigation of climate change.* Photo by IITA

**Mitigation**

This activity aims to generate knowledge that people in the private and public sector can use to understand the carbon footprint of various technology/management options. This objective is to help set up an incentive structure that may encourage behavior that reduces the carbon footprint—the work starts with coffee and cocoa. Cocoa and coffee are the primary sources of income of millions of African smallholder farmers and are key foreign revenue generators. Coffee and cocoa are highly sensitive to progressive climate change.

During 2012, IITA initiated a large number of new activities on mitigation-adaptation synergies and trade-offs in these systems, often in collaboration with CIAT. The most significant project developed was the BMZ-funded project on Trade-offs and synergies for climate change adaptation/mitigation in coffee/cocoa systems. The work on climate-smart perennial systems (i.e., particularly coffee-banana intercropping) got very high media exposure, particularly on coffee in East Africa. Due to this exposure, IITA has been requested by the coffee industry (united in the Sustainable Agricultural Initiative - SAI) to help develop a Product Category Rule (PCR) for carbon foot-printing of coffee. The suitability change maps, developed by CIAT and IITA, for coffee and climate change, have alerted the private sector and coffee authorities that climate change is a very serious problem and that smart shade systems are needed to adapt it and mitigate it. Time series analysis revealed that increments in temperature and rainfall during the dry season have a strong negative impact on coffee yields. An analysis of the institutional organization of the coffee sector in Uganda (and the region) revealed that climate-smart shade systems have not received sufficient attention in the past, due to the recommendation from the respective public authorities to promote coffee monocropping. However, due to the research initiated by CCAFS, the demand for climate-smart shade

systems that contribute to adaptation and mitigation is on the agenda. IITA has been invited by the coffee authorities and the private sector to assist in the quest for improved coffee shade systems. In the Reducing Emissions from All Land Uses (REALU project in Cameroon, IITA has been collaborating with ICRAF to explore high-carbon land uses and understand the drivers of deforestation, including exploring benefit sharing and linkages to REDD+ (Reducing Emissions from Deforestation and Forest Degradation).

**Integration for decision-making**

Rakai in Uganda is representative of the perennial-based farming systems dominant in South Uganda, East DR Congo, Rwanda, Burundi, NW Tanzania, and in the humid high-altitude areas of Kenya and Tanzania. A case study in Rakai in October 2012 was started to understand adaptation-mitigation options by combining quantitative data with a participatory analysis of constraints, risks, and opportunities to deal with climate change. Twenty focus group discussions were organized with women and men separately. Some 60 farms were fully mapped and characterized in terms of their production system and production constraints (including soil analysis). These farmers were individually interviewed to capture past experiences and knowledge on the impact of climate shocks on crop production and livelihood vulnerability. Landscape maps were developed using aerial photographs. Together with ILRI, a protocol was developed to quantify greenhouse gas costs of various land uses and land use changes.

Individual interviews and focus group discussions revealed that changes in land use (i.e., drainage and tree planting in wetland) and land ownership (i.e., fencing off of wetlands and grazing lands that were previously 'communal' land) have greatly exposed farmers to climate variability. Focus groups revealed that policy constraints, particularly at the local level, exacerbated farmers' vulnerability. In the past, farmers had access to communal grazing lands and wetlands, which were used during periods of fodder scarcity and crop production failures. Recently, communal grazing lands and wetlands were leased out to a few well-off farmers, who fenced them off to keep poor villagers out. Commercial eucalyptus woodlots in the wetlands have lowered the water table and dried up wells, requiring women and children to walk up to 4 km to fetch water during the dry season. The most vulnerable farmers have cut down their trees to sell the wood/charcoal, exposing them even further to climatic variability. Hence, the most vulnerable group now seems to be least capable of adopting climate-smart practices. Laws in place are not properly defined and enforced to constrain degradation and the 'grabbing' of communal resources. There is need to engage policy and decision-makers to address issues of natural resource access and sustainable management. Technical efforts will become more profitable if there is political will to jointly address constraints, particularly to support equitable access to natural resources.


*IITA Agricultural Economist Jim Gockowsi (second from left) sat as a panel member of the UN's Climate Change Conference in Poznan, Poland.*

*Capturing phenotypic data in the Musa field.* Photo by IITA

**Genebank to the Rescue!**

Areas hit by widespread floods in the Bayelsa region of Nigeria are benefiting from seeds conserved in IITA's genebank, as the Institute assists farmers to rebuild their livelihoods with new improved varieties. The floods, the worst ever in recent times according to residents, affected the homes and crops of thousands of farmers, threatening food security in the nation.

"Our farmers lost almost everything and we need help," says Dr Rodger Obubo, a top official with the Bayelsa State government who first contacted IITA for help.

"The 2012 floods were extraordinary and caused a lot of devastation of farmlands and human habitation. Our people became refugees in their own land," Obubo added.

Crops worst hit by the flood included cassava, plantain, yam, maize, and pawpaw which are major staples in the region.

The IITA genebank holds the largest collection of cowpea varieties, and is also a major bank to Africa's major crops: cassava, yam, soybean, maize, banana, and plantain. In the recent past, the genebank has played a critical role in reestablishing farms in regions that have been hit by disasters such as civil wars and fire outbreaks.

IITA had sent improved cassava cuttings, plantain, and maize to the state. These crops are part of the food basket of the state. More importantly, the maize varieties to be deployed are early maturing and will help farmers to recover and adjust quickly.

## Genebanks

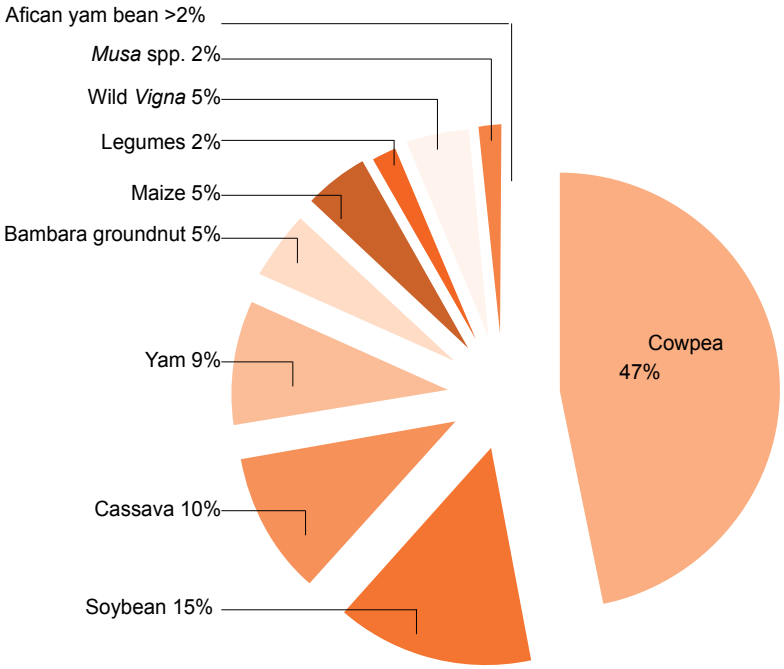
The conservation of plant genetic resources is a critical underpinning of crop improvement now and into the future. The Genetic Resources Center (GRC) at IITA represents a key CGIAR collection with a focus on major staple crops of sub-Saharan Africa, namely cassava, cowpea, yam, soybean, banana and plantain, maize, and other important but more minor crops, particularly legumes.

The CGIAR Research Program for Managing and Sustaining Crop Collections (Genebanks) has been developed by the Global Crop Diversity Trust (GCDT) and is currently managed by a committee of the GCDT with input from the CGIAR Consortium Office. It encompasses all the genebanks of the CGIAR system and has the following overarching objective:

"To conserve the diversity of plant genetic resources held in CGIAR collections and make this diversity available to breeders and researchers in a manner that meets high international scientific standards, is cost efficient, is secure, reliable and sustainable over the long term, and is supportive of and consistent with the International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA)."

**IITA GRC crop collection.**

| Crop | Number of accessions |
|---|---|
| Cowpea | 15,379 |
| Soybean | 4,841 |
| Cassava | 3,499 |
| Yam | 3,156 |
| Bambara groundnut | 1,752 |
| Maize | 1,565 |
| Miscellaneous legumes | 558 |
| Wild *Vigna* | 1,543 |
| Banana/plantain | 546 |
| African yam bean | 456 |




IITA Genebank Collection

Within this, there are four major objectives:

1. Crop diversity in International Collections under Article 15 (ITPGRFA) is secured in perpetuity.

The collection at IITA includes the major clonal crops, such as cassava, yam, and banana/plantain, which are maintained through a fieldbank and in an in vitro genebank. Accessions of these collections are also held (safety duplication) at the Africa Rice Centre in Cotonou, Republic of Benin (see box). The seed-propagated crops are held in both medium-term storage (MTS) at 5 C and long-term storage at -20 C. The

**Safety Duplication**

It is critically important to duplicate our collections elsewhere to ensure their safety in case of any natural or man-made threats to the genebank at Ibadan.

Yam and cassava in the Genetic Resources Center's in-trust collection are duplicated for safety at the Africa Rice Center facility in Cotonou, Republic of Benin. The total accessions of these two crops at IITA are 4413 out of which 3643 accessions have been duplicated since 2004.

Safe duplicates of seeds from IITA's seedbank collections are stored at the Svalbard Global Seed Vault (established in the permafrost in the mountains of Svalbard and designed to store duplicates of seeds from seed collections around the globe) as well as in the Saskatoon genebank in Canada and also at CIMMYT. In the last four years we have duplicated a total of 16,472 (65%) accessions of our collections.

The table below summarizes the safety duplication so far. The aim is to duplicate the entire collection by 2016.

| Crop | Total accessions in collection | Accessions safely duplicated | |
|---|---|---|---|
| | no. | no. | % |
| Cowpea | 15,379 | 11,761 | 76% |
| Soybean | 4,841 | 1,522 | 31% |
| Bambara groundnut | 1,752 | 932 | 53% |
| Maize | 1,565 | 713 | 46% |
| Wild *Vigna* spp. | 1,543 | 1,517 | 98% |
| African yam bean | 456 | 27 | 6% |
| Yam | 1,619 | 1,386 | 86% |
| Cassava | 2,794 | 2,257 | 81% |
| **Grand total** | **29,949** | **20,115** | **67%** |

collections of yam and cowpea (and related *Vigna* species) are probably the most important in the world; that for cassava is a key asset for crop improvement for sub-Saharan Africa as it includes African diversity and is complementary to the collection at CIAT. Safety duplication of the IITA seed collection is ongoing at the Svalbard Global Seed Vault (see box). The collections are kept by IITA's GRC following international standards for plant genetic resources (PGR) conservation.

2. Conserved crop germplasm is clean, available, and disseminated

Phytosanitary considerations are major constraints to germplasm movement in many crops and lack of clean (i.e., disease-free) planting material is an important reason for poor yields. This is particularly true of the clonal crops yam and cassava. The GRC, together with the Germplasm Health Unit (GHU) at IITA, invests considerable effort in developing new ways to obtain clean planting material and to improve germplasm sanitation processes.

*Hand pollination for wild Vigna regeneration.* Photo by IITA

Almost the entire collections conserved at IITA's GRC is in trust, available, and ready to be distributed to the national and international community for research to ensure food security. This is carried out in line with the ITPGRFA recommendations in a multilateral system.

3. Use of conserved crop diversity is informed and facilitated

The IITA 'in trust' collection is available to researchers, breeders, and other users around the world under the terms of a Standard Material Transfer Agreement, developed under the ITPGRFA and provided that import/export conditions can be met. Accessions are characterized in the field using standard agromorphological descriptors and, increasingly, molecular markers. The accessions with passport data and information on their characterization are available online (http://www.iita.org/genetic-resources-center). We are increasingly concerned with tracking the utilization of germplasm derived from GRC and ascertaining the impact of this germplasm, through breeding programs, on food security and livelihoods.

The accessibility of IITA's germplasm, together with that from other CGIAR centers and beyond, will be enhanced during the course of implementation of the CGIAR Research Program by the development of GENESYS, a portal for the management of information currently held by databases within individual centers.

4. Crop diversity is conserved within a rationalized, cost-effective, and globalized system

This objective is in line with the first as conservation in perpetuity of PGRFA requires sustainable germplasm management. Hence, IITA's GRC is working continuously and in different means to optimize and rationalize the conservation systems used to maintain the collections. Emphasis is put on the development of new or updated processes which make conservation more efficient, e.g., the maintenance only of unique accessions by identification of duplicates though molecular techniques. Clonal crop long-term storage has been developed for cassava (ongoing for yam) using cryogenic techniques. There is also a constant collaboration within CGIAR centers and partners for expertise sharing, e.g., the CIAT

cassava in vitro medium-term conservation is about to be adopted at IITA GRC.

In addition to these core areas, other funding will be targeted at new collections. We have identified genetic gaps in our collections and developed plans for new collecting missions. In 2013/2014 this will involve landraces and wild relatives of yam in Nigeria and Bénin. Other diversity captures are also planned for the enrichment of important crop collections such as cowpea and cassava, as well as new crops, particularly cocoa and cocoyam.

*Growth stages of yam in vitro plantlets.* Photo by IITA

Another key component is cryobanking. Cryopreservation (storage in liquid nitrogen) of clonal crops is an important endeavor for many genebanks in the world as it brings considerable cost savings and efficiency gains. At IITA we have developed a technique for cryopreservation which is working effectively in cassava and will be extended to yam and possibly also to other crops.

*Cassava cryopreservation experiment: sample cooling in liquid nitrogen.* Photo by IITA

**Partnerships**

Partnership is fundamental to this program as the objectives cut across centers and crops. However, collaboration involves not just CGIAR centers but also NARS and the private sector. Such linkages help build expertise and enhance procedures and crop exchanges between partners. In IITA's GRC, past collaborations are reinforced and new ones are built in many domains and crops, especially with national genebanks as well as international research institutes.

**Capacity building**

Capacity building is an important part of the mission of GRC. We are extensively involved in the training of scientists from national programs (e.g., in tissue culture techniques) and in giving technical advice to laboratories around the world (e.g., in the establishment of a tissue culture laboratory in Vietnam, or techniques of maize pollination in the Republic of Guinea).

Photo by IITA

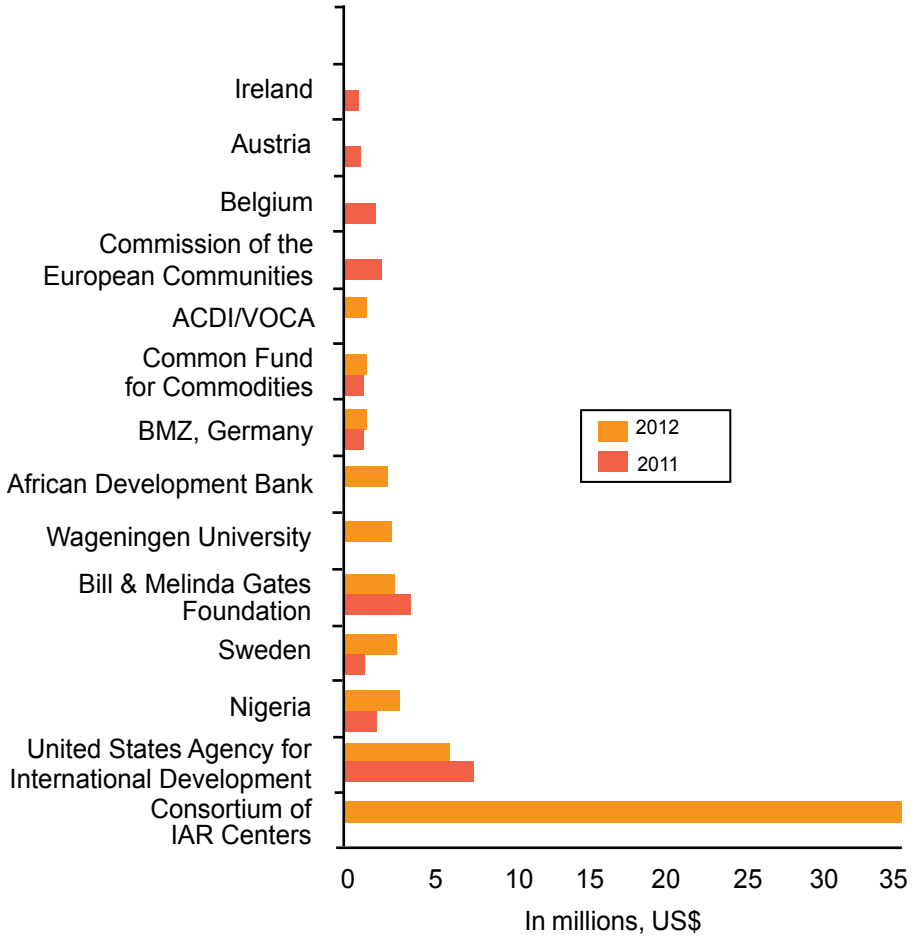
# **Financial** Information

Funding for 2012 was US$71.629 million, of which 98.6% came from CGIAR investors and 1.5% from other sources. Expenditure was US$69.097 million (net of indirect cost recovery of US$8.028 million), of which 91.4% was used for program expenses and 8.6% for management and general expenses.

The governments and agencies that provided the largest share of our funding in 2011 and 2012 are shown in Figure 1 (top 10 donors) while IITA`s 2012 investment, by CGIAR Research Program, is reflected in Figure 2.

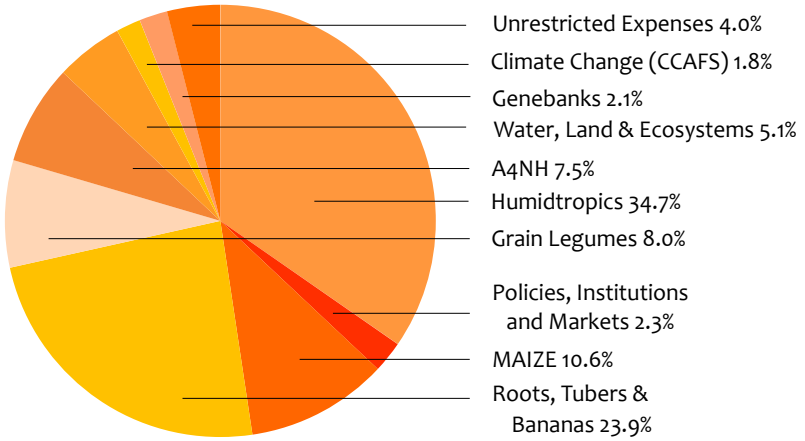
Table 1 shows IITA`s 2012 Investment by CGIAR Research Program, Table 2 shows the financial indicators, whereas Table 3 lists the 2011 and 2012 IITA investors.

Figure 1. Funding: Top 10 donors, 2011-2012




*Truckload of agricultural produce for the market.* Photo by IITA

Figure 2.
2012 Investment by CGIAR Research Program Budget




Investment by CGIAR Research Program Expenditure

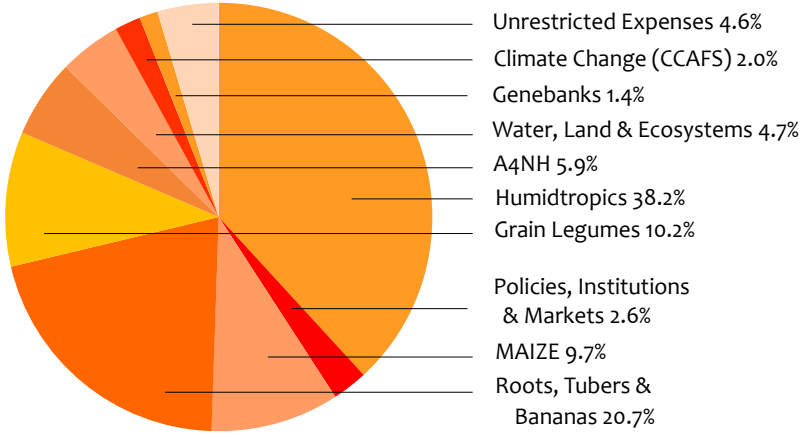


**Table 1. 2012 Investment by CGIAR Research Program.**

| | Budget ($`000) | | | Actual Expenses ($`000) | | |
|---|---|---|---|---|---|---|
| CGIAR Research Program | Unrestricted/ Windows 1&2 | Window 3/ Bilateral Project | Total | Unrestricted / Windows 1&2 | Window 3 / Bilateral Project | Total |
| Humidtropics 1 | 6,163 | 20,808 | 26,971 | 7,170 | 19,219 | 26,389 |
| Policies, Institutions and Markets | 627 | 1,194 | 1,821 | 527 | 1,301 | 1,828 |
| MAIZE | 1,696 | 6,573 | 8,269 | 1,697 | 5,013 | 6,710 |
| Roots, Tubers and Bananas | 5,170 | 13,412 | 18,582 | 4,480 | 9,841 | 14,321 |
| Grain Legumes | 2,283 | 3,965 | 6,248 | 1,823 | 5,211 | 7,034 |
| Agriculture for Nutrition and Health | 1,460 | 4,368 | 5,828 | 990 | 3,088 | 4,078 |
| Water, Land and Ecosystems | 230 | 3,706 | 3,936 | 230 | 3,004 | 3,234 |
| CCAFS | 955 | 462 | 1,417 | 966 | 383 | 1,349 |
| Genebanks | 966 | 683 | 1,649 | 775 | 189 | 964 |
| W1&2 and Restricted - CGIAR Research Programs | 19,550 | 55,171 | 74,721 | 18,658 | 47,249 | 65,907 |
| Unrestricted | 3,086 | - | 3,086 | 3,190 | - | 3,190 |
| | **22,636** | **55,171** | **77,807** | **21,848** | **47,249** | **69,097** |

1 Includes Humidtropics Windows 1&2 Partners' costs per CGIAR Advisory Note.

**Table 2. Performance indicators: financial health.**

| | 2011 | 2012 |
|---|---|---|
| Short-term Solvency (or Liquidity) | 159 days | 31 days |
| Long-term Financial Stability (Adequacy of Reserves) | 159 days | 31 days |
| Indirect Cost Rates | 17.52% | 14.84% |
| Cash Management on Restricted Operations | 0.09 | 0.11 |
| Audit Opinion | Unqualified / Clean Bill of Financial Health | |

**Table 3. List of IITA investors.**

| IITA investors | 2011 | 2012 |
|---|---|---|
| | (expressed in US$ thousands) | |
| Agricultural Cooperative Development International/ Volunteers in Overseas Cooperative Assistance (ACDI/VOCA) | - | 1,055 |
| African Agricultural Technology Foundation (AATF) | 513 | 142 |
| African Development Bank (AfDB) | 358 | 2,573 |
| Alliance for a Green Revolution in Africa (AGRA) | - | 173 |
| Austria | 773 | 50 |
| Belgium | 1,732 | 385 |
| Bill & Melinda Gates Foundation | 3,961 | 3,050 |
| BMZ, Germany | 1,110 | 1,210 |
| Canada | 73 | 68 |
| Catholic Relief Services (CRS) | 386 | 30 |
| Chemonics International | 8 | - |
| *Centro Internacional de Agricultura Tropical* (CIMMYT) | 2,031 | 168 |
| Commission of the European Communities | 1,959 | 141 |
| Common Fund for Commodities (CFC) | 1,011 | 1,196 |
| Consortium of IAR Centers | 11,271 | 35,493 |
| Denmark | - | 62 |
| Donald Danforth Plant Science Center (DDPSC) | - | 100 |
| Food and Agriculture Organization (FAO) | 239 | 227 |
| France | 330 | 330 |
| Global Crop Diversity Trust (GCDT) | 314 | 189 |
| International Centre of Insect Physiology and Ecology *(icipe)* | 246 | - |
| International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) | 1,613 | 27 |
| International Fund for Agricultural Development (IFAD) | 132 | - |
| International Food Policy Research Institute (IFPRI) | 402 | 427 |
| Ireland | 724 | 166 |
| Japan | 410 | 796 |
| L`Union Economique et Monetaire Ouest Africaine | - | 520 |
| Meridian Institute | - | 743 |
| Nestlé | - | 268 |
| Netherlands | 495 | 448 |
| Nigeria | 1,890 | 3,453 |
| Norway | 78 | - |
| Purdue University | - | 497 |
| Sweden | 1,018 | 3,108 |
| Switzerland | 173 | - |
| United States Agency for International Development (USAID) | 7,929 | 6,478 |
| Wageningen University | - | 2,910 |
| WASCO | - | 437 |
| World Bank | 55 | 62 |
| Miscellaneous Projects | 3,750 | 2,278 |
| Challenge Programs | 1,872 | 1,385 |
| **Grand total** | **46,856** | **70,645** |

*Sacks of grain in the cowpea market.* Photo by IITA

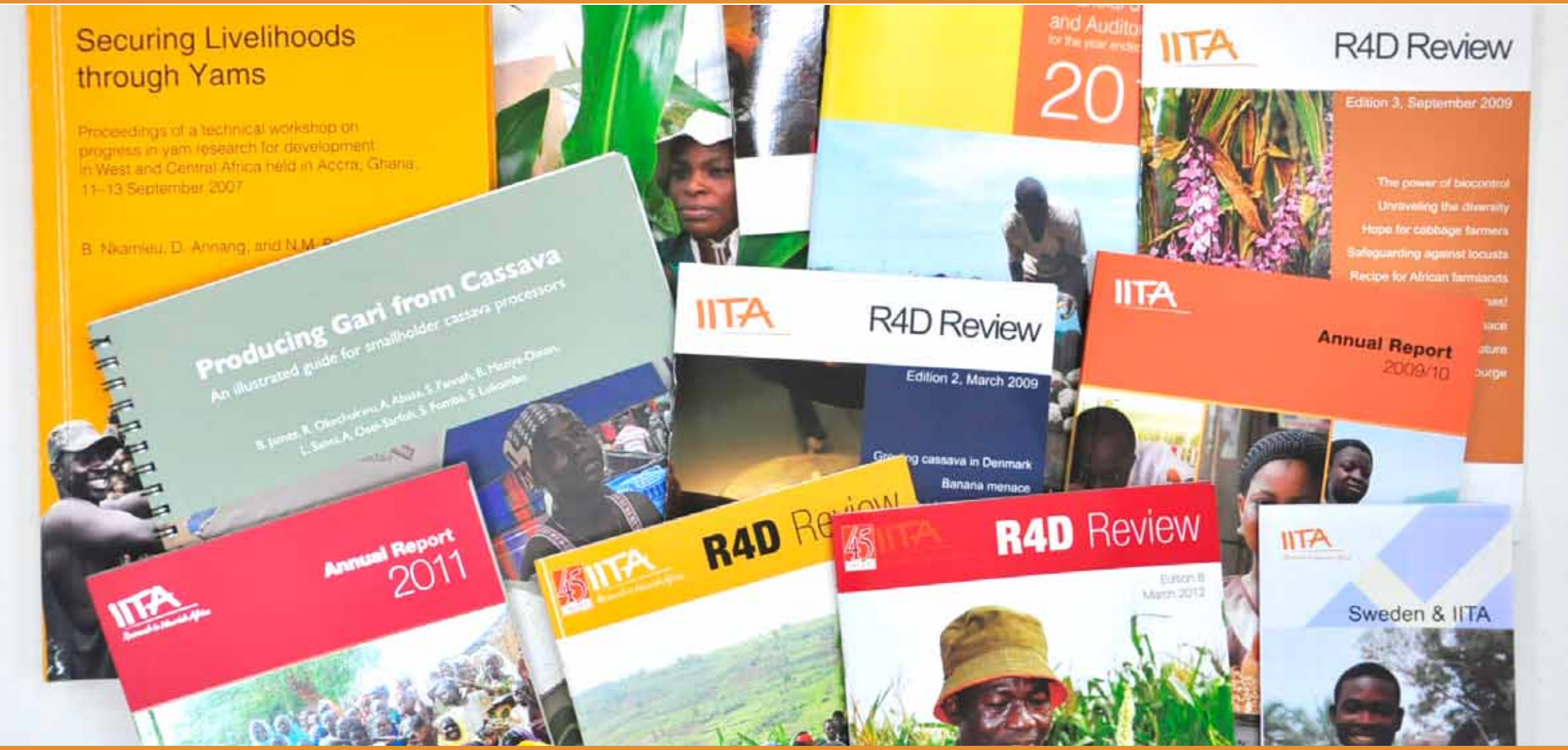



Photo by IITA

# Publications

IITA scientists and partners published journal articles, book chapters, review articles, and chapters in conference proceedings and numerous publications. See list below for top articles from the hubs categorized by research theme or core/ competency.

**Natural resource management**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Paul BK, Vanlauwe B, Ayuke F, Gassner A, Hoogmoed M, Hurisso TT, Koala S, Lelei D, Ndabamenye T, Six J, and Pulleman MM. 2013. Reduced tillage (12 cropping seasons) improves soil aggregate stability, but depresses soybean yields when crop residues are removed. Agriculture, Ecosystems, and Environment. In Press. http://biblio.iita. org/index.php?page=publication&kind=single&ID=8281.

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Pypers P, Ndayisaba C, Gahigi A, and Vanlauwe B. 2012. Principles of Integrated Soil Fertility Management confirmed for the Eastern Province of Rwanda. Field Crops Research. In Press.

Valbuena D, Erenstein O, Homann-Kee Tui S, Abdoulaye T, Claessens L, Duncan A, Gerard B, Rufino M, Teufel N, van Rooyen A, and van Wijk MT. 2012. Conservation Agriculture in mixed crop-livestock systems: scoping crop residue trade-offs in sub-Saharan Africa and South Asia. Field Crops Research 132, 175-184. http://biblio.iita.org/ index.php?page=publication&kind=single &ID=7758.

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Photo by IITA

# **Capacity** Building

In line with IITA's strategic objectives, capacity building activities continue to expand through increased partnership activities with regional economic commissions, the private sector, NARS, advanced research institutes, government ministries, and universities. IITA will continue to develop the best production practices which optimize the use of natural and other resources and contribute to the sustainability of these resources for future generations. Several individual and group training activities to strengthen and improve farmers' agricultural practices were undertaken, with training of trainers (ToT) activities organized in different countries across East and Central Africa.

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### Individual training activities

During the year, 99 graduate students were admitted, while 88 continuing students were supported in various disciplines within various research programs. Fifty-one RTAs/Interns from the NARS were trained in Breeding, Soil Science, and Genebank activities; 163 trainees finished their research work with IITA. Two hundred and fifty-one National Youth Corpers and Student Industrial Work-Experience participants were also trained.

### Group training activities

One hundred and sixty-one Group Training Courses, including ToTs, were conducted at 131 locations (see table) on agricultural enabling environments, productivity, food security, technology transfer, and best management practices in which 2731 females and 7380 males participated.

### Staff development activities

In recognition of the increased need to enhance staff competencies and capacities for better performance, seven staff development training activities were organized during 2012 involving 180 staff members in the areas of management in the work environment, supervisory skills, communication in the workplace, on-the-job capacity building for better performance, and specialized training to address specific needs.

In the near future, overall competencies of staff will be enhanced to deliver effective and efficient services to our partners and stakeholders and also to support future challenges.

**Graduate training undertaken in 2012.**

| | Graduate students recruited in 2012 | | | Graduate students carried over from 2011 | | |
|---|---|---|---|---|---|---|
| | M | F | Total | M | F | Total |
| PhD | 17 | 8 | 25 | 36 | 10 | 46 |
| MSc | 28 | 18 | 46 | 29 | 11 | 40 |
| BSc | 19 | 9 | 28 | 2 | 0 | 2 |
| Total | | | 99 | | | 88 |

**Collaborating countries in 2012 (including non-degree training).**

| Countries | Trainees (no.) | Countries | Trainees (no.) |
|---|---|---|---|
| Uganda | 9 | Zambia | 5 |
| Ethiopia | 2 | Togo | 1 |
| Sierra Leone | 28 | Mali | 1 |
| Cameroon | 3 | Mozambique | 27 |
| Kenya | 10 | Malawi | 4 |
| Nigeria | 39 | Belgium | 1 |
| Burkina Faso | 1 | Namibia | 1 |
| Ghana | 4 | South Sudan | 1 |
| Tanzania | 5 | DRC | 4 |
| USA | 2 | South Africa | 1 |
| UK | 1 | **Total** | **150** |

Photo by IITA

# Staff

IITA's dynamic and professional team of nationally and internationally recruited staff total about 945, spread in 15 locations in sub-Saharan Africa. Of this total, 739 (78%) are male and 206 (21.8%) are female employees, with 603 or 63.8% based at headquarters in Ibadan, Nigeria.

**Breakdown of staff by location, 2012.**

| | Internationally recruited | | | Nationally recruited | | |
|---|---|---|---|---|---|---|
| Station | Male | Female | Total | Male | Female | Total |
| Bénin | 6 | 0 | 6 | 0 | 0 | 0 |
| Burundi | 1 | 0 | 1 | 0 | 0 | 0 |
| Cameroon | 4 | 0 | 4 | 17 | 7 | 24 |
| DR Congo | 3 | 0 | 3 | 30 | 8 | 38 |
| Ghana | 4 | 0 | 4 | 9 | 2 | 11 |
| Ibadan, Nigeria | 44 | 19 | 63 | 431 | 109 | 540 |
| Kano, Nigeria | 4 | 0 | 4 | 36 | 4 | 40 |
| Kenya | 3 | 4 | 7 | 3 | 2 | 5 |
| Liberia | 1 | 0 | 1 | 17 | 3 | 20 |
| Malawi | 4 | 1 | 5 | 20 | 3 | 23 |
| Mozambique | 1 | 1 | 2 | 22 | 9 | 31 |
| Sierra Leone | 1 | 0 | 1 | 8 | 1 | 9 |
| Tanzania | 11 | 2 | 13 | 20 | 12 | 32 |
| Uganda | 1 | 1 | 2 | 18 | 7 | 25 |
| USA | 2 | 1 | 3 | 0 | 0 | 0 |
| Zambia | 3 | 5 | 8 | 15 | 5 | 20 |
| **Total** | **93** | **34** | **127** | **646** | **172** | **818** |

*Training of trainers on plantain macropropagation.* Photo by IITA

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*Until July 2012

**Joined November 2012

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*State-of-the-art Science Building, IITA, Dar es Salaam, Tanzania, April 2013.* Photo by IITA

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# annual report 2012

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**With support from:** Olusegun Adebayo, Ezekiel Bolarinwa, Adejare Adetunji, Christopher Adeyemi, Mike Oke

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