IITA

Research to Nourish Africa

2012

regional highlights

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Cover photo: A farmer beneficiary of the MIRACLE Project in Malawi with her bumper harvest of improved soybean, the seeds of which were provided to her by the project. Photo by Jeffrey T Oliver, IITA.

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From the DDG-R4D

Dr. Ylva Hillbur
Deputy Director General
Research for Development

It is with great pleasure that I present to you IITA's 2012 Regional Highlights. This report, which complements the institute's corporate annual report, showcases research-for-development activities in each of the institute's four regional hubs: Central Africa, Eastern Africa, Southern Africa, and Western Africa.

We work in countries that represent all the agroecological zones across sub-Saharan Africa (Figure 1). As stated in the IITA Refreshed strategy 2012-2020, our research agenda will be implemented within four impact zones, representing major agroecological zones and farming systems. These impact zones are based on: (i) the large population depending on these systems for food and nutritional security and income, (ii) an understanding of farm baseline conditions and opportunities based on past research, (iii) the need for intensification due to high population pressure on land, (iv) the proximity to large local and regional markets and processing centers, and (v) the presence of ongoing complementary projects dealing with specific aspects of this strategy.

Already in 2000 we envisioned a decentralized IITA that would be able to better and more efficiently to do research in the countries that we work in. The Western Africa Hub was the

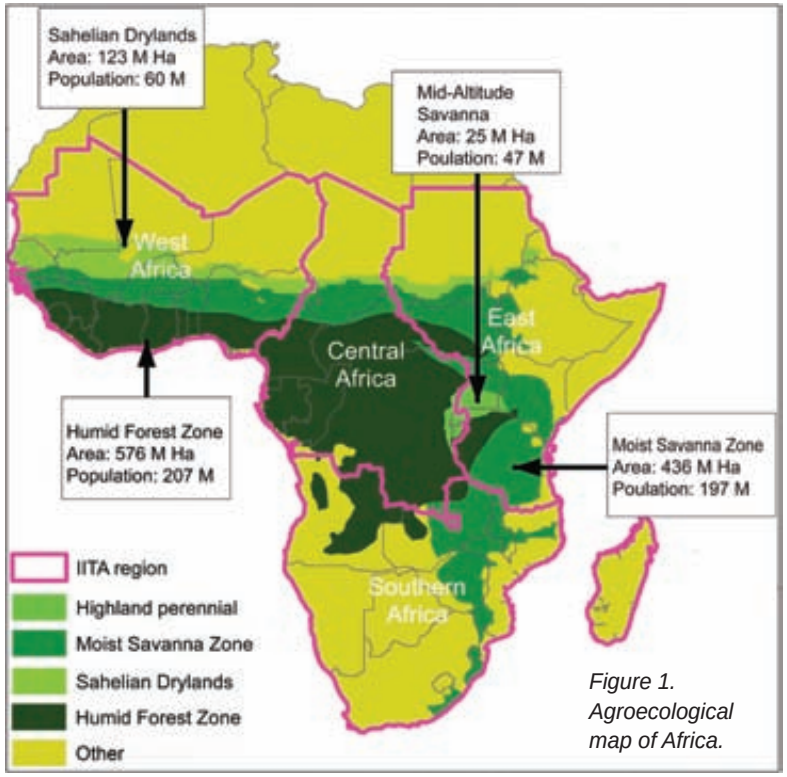

Figure 1. Agroecological map of Africa.

first hub established as it is also housed in Ibadan, Nigeria, where the institute's Headquarters are located. In 2008, the Eastern Africa Hub was set up in Dar es Salaam, Tanzania, followed by the Southern Africa Hub in Lusaka, Zambia in 2010. The Central Africa Hub, established in 2012, is currently administered out of Nairobi, Kenya but will eventually transfer to its permanent location in Kinshasa, DR Congo.

Each Hub is administered by a regional director: Dr Bernard Vanlauwe for Central Africa, Dr Victor Manyong for Eastern Africa, Dr David Chikoye for Southern Africa, and Dr Robert Asiedu for Western Africa. The Hubs oversee the operations of our research work and projects in their respective regions (Figure 2).

The Regional Hubs represent important strategic assets to remain engaged in local and regional contexts, establishing partnerships and mobilizing resources, implementing research programs, and managing risks – in short, they define IITA as an institution.

I would like to invite you – partners, investors, and stakeholders – to read this regional highlights report, as well as the accompanying corporate annual report, to see the breadth and depth of our research for development work and impact in the past year. These reports are also in testament to your continued support of our mission and vision of a hunger- and poverty-free Africa.

Figure 2. Our operational map indicating hub locations, regional coverage, and project countries.

central
africa

From the Regional Director

Dr. Bernard Vanlauwe
Director
Central Africa Hub

Through a realignment of the IITA strategy, the Central Africa hub of IITA was formally established in 2012 and provides the opportunity to advance the earlier good work in the Central African region to new heights, in terms of both science and impact. Rural households in Central Africa are facing major challenges while the region is under-resourced in terms of research for development capacity and presence of the international scientific research community. Notwithstanding, substantial progress is reported for the various research areas of IITA.

Seven improved cassava varieties were released this year, five in Cameroon and two in DR Congo. In Burundi, substantial progress is reported with advancing access to healthy banana planting material through macro-propagation. In Cameroon, the first experimental evidence was gathered of the susceptibility to Banana Bunchy Top Disease (BBTD) and aphids among local and hybrid plantain and cooking banana used in West and Central Africa. This will form a basis for selecting *Musa* genotypes in which BBTD disease develops most slowly. In East DR Congo, the large potential to increase productivity in cassava–legume systems through the application of Integrated Soil Fertility Management (ISFM) practices was demonstrated. In West DR Congo, the production of micro-chips for transformation into high quality cassava flour is an excellent example of how innovative approaches can be used to add value to farmer's produce. Central Africa also has some of the last remaining primary forests in the world, often resulting in conflicting interests between the needs of primary households and the interests of the global community. The activities in Cameroon of Reduced Emission from all Land Uses (REALU) have shown that perennial systems exist that provide agricultural outputs while retaining carbon stocks.

Many of above results were obtained through effective partnerships with various stakeholder groups, as illustrated with examples from Burundi, DR Congo, and Cameroon. A total of 17 PhD and 13 MSc students were engaged in scientific programs in 2012 and 36 scientific papers were produced.

In short, the current report reflects the excellent science with impact that is already going on in Central Africa and provides the necessary confidence that science and impact delivery will grow in the coming years.

I would also like to take this opportunity to acknowledge the scientists and students that have invested their time and expertise in the Central African hub, the many partners that have cooperated with IITA to deliver products to the end-users, the farmers' organizations that have continuously provided a reality check on those products, the national support staff that have provided a conducive environment for science to flourish, and last-but-not-least, the donor community that has retained interest in investing in Central Africa.

Banana systems in Rwanda.
Photo by Piet van Asten, IITA.

The Central Africa Hub
at a glance

Central Africa: potentials and challenges

Agro-ecologically, Central Africa contains important rainfall gradients with maxima in the Congo basin moving towards semi-arid areas north and south although most of the region has lengths of growing period of more than 210 days. As a result, the most prominent farming systems are forest-based, root crop systems, cereal-root crop systems, and tree crop systems with many people living within highland perennial systems.

Mixed systems are less present although ruminant densities are relatively high in northern Cameroon, southern Chad, southern Angola, and the eastern Highlands. Due to the high rainfall, most soils in Central Africa are old and weathered and have lost a lot of their inherent nutrient stocks and fertility. The Central Africa region is also home to some of the last remaining primary forests in Africa.

Notwithstanding the relatively high agricultural potential of the region, poverty is widespread with over 75% of the population living below 2 US dollars per day. Several challenges to intensify agriculture are apparent: (i) over half of the territory of Central Africa has poor market access, (ii) the current use of agricultural inputs is basically nil, resulting in very low crop productivity, and (iii) national investment in agricultural development are still low though some recent signals show important improvements.

While most of our current R4D activities are implemented in DR Congo, Cameroon, Burundi, and Rwanda, initiatives are taken to get engaged in the Republic of Congo, the Central African Republic, and Gabon.

Our vision of success

In line with the overall vision of IITA, our vision for the Central Africa region is 'Be the leading research partner in finding solutions to hunger, poverty, and environmental degradation in Central Africa'. Our mission is 'Increase productivity, income, and health of smallholder farmers through sustainable intensification of important farming systems and creation of an enabling environment for such intensification'.

Implementing our mission happens through the CGIAR Research Programs (CRPs) which are multi-institutional programs tackling important global agricultural development issues. Besides the Humidtropics, other important CRPS have a major role to plan in Central Africa, and especially (i) Roots, Tubers, and Bananas, (ii) Water, Land, and Ecosystems, Climate Change and Food Security, Policies and Markets, Agriculture for Nutrition and Health, Maize, and Grain Legumes.

Our human assets

The key disciplinary groupings of the 12 scientists working for IITA in Central Africa are Biotechnology and Crop Improvement (1), Social Science and Agribusiness (3), Natural Resource Management (6), and Plant Production & Health (2). The distribution of scientist time over the new CGIAR Research Programs (CRPs) are as follows: Humidtropics (10); Policies, Institutions and Markets (2): Roots, Tubers, & Bananas (4); Agriculture for Nutrition & Health (1); Water, Land, Ecosystems (4); and Climate Change (4). Most of the scientists contribute their disciplinary expertise and experience to two or three CRPs. This multiple membership enhances broader understanding of the CRPs as well as the sharing or transfer of results from one CRP to other ones where they are needed.

The hub also has 36 national support staff in Kinshasa (DR Congo), 7 in Bukavu (DR Congo), 26 in Yaoundé (Cameroon), and 3 in Bujumbura (Burundi).

Our partners

In Burundi, in the framework of the Consortium for Improving Agriculture-based Livelihoods in Central Africa (CIALCA), IITA works with researchers, development partners, farmers' associations, policymakers and the private sector. As a result of the research and development outcomes of CIALCA, partnerships were established related to macro-propagation, improved crop management practices, and Integrated Pest Management (IPM) for banana-based systems. Factsheets, newsletters, videos, and radio programs are used as communication tools. A series of training videos for farmers have been broadcast on national television and radio stations. The videos, produced in English French, Kiswahili, Kinyarwanda, and Kirundi, cover topics on banana seed multiplication, integrated pest and disease management, and novel soil and crop management systems. The video on Banana *Xanthomonas* Wilt (BXW) is also used by the Food and Agriculture Organization (FAO) to train trainers, which are helping to fight the disease that is rapidly spreading in Burundi.

Dr Peter Holmgren (left), Director General of the Center for International Forestry Research (CIFOR), during a visit to IITA-Cameroon. Photo by IITA.

In Cameroon a partnership with the Ministry of Agriculture and Rural Development focused on the production of disease-free local and improved plantain varieties for the establishment of community-based multiplication fields. 'Multipliers' were trained on the establishment and management of multiplication fields and six technical notes were produced that accompanied the training sessions. To date, we have produced 12,600 tissue culture plants of 8 varieties that have been used by both the government and private sector in establishing multiplication fields.

Other partnerships with the *Centre Africain de Recherche sur Bananiers et Plantains* (CARBAP) and the *Institut de Recherche Agricole pour le Développement* (IRAD) on integrated plantain management cover aspects such as the characterization of production systems, evaluation of hybrids and soil fertility amendments to determine their effects on productivity, major pests and diseases, training of trainers on sanitary propagation techniques, production of training materials, and establishment of innovation platforms for the enhancement of plantain productivity and profitability.

IITA, ICRAF, CIRAD, local universities and Cameroon government ministries cooperate in the context of the REALU project which has the principal objective of developing effective landscape-based strategies. REALU aims at identifying options for climate change mitigation and benefits for local people in the South Region of Cameroon in the context of the Reducing Emissions through Reduced Deforestation and Forest Degradation (REDD+) initiative. Attention is focused on the interactions between forest carbon stocks, other carbon stocks affected by land use, the major drivers of land use and forest change, and the livelihoods of

the hundreds of millions of people in the forest margins in the humid tropics.

In DR Congo, the private sector collaborates with IITA in the fabrication and development of equipment for improving the quality of processed cassava products, focusing on solving constraints to root drying and peeling. Benifood has fabricated a full set of machines for starch extraction. Acommer is contributing in the development of a cassava starch flash dryer. The Association of Cassava Producers and Processors are key actors in the promotion of fermented cassava flour and fermented cassava chips of superior quality. The *Institut National des Etudes et des Recherches Agricoles* (INERA) is the principal partner in the development of technologies and training of beneficiaries. The University of Kinshasa (UNIKIN) collaborates with IITA in the development of a solar dryer which is now tested on-farm. Both UNIKIN and the University of Kisangani (UNIKIS) collaborate with IITA in the training and co-supervision of students. The *Service National des Semences* (SENASEM) ensures seed certification, and the promotion of healthy planting material multiplication. Several NGOs collaborate in multi-locational trials, participatory variety selection (PVS), and the promotion and dissemination of technologies. IITA ensures the training-of-trainers of NGOs.

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Researchers conducting molecular diagnostics of BBTV in plantains and banana aphid. Photo by IITA.

Research Highlights

Enhancing the availability of healthy planting materials of improved banana varieties in Burundi

Emmanuel Njukwe, Piet van Asten, and Perez Muchunguzi

In Burundi, FHIA-17 is appreciated for its short stature, sweet flavor and large finger size and is gradually replacing the most common dessert bananas 'Kamaramasenge' and 'Gros Michel', widely cultivated in the rural areas now increasingly affected by *Xanthomonas* wilt. FHIA-17 is sold as a dessert banana in the Bujumbura markets where a bunch is sold for around 10,000 Burundian Francs (about US$6.38) but its expansion is constrained by lack of planting material. The situation is further aggravated by the lack of formal systems for producing and distributing quality planting material, thereby forcing farmers to depend on the natural regeneration of plants for their supply. For easier access for farmers and to ensure a regular source of healthy suckers, NGOs in Burundi are adopting the concept of tissue culture mother gardens for subsequent macro-propagation and false decapitation. Such gardens are managed by NGOs and agricultural extension agents to bridge the gap between the farmers and the private suppliers of tissue culture plantlets by disseminating healthy banana planting material from properly managed plots and thereby preventing the spread of pests and diseases. This model increased the demand for tissue culture plantlets.

In 2012, IITA organized training-of-trainer (TOT) workshops to promote the concept of tissue culture mother gardens, macro-propagation technology, and field management practices with support from partner NGOs, FAO, Belgium Technical Cooperation, and the government of Burundi through DPAEs. This led to the establishment of over 60 tissue culture mother gardens and the installation of macro-propagation units in major banana producing provinces, Cibitoke, Muyinga, Kirundo, Makamba, Kayanza, and Gozi by farmers and NGOs. It also stimulated high demand for tissue culture planting material with a significant increase of about 60% from 2011. Phytolabu's tissue culture lab then received material support from the government of Belgium to expand and produce more tissue culture banana planting material as starting stocks to establish new fields free from *Xanthomonas* wilt (BXW). FAO also revised its banana seed system strategy from the direct distribution of tissue culture plantlets to farmers to the establishment of tissue culture mother gardens for subsequent macro-propagation because tissue culture planting materials are costly and cannot withstand dry weather conditions if established towards the end of the rainy season and they require extra care and management for successful field establishment.

Macro-propagated banana plants at Muyinga ready for field planting. Photo by IITA.

More than 60 members of the Garukirigitoke Farmers' Association in Muyinga province, eastern Burundi, were also trained on tissue culture mother garden and macro-propagation technology and they installed four macro-propagation units and now have over 8 hectares of FHIA-17 and FHIA-25 varieties established. They sell FHIA bunches to factories in Tanzania where they are processed into banana juice and banana chips.

They recently started selling plantlets of FHIA varieties to farmers in neighboring provinces and are involved in farmers' organized training on macro-propagation and field management practices led by NGOs and MINAGRIE/DPAE. Due to the high agronomic performance of improved hybrids, the government of Burundi ordered over 1,200,000 FHIA plantlets for distribution. Donors also became interested in fast-tracking the distribution of healthy FHIA plantlets as an effort to overcome food insecurity. With technical support from IITA, the NGO Floresta received financial support from the government of Belgium, the Netherlands, and USA. The NGO CADEK received financial support from the government of Italy to expand macro-propagation activities. Concern Worldwide, another NGO in Kirundo, and Caritas International Belgique in Mwakiro and Muyinga are also promoting good management practices for healthy FHIA planting material with the support of the Belgium government.

A Muyinga farmer inspecting macropropagated banana plants at the macropropagation unit. Photo by IITA.

As the demand for improved varieties is steadily increasing, plantlets are currently also multiplied via macro-propagation around Bujumbura town by the NGO Floresta as an income generating activity. Wide-scale cultivation of improved banana varieties in Burundi may contribute to sustainable production for food and income security for the population.

REALU: effective landscape-based strategies for REDD+ within the Efoulan Council

Martin Yemefack, Anne Magne, Natalie Ewane, and Valentina Robiglio

Reducing Emission from Deforestation and Forest Degradation (REDD+) with conservation and sustainable management of forest to enhance carbon stocks is one of the mitigation strategies for climate change. REDD+ can be a valid and viable mechanism, but it will be much more effective if it addresses all land use in developing countries. The broad-based approach of the Reducing Emissions from All Land Uses (REALU) project can lead to greater reductions of emissions and larger benefits for local people. REALU aims to greatly increase the effectiveness of the REDD+ mechanism by developing methods and tools that include all transitions in land cover affecting carbon storage. More attention is focused on the interactions between forest carbon stocks, other carbon stocks affected by land use, the major drivers of land use and forest change, and the livelihoods of the hundreds of millions of people in the forest margins in the humid tropic. REALU's activities in Efoulan area were thus based on the need to account for all sources of emissions to fulfill the targets for mitigation and emission reduction.

Efoulan is one of the poorest municipalities of southern Cameroon. This ecologically and economically valuable forest region is under serious threat of deforestation and forest degradation from the actions of local people through the establishment of food and cash crops (cocoa and oil palm) plantations and from logging. Aboveground vegetation biomass in this system is very dynamic and the carbon stock varies from 25 t C/ha in cropland to 185 t C/ha in old fallow plots as compared with the primary forest with 305 t C/ha. The perennial plantations of cocoa and oil palm

are less dynamic and the carbon stock of the vegetation biomass varies from 50 to 115 t C/ha depending on the age of the plantation. These land use practices in the Efoulan municipality have been taken into account to evaluate the feasibility of emission reduction or avoidance in the coming years.

In the cocoa farming systems, the carbon stock largely depends on the farm management model. Timber trees play the most important role in carbon stocking, with about 70% of the total system carbon. A REDD+ strategy including tradeoff analyses and the orientation of interventions towards conservation/enrichment of the system using appropriate timber species in a suitable density would be a promising alternative to increase the farmer's revenues and livelihoods while providing more environmental services. The following specific actions should therefore have a significant impact in the cocoa farming in the area: (i) regulate tree density (thinning and distance control) in the existing cocoa farms considering the main role of big timber trees species in carbon pools; (ii) enrich young cocoa farms with timber species with good potential of carbon stock; (iii) proceed with a selective introduction of associated species with a preference for species of timber and fruit tree and other non-timber forest products in the new cocoa farms; (iv) promote the intensification of cocoa farms through high quality seeds and the application of modern techniques (treatment with pesticides and fertilizers, mechanization, and regular weeding).

Aboveground carbon stock in cocoa agro-forests in association with fruits and timber trees is as much as the carbon stock in secondary forests (around 140 t C/ha) and the farm income can be increased by 2 to 3 times. Within the current context of government policy on agricultural intensification, REALU studies show that an intensified mature cocoa plantation without additional trees can stock only about 90 t C/ha.

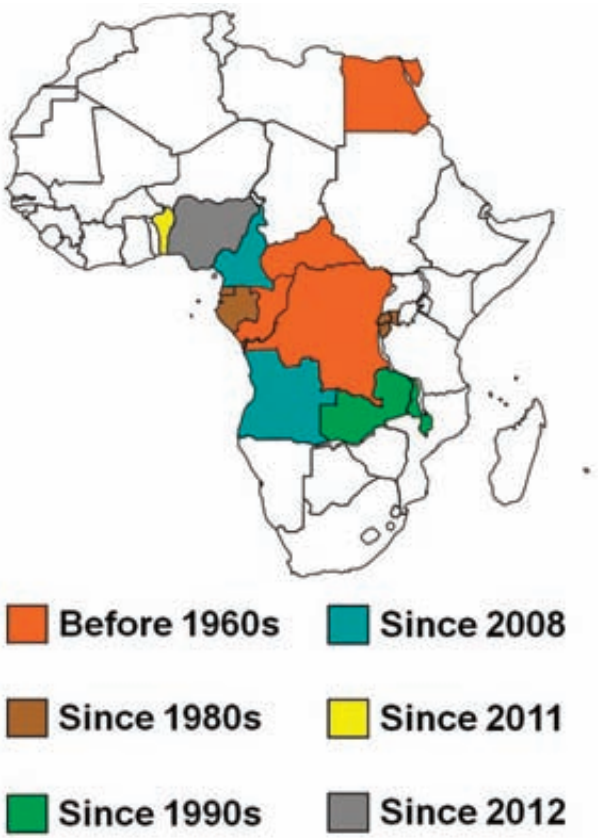
Controlling banana bunchy top in Cameroon

Rachid Hanna, Sergine Ngatat, and Lava Kumar

Plantain and banana (*Musa* spp.) are major staple and income-generating food crops in Africa that are largely produced on smallholder farms with yields remaining far below the potential, largely due to persistently high pest and disease pressures and declining soil fertility.

Banana bunchy top disease (BBTD) is one of the most serious threats to plantain and banana production. The global disease is caused by banana bunchy top virus (BBTV genus Babuvirus, family *Nanoviridae*) and has been reported in 14 African countries. The disease is spreading rapidly as it has invaded two countries in West Africa: Bénin and Nigeria, in the last three years. The disease is of serious economic concern as plants infected early in their growth do not produce fruit, resulting in total yield loss. Plants infected at later stages may produce normal or deformed fruits but the ratoon crop (the second bunch after the bunch produced by the mother plant) will bear fruit. IITA in collaboration with national and international partners has been conducting research – largely in West and Central Africa where nearly 90% of the world's plantain are produced – with

BBTD-infected banana plants (Abang Minko) in Cameroon. Photo by IITA.



Banana bunchy top disease distribution in Africa. Illustration by IITA.

emphasis on understanding the virus and vector diversity, disease epidemiology, plant-virus-vector interactions, and factors affecting vector abundance for the purpose of developing economically and ecologically-based options for the sustainable management of BBTD.

In an on-going experiment in an infected area in southern Cameroon, we have so far followed the development of the disease and the population of the aphid vector of the causal agent for more than two years using 16 *Musa* genotypes. Symptom expression of BBTD varies widely among the genotypes without any specific patterns related to their genomic composition. The dessert banana Williams and the hybrid plantain PITA 23 were the most susceptible (at nearly 95% infection). A larger group including local plantain landraces, several hybrid plantains, the cooking banana FHIA 25 and the dessert banana Grande Nain were moderately susceptible. The least susceptible group contained only two genotypes, the dessert banana Gros Michel and the cooking banana Fougamou or *Pisang Awak* that had less than 10% infection after 27 months. In contrast, aphid vector populations followed a predictable pattern of increasing abundance with the presence of the B genome. These findings represent the first experimental evidence of the susceptibility to BBTD and aphids in local and hybrid plantain and cooking banana used in West and Central Africa and provide a basis for the selection of *Musa* genotypes in which BBTD disease develops slowly.

These genotypes can be combined with other management measures, such as the use of disease-free planting material as well as vector control for sustainable BBTD management in sub-Saharan Africa. IITA and Bioversity International, in collaboration with local and international partners, will convene a scientific meeting in Arusha, Tanzania, in February 2013 to build a collaborative, public-private R4D alliance to address BBTV in sub-Saharan Africa.

(Top) An IITA-Cameroon staff interviewing plantain farmers during the BBTD diagnostic survey of the Center Regions of Cameroon. (Bottom) A banana aphid colony. Photos by IITA.

Cassava micro-chips: synonym for high quality fermented cassava flour in DR Congo

Nzola Meso Mahungu, Singi Simon Lukombo, and Solomon Jean Marie Nluta

Cassava is the most important food crop in the Democratic Republic of Congo (DRC). Its roots and processed products constitute the most important source of energy for almost 70% of the population. Cassava is cultivated across the country and occupies half of the area under food crops. Within two days after harvest, the perishable cassava tubers are traditionally processed to more storable products, particularly chips, fermented paste, and chikwangue.

Generally, cassava tubers are manually processed. However, most of the marketed chips in DRC are of low quality due to poor drying conditions leading to fungal colonization. The chips are almost exclusively sold in local and rural markets as the low quality prevents supermarkets from stocking the products.

Through an IITA-led project on *Cassava Rehabilitation in Response to the Outbreak of Cassava Mosaic Disease in the DR Congo*, high yielding and disease resistant varieties which increased yield were introduced and disseminated in targeted areas. In its second phase, the project initiated the diversification of cassava uses, introduced improved cassava processing technologies, mainly chippers, graters, presses, and concrete fermentation tanks.

With the introduction of cassava chippers for micro-chip production, both rural processors and small entrepreneurs became interested in the product. The micro-chips, being small sizes, are dry after a maximum of 16 hours in the sun. The shortening of drying time, from 5 to 7 days for macro-chips to 16 hours for micro- chips, resulted in the production of snow white micro-chips that can then be milled into fermented flour of superior quality. Consumers in Kinshasa give a premium price for white cassava flour compared with darker locally available flour. When Dr Manoka, the owner of MATCHEM, saw the micro-chips, she said: "This is the quality I have been looking for!"

The improvement of the quality of cassava chips and flour and the possibility of processing a large quantity of roots s by using machines pushed entrepreneurs to the cassava processing business. Several cassava processing enterprises were established. IITA through USAID funding provided technical and financial support to the emerging small and medium enterprises (SMEs). IITA organized a study tour for the cassava entrepreneurs in Thailand, increased their capacities by training producers, processors, and equipment fabricators. The quality of the products from these enterprises stimulated others to adopt and to produce fermented micro-chips and flour of superior quality.

Today, Matchem, QualAgric, IBI FARM, LAYUKA, GROUPEDI, MIDEKI, and other processors each regularly process between 2.5 and 10 t of cassava roots into high-quality fermented chips and flour, respectively,

(Top) Cassava micro-chips fermentation tank. (Bottom) Bags of superior-quality cassava flour in a store in Kinsasha. Photo by IITA. Photos by IITA.

every month. Processors regularly require large quantities of fresh cassava roots from producers. Thus, large-scale cassava farms have become common in Kinshasa and Bas-Congo province. Micro-chips of superior quality are sold in local markets and supermarkets located in Kinshasa now regularly sell cassava flour of superior quality supplied by cassava processing SMEs.

Micro-chips are very popular and are considered to be the way to better quality fermented cassava flour. The increasing involvement of small and medium-scale processors of flour from micro-chips will surely act as a market pull for small-scale farmers to sell their cassava roots and/or chips to processors/millers. This future outlook is further supported by the recently held agricultural fair in Kinshasa, organized from 20 December 2012 to 5 January 2013 which had a full dedicated wing with only micro-chip stands co-sponsored by an USAID project Food Production, Processing and Marketing with the theme "Micro-chips for Better Quality Cassava Flour". *(With additional contributions from Paul Ilona, HarvestPlus; Mpansu Sylvain Bidiaka, CIAT-DR Congo; and Ki-Munseki Albert Lema, University of Kinsasha, DR Congo)*

Boosting the productivity of cassava-based systems in the DR Congo through Integrated Soil Fertility Management

Bernard Vanlauwe

In the highlands of Sud-Kivu province, cassava and common beans are among the main food crops, traditionally cultivated in mixed cropping systems. Cassava mono-cropping is done only in marginal fields, where other crops fail to yield. Farmers generally allocate about 0.2–0.3 ha (30–45% of their farm area) to cassava–legume intercropping, and obtain average yields of 400–800 kg ha–1 of legume grains and 10–15 t ha–1 of fresh cassava storage roots. Pressure on land is very high due to high population densities and justifies agricultural intensification and investment in soil productivity. In Bas-Congo Province, on the other hand, farmers practice slash-and-burn agriculture and grow cassava for one or two years, followed by fallow periods of two to four years. In the past two decennia, population has grown by more than 50%, leading to more demand for food, especially from nearby Kinshasa. Improved and sustainable, fire-free production systems are urgently needed. In DR Congo, most farmers have no access to improved varieties, and are very limited in their possibilities to improve soil fertility.

First, the utilization of improved varieties resistant to pests and diseases in combination with appropriate rates of NPK fertilizer was observed to result in a 30-160% increase in cassava root yields in East DR Congo and a visible increase in stem yields, important for planting material production (Fig. 1). In West DR Congo, cassava yields doubled from 12 to 25 t ha-1 with moderate rates of NPK fertilizer, and reached over 40 t ha-1 with higher rates of fertilizer application. Several initiatives are taking place to ensure that these resistant varieties are reaching smallholder farmers at scale with specific attention given to planting material resistant to CMD and CBSD.

Fertilizer response and the effect of combining inorganic and organic nutrient resources were also evaluated in cassava systems. The most common fertilizer, NPK 17:17:17, was applied in West DR Congo with or without green manure made from *Tithonia* sp. or *Chromolaena* sp., and the effects on storage root yield were evaluated in two locations with differing soil fertility status. Both plants are commonly found in fallow vegetation in West DR Congo. Control yields were similar at the two

Figure 1. *(Left) Control - no inputs; (Right) NPK applied at 2 bags per hectare. In the DR Congo, application of 2 bags of NPK fertilizer per hectare resulted in root yield increases of 30 to 160%.*

sites (12 t ha-1), but response to fertilizer differed between the sites: storage root yields reached 40 t/ha at Kiduma but only 20 t/ha at Mbuela with the addition of 200 kg K ha-1. A much larger response to *Tithonia* sp. green manure was also observed at Kiduma, which was likely to have been related to the better quality and higher nutrient contents of the green manure grown at that site. Combining organic and inorganic nutrient resources did not result in positive interactions. No significant differences in yield were observed from comparing the sole application of fertilizer or green manure added to the control, relative to the yields obtained with the combined application of both nutrient sources. In maize-based systems, positive interactions between organic and inorganic fertilizers often arise from better synchrony in N release and N uptake by the crop. In cassava systems, where K is more often the most limiting nutrient, such a mechanism is likely to be less relevant.

In East DR Congo, the use of improved germplasm did not result in yield increases without the simultaneous implementation of other ISFM components. Modifying crop arrangement by planting cassava at 2 m between rows and 0.5 m within the row, intercropped with four legume lines, increased bean yields during the first season and permitted a second bean intercrop, which can increase the total legume production by up to 1 t/ha–1 and resulted in additional revenues of almost US$ 1000/ha–1 (Fig. 2). Crop arrangement or a second legume inter crop did not affect yields of cassava storage roots. Fertilizer application increased both legume and cassava yields and net revenue by US$ 400–700 /ha–1 with a marginal rate of return of 1.6–2.7. Replacing the common bean intercrop by groundnut increased net revenue by US$ 200–400/ha–1 partly because of the higher market value of the grains, but mostly due to a positive effect on the yields of cassava storage roots. Soybean affected

Figure 2. (Left) 1st legume: groundnut (2 months after planting); (Right) 2nd legume: climbing beans (6 months after planting). In the highlands of eastern DR Congo, alternative spacing of cassava (2 by 0.5 m instead of 1 by 1 m) allows the integration of 4 lines of legumes during one season and 2 lines of legumes during the second season without affecting cassava densities and yields.

cassava yields negatively because of its high biomass production and long maturity period; modifications are needed to integrate a soybean intercrop into the system. Due to the high variability in soil fertility status, the varying landscape features, and the variation in access to inputs for cassava-producing households, local adaptation is required to ensure that the investments made in cassava production result in the highest returns on investment, in line with the resources (e.g., cash, land, labor) that these households have (Fig. 3). Such adaptation efforts are best led by extension and development partners that have the skills and capacity to implement those efforts at scale. In East DR Congo, erosion control is the most urgent issue to be tackled to enhance the sustainability of cassava-based systems and experiences from Southeast Asia with live hedges should be explored for these environments.

These findings demonstrate the large potential of ISFM to increase productivity in cassava–legume systems in DR Congo. This is crucial in view of the fact that cassava is changing from a crop was almost entirely for food security to a crop for which there is high demand in local and urban markets. The intensification of cassava production is thus a prerequisite for sustaining cassava-producing households and ISFM can assist in achieving such benefits. These benefits were, however, not observed in all study sites. In poor soils, productivity increases were variable or absent, and soil amendments are required. A better understanding of the conditions under which positive effects occur can enable better targeting and local adaptation of the technologies. (*With additional contributions from Peter Pypers, CIAT-Kenya*)

Figure 3. (Left: Bas-Congo; Right: Sud-Kivu) Cassava land preparation varies widely in DR Congo, partly affected by the sloppiness and water status of the land.

New varieties released

In 2012, seven IITA-developed cassava varieties were released through the national systems in Cameroon and the DRC. In Cameroon, the following varieties have been released: TMS 92/0326, TMS 96/0023, TMS 92/0057, and TMS 92/0067. In DRC, the following varieties were released: MM 96/4653, MM 97/2015, M98/115, and 2006/114.

TABLE 1. Cassava varieties released in Cameroon and DR Congo in 2012

Country	Lead partner institution	IITA accession number	Release name
Cameroon	IRAD	TMS 92/0326 (TMS 91934 x TME 1) HS	Abui-Kpwem
		TMS 96/1414 (TMS 91/02319 x MANGAZO)	Nko'h Menzui
		TMS 96/0023 (TMS 91934 (4x)) HS	Abeng-Lengon
		TMS 92/0057 (30555 x TME 1) HS	Ayeng ye-sahti
		TMS 92/0067 (91934 x TME 1) HS	Mbong wa tobo
DR Congo	INERA	MM 96/4653	Nabana
		MM 97/2015	Mugoli

Farmer showing cuttings of IITA and IRAD-improved cassava cutting to the Minister of Agriculture and Rural Development during the annual Agricultural Show in Abong Mbang Cameroon. Photo by IITA.

Training trainers in plantain macropropagation techniques in the south region of Cameroon. Photo by IITA.

Capacity Building and **Publications**

Seminar

During the year, Dr Rachid Hanna organized a seminar on "Community Genetics in a Plant-Aphid System" facilitated by Dr Sharon Zytinska of the Technical University of Munich. The event was held on 14 November 2013 at IITA's station in Cameroon.

Training workshops

In 2012, the Hub organized 17 training courses covering a wide spectrum of research themes and benefitting some 1400 individuals. Below is the list of the training activities conducted by country:

DR Congo

- Training of trainers (TOT) of TROCAIRE farmers associations on multiplication, processing, and business plan: 56 participants.
- FH supervisors' training on plant protection and marketing: 55 participants.
- INERA and others partners on special research methodologies: 42 participants.
- PANA Integration of climate changes in plant selection, certified seed production, and food crops production and management (cassava, maize, rice, cowpea, and beans): 436 participants.

Cameroon

- Best practices in cassava cultivation and multiplication: 66 participants.
- Identification and integrated management of cassava pests and diseases – on-field training in relation to PSMNR project in Southwest Cameroon: 239 participants in 10 villages.
- Identification and integrated management of fruit flies and their natural enemies in West and North Cameroon in collaboration with IRAD: 15 participants.
- Training of quarantine officers on the identification and management of plantain pests and diseases: 25 participants.

Cameroon and Burundi

- Establishment of plantain innovation platforms in the Central and South Regions of Cameroon: 54 participants.
- Forest trees on agricultural land – a solution to meet the timber needs of the domestic sector in Cameroon: 30 participants.
- Expert analyses of the causes of deforestation and questions for land use planning for REDD+ strategy: 25 participants.
- Land use planning for low emission development strategies (LUWES): 20 participants.
- Banana disease and pest management - Training on the use of healthy planting material, removal of male bud, eradication of affected plants, sterilization of farm implements, and appropriate intercropping (PADAP/BTC): 161 participants.
- National strategy to control banana BXW and BBTD (FAO, MINAGRIE): 67 participants.

Farmers being trained on field monitoring of fruit flies. Photo by IITA.

- Training of enumerators to assess the incidence and severity of BXW and BBTD (FAO): 42 participants.
- Rapid multiplication of healthy banana planting material: 39 participants.

Graduate and post-graduate studies

Below is a list of students who are undertaking graduate and post-graduate degree programs in the hub, categorized by research area, and supervised by IITA scientists posted in the region:

Natural resource management

- Bizimana, Syldie. PhD, UCL, Belgium. Thesis title: Effect of soil management on nutrient availability and nutrient cycling in highland banana cropping systems. Supervisor: Dr Bernard Vanlauwe (IITA).
- Nibasumba, Anaclet. PhD, UCL, Belgium. Thesis title: Arabica coffee x Banana intercropping and its impact on yield, post-harvest quality and farm revenue in Burundi. Supervisor: Dr Bernard Vanlauwe (IITA).
- Niyuhire, Marie Chantal. PhD, KUL, Belgium. Thesis title: ISFM in maize-based systems in Central Burundi". Supervisor: Dr Bernard Vanlauwe (IITA).
- Ndonda, Adrien. MSc, University of Kisangani (UNIKIS), DR Congo. Thesis title: *Evaluation des pratiques agricoles appropriées comme alternative à la résilience aux changements climatiques: Cas du manioc en condition de non incinération d'une friche herbeuse dans la zone de forêt de transition de Kisangani*. Supervisor: Dr Bernard Vanlauwe (IITA).

Biotechnology and genetic improvement

- Abang, Albert. PhD, University of Yaounde I, Cameroon. Thesis title: Development of okra resistance to the cotton aphid. Supervisors: Dr Rachid Hanna (IITA) and Sirin. Ramasamy (AVRDC).
- Doumtsop, Armand. PhD, University of Dschang in Cameroon in collaboration with Dr B. Normark at the University of Massachusetts, USA. Thesis title: Population genetics and diversity of the African root and tuber scale: understanding mechanisms of host shifts and identifying molecular markers for use in the development of sustainable scale control options. Supervisor: Dr Rachid Hanna (IITA), Dr Benjamin Normark (University of Massachusetts, USA), and Prof Abraham Fomena (University of Yaounde I).
- Famah, Nazer. PhD, University of Amsterdam, the Netherlands. Thesis title: Molecular and morphometric characterization of geographic populations of two species of predatory mites associated with the coconut mite in Brazil, Bénin, and Sri Lanka. Supervisors: Dr Rachid Hanna (IITA) and Profs. Maurice Sabelis (UvA).
- Njukwe, Emmanuel. PhD. Kyoto University, Japan. Thesis title: Drivers of cassava germplasm performance and adoption in contrasting environments in Cameroon. Supervisor: Dr Rachid Hanna (IITA) and Dr Araki Shigeru (Kyoto University, Japan).
- Nduwimana, Innocent. MSc, University of Burundi, Burundi. Thesis title: *Evaluation de la technique de macro-propagation du bananier et du plantain dans les conditions rurales: Cas de la commune Rugombo*. Supervisor: Dr Bernard Vanlauwe (IITA).

Social science and agribusiness

- Chabikuli, Bibi. PhD, University of South Africa, Johannesburg, South Africa. Thesis title: Functionality of crude fibre extracted from cassava leaf compared to imported dietary fibre used within the food industry. Supervisor: Dr Bernard Vanlauwe (IITA).
- Oleke, Jofrey. PhD, Morogoro University, Tanzania. Thesis title: Stakeholders and socioeconomic analysis of coconut production in Bénin and Tanzania and impact of classical biological control of coconut mite on income and food security. Supervisors: Dr Victor Manyong (IITA), Dr Rachid Hanna (IITA), and Dr Aida Isineka (Sokoine University, Tanzania).

Plant production and plant health

- Akanksha, Singh. PhD. Thesis title: Multitrophic interactions in a plant-aphid-parasitoid-ant system: Okra in Cameroon and implications for sustainable aphid management. Supervisors: Dr Rachid Hanna (IITA) and Drs Wolfgang Weisser Sharon Zytinska (Technical University of Munich, Germany).
- Djomaha, Edwige Sidoine. PhD, University of Dschang, Dschang, Cameroon. Thesis title: Bionomics and management of aphids associated with cabbage in the highlands of Cameroon with emphasis on interactions between aphid and diamondback moth management. Supervisor: Dr Rachid Hanna (IITA) and Dr Richard Ghogoumu (University of Dschang).
- Eleko, Nestor. PhD, University of Kinshasa. Thesis title: Distribution and abundance and host plant relations of the African root and tuber scale in North Kivu, Democratic Republic of Congo. Supervisors: Dr Rachid Hanna (IITA), Prof A. Lema (University of Kinshasa), and Dr S. Hauser (IITA).
- Koffi, Negloh. PhD, Department of Applied Plant Sciences and Plant Biotechnology, Institute of Plant Protection, University of Natural Resources and Applied Life Sciences, Vienna, Austria. Thesis title Ecology and classical biological control of the coconut mite in Africa. Supervisors: Dr Rachid Hanna (IITA) and Peter Schausberger (BOKU).
- Fernando, Rodriguez. PhD, University of Amsterdam. Thesis title: Explorations for coconut mite natural enemies in South America. Supervisors: Dr Rachid Hanna (IITA), Prof. M.W. Sabelis (UvA), and Gilberto de Morales (University of Sao Paulo, Brazil).
- Ngatat, Sergine. PhD, University of Dschang, Dschang, Cameroon. Thesis title: Population dynamics and management of the banana aphid and epidemiology of banana bunchy top disease. Supervisors: Dr Rachid Hanna (IITA), Dr P. Lava Kumar (IITA), and Dr Dominic Fontem (University of Dschang, Cameroon)
- Niyongere, Celestin. PhD, JKUAT, Nairobi Kenya. Thesis title: Characterization and integrated management of BBTV in the Great Lakes region. Supervisor: Dr Bernard Vanlauwe (IITA).
- Ahandessi, Marie-Anne. MSc, University of Abomey-Calavi, Bénin. Thesis title: Interactions between weaver ants, fruit flies, and the parasitoid *Fopius arisanus*. Supervisors: Dr Rachid Hanna (IITA) and Dr Desire Gnanvossou (IITA).
- Dongmo, Michel. MSc, University of Yaoundé I. Thesis title: Thermal response of the Sri Lanka fruit fly *Bactrocera invadens* for risk assessment of the effects of climate change on its distribution and abundance. Supervisors: Dr Rachid Hanna (IITA), Dr Jurgen Kroschel (CIP), and Dr Sevillor Kekenou (University of Yaounde I, Cameroon).
- Frangoie, Antoine. MSc, University of Kinshasa, DR Congo. Thesis title: *Contrôle des mauvaises herbes et effets sur la variabilité des*

composantes du rendement du manioc en fonction du type de sol et de l'architecture de la plante. Supervisor: Dr Bernard Vanlauwe (IITA).

- Gertrude Ambang. MSc, University of Yaounde I, Cameroon. Thesis title: Pathogenicity of Cameroon isolates of the entomopathogens *Beauvaria bassiana* and *Metarhizium anisopliae* to the banana weevil. Supervisors: Dr Rachid Hanna (IITA), Dr Apollin Fotso (IITA), and Dr Zaché Ambang (University of Yaounde I).
- Kantungeko, Deo. MSc, University of Burundi, Burundi. Thesis title: *Dynamique du BXW au Burundi*. Supervisor: Dr Bernard Vanlauwe (IITA).
- Karerwa, Ollivier. MSc, University of Burundi. Thesis title: *Etude de la biologie de Pentalonia, vecteur du BBTD au Burundi*. Dr Bernard Vanlauwe (IITA).
- Nanga, Nanga Samuel. MSc, University of Yaoundé I, Cameroon. Thesis title: Thermal response of the parasitoid *Fopius arisanus* and risk assessment of the effects of climate change on its distribution and abundance. Supervisors: Dr Rachid Hanna (IITA), Dr Jurgen Kroschel (CIP), and Dr Sevillor Kekenou (Univerisyt of Yaounde I).
- Sama, Ruth. MSc, University of Dschang, Cameroon. Population dynamics of *Bemisia tabaci* and its associated parasitoids on CMD-resistant and CMD-susceptible cassava genotypes. Supervisor: Dr Rachid Hanna (IITA) and Prof. Richard Ghogomu (University of Dschang).
- Winsou, Jeanette. MSc, University of Abomey-Calavi, Bénin. Thesis title: Effect of relative humidity on pupal survival of six species of economically important tephritid fruit flies. Supervisors: Dr Rachid Hanna (IITA) and Dr D. Gnanvossou (IITA).

Publications

Our scientists based in the region produced a number of scientific and popular literatures during the year. Below is a selection of publications produced in 2012 categorized by type and research area:

Peer-reviewed Thomson

Natural resource management

Pypers P, Bimponda W, Lodi-Lama JP, Lele B, Mulumba R, Kachaka C, Boeckx P, Merckx R, and Vanlauwe B. 2012. Combining mineral fertilizer and green manure for increased, profitable cassava production. Agronomy Journal, In Press. http://biblio.iita.org/index.php?page=publication&kind=single&ID=8278.

Jefwa JJ, Kahangi E, Losenge T, Mung'atu J, Ngului W, Sanginga N, and Vanlauwe B. 2012. Arbuscular mycorrhizal fungi (AMF) in the rhizosphere of banana and plantain and the growth of tissue culture. Agriculture, Ecosystems and Environment. In Press. http://biblio.iita.org/index.php?page=publication&kind=single&ID=8277.

Koech M, Pypers P, Okalebo R, Otieno C, Khan Z, Picket J, Kipkoech AK, and Vanlauwe B. 2012. Impact of Desmodium specios and cutting regime on the agronomic and economic performance of the 'Push-pull' intercropping system in Western Kenya. Field Crops Research. In Press. http://biblio.iita.org/index.php?page=publication&kind=single&ID=8279.

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.

Guto SN, Pypers P, Vanlauwe B, de Ridder N, Giller KE. 2012. Socio-ecological Niches for Minimum Tillage and Crop-residue Retention in

Continuous Maize Cropping Systems in Smallholder Farms of Central Kenya. Agronomy Journal 104, 188-198.

Otinga AN, Okalebo JR, Njoroge R, Emong'ole M, Six L, Vanlauwe B, Pypers P and Merckx R. 2012 Partial substitution of phosphorus fertilizer by farmyard manure and its localized application increases agronomic efficiency and profitability of maize production. Field Crops Research. In Press.

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.

Kibor B, de Ridder N, Vanlauwe B, Pypers P, and Giller KE. 2012. Participatory identification of 'Socio ecological niches' for agroforestry tree species within smallholder farms in Kenya. Agroforestry Systems. In Press.

Plant production and health

Agboton, B. V., R. Hanna, A. Onzo, S. Vidal, and A. von Tiedemann. 2012. Interactions between the predatory mite Typhlodromalus aripo and the entomopathogenic fungus Neozygites tanajoae and consequences for the suppression of their shared prey/host Mononychellus tanajoa. Experimental and Applied Acarology DOI 10.1007/s10493-012-9630-1. http://biblio.iita.org/index.php?page=publication&kind=single&ID=8112.

Negloh, K., R. Hanna, and P. Schausberger. 2012. Intraguild predation and cannibalism between the predatory mites Neoseiulus neobaraki and N. paspalivorus, natural enemies of the coconut mite Aceria guerreronis. Experimental and Applied Acarology 58: 235-246. http://biblio.iita.org/index.php?page=publication&kind=single&ID=8111.

Oleke, J., V. Manyong, R. Hanna, A. Isinika, and M. W. Sabelis. 2012. Farmers' perception on coconut mite-damage and crops diversification alternatives in the coastal belt of Tanzania. International Journal of Acarology 38: 471-479. http://biblio.iita.org/index.php?page=publication&kind=single&ID=8124.

Onzo, A., R. Hanna, and M. W. Sabelis. 2012. The predatory mite Typhlodromalus aripo refers green-mite induced plant odors from pubescent cassava varieties. Experimental and Applied Acarology 10.1007/s10493-012-9595-0. http://biblio.iita.org/index.php?page=publication&kind=single&ID=8110.

Sourassou, N. F., R. Hanna, I. D. Zannou, H. Breeuwer, G. J. de Moraes, and M. W. Sabelis. 2012. Morphological, cross-breeding and molecular analysis of the coconut mite associated predatory mites identified as Neoseiulus baraki: evidence for cryptic species. Experimental and Applied Acarology 57: 15-36. http://biblio.iita.org/index.php?page=publication&kind=single&ID=8106.

Lokossou, B., D. Gnanvossou, O. Ayodeji, F. Akplogan, A. Safior, D. Z. Migan, M. A. Pefoura, R. Hanna, and P. L. Kumar. 2012. Occurrence of Banana bunchy top virus in banana and plantain in (*Musa* sp.) in Bénin. New Disease Reports 25: 13. http://biblio.iita.org/index.php?page=publication&kind=single&ID=7783.

Onzo, A., A. F. Hoedokoho, and R. Hanna. 2012. Potential of the predatory mite, Amblyseius swirskii to suppress the broad mite, Polyphagotarsonemus latus on the gboma eggplant, Solanum macrocarpon. Journal of Insect Science 12:7. Available online: insectscience.org/12.7. http://biblio.iita.org/index.php?page=publication&kind=single&ID=7716.

Peer-reviewed non-Thomson

Natural resource management

Vanlauwe B, P Pypers, E Birachi, M Nyagaya, B van Schagen, J Huising, E Ouma, G Blomme, and P van Asten. 2012. Integrated Soil Fertility Management in Central Africa: Experiences of the Consortium for Improving Agriculture-based Livelihoods in Central Africa (CIALCA) In: An Eco-Efficiency Revolution in Tropical Agriculture: Climate-smart production systems for smallholders, CIAT, Cali, Colombia. In Press.

Vanlauwe, B. 2012. Organic Matter Availability and Management in the context of Integrated Soil Fertility Management in sub-Saharan Africa In: Soils and Food Security, Eds. RE Hester and RM Harrison, the Royal Society of Chemistry, UK, pp 135-157.

Bationo A, Waswa B, Kihara J, Adolwa I, Vanlauwe B, and Saidou K . 2012. Lessons learned from Long-term Soil Fertility Management Experiments in Africa. Springer, Dordrecht, the Netherlands.

Biotechnology and genetic improvement

Njukwe E., E. A. Ouma, P. van Asten and P. Muchunguzi. 2012. Challenges and opportunities for macro- propagation technology for Musa among small-holder farmers and small and medium size enterprises. Paper presented at CIALCA International conference, 24 to 27 October 2011, Kigali, Rwanda. Accepted for publication in CABI banana book.

Swennen Rony, Guy Blomme, Piet van Asten, Pascale Lepoint, Eldad Karamura, Emmanuel Njukwe, William Tinzaara, Altus Viljoen, Patrick Karangwa, Danny Coyne and Jim Lorenzen. 2011. Mitigating the impact of biotic constraints to build resilient banana systems in Central and Eastern Africa. Paper presented at CIALCA International conference, 24 to 27 October 2011, Kigali, Rwanda. Accepted for publication in EarthScan book.

Reports

Social science and agribusiness

Wambo A, E. O'Brien, G.A. Kemtsop, N. Waiyaki and N.M. Mahungu, 2012: Cassava investment in Africa: taking inventory of initiatives in Africa in view of positioning cassava as a strategic commodity, NPACI/IITA. 82 pp. ISBN 978-978-50368-1-7.

Extension materials

Biotechnology and genetic improvement

CIALCA; Banana GCP (Good Cultural Practices). Burundi: Factsheet.

Frangoie A. and Mahungu N.M. 2102. *Intégration du changement climatique dans la sélection, la maintenance variétale et la production des semences de base. Module I: Manuel destiné aux Chercheurs œuvrant dans la filière semencière*. 51 pp. DR Congo.

DR Congo: Frangoie A., Bidiaka S. and Mahungu N.M. 2102. *La production des semences certifiées. Module II: Manuel destiné aux Agri-multiplicateurs*. 48 pp.

DR Congo: Frangoie A., Bidiaka S., Tata-Hangy W. and Mahungu N.M. 2102. *Les systèmes de production et de gestion des principales cultures vivrières. Module III: Manuel destiné aux Producteurs*. 45 pp.

DR Congo: Lukombo S. and N. Mahungu, 2012. *Manuel de formation destiné aux agents de transformation du manioc*. 24 pp.

Plant production and plant health

Fotso, A., Hanna, R., Doumtsop, A., Nanga Nanga, and S. Ngatat, S. 2012. Guide to the integrated management of fruit flies, banana bunchy top diseases, black sigatoka leaf spot, banana weevil, banana nematodes, cassava mosaic virus disease, African root and tuber scale, and beneficial and pest ants; establishment and management of plantain multiplications fields, plantain macropropagation, plantain sucker sanitation with hot water treatment, and production of tissue culture plantains.

eastern africa

From the Regional Director

Dr. Victor Manyong
Director
Eastern Africa Hub

I have the pleasure of presenting to you the first annual report of IITA's Eastern Africa Hub. In this report, we highlight our research-for-development (R4D) achievements in 2012 in pursuit of sustainable solutions to the complex challenges that smallholder farmers in the region are facing.

Operating from Dar es Salaam, Tanzania, the Hub covers eight countries with a population of about 250 million people. Over 70% are poor, earning less than US$1.25/day. Majority of the people is engaged in agriculture in one way or another. The sector, therefore, has immense potential for reducing poverty and improving food security.

This year has been both good and challenging for the Hub as we re-aligned our activities with the new CGIAR Research Programs (CRPs) that are geared towards having all 15 member centers of the CGIAR – IITA is one of them – and their partners to work more closely for more impact. Our key achievements for the year, which would not have been possible without the support of our donors and partners, are :

- Quality of science: Researchers based at the Hub produced a total of 74 publications including 53 in peer-reviewed journals;
- Capacity building: We are currently supporting 19 PhD students and 26 MSc students who are carrying out their research projects. Over 160 participants took part in various group trainings organized by the institute;
- New improved crop varieties: Four improved varieties of cassava were officially released; these have dual tolerance to Cassava Mosaic Disease (CMD) and Cassava Brown Streak Disease (CBSD) were developed together with our national partners in Tanzania:
- Branded cassava flour: We have developed a market brand for cassava flour which will be launched in early 2013 and persuaded a major wheat flour milling plant, Coast Millers, to invest in its distribution;
- Funding opportunities: Three new major grants were funded that will bring in nearly US$20 million over the next four years;
- Increased human resources: Internationally recruited staff (IRS) based in the region grew from 16 in 2011 to 20 in 2012. This brings us closer to our target of having 45 IRS in the Hub by the year 2020. Our nationally recruited staff (NRS) have also increased to 104, with 63 in research and 41 in administration;
- Science Building: We made steady progress in the construction of our state-of-the-art science building for the Hub. The foundation stone was laid in December 2011 by the Tanzanian Prime Minister, Hon. Mizengo Pinda, and completion is expected in March 2013. We are planning for its inauguration in May 2013.

We will continue to build on these successes in the coming years, strengthening our partnership in the region and intensifying our efforts to improve the livelihoods of smallholder farmers. We will continue to be guided by the Institute's refreshed strategy which, among others, aims to increase the production of major staple crops such as cassava, yam, maize, banana/plantain, soybean, and cowpea by 60% and lift 11 million out of poverty in Africa in the next 10 years. We will also ensure that our activities are also in line with the priorities of the governments of the different countries in which we are working.

I wish you happy reading.

The recently completed ultra-modern science building of the IITA Eastern Africa Hub, which is slated to be commissioned in May 2013. Photo by IITA.

The Eastern Africa Hub at a glance

The Eastern Africa hub was established as a result of the Institute's thrust to decentralize its R4D activities to better serve the continent. It is one of the Institute's four hubs in the continent; the other three are the West, South, and Central Africa.

Eastern Africa: a land of contrasts

The Hub covers a vast region that expands from the East African Community (EAC) to the west to the Horn of Africa in the north of the continent. The region is characterized by three major agroecological zones: (1) a fringe of the Sahelian drylands in the north with less than 90 days length of growing period (LGP) and less than 300 mm rainfall; (2) the mid-altitude savannas covering most of the Great Lake Region and highlands in the Horn of Africa, which has an elevation of 1200 m above sea-level and bimodal rainfall patterns; and (3) the wide lowland moist savanna and woodland zones area in the south with LGP between 210 and 270 days and a bimodal rainfall pattern in the northern part and unimodal in the south. There is a huge contrast between the wet and very dry areas, with very frequent droughts and floods in many parts of the region.

The major development challenges in the region include extreme poverty, where more than 70% of the population lives below the poverty line of US$1.25/day/person, and there is chronic/cyclic food insecurity. However, agriculture holds great potential to make a positive difference as again over 70% of the population is engaged in agriculture in one way or another.

Most of our R4D activities take place in Tanzania, Uganda, and Kenya, where our offices are located, but we work beyond these countries. In Tanzania, our activities focus on the sustainable intensification of mixed maize-legumes-livestock systems and on cassava and banana research. Uganda is at the forefront of our research on climate change in the coffee-banana systems and banana. Most of our biotechnology work takes place in Kenya at the Biosciences East and Central Africa (BecA) Hub.

Our vision of success

We aim to sustainably intensify agriculture in the major impact zones of east Africa. We aim to increase the yield of our research crops by 60% and add value to primary products to contribute to the Institute's target of lifting 11 million people out of poverty and reclaiming 7 million ha to sustainable agriculture in Africa in the next 10 years as outlined in IITA's refreshed Institutional Strategy for 2012 to 2022.

Our work in the region is guided by the CRPs – multi-center and multidisciplinary programs that tackle cross-cutting issues in agricultural development across the globe. In 2012, scientists based in the Hub were involved in seven of the 15

A region of contrasts: (top) pastoralists digging deep into the earth just to get water for their livestock in Tanzania, while in Uganda (bottom) a farmer stands in the lush greenery of his farm with very healthy looking cassava. Photo by IITA.

Healthy crops, healthy people: a farmer in Zanzibar with his spinach packed and ready for the market. We are working to improve health and income of smallholder farmers. Photo by D. Coyne, IITA.

CRPs: Humidtropics; Roots, Tubers, and Bananas (RTB); Grain Legumes; Policies, Institutions, and Markets (PIM); Agriculture for Nutrition and Health (A4NH), and Climate Change, Agriculture, and Food Security (CCAFS).

Our research focuses on boosting production of cassava and banana – two of the most important cash and food security crops for smallholder farmers in the region. We also work on soybean, which is important for human and soil nutrition, and horticultural crops (i.e., vegetables), which have high nutritional and commercial values.

We work using the value chain approach in our research, addressing all related issues from crop production to marketing and processing that smallholder farmers are facing. We focus on closing the yield gaps by developing improved high yielding varieties, controlling pests and diseases, developing sustainable production systems, and deploying viable seed systems, especially for clonal crops, and addressing post-harvest losses—over 40% of farmers' produce is lost during post-harvesting operations such as storage, processing, and transportation.

We are also addressing food safety and nutrition issues such as mycotoxins – highly poisonous and carcinogenic chemicals produced by fungi that attack crops both in the field and in storage – as well as pesticide residues in vegetables.

Our human assets

The East Africa Hub currently has a complement of 16 scientists with key disciplinary competencies in the areas of Biotechnology and Crop Improvement (two crop breeders and three biotechnologists), Social Science and Agribusiness (an outcome/impact socio-economist, a food technologist, a cassava value chain expert, and an agricultural economist), Natural Resource Management (three agronomists and an aflatoxin specialist), and Plant Production and Health (two plant pathologists, one virologist, and one soil health expert).

As of December 2012, the hub has 83 national research staff spread across its three main locations: 19 in Kenya, 32 in Uganda, and 32 in Tanzania. The hub also has 4 administrative IRS and 41 NRS support staff (two in Kenya, 16 in Uganda, and 23 in Tanzania).

Hub staff at work (clockwise from top left): Beatrice Bachwenkizi, Research Associate, visiting a cassava processing center established by IITA; Harun Maruthi, Plant Pathologist, assessing rust damage in soybean farmer's field; Piet van Asten, System Agronomist, inspecting a coffee-banana intercrop trial; Adebayo Abass with a research technician in the lab.

Our partners

Partners are the key to the success of our work. In 2012 we continued to strengthen our relationships with a wide range of local and international NGOs, extension partners, and the private sector in Tanzania, Kenya, Uganda Rwanda, Burundi, and South Sudan. Entities that participate directly in our R4D work and also support us in disseminating our research outcomes include the following:

- Advanced Research Institues (ARIs), such as Michigan State University, University of California, Berkeley, Paris School of Economics and University of Vienna, among others;
- CGIAR member centers, such as the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) and the World Agroforestry Center (ICRAF), as well as other international development organizations, such as the World Vegetable Center (AVRDC) and the African Agricultural Technology Foundation (AATF), among others;
- Academic institutions, such as Sokoine University of Agriculture, Makerere University, and University of Nairobi;
- Sub-regional organizations, such as the Association for Strengthening Agricultural Research in Eastern and Central Africa (ASARECA), Biosciences Eastern and Central Africa (BecA), and the East African Community (EAC);
- National research institutes (NARIs), such as Uganda's National Research Organization (NARO), Kenya Agricltural Reserch Institute (KARI), Tanzania Food and Nutrition Centre (TFNC), Agriculture Research Institute (ARI) - Naliendele, and the Salian Research Institute in Tanzania;
- Private sector partners, such as the Pan-African Agribusiness and Agro Industry Consortium (PanAAC) and various seed companies and millers;
- Farmers' organizations such as the East African Farmer's Federation and the *Mtandao wa Vikundi vya Wakulima Tanzania* (MVIWATA) – a national network of farmers' associations in Tanzania.
- NGOs such as the Catholic Relief Organization (CRS) and AFRICARE; and
- Government agencies such as the Ministry of Agriculture and the Commission for Science and Technology (COSTECH) in Tanzania.

Dr Victor Manyong (left) handing over an IITA branded clock to Engr. Christopher Chiza, Minister for Agriculture Food Security and Cooperatives, during a courtesy visit to congratulate him on his appointment. Photo by C. Njuguna, IITA.

We also maintain close relationship with development investors, such as the US Agency for International Aid (USAID), *Deutsche Gesellschaft für Internationale Zusammenarbeit* (GIZ), Bill & Melinda Gates Foundation (BMGF), African Agricultural Technology Foundation (AATF), and Common Fund for Commodity (CFC), among many others, who provide funds that enable us to effectively carry out our work in the region. We also collaborate with policymakers at all levels who provide guidance in the direction of our programs.

Our projects in Eastern Africa

Currently, IITA is implementing three large projects (with a budget of more than US$1 million) in the region:

- *Biotechnology Applications to Combat Cassava Brown Streak Disease* - Budget: US$2,424,683; Duration: 2009-2013; Donor: BMGF.
- *Improving Agriculture-based Livelihoods in Central Africa through Sustainably Increased System Productivity to Enhance Income, Nutrition Security, and the Environment (CIALCA II)* – Budget: US$4,565,445; Duration: 2009-2013; Donor: Directorate-General for Development Cooperation (DGDC), Belgium.
- *Small-Scale Cassava Processing and Vertical Integration of the Cassava Sub-sector in Southern and Eastern Africa, Phase II* - Budget: US$2,298,370; Duration: 2009-2014; Donor: CFC.

(Left) A beneficiary of the CFC-funded project promoting commercialization of cassava shows the well-packed high quality cassava flour. (Right) A farmer in Zanzibar, Tanzania, shows tomato roots infested with nematodes. Photos by C. Njuguna and D. Coyne, IITA.

Three major projects were also started in the hub in 2012:

- *Sustainable Intensification of Key Farming Systems in East and Southern Africa* (Africa RISING, http://africa-rising.net/) – funded by the USAID through its Feed-the-Future (FtF) Initiative, the project focuses on creating opportunities for smallholder farm households to move out of hunger and poverty through sustainably intensified farming systems that improve food, nutrition, and income security, particularly for women and children, and conserve or enhance the natural resource base. Its main action area is the moist savanna of Tanzania with minor activities in Malawi and Zambia. In 2012, the project focused on planning and developing strategic partnerships to lay a good foundation for its successful implementation. At the same time, the project implemented 10 "quick-win" subprojects to strengthen partnerships and produce results to build on in the following years.
- *Safe and Effective Pest and Crop Management Strategies to Strengthen the Vegetable Value Chain in the Humid Tropics* - This project is being implemented in Tanzania and Kenya with some activities in Madagascar and Thailand.
- *New Cassava Varieties and Clean Seed to Combat CBSD and CMD (5CP)* – The project, funded by BMGF, is expected to make available breeders' clean seeds that would feed the supply chain of clean planting materials to end-users in the five countries in east and southern Africa.

Additionally, the CIALCA II Project in the highlands of East and Central Africa was extended during the year to effect the transition of the action area to the mid-altitudes under the Humidtropics CRP.

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The dedication plaque installed at IITA Eastern Africa's ultra-modern science building marking the laying of the foundation stone by Tanzania's Prime Minister, Honorable Mizengo Kayanza Pinda, on 6 December 2011. Photo by JTOliver, IITA.

Dr Edward Kanju (right), IITA scientist, with local partners looking for symptoms of cassava disease in the field. Photo by IITA.

Research Highlights

Towards safer staples

Fen Beed, Charity Mutegi, and Ranajit Bandyopadhyay

Aflatoxins are highly toxic chemicals that suppress the immune system, impede growth and development, and cause liver disease and even death. Children and the poor are usually the most affected. Because of these recognized health risks, aflatoxins are heavily regulated in international shipments. African nations are unable to realize the full potential of export of some agricultural commodities due to aflatoxin contamination. The exact value of this export loss is not known but estimated to be tens of millions of US dollars. African economies lose upwards of US$450 million each year because of contamination. In Kenya, there have been a number of fatalities over the years due to food poisoning. There have also been huge food losses, for example in 2010 when 2.3 million bags of maize were destroyed as a result of aflatoxin contamination.

Aflatoxins are produced in a range of staple crops by the fungus *Aspergillus flavus* and *A. parasiticus*, both in the field and during storage. To improve the health and livelihoods of farming families and consumers in Africa, we partnered with the United States Department of Agriculture's Agricultural Research Service (USDA-ARS) and the African Agriculture Technology Foundation (AATF) to develop aflasafe™, a natural, safe, and cost-effective biocontrol product that cuts aflatoxin contamination in food crops by as much as 90%.

Aflasafe™ uses native strains of *A. flavus* belonging to distinct genetic groups containing members that do not produce aflatoxins, are unable to exchange genetic material with the toxigenic forms, and are widely distributed and ecologically competitive. These atoxigenic – or non-poison-producing – strains are applied to "push out" their toxic cousins so crops are less contaminated, in a process called "competitive exclusion'. This biocontrol method has proved to be practical and effective in reducing aflatoxin in the field.

Controlling aflatoxin in Kenya

Biocontrol trials to manage aflatoxin in Kenya started in 2010 with testing in Bura, Katumani and Kiboko research stations of 13 atoxigenic indigenous strains, introduced as three mixtures each containing 4-5 strains. In Kiboko, the three strain mixtures completely displaced the highly toxic S-strains of *A. flavus* and *A. parasiticus* that initially constituted 33-56% of the *Aspergillus* population. In Katumani, where up to 83% of the *Aspergillus* population was highly toxic, their displacement by the strain mixtures too were almost complete The work led to the selection of the four most effective strains, which were used in maize trials during the long and short rain seasons of 2012 in 14 districts in Eastern, Coast, and Nyanza provinces involving 840 farmers.

The process of registration of aflasafe™ for Kenya is ongoing. The trademark "aflasafe-KE01™" has been

(Top) Groundnut colonized by Aspergillus *species. (Bottom) A farmer applying aflasafe in his field in Kenya. Photos by R. Bandyopadhyay and H. Mburu, IITA.*

approved under the Kenya Industrial Property Institute (KIPI) and a laboratory at KARI-Katumani has been renovated to advance mycotoxin research within the national program.

Controlling aflatoxin in Tanzania

The aflasafe™ program (http://www.aflasafe.com/) has now been expanded to Tanzania where prevalence studies of mycotoxin in maize and cassava were completed in 2012 in collaboration with the Tanzania Food and Drug Agency (TFDA), Ministry of Agriculture, Food Security and Cooperatives (MAFC), Tropical Pest Research Institute (TPRI), Sokoine University of Agriculture (SUA), and the Center for Analytical Chemistry (IFA-Tulln), Austria. A key component of the project was to raise awareness of the harm that aflatoxins can cause. To achieve this, we developed and distributed factsheets in Swahili to 2500 farmers and market vendors who supplied crop samples for aflatoxin testing, as well as 600 factsheets in English to other traders and district and regional extension officers. *(With contributions from Peter J Cotty, USDA-ARS)*

Battling a dual threat on cassava

James Legg, Edward Kanju, Morag Ferguson, and Leena Tripathi

Farming communities in East African have for many years relied on cassava as a food security crop. Increasingly, however, the role of the crop has broadened, as improved utilization and marketing have provided new opportunities for generating cash income. Pests and diseases threaten this progress. Although there is a great diversity of these biotic constraints, the most economically important are the virus diseases CMD and CBSD. We are tackling these problems in two ways: though germplasm development and crop health management.

Management through germplasm development

Conventional breeding

We have carried out several breeding trials in Tanzania and Uganda to develop new varieties that have dual resistance to CMD and CBSD and characteristics preferred by farmers or end users. In Tanzania, we have selected 121 clones for further evaluation under Advanced Yield Trials (AYTs) across several sites in the Lake, Eastern, and Southern Zones. We have also selected 54 clones for further observation under Uniform Yield Trials (UYTs) across sites in the Eastern, Southern, and Central Zones. In Zanzibar and Uganda, we have evaluated nine clones in each country.

Four IITA varieties have been released in Tanzania; three new varieties are in the final stages of being officially released by the government.

Molecular markers

We are working with the national programs in Tanzania and Uganda to find molecular markers (or tags) associated with resistance to CBSD in

Arthur Karugu, IITA staff based at BeCA, doing molecular marker research. Photo by M. Ferguson, IITA.

six cassava varieties for use in marker-assisted breeding. Approaches being used include quantitative trait loci (QTL) mapping and gene expression studies.

In 2012, six bi-parental populations were assessed for integrity using SSR markers and true crosses identified. High density SNP genotyping through genotyping-by-sequencing was outsourced. The populations were planted in a first phenotyping trial at Chambezi, Tanzania. Furthermore, five students were trained in this activity.

For gene expression studies, RNA was extracted from CBSD infected and non-infected plants of resistant and susceptible varieties grown under controlled conditions, and mRNA-focused libraries were generated for multiplex sequencing. Next-generation sequencing was outsourced, and a Ugandan PhD student visited the University of Berkeley to learn the bioinformatics required for data analysis.

Transgenics

As known sources of resistance are difficult to introgress into farmer preferred cultivars by conventional methods, the integration of resistance traits via transgenics holds significant potential to address CBSD. Of the available biotechnological approaches to control plant viral diseases, RNAi is a very promising strategy.

We are collaborating with the Donald Danforth Plant Science Centre (DDPSC) to develop CBSD-resistant cassava for preferred cassava cultivars in East Africa. In introducing CBSD resistance we have made attempts towards developing protocols for the transformation and regeneration of cassava plants through somatic embryogenesis. The transformation system has already been established at IITA for three cultivars preferred by African farmers and this will be extended to other cultivars.

Management through sanitation/crop health

All cassava varieties, whether research-bred or traditional farmer-grown, can benefit from basic phytosanitary measures that aim to maximize the health of planting material and minimize the level of infection by pathogens. We have begun working closely with NARS, NGOs, and commercial partners in the region to establish sustainable cassava 'clean seed" systems that make use of formal certification standards, including virus testing. Farm-level management of cassava health is being further strengthened by our support to a pilot-level community phytosanitation project being led by NARS in Tanzania.

The dual pandemics of CMD and CBSD continue to ravage East Africa's cassava. Although great success has been achieved in managing CMD through the deployment of resistant varieties, CBSD represented a setback to our work in the region. However, 2012 has seen major advances made in several areas of breeding for CBSD resistance, including conventional approaches, molecular marker development, and transgenic methods. Combined with the improved crop health management systems being developed, we hope that the successes previously realized for CMD will also be replicated for CBSD and consequently benefit East Africa's cassava-growing and cassava-consuming communities.

Growing disease-free cassava in Muheza District, Tanzania. Photo and J. Legg, IITA.

Keeping a banana menace in check

Fen Beed and Leena Tripathi

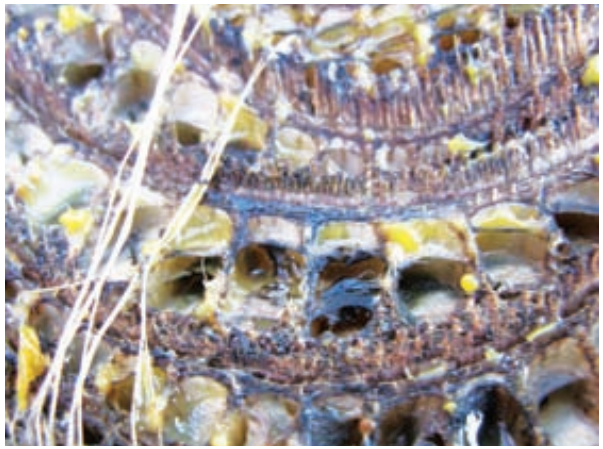
Banana *Xanthomonas* Wilt (BXW), caused by the bacterium *Xanthomonas campestris* pv. musacearum (Xcm), is threatening banana production across the Great Lakes region of East and Central Africa. No banana cultivar has resistance to the disease, yet the people of this region are highly dependent on the crop for food security and income generation.

In collaboration with national research and regulatory partners, we led regional surveillance initiatives to map the presence and spread of BXW. To overcome the problem of BXW symptoms being confused with those of other diseases and abiotic factors, diagnostic methods have been developed using serological and molecular-based techniques that are both rapid and sensitive – able to detect BXW in recently infected banana plants or suckers that have not yet shown any symptoms.

Since not all countries have the technical capacity to implement lab-based diagnostics, systems have been established to collect DNA from banana plants using novel portable kits that are cheap and easy to use and transfer across country borders. The kits are being used to facilitate simultaneous high throughput testing of several samples using the same protocols to produce directly comparable results.

Once the disease is confirmed in a location, disease awareness campaigns are mediated through SMS (text messaging), factsheets, booklets, radio messages, and community-based action to identify and manage the disease through cultural practices. These include the routine removal of the male bud (to prevent infection from insects), use of sterilized farm tools (using household bleach) and destruction of single infected stems (recently revised from the recommendation of destroying whole plants based on experimental work undertaken by IITA and observations by NARO). However, the level of BXW control by cultural practices can be inconsistent as it is dependent on the individual growers and traders implementing them.

Symptoms of BXW infection (L to R): Discolored fruits, early ripening and withering of bunches, and yellow ooze when pseudostem is cut. Photos by F. Beed, IITA.



A more robust solution is to develop cultivars that are resistant to the disease. Our researchers, in partnership with NARO-Uganda and AATF, have done just that by using transgenic lines of banana containing genes from sweet pepper that confer resistance against BXW. The transgenic banana plants have exhibited strong resistance to BXW in the laboratory and screenhouse tests. The best 65 resistant lines have been planted in a confined field trial at NARO's National Agricultural Research Laboratory (NARL) in Kawanda, Uganda, for further evaluation. Twelve transgenic lines have been found to be completely resistant to BXW after the evaluation of three generations of crops. Furthermore, the transformed lines also showed characteristics of flowering and yield (bunch weight and fruit size) comparable to those of non-transgenic varieties.

The wilt-resistance genes from pepper, *Pflp* and *Hrap*, were obtained under an agreement from Academia Sinica in Taiwan and the proteins they confer are not listed as being a potential allergen in AllergenOnline and should be safe for human consumption. These proteins are widely distributed across a broad range of plant species including rice and fruits that are eaten raw. Even so, the transgenic lines will be tested for food and environmental safety in compliance with biosafety regulations. The risk of gene flow from banana to another crop species will not be an issue as most edible banana are sterile and the clonal mode of propagation does not make this possible.

Given the rapid spread and devastation of BXW across the continent, genetic transformation through the use of modern biotechnology tools offers -- at least for the time being -- the most effective, fast, safe, and viable way to develop resistant varieties and help save the livelihoods of millions of smallholder banana growers.

(Top and bottom) Transgenic bananas growing in confined field trials in Uganda. Photos by L. Tripathi, IITA.

One of the many women project beneficiaries trained by IITA in the production of high value cassava-based products. Photo by C. Njuguna, IITA.

Capacity Building and **Publications**

Training workshops

- Plant pest and disease training under the International Plant Disease Network: Over 20 participants attended the course held at Sokoine University of Agriculture at Morogoro, Tanzania in March 2012. IITA contributed to the training and development of training materials. The course was funded by International Plant Diagnostic Network (IPDN)/USAID.
- Training of cassava processing equipment fabricators: Five participants were trained for one week at the Zambia Agricultural Research Institute (ZARI), Zambia, in April 2012. Funded by CFC.
- Nematology techniques and identification training: Five participants were trained at Sugarcane Research Institute (SRI) in Kibaha, Tanzania for one week in August 2012. Funded by BMZ and USAID.
- Banana diagnostics training: Eleven participants attended the course held in September 2012 at the IITA station in Bukavu, DRC. Funded by Feed the Hungry, USAID/FFP.
- Training in diagnostics (symptom recognition, selective media, serological and molecular) of banana diseases: Two lead scientists from ISABU, Burundi, were trained in December 2012 at IITA-Uganda. Funded by BTC.
- Training in disease assessments for soybean: 18 participants were trained in June 2012 in Maseno, Kenya. Funded by N2 Africa.
- Training on cyanide analysis and enzyme extraction: one member of staff from IITA and one from TFNC were trained 9-15 April 2012 at IITA-Ibadan, Nigeria.

Other major R4D training-related events

- IITA/Center of Evaluation for Global Action (CEGA) workshop brought together 30 participants for training on advanced tools in adoption and impact evaluation in January 2012 in Nairobi, Kenya.
- GIS Training course for staff of IITA and the Ministry of Food Security and Cooperatives (MAFC) held in Tanzania in October 2012.
- Launching of Partnership for Aflatoxin Control in Africa (PACA) at the Africa Union Commission, in October 2012 in Addis Ababa, Ethiopia. IITA is a member of the PACA Steering Committee.
- Five-day training of administration staff in Tanzania on online procurement and purchasing held at the IITA Eastern Africa Hub office in Mikocheni, Dar es Salaam, Tanzania.
- Global Cassava Partnership for 21st Century (GCP21) Conference in June 2012 in Kampala, Uganda. Scientists from the Hub presented papers and exhibited research posters. ITA also had a display at the conference.
- African Green Revolution Forum in Arusha, Tanzania in October 2012. One of IITA's staff served as a discussant in a panel session on cassava value addition; IITA also had an exhibition booth.
- Cassava transformation training workshop funded by USAID and held 6-7 November 2012 at IITA in Nairobi and on 8 November in Dar es Salaam.

Graduate and post-graduate studies

In 2012, 19 PhD and 26 MSc students from various academic institutions were carrying out their research work at the Hub under the supervision of IITA scientists. Nine have completed their degree programs during the year (listed below by research area):

Biotechnology and genetic improvement

- Jaindra, Nath Tripathi. MSc, University of Stellenbosch, South Africa. Thesis title: Genetic engineering of banana and plantain for resistance to bacterial wilt disease. Supervisor: Dr Jim Lorenzen.
- Kimata, Bernadetha Pendamali. MSc, Egerton University, Kenya. Thesis title: Genetic linkage mapping of cassava brown streak disease. Supervisor: Dr Morag Ferguson.
- Nyine, Moses, MSc, Makerere University, Kampala, Uganda. Thesis title: Gene transcript analysis in drought stressed 'AAA' and 'ABB' bananas using next generation sequencing technologies. Supervisor: Dr Jim Lorenzen.
- Onyango, Stephen Odhiambo. MSc, Kenyatta University, Kenya. Thesis title: Nematode-resistant plantain for African subsistence growers. Supervisor: Dr Leena Tripathi.
- Tukahirwa, Benius. MSc, Makerere University, Kampala, Uganda. Thesis title: Characterizing Type III secretion system (TTSS) genes implicated in hypersensitive response (HR) induction and pathogenicity of *Xanthomonas campestris* pv. Musacearum. Supervisor: Dr Leena Tripathi.

Social science and agribusiness

- Zagabe, Roger. MSc, Egerton University, Kenya. Thesis title: Adoption and Impact of selected Banana technologies promoted by CIALCA. Supervisor: Dr Piet Van Asten.
- Masahi, Jofrey. PhD, Sokoine University of Agriculture (SUA), Tanzania. Thesis title: Ex-ante analysis of economic returns from biological control of coconut mite in Bénin and Nigeria: A market chain analysis. Supervisor: Dr Victor Manyong.

Plant production and health

- Karangwa, Patrick. PhD, University of Stellenbosch, South Africa. Thesis title: Diversity, Distribution and Management of *Fusarium oxysporum* f.sp. cubense in East and Central Africa. Supervisor: Dr Fen Beed.
- Mbewe, Willard Kamowa. MSc, Chancellor College, Malawi. Thesis title: Epidemiology and characterization of cassava brown streak viruses in Malawi. Supervisor: Dr James Legg.

Publications

In 2012, our Hub-based scientists produced 74 publications including 53 papers in peer-reviewed journals (28 papers in Thomson and 25 in non-Thomson as books, book chapters, or conference papers). Some of the most notable peer-reviewed Thomson publications, categorized by research area, are as follows:

Biotechnology and genetic improvement

Kulembeka, H.P., Ferguson, M., Herselman, L., Kanju, E., Mkamilo, G., Masumba, E., Fregene, M., and Labuschagne, M. 2012. Diallel analysis of

field resistance to brown streak disease in cassava (*Manihot esculenta* Crantz) landraces from Tanzania. Euphytica, 13 June 2012. http://biblio.iita.org/index.php?page=publication&kind=single&ID=7820.

Roderick, H., Tripathi, L., Babirye, A., Wang, D., Tripathi, J.N., Urwin, P.E., and Atkinson, H.J. 2012. Generation of Transgenic Plantain (*Musa* spp.) with resistance to plant pathogenic nematodes. Molecular Plant Pathology, 13:842-851. DOI: 10.1111/J.1364-3703.2012.00792.X. http://biblio.iita.org/index.php?page=publication&kind=single&ID=7804.

Social science and agribusiness

Meenakshi, J., Banerji, A., Manyong, V., Tomlins, K., Mittal, N., and Hamukwala, P. 2012. Using a discrete choice experiment to elicit the demand for a nutritious food: willingness-to-pay for orange maize in rural Zambia. *Journal of Health Economics*, 31(1):62—71. http://biblio.iita.org/index.php?page=publication&kind=single&ID=7736.

Plant production and plant health

Abarshi, M.M., Mohammed, I., Jeremiah, S.C., Legg, J., Kumar, P.L., Hillocks, R.J., and Maruthi, M.N. 2012. Multiplex RT-PCR assays for the simultaneous detection of both RNA and DNA viruses infecting cassava and the common occurrence of mixed infections by two cassava brown streak viruses in East Africa. *Journal of Virological Methods*, 179:176-184. ISSN 0166-0934. http://biblio.iita.org/index.php?page=publication&kind=single&ID=7690.

Atim, M., Beed, F., Tusiime, G., Tripathi, L., and Van Asten, P. 2012. High potassium, calcium and nitrogen application reduce susceptibility to banana *Xanthomonas* wilt caused by *Xanthomonas campestris* pv. Musacearum. *Plant Disease*, pp 1 – 36. ISSN 0191-2917, 2012. http://biblio.iita.org/index.php?page=publication&kind=single&ID=7958.

Beed F., Dubois, T., and Markham, R. 2012. A Strategy for Banana Research and Development in Africa. *Scripta Horticulturae*, Number 12. ISSN 1813-9205. ISBN 978 90 6605 664 0. International Society for Horticultural Science (ISHS). 107 pages. http://www.actahort.org/chronica/pdf/sh_12.pdf; http://biblio.iita.org/index.php?page=publication&kind=single&ID=7761.

Bouwmeester, H., Heuvelink, G.B.M., Legg, J.P., and Stoorvogel, J.J. 2012. Comparison of disease patterns assessed by three independent surveys of cassava mosaic disease in Rwanda and Burundi. *Plant Pathology*, 61:399-412. http://biblio.iita.org/index.php?page=publication&kind=single&ID=7699.

Legg, J.P. 2012. Cassava diseases: ecology and control. In Encyclopedia of Pest Management. Taylor and Francis (Ed.), London, UK. DOI: 10.1081/E-EPM-120041170. http://biblio.iita.org/index.php?page=publication&kind=single&ID=8083.

Natural resource management

De Luca, F., Troccoli, A., Dunca, L.W., Subbotin, S.A., Waeyenberge, L., Coyne , D.L., Brentu, F.C., and Inserra, R.N. 2012. *Pratylenchus speijeri* n. sp., a new root-lesion nematode pest of plantain in West Africa. *Journal of Nematology*, 14:987-1004. http://biblio.iita.org/index.php?page=publication&kind=single&ID=8064.

Kagoda, F., Derera, J., Tongoona, P., Coyne, D.L., Talwana, H. 2011. Grain yield and heterosis of maize hybrids under nematode infested and nematicide-treated conditions. *Journal of Nematology*, 43:209-219. http://biblio.iita.org/index.php?page=publication&kind=single&ID=7829.

southern africa

From the **Regional Director**

Dr. David Chikoye
Director
Southern Africa Hub

The IITA Southern African Hub is relatively new, having been established barely three years ago. In this short period of time, the hub has rapidly grown from 8 scientists to 15 and more than 60 support staff. We have also expanded our geographical research coverage from just two major stations (Malawi and Mozambique) to six additional countries. We have enhanced our partnerships by signing formal agreements in new countries and with new partners. A distinctive characteristic of the Hub has been the ability to secure competitive funding from external donors to support our research and development activities. Today, we have a fully functional administrative and research Hub based in Lusaka, Zambia. I take this opportunity to thank all those who directly and indirectly contributed to this success and are still deeply committed to take our Hub to greater heights.

Our goal is to achieve greater food security and availability by intensifying and diversifying the maize-dominated cropping systems without compromising the natural resource base and to increase farmers' incomes by providing more marketing opportunities through value addition and enterprise development. Our scientists conduct research which is an integral part of six CGIAR Research Programs (CRPs): Maize; Grain Legumes; Roots, Tubers and Bananas; Agriculture and Health; Climate Change; and Markets, Institutions and Polices. We are implementing more than 10 research projects with an annual budget of approximately US$10 million. These projects represent a continuum from fundamental discoveries to adaptive research that applies findings to actual production, processing, marketing, and natural resource management. Our main research foci are in the areas of soybean and cassava breeding, agronomy, food safety, human nutrition, and socio-economics. We share our results through popular media, field days, workshops, seminars, and peer-reviewed publications.

We serve our main clientele – the small-scale producers and processors – by developing sustainable farming and food systems. The IITA Southern Africa team is driven by professionalism, sincerity, hard work, and teamwork to overcome challenges. Although faced with limited research facilities, we have been able to provide a favorable training environment for students, technicians, and scientists from local partners and national programs. We have also produced and distributed large quantities of breeder and foundation seeds, and developed crop management and processing technologies with the aim of benefitting millions of farmers in the region.

I assure our partners and investors that we will continue to actively engage with you to develop, introduce, and disseminate modern agricultural technologies for the best benefit of the region. I am confident that with your continued support and the dedication of our staff and stakeholders, we shall take IITA to new heights in the years to come and realize the Institute's vision of becoming ''the leading partner in finding solutions to hunger and poverty in Africa".

I hope that you find this annual hub report useful and informative, and thank you for your continued support of IITA Southern Africa.

Children of farmers walking amidst a lush soybean-maize demonstration field of the Zambia FtF R&D Program. Our work helps ensure a brighter and more food secure future of them. Photo by JT Oliver, IITA.

The Southern Africa Hub

at a glance

The need for a hub

Southern Africa, comprising of Angola, Botswana, Lesotho, Madagascar, Malawi, Mauritius, Mozambique, Namibia, Seychelles, South Africa, Swaziland, Zambia, and Zimbabwe is a region with significant unfulfilled agricultural potential. It has a population of more than 120 million people, with 40 to 80% being generally poor and food insecure except in South Africa and Botswana. The key agricultural research and development (R&D) challenges in the region include limited staff and institutional capacities, weak linkages between national agricultural research systems (NARS) and international agricultural research centers (IARCs), and poor linkages between technology generation and dissemination institutions and between technology generation and markets. There is also very little investment by member states in agriculture in general, and agricultural R&D in particular, despite the Dar Declaration mandating countries to earmark 10% of their annual GDPs for the development of the agriculture sector.

Except in South Africa, most NARS in the region are unable to independently meet their research needs and could benefit from stronger collaboration with IARCs. At a consultative workshop organized by the Centre for Coordination of Agricultural Research and Development for Southern Africa (CCARDESA) held on 20 October 2011 in Gaborone, Botswana, the CGIAR Consortium member centers were requested to play a key role in the formulation and implementation of regional research and develop priorities given their comparative advantage and the need to provide context for their work.

IITA and some of our sister CGIAR member centers have been working extensively in the region for a long time. IITA has operated and implemented over 1000 projects in 12 of the 14 countries in the region over the past 25 years, with most of the activities focusing on cassava, cowpea, and soybean value chains. We have also supplied maize germplasm to many national programs and private sector partners, as well as trained many scientists who have been integrated in national research programs. In most countries, IITA is (was) hosted by the respective Ministries of Agriculture but we also collaborate with many other national entities such as non-governmental organizations (NGOs), universities, and the private sector. Operating in 'a project mode' presents a number of challenges such as discipline isolation, pursing opportunistic research activities which at times do not fit in IITA's main agenda, lack of a clear exit strategy which often results in competition between IITA and national programs, and inadequate administrative support.

To resolve these challenges and to be able to work more efficiently with partners in the region for more effective research-for-development (R4D), IITA expanded its research presence in southern Africa by establishing a Regional Research and Administration Hub in Lusaka, Zambia. Our presence and work in the country is governed by a Memorandum of Understanding on Scientific and Technical Cooperation, Research and Training with the Government of the Republic of Zambia (GRZ) through the Ministry of Agriculture and Cooperatives. After several consultations, the GRZ officially classified IITA as an international organization with a duty and VAT-free status.

Our vision of success: a region primed for growth

Southern Africa is highly diverse in terms of incomes and development. South Africa and seven middle income countries (Angola, Botswana, Mauritius, Namibia, Seychelles, Swaziland and Zambia) together account for over 80% of the regions' total economic activity. Agriculture is the dominant sector in the region which over 70% of the total population depends on for food, income, and employment. The agricultural sector contributes approximately 19 to 36% to the GDP. More than 50% of

One of our project beneficiaries in the Eastern Province of Zambia. Our work in the region is geared towards providing smallholder farmers options and alternatives to improve their livelihoods and enhance their food security. Photo by JT Oliver, IITA.

agricultural land (42 million ha) is allocated to cereal production with maize alone accounting for over 40% (33 million ha cultivated by 155 million people). The region can be divided into four agro-ecologies: 1) humid zone mostly found in Madagascar with LGP > 240 days; 2) sub-humid (wet savanna) zone covering northern Angola, Zambia, Malawi, Madagascar, and Mozambique with 150 to 240 days; 3) semi-arid (dry savanna) zone in the southern part of Angola, Zambia, Zimbabwe, Mozambique and South Africa with 60 to 150 days; and 4) Arid zone (drylands) covering the desert areas of Botswana, Namibia and Southern Africa with less than 60 days. IITA interventions are implemented in the sub-humid and semiarid zones, which dominates the region with respect to area (276 million ha) and population (276 million persons). Within these zones, the targeted farming systems is maize based (155 million people cultivating 33 million ha) and consists of cereal-root crop and maize-maized systems.

Key staple crops in the targeted farming systems are maize, cassava, sorghum and millet while key legumes include soybean, groundnut and cowpeas. Our countries of focus are Angola, Madagascar, Malawi, Mozambique, Zambia, and Zimbabwe.

Southern Africa is extremely vulnerable to high food prices and food insecurity, despite competitive advantages such as abundant agricultural land and a generally favorable climate. A large proportion of its population is still based in rural areas. The prevalent land cultivation methods being practiced by farmers tend to be destructive and unsustainable, such as burning of crop residues and monocropping. Additionally, global agricultural trade regimes tend to lock the region into its current status. There are alarming socio-economic implications regarding these issues, which threaten to aggravate pervasive poverty and the lack of human development that characterize the region. The issues around food security and agriculture in Southern Africa are dynamic, complex, uncertain, and difficult to address.

Our human assets: responding to the agricultural R&D challenges of the region

Our work of addressing the agricultural R&D issues of Southern Africa is led by our complement of 15 multi-disciplinary scientists whose areas of expertise range from biotechnology and genetic improvement (2 scientists) to plant production and health (5 scientists), natural resource

Himonga Mugubo, MIRACLE Project Officer, addressing a query by a farmer on growing maize. Photo by JT Oliver, IITA.

management (1 scientist), social science, and agribusiness (3 scientists). Two scientists (nutritionist and food technologist) work across the four disciplines, while three staff are research support (1 communication officer and 2 research managers). Our scientists are also involved in the following CRPs: HumidTropics; Policies, Institutions and Markets; Maize; Roots, Tubers, and Bananas; Grain Legumes; Agriculture for Nutrition and Health; and Water and Land Ecosystems. They are backstopped by more than 60 support staff spread across our major locations in Zambia, Malawi, Mozambique, and Swaziland.

Our partners

Our research-for-development (R4D) interventions in Southern Africa focus on introducing modern technologies that intensify farming and enhance productivity while reducing producer and consumer risks and protecting the natural resource base. At the same time, our sustainable approaches are also characterized by the importance placed on social issues such as HIV/AIDS, health and nutrition, community involvement, local capacity development, inclusion and empowerment of disadvantaged groups particularly women, gender equity, and protection of local societies. We carry out these initiatives primarily with key national and regional partners for complementarity and sustainability.

In 2012, we worked with six advanced research institutions: Laval University in Canada, Michigan State University in the US, University of Belgium/UTH in Belgium, Wageningen University in the Netherlands, University of Gent in Belgium, and the University of Londrina in Brazil; eight national research institutions: Department of Agricultural Research Services, Malawi; Zambia Agricultural Research Institute (ZARI), National Cereals Research Institute (NCRI) - Nigeria, National Institute for Scientifc and Industrial Scientific Research (NISIR) - Zambia; Golden Valley Research Trust, Seed Certification Control Institute (SCCI) - Zambia; and the *Instituto de Investigaçao Agraria de Mozambique*; and six African-based institutions if higher learning: Universities of Tshwane, Pretoria, Zambia, Kwazulu Natal, Lilongwe, and Unilurio. Research areas that we collectively work on include Asian rust characterization, biological nitrogen fixation, agronomy, breeding for quality traits in soybean, and socio-economics, as well as the CRPs on HumidTropics; Policies, Institutions and Markets; Maize; Roots, Tubers, and Bananas; Grain Legumes; Agriculture for Nutrition and Health; Water, Land, Ecosystems; Climate Change; and Genebank.

Kennedy Kanenga, Manager of Msekera Research Station of ZARI, explaining to an IITA delegation about the collaborative research being conducted there. Photo by JT Oliver, IITA.

We also partnered with a number of organizations and institutions for outreach and technology testing and dissemination such as World Vision, the Department of Agricultural Extension Services (DAES), Concern Universal, Agro-Dealer Input Association of Malawi, Catholic Relief Services (CRS), National Association of Small-Scale Farmers of Malawi (NASFAM), Total Land Care, Department of Agriculture - Zambia, IKURU, OLIPA-ODES, and the Consultative League of USA (CLUSA), among many others.

We collaborated with five international agricultural research centers: International Maize and Wheat Research Center (CIMMYT), International Potato Center (CIP), the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), International Center for Tropical Agriculture (CIAT), and the World Vegetable Center (AVRDC).

Our projects in Southern Africa

During the year, eight R4D projects were being implemented by IITA in the region with a combined budget of more than US$17 million. These projects encompass a wide spectrum of research themes ranging from socio-economics and agribusiness to agronomy and crop value chains. These major projects are:

- *Making Agricultural Innovations Work for People Affected by HIV/AIDS in Southern Africa (MIRACLE)* – Principal Investigator (PI): Ms Melba Davis-Mussagy. Budget: US$3.3 million. Duration: 2010-2013. Donor: Swedish International Development Agency (SIDA). Target countries: Zambia, Malawi, Mozambique, and Swaziland.
- *Zambia Feed-the-Future Research and Development Program.* Sustainable Intensification of Maize and Legume Systems in the Eastern Province of Zambia (SIMLEZA) component project – PI: Dr David Chikoye; Budget: US$450,000; Mitigating Cassava Disease Threats component project – PI: Dr Pheneas Ntawuruhunga; Budget: US$329,000; Aflatoxin Mitigation component project – PI: Dr Thomas Dubois; Budget: US$334,000. Program Coordinator: Naomi Kamanga. Duration: 2011-2015. Donor: USAID/ Feed-the-Future Initiative. Target country: Zambia.
- *Improving the Livelihoods of Smallholder Farmers in Drought-Prone Areas of Sub-Saharan Africa and South Asia through Enhanced Grain Legume Production and Productivity, Tropical Legumes Phase 2 (TL II) project* – PI: Dr Boukar Ousmane. Budget: US$4.5 million. Duration: 2011-2015. Donor: Bill & Melinda Gates Foundation. Target countries: Malawi, Mozambique, Tanzania, Nigeria, Mali, Niger, Burkina Faso.
- *Integration of Small-Scale Farmers into the Market Economy through Soybean Value Chains in Malawi and Mozambique* – PI: Dr Penina Muoki. Budget: US$1.8 million. Duration: 2011-2015. Donor: Common Fund for Commodities (CFC). Target countries: Malawi and Mozambique.
- *Strengthening Partnerships for Innovation in Beans, Groundnuts, and Sesame Research and Technology Transfer in Northern Mozambique* – PI: Dr Steve Boahen. Budget: US$300,000. Duration: 2012. Donor: USAID. Target country: Mozambique.
- *Public-private Partnership for Innovation in Soybean and Cowpea Value Chains in Mozambique* – PI: Dr Steve Boahen. Budget: US$300,000. Duration: 2012. Donor: USAID. Target country: Mozambique.
- *Small-Scale Cassava Processing and Vertical Integration of the Cassava sub-sector in Southern and Eastern Africa* – PI: Dr Adebayo Abass. Budget: US$2.3 million. Duration: 2009-2013. Donor: CFC. Target countries: Tanzania, Madagascar, and Zambia.
- *Putting Nitrogen Fixation to Work for Smallholder Farmers in Africa (N2Africa)* – PIs: Dr Anne Turner and Dr Steve Boahen. Budget: US$6.4 million. Duration: 2009-2013. Donors: Bill & Melinda Gates Foundation and Howard G Buffet Foundation. Target countries: Democratic Republic of Congo, Ghana, Kenya, Malawi, Mozambique, Nigeria, Rwanda, Zimbabwe, Ethiopia, Uganda, Tanzania, Liberia, and Sierra Leone.

A woman farmer participating in the Zambia FtF R&D Program explaining to project implementers and donor representatives about activities in her farm relating to conservation agriculture, a concept being espoused by the project. Photo by JT Oliver, IITA.

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The Southern Africa Hub premises in Lusaka, Zambia. Photos by JT Oliver, IITA.

IITA project staff and staff from the local agriculture extension office during a participatory appraisal exercise with project farmers in Chipata, Zambia. Photo by JT Oliver, IITA.

Research Highlights

In Zambia: aflatoxins no more!

Thomas Dubois

Zambian farmers are in high spirits as IITA and partners develop and distribute aflasafe™ that is tailor-made for the country, giving hope of crops that are safe from deadly aflatoxins.

In mid-January 2013, maize farmers in the Eastern Province of Zambia started receiving the first-ever batch of the Zambian aflasafe™ that is now being applied in their fields. This marks the first official field application of the biocontrol product in the country and comes only a year after researchers from IITA, ZARI, and NISIR began work to identify the best atoxigenic – or non-poison forming – strains of the Aspergillus flavus fungi. The product was developed under the "Aflatoxin Mitigation Project" component of the Zambia Feed-the-Future Research and Development Program.

Over a course of 12 months starting in January 2012, researchers from IITA and the Agricultural Research Service of the United States Department of Agriculture (USDA-ARS) selected eight unique and naturally-occurring atoxigenic strains from over 3000 Zambian fungi initially gathered from various regions of the country. These strains do not possess the genetic machinery to produce aflatoxins, are unrelated to aflatoxin-producing fungi, and are highly competitive. From these eight strains, four were finally selected after exhaustive on-farm and on-station evaluations and used to develop the aflasafe™ that is now being deployed in Zambian fields.

Belita Kayumba, the first farmer to receive and apply aflasafe™ in Zambia, said, "We know that some of the crops we produce are not safe to eat, but what can I do when my children say that they are very hungry? We just take our chances".

But now with aflasafe™ here in my field I am sure that my children will finally be safe and healthy!" she said excitedly.

Dr Thomas Dubois, the IITA scientist who led the research to develop aflasafe™ for Zambia, said, "In a couple of months, after harvest, she and other farmers like her will know how good aflasafe™ is in reducing aflatoxins in their crops and in their food.

The use of aflasafe™ reduces aflatoxins during crop development, in postharvest storage, and throughout the value chain. Based on our experience in West Africa, we estimate that aflatoxin levels in fields treated with aflasafe™ will be reduced by 80 to 90 %, he added.

The ZARI-IITA team with Mrs Belita Kayumba (middle, in green skirt), a maize farmer, as she happily receives her batch of aflasafe as part of the first widescale field application of the aflatoxin biocontrol product in Zambia. Photo by ZARI.

Maize and groundnuts—two of Zambia's most important cash and food security crops—are prone to aflatoxin contamination. This is a major concern as it negatively affects the health of humans and domesticated animals, causing stunting in children and cancer. Aflatoxin contamination also hampers international trade and economic growth as it prevents affected export commodities from meeting stringent trade and food safety standards.

Worse still is the fact that rejected contaminated produce is not usually destroyed but find its way into the domestic food chain, wreaking havoc on consumers.

The aflasafe™ Zambia journey: From the field to the lab and back again

In January 2012, IITA and ZARI scientists collected 267 samples of groundnut, maize, and soil for the identification of biocontrol candidates in the Central and Eastern Provinces of Zambia. To maximize chances of finding good biocontrol agents, samples were collected from as many sites in the provinces as possible. Some 3071 isolates were obtained from the samples using selective media.

Non-toxicity of isolates was established using qualitative and quantitative thin-layer chromatography (TLC). TLC separates the aflatoxins by molecular weight and polarity and, using a standard, these toxins can be identified as discrete bands under UV light. Two hundred and fifty-four isolates were found to be atoxigenic and further investigated for their biocontrol potential.

ZARI-IITA staff at the aflasafe production laboratory in ZARI's Mt Makulu Research Station storing bags of the biocontrol product prior to shipment to farmers. Photo by JT Oliver, IITA.

Starting June 2012, as the strains were being identified, samples were shipped under sterile conditions to the University of Arizona in Tucson, USA, for genetic analysis through single sequence repeats (SSR) and cluster amplification pattern (CAP). Through SSR and CAP, IITA researchers were able to identify 12 potential biocontrol candidate strains. Results from the competition assay showed great ability of all 12 strains to outcompete their toxigenic – or poison-forming – cousins. These atoxigenic candidate strains reduce aflatoxin production by more than 96% in competition assays, similar to the strains currently applied in farmers' fields in West and East Africa.

Prior to field release, Vegetative Compatibility Grouping (VCG) was done on the strains to ensure that they are widely distributed across all agro-ecological zones, implying they are well adapted to a good performance in Zambia, and that the biocontrol candidate strains are complemented with a large set of toxigenic strains from across Zambia. Only biocontrol candidates that do not complement with a single toxigenic strain would be retained. Eventually, four candidate biocontrol strains were found to complement with toxic isolates and were eventually eliminated from the selection of strains for further testing.

In December 2012, the eight remaining biocontrol strains (01MS-6, 01MS-9, 17MS-3, 38MS-3, 46MS-2, 47MS-12, 64MS-3, and 110MS-5) were selected for field testing. Six out of the eight strains came from the Central Province. IITA researchers mass-produced inoculum from the eight strains at IITA-Ibadan. For each strain, a spore suspension was suspended in a polymer and a blue dye. The mixture was then inoculated onto clean "dead" sorghum grains. About 125 kg of inoculum was produced for each strain, which were then carefully packed, labeled, and shipped to Zambia for field testing and evaluation.

Testing the prototype under Zambian field conditions

In October and November 2012, a team from IITA and ZARI-Mount Makulu Station identified and gathered a number of Zambian farmers, government staff, and extension workers with the aim of field testing two prototype aflatoxin biocontrol products. Each prototype bicontrol product consisted of four of the identified candidate strains.

IITA and ZARI researchers devised a design for testing the strains in Zambia in which the strains were applied on 80 maize and groundnut fields of about 1 ha each in the Central and Eastern Provinces. Each of the application sites was paired with a control field for comparison. In total, 160 fields were incorporated in the first field testing of the two prototype aflatoxin biocontrol products.

After harvest, the best four strains were identified based on their performance. These strains eventually became aflasafe™-Zambia; the very first batch was distributed to farmers in January 2013. We recommended that farmers apply aflasafe™-Zambia 30 to 40 days after planting and at a rate of 10 kg/ha for optimum efficacy.

Building local capacities for sustainability

During the development of the biocontrol product, the Zambia FtF R&D Program provided funds to the national partner ZARI to refurbish and upgrade a laboratory at its Mt Makulu Station in Lusaka, the country's capital, to serve as the focal point for biocontrol work in Zambia. The laboratory has been provided with modern facilities and equipment, such as autoclaves, laminar flow hoods, microscopes, water purification system, freezers, refrigerators, and incubators for toxin extraction, sterile work, and actual production of aflasafe™. The laboratory became fully operational in December 2012.

The program also facilitated the intensive training of one ZARI staff and one ZARI-based IITA staff for six months in 2012 at IITA-Ibadan in the production of aflasafe™. Together with an IITA field technician, this team now operates the aflasafe™-Zambia laboratory and production facility at Mt Makulu Station.

Stemming an invasion of cassava diseases

Pheneas Ntawuruhunga

The Cassava Mosaic Disease (CMD) is one of the most devastating diseases of cassava – a vital staple and cash crop in many African countries. The disease is known to be well-established in many countries in East and Central Africa; luckily, it has not yet fully reared its ugly head in Southern Africa. However as the disease slowly creeps southwards, we are finding ways to stem this slow invasion into Zambia.

During the year, the *Mitigating Cassava Disease Threats for Improved Cassava Production* component of the Zambia Feed-the-Future Research and Development Program conducted an extensive diagnostic survey in the Western, Northern, Eastern, and Luapula Provinces to get a general picture of the CMD situation in these cassava-growing areas. Although the surveys indicated that symptoms of the disease were mild, our researchers detected two distinct viruses: the Africa Cassava Mosaic Virus (ACMV) and the East Africa Cassava Mosaic Virus (EACMV). Of the two, ACMV was found to be more widely distributed than EACMV. On the other hand, we did not find symptoms of the Cassava Brown Streak Disease (CBSD) in the areas surveyed; neither did we detect the cassava brown streak virus in the plant samples gathered from the sites.

Dr Pheneas Ntawuruhunga, IITA Cassava Breeder based in Malawi, supervising the harvesting of cassava from one of the PVS trial plots in Luapula Province, Zambia. Photo by JT Oliver, IITA.

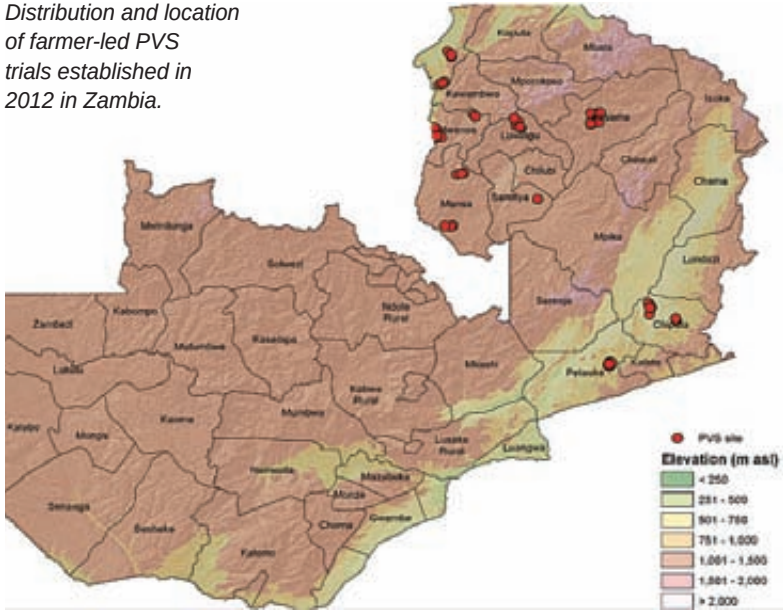
Though there were no significant differences in severity of CMD across provinces, Luapula Province – the major cassava-producing area in Zambia – had the highest disease incidence (59.6%), while the Eastern Province had the lowest (27.9%). This finding has an implication on the spread of the disease as farmer to farmer is the predominant way of exchanging planting material. Results of this survey will guide us and other researchers on where to bring and intensively multiply clean cassava planting materials.

In support of breeding CMD-resistant varieties, researchers selected three new clones from the uniform yield trials (UYT) conducted at ZARI's Msekera Research Station in Chipata in the Eastern Province of Zambia (Table 1). These best performing genotypes (TME 579, 94/0026, and 94/0039) were identified as candidates for further testing under farmer-led participatory variety selection (PVS) in 2013.

TABLE 1. Performance of cassava clones of Uniform Yield Trial (UYT) at ZARI's Msekera Research Station in 2012.

Clone	Fresh root yield (t/ha)	DM (%)	CMD incidence (%)	CMD severity
TME 579	17.76	34.57	0.0b	1.0
94/0026	17.59	34.43	13.3 ab	1.3
Mweru	16.99	33.64	0.0 b	1.0
94/0039	16.39	39.18	0.0 b	1.0
Manyopola	15.77	37.29	35 a	1.7
TME 434	13.25	37.16	42 a	2.0
TME 435	11.25	29.66	0.0 b	1.0
Mean	15.61	35.29	13.0	1.3
LSD	4.778	5.705	19.72	0.52
p<0.05	0.119	0.077	0.001	0.005

PVS trials allow farmers to test in their own fields the different CMD-resistant and high-yielding varieties under diverse socio-economic and local agro-ecological conditions. During the year, the project established 57 PVS trials in Luapula, and in the Northern and Eastern Provinces. Our researchers continuously monitor these PVS trials in partnership with the participating farmers. We started evaluating the PVS trials in December 2012, or one year after planting.



Distribution and location of farmer-led PVS trials established in 2012 in Zambia.

Through the project, we initiated the review and modification of the country's Cassava Seed Standards to make them more practical and relevant. The goal is to establish a decentralized and sustainable seed system in Zambia that will minimize – if not entirely eliminate – the spread of cassava diseases through the safe exchange of high-quality

clean cassava planting material. The standards have been integrated in the National Seed Regulation which has been submitted to the Ministry of Justice for enactment.

To ensure that there is adequate local capacity to combat cassava diseases, we organized several training activities for more than 100 technicians and extension staff of partner institutions such as ZARI, SCCI, the University of Zambia (UNZA), local NGOs, and farmers' groups in the areas of agronomy, seed quality control, PVS approaches and methodologies, and tissue culture production and virus indexing.

To complement capacity building activities, the project also provided funds to ZARI to upgrade the tissue culture laboratory located at its Mt Makulu Research Station. This included the procurement and installation of a gel documentation system and other vital lab equipment. Cassava tissue cultures have also been cleaned, indexed, and produced in preparation for distribution to seed multipliers across the country. The laboratory upgrade has also expedited the exchange of germplasm from Zambia to IITA's station in Tanzania for screening under conditions of high CBSD pressure.

Some of the recently acquired equipment for the tissue culture laboratory at ZARI's Mt Makulu Research Station in Zambia.

A Southern MIRACLE

Arega Alene, Isabel Madzorera, Therese Gondwe, and Melba Davis-Mussagy

In an effort to unleash the potential of agriculture and agricultural research to achieve health and nutritional outcomes in Africa, we are implementing with partners in the region a multi-country and multi-year project entitled *Making Agricultural Innovations Work for Smallholder Farmers Affected by HIV and AIDS in Southern Africa* (MIRACLE) in identified HIV/AIDS hotspots in Malawi, Mozambique, Swaziland, and Zambia.

The priority action sites are those where research and development partners already have ongoing activities, such as the provision of anti-retroviral drugs (ARVs), and the implementation of nutrition or agriculture-based interventions. MIRACLE adds value to these existing initiatives by improving linkages among agriculture, nutrition, and health. Its goal is to improve the health and nutritional status, food security, and income of people affected by HIV and AIDS in the target countries through the production, consumption, and marketing of nutritious crops by advocating supportive agricultural and health policies and by strengthening the capacity of key stakeholders engaged in agricultural activities.

One of MIRACLE's key objectives is the improvement of the health and nutrition of people affected by HIV/AIDS through the promotion of nutritious crops both for home consumption and for selling. Photo by JT Oliver, IITA.

Better understanding = better interventions

To develop suitable and effective interventions, MIRACLE conducted a baseline survey of beneficiary households across the four participating countries to identify constraints to production, marketing, and technology adoption. More than 600 farm households were surveyed in each participating country.

The results of the survey provided a clearer picture of the livelihood status of the target communities and guided our researchers in developing appropriate strategies in the areas of agricultural research and institutional innovations. It also helped us to identify already existing complementary initiatives and formed the basis for assessing progress and initial outcomes of the MIRACLE project.

MIRACLE beneficiaries in Swaziland (L) and in Malawi (R) with their maize and cowpea harvests from improved seeds provided by the project. Photos by JT Oliver, IITA.

For example, the study indicated that a substantial number of the sampled households affected by HIV/AIDS are headed by widows, the highest number, almost half the households surveyed, being in Zambia. A good number of households also keep HIV/AIDS orphans, particularly in Mozambique, Swaziland, and Zambia. This implies that interventions that center on women and geared towards children would be most effective in these countries.

In terms of cultivated land, the average size for beneficiary households is between 1 and 2 ha – from 1.2 ha in Swaziland and 1.5 ha in Malawi to nearly 2 ha in Mozambique and Zambia. This finding has implications on the type of production technologies that could be effectively deployed, as well as the level of farm intensification and diversification that could be achieved in these small landholdings.

We found that maize is the dominant food crop cultivated by over 90% of the sampled households and accounts for some 40% of the cultivated land. The other common major food crops identified are cassava, cowpea, and soybean. In Zambia, cassava ranks as the second most important food crop in the target communities and is cultivated by 9 out of every 10 sampled households. Soybean, on the other hand, is emerging as a major cash crop in Malawi and Mozambique. In both countries, over 80% of the surveyed households produced and sold soybean to earn cash. This finding holds promise for the introduction of high-value products based on the crops commonly grown in the communities and opens up opportunities for additional income streams and food alternatives for the households.

A woman farmer with 'Opatampa', a maize variety being promoted by MIRACLE that has double the protein content of other local varieties in Zambia. Photo by JT Oliver, IITA.

Although a majority of the sampled households produced maize, most of them also still bought maize from the market to supplement what they had. This means that the households consumed more maize than they could produce, thereby offering opportunities for introducing technologies that could increase their production of the grain crop to meet their domestic needs and, if possible, still produce a surplus to sell for additional income.

Most of the households in the participating countries sell crops at the farm gate. However, producer prices at the time of harvest are generally two to three times lower than prices at the time of planting. As a result, farmers receive a lower share of the final price paid by consumers. Knowing this, MIRACLE could then introduce technologies that would enable farmers to produce crops off-season or use effective post-harvest and storage techniques that would enable them to keep their produce and sell at a time when prices are more favorable.

Farmers in the surveyed sites indicated that they preferred cowpea and maize varieties that mature early and are tolerant to drought. They also said that they wanted cassava varieties with better taste and root size, sweet potato with better taste and color, and soybean with higher yields and bigger grains. This finding already makes clear the characteristics of the varieties that could be introduced in the target communities.

Adoption rates of improved crop varieties varied widely in the participating countries. In Malawi, Swaziland, and Zambia, adoption rates for improved maize were over 70% but only 20% in Mozambique. For improved cowpea, adoption rates ranged from 5 to 15% in Malawi, Zambia, and Mozambique but over 45% in Swaziland. Adoption of improved cassava ranged from less than 10% in Swaziland and between 10 and 15% in Mozambique and Zambia to some 20% in Malawi. Adoption of improved soybean ranged from less than 5% in Swaziland and Zambia to over 20% in Malawi and Mozambique. These variations in adoption rates can be used by our researchers to determine the most effective way of increasing awareness about the advantages of these improved varieties among the target population and encourage the adoption of improved crops where the rates are low. This, in turn, could result in a corresponding increase in the productivity of the major cash and food security crops in the participating countries.

Farmers cited the lack of access to improved seeds and planting material as the major reason for not adopting improved varieties of cowpea, soybean, cassava, and sweet potato. However, for improved maize, farmers cited the lack of access to capital as the main reason for non-adoption. These findings present opportunities for MIRACLE to introduce interventions to establish and improve the seed distribution systems for legume and root crop-producing areas of

(Top) A MIRACLE farmer in his vegetable field in Swaziland. (Bottom) Project staff in Mozambique during a survey to establish baseline data in the sites. Photos by JT Oliver, IITA.

As an intervention, MIRACLE also raises awareness about the causes, effects, and ways of preventing HIV/AIDS among its target beneficiaries. Photo by JT Oliver, IITA.

the project. For the maize-producing communities, the project could link up farmers with relevant public and private sector entities who could extend affordable microcredit for seeds and other farm inputs.

High levels of poverty and food insecurity characterize the target households in the MIRACLE project areas affected by HIV/AIDS. Results showed that some 66% of the households in Malawi and over 35% in Mozambique, Swaziland, and Zambia live on less than US$1.25 per capita per day. Furthermore, a self-assessment of the state of food insecurity among the target households based on the availability of, and access to, enough food throughout the year revealed high levels of perceived food insecurity, ranging from some 35% in Malawi to over 55% in Mozambique and Zambia and more than 75% in Swaziland. This finding reinforces the need for a multi-pronged strategy to address both poverty and food insecurity in the target areas, such as that being espoused by MIRACLE. It also presents the need to introduce crops that address the issues of food security and nutrition for household-level production and consumption.

Innovation Platforms: harnessing partnerships for development

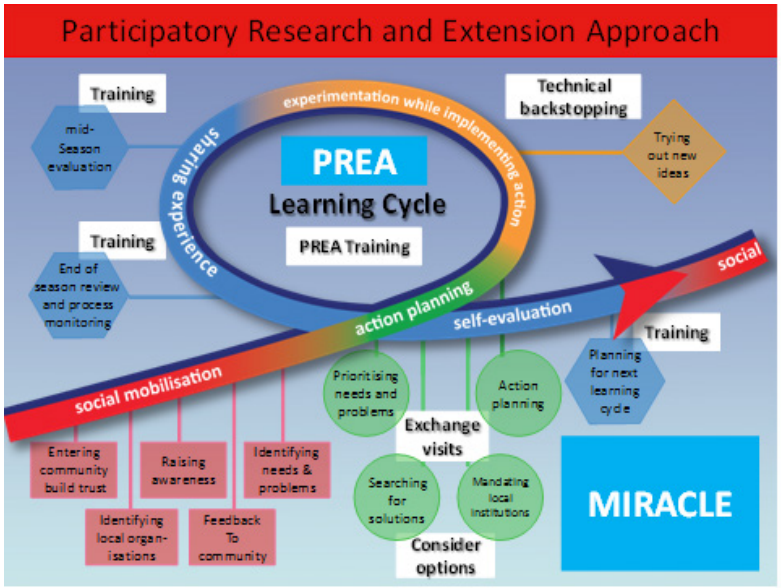
Since its inception, the MIRACLE project has promoted the use of an innovative approach to build and strengthen partners' capacities in its operational countries. In this approach – called the "Innovation Platforms" (IPs) – stakeholders from local communities, research, extension, NGOs, and the private sector who share a common developmental vision come together to interact, prioritize issues, identify challenges and opportunities, and share experiences to help people affected by HIV/AIDS to improve their plight.

Under MIRACLE, IPs provide a springboard for building functional linkages between entities focused on HIV/AIDS, agriculture, nutrition, and community health R4D. IPs are started with the conduct of a series of community workshops involving these entities, which provide a forum for multi-stakeholder interactions. These grassroots IPs help to develop a sense of local ownership among the project's beneficiaries and partners and create an environment conducive to sustain MIRACLE'S interventions. For example in Zambia, Camp Agricultural Committees (CACs) comprised of indigenous leaders, local extension officers, and community-based organizations (CBOs) were identified as the nucleus for operational-level IPs, with district-level stakeholder panels or development committees providing guidance.

To be more effective, grassroots IPs make use of another MIRACLE-introduced approach called "Participatory Research and Extension Approach" or PREA. This emphasizes a "bottom-up" approach with a focus on locally defined priorities and local perspectives. It involves a four-stage learning cycle: social mobilization, action planning, implementation, and lesson learning.

The success of the community-level IP led to the formation of

A community-level IP meeting in Mumbwa District, Zambia. Photo by JT Oliver, IITA.



The PREA Learning Cycle.

higher (district and even national) level IPs in MIRACLE's participating countries that follow the same principles and approach. The project initiated steps to form strategic-level IPs by convening representatives of the Ministries of Agriculture, NARES, HIV/AIDs support groups, microfinance institutions, food and nutrition councils, food processing companies NGOs, society leaders, and policymakers at roundtables in the respective countries..

It is important to note that higher-level IPs are expected to provide avenues for the creation of supporting government policies that will promote agriculture-based HIV/AIDS research initiatives. Such enabling policies, if and when in place, will complement and strengthen community-level IPs and help to ensure the adoption of MIRACLE's interventions on a wider scale.

At the social mobilization and action planning stage, meetings focus on identifying local CBOs willing to participate, and on selecting lead and secondary farmers based on agreed criteria among IPs. Research activities were based on a "Mother-Baby trial" approach designed to promote farmer-to-farmer extension. This is an approach in which farmers replicate in their own farms the technologies and protocols demonstrated on a larger scale in research stations or communal project farms. The idea is for farmers to test at a smaller scale and under local conditions the technologies being introduced by the project.

In the implementation and lesson learning stages, community members evaluate research activities implemented during the season, identify and prioritize common challenges, and assess how MIRACLE is addressing these at IP workshops. Utilizing both the researcher-managed and farmer-managed trials, IP workshops were conducted during the middle of the last cropping season (with crops still standing) as well as at the end of the cropping season (after crops have been harvested). Farmers also identified the preferred characteristics of new soybean and cowpea varieties promoted by the project, such as yield, tolerance to pests and diseases, taste of grain and leaves, labor requirements, market acceptability, and general profitability. Results of these meetings and workshops served as a basis for lesson

Dr David Chikoye looking over a cowpea-soybean 'Mother' trial site in Manza, Luapula Province in northern Zambia. Photo by JT Oliver, IITA.

learning, feedback to IPs and research and extension staff, and re-prioritization of activities for the next learning cycle.

In the future, MIRACLE will, through IPs, take steps to strengthen the capacity of participating CBOs and farmers through training in group dynamics, leadership, communication, and management practices associated with the promoted technologies.

Building a successful agro-enterprise

MIRACLE wants its beneficiaries to be self-sufficient – not only able to produce for their own needs but also to establish small-scale businesses to help others as well. However, encouraging farmers to do so is a daunting task. To achieve this, the project made effective use of "technology demonstrations" to entice potential adopters. Many farmers in the target communities hardly know some of the crops and crop varieties espoused by the project. To raise awareness about these crops and crop varieties, MIRACLE established demonstration trials – both researcher-managed and farmer-managed – in its four participating countries. These demonstration exposed farmers to various improved crop varieties, promoted the technical and economic benefits of improved varieties, and facilitated the selection of varieties preferred by farmers. Having seen the performance of the different varieties and learning about modern agronomic practices for optimum productivity, farmers quickly became interested. This resulted in an increase in demand for the showcased crop varieties by the end of the 2011-2012 cropping season. However, farmers were still unsure about the crops' marketability.

Attendees to a technology demo field day organized by MIRACLE listening to a women's group leader as she explains how they prepared dishes made from crops introduced by the project and that they are growing in their own backyards. Photo by JT Oliver, IITA.

To address this, MIRACLE embarked on broadening farmers' knowledge and skills on the use of soybean, cowpea, sweet potato, and cassava. The project conducted crop utilization training in all its participating communities by first training potential trainers, who were then sent to communities to train others. In areas where sweet potato and cassava are abundant, the project trained existing wheat flour users and producers in processing the two root crops with the intention of encouraging them to also go into the production of soybean, sweet potato, and cassava-based flour.

Before the training, many of the project's partners and beneficiaries were not aware of the wide variety of products that can be produced from these crops. After the training activities, farmers committed themselves to producing particularly soybean in addition to their main crop, usually maize. Some have even expressed plans to produce soybean-based products for sale in the communities.

MIRACLE also trained beneficiaries on conserving and processing indigenous vegetables such as amaranths and leaves of cowpea, sweet potato, pumpkin, cassava, blackjack, and moringa. Since these

vegetables are abundant only during the rainy season, the project also taught farmers how to preserve the vegetables so that they are always available for use and thus have affordable sources of important vitamins and minerals for the whole year.

To further ensure that farmers to adopt the technologies and venture into small-scale agribusiness, MIRACLE provided them with reliable market information such as potential buyers, their locations, commodities sought, product specifications, and prices. Through market studies and needs assessment, MIRACLE was able to identify products of high demand that suit the existing interest and farming systems in the project sites.

The market identification and assessment exercise, for example, identified a company in Zambia that has been struggling to meet its demand for dried indigenous vegetables as well as dried cassava chips. It partnered with IITA-Zambia to train groups of potential community-based entrepreneurs (to ensure standard product quality), and signed a supply-buy agreement initially with nine MIRACLE groups. The company has expressed willingness to extend the same agreement to groups in the other countries participating in the project.

The three stages described above: demonstration, capacity building, and provision of solid market information, were the key to MIRACLE's efforts to develop local-based agro-enterprises for increased farmers' income. Beneficiaries who have actually ventured into agribusiness have been given support by the project in terms of business management coaching, infrastructure, such as processing equipment and low-cost bulking centers, and provision of regular marketing advice.

Today, MIRACLE's farmer-beneficiaries are committed to producing the key commodities that are in high demand. As proof of the project's success in this area, four cassava processing centers that produce high quality cassava flour (HQCF), starch, and chips have been established; nine community groups have begun commercially processing indigenous vegetables for an identified market; and 11 commercial entities (bakers, restaurants, caterers, lodges) now have existing arrangements with MIRACLE beneficiaries to supply them with cassava and sweet potato produced in the communities.

After being trained on the mechanized production of high quality cassava flour, farmer-entrepreneur and MIRACLE beneficiary Mr Abrahan Lwando decided to set up his own cassava processing facility in the Mibenge Agricultural Camp in Mansa District, Luapula Province, northern Zambia. Photo by JT Oliver, IITA.

Mathias Tembo, an MSc student under the Zambia FtF R&D Program, doing cassava disease inoculation work in a screenhouse at ZARI's Mt Makulu Station. Photo by JT Oliver, IITA.

Capacity Building and **Publications**

Training workshops

N2Africa

In Malawi during the 2011/12 season, the project organized 20 training sessions for 2972 of its target beneficiaries, lead farmers, and extension staff. The training workshop covered a wide array of topics such as overview of the N2Africa Project, legume production practices, demonstration plot layout, the Lead Farmer Concept, business and marketing plan development, gross margin and production cost analysis, record-keeping, Training of Trainers (TOT) Plan for lead farmers, nitrogen, rhizobia and inoculants, legumes harvesting, post-harvest handling, aflatoxin control and management, participatory market research, collective marketing, microcredit and seed repayment, moisture content measurement, food nutrition and processing.

In preparation for the 2012/13 season, the project facilitated the training of 696 farmers and extension agents by the end of December 2012. Topics covered included overview of the N2Africa Project, farming business, the nitrogen cycle (nitrogen and rhizobia), legume production practices (bean, groundnut, soybean, and cowpea), establishing demonstration plots, crop inoculation, farm record-keeping, gross margin analysis in farming business, and the Lead Farmer Concept.

In Malawi, N2Africa also convened two workshops with national partners. The first, in April 2012, consisted of a review of the 2011/12 growing season's activities, constraints, and possible solutions. The second, in July 2012, reviewed the results of the 2011/2012 growing season (including implementation of the Field Evaluation Book) together with each partner's plans and expectations for the 2012/2013 growing season, which will attempt to reach 16,000 farmers through training, demonstration plots, and field days.

Zambia FtF R&D Program: Cassava Disease Mitigation Project

Under the project, 120 technicians and agricultural extension staff from partner organizations were trained in the following areas:

- PVS approaches and methodology: 47 extension officers from ZARI and the Ministry of Agriculture;
- Tissue culture production and virus indexing: 14 technicians from ZARI, SCCI, and UNZA;
- Seed quality production and control: 17 seed inspectors from SCCI;
- Agronomic practices and disease control: 23 technicians from ZARI; and
- Cassava pest and disease management, and managing the quality of planting materials through an improved cassava seed system: 19 crop husbandry and senior agricultural officers from the Ministry of Agriculture in the Northern and Eastern Provinces of Zambia.

The project also organized a farmers' field day in Mwense in the Northern Province of Zambia on 7 September 2012 to showcase the various technologies and improved cassava varieties that farmers are evaluating in the site. More than 45 farmers from adjacent communities and districts attended.

Partners' training on establishing cassava PVS trial plot. Photo by IITA.

MIRACLE

During the year, MIRACLE provided health and nutrition education through workshops on food processing and the utilization of legumes and other essential crops. Training manuals were developed together with the Ministry of Agriculture and Livestock in Zambia to guide the training workshops, and adjusted to fit local conditions in other countries. A total of 154 individuals from the Ministry of Health, the Ministry of Agriculture, CBOs, volunteers, and community members were trained as trainers. The TOT was facilitated by IITA staff and key partners in each country. After the TOT, MIRACLE provided the graduates with training kits and technical backstopping to conduct their own training in the project communities, from which more than 7700 community members benefitted. In addition, community food fairs combined with cooking demonstrations were also held in Zambia to showcase the products made by farmers from soybean, cowpea, orange-fleshed sweet potato, and traditional vegetables.

MIRACLE beneficiairies learning how to make soya biscuits. Photo by IITA.

The project also trained selected groups in Zambia on drying of traditional vegetables both for sale and home consumption. Fifteen individuals were trained as trainers who then conducted echo training in the participating communities where 300 project beneficiaries were trained. Although the project primarily promoted amaranths, pumpkin and sweet potato leaves for home consumption because of their high contents of vitamins A and E and minerals, the farmers were also trained and encouraged to include other traditional vegetables that grow in their communities, such as leaves of cowpea, cassava and blackjack, among others, since potential buyers are also highly interested in these vegetables in their dried forms.

Other capacity building activities

Upgrading of ZARI's tissue culture laboratory

Under the project Mitigating Cassava Disease Threats, the tissue culture laboratory at ZARI's Mt Makulu Station has been upgraded with the procurement and installation of a Gel Documentation System (Bio-Rad) at the station's pathology/biotechnology laboratory. The system has been calibrated and test runs have been performed to ensure smooth operations. Other equipment procured includes a thermo shaker, micro-pipettes, and PCR consumables.

The rehabilitation and equipment upgrade has enabled the laboratory to conduct detection and analysis of cassava mosaic disease virus types in plant samples. ZARI researchers have been able to identify two strains: ACMV and EACMV. It is now possible to clean and index planting materials, with tissue culture planting materials now being produced in the lab. The tissue culture protocol for cassava has been validated, and plants have been raised and shipped to IITA-Tanzania in December 2012 for CBSD evaluation under high disease pressure.

Additionally, the screenhouse at the station, where the tissue culture plantlets produced in the lab are transferred for acclimatization, has also been renovated.

Establishing a decentralized seed quality control system

Under the Zambia FtF R&D Program, a training workshop for seed inspectors of SCCI was held from 23 to 26 April 2012 in Lusaka (*see related section under "Training Workshops"*). During the workshop, strategies to improve the inspection protocol were also discussed, resulting in the

development of the proposed cassava field inspection standards for Zambia. The Cassava Seed Standards was also reviewed and modified to facilitate the establishment of a decentralized and sustainable seed system for the country.

These standards were tested in the field by select field officers to check their applicability. The observed challenges were presented to partners for consultation and validation. These have also has been integrated in the seed regulations which were submitted to the Ministry of Justice later in the year. A national stakeholders' meeting was held in November during which proposed changes to the Seed Law and regulations were presented and refined for submission to the Ministry of Justice in December.

Also, as an offshoot of the seed quality training workshop, the participants developed standards for routine monitoring and certification of the quality of cassava seeds. The standards have since been successfully tested in the Eastern, Central, and Lusaka Provinces of Zambia. Observations were made on some aspects of the standards which need to be further adjusted before nationwide deployment.

Graduate and post-graduate studies

In 2012, the hub hosted 12 MSc and two PhD students who were undertaking their research work supervised by scientists based in the region. Of these, two MSc students finished their degree programs during the year. Below is the list of graduate and post-graduate students hosted by the hub in 2012, grouped by research area.

Biotechnology and plant breeding

- Cheelo, Pride. MSc, University of Zambia. Thesis title: Genotype x Environment interaction and stability analysis for yield and other components in soybean (*Glycine max* L. Merril) in Zambia. Supervisor: Dr Hesham Agrama. Status: Ongoing.
- Guwela, Veronica. MSc, Bunda College, University of Malawi. Thesis title: Assessing the susceptibility, severity, and extend of yield loss of soybean (*Glycine max* L. Merill) genotypes caused by soybean rust (*Phakopsora pachyhrizi*) at Bvumbwe and Bunda in Malawi Supervisor: Dr Hailu Tefera. Status: Completed.
- Mbewe, Willard Kamowa. MSc, Chancellor College, Malawi. Thesis title: Distribution of Cassava Brown Streak Disease and characterization of Cassava Brown Streak Virus (*Potyviridae*: Ipomovirus) in Malawi Supervisor: Dr Pheneas Ntawuruhunga. Status: Completed.
- Muimui, Arnold Aibu. MSc, University of Zambia. Thesis title: Assessment of farmer's preferences on characteristics of cassava through Participatory Variety Selection (PVS) in Zambia Supervisor: Dr Pheneas Ntawuruhunga. Status: Ongoing.

Plant production and health management

- Chibeba, Amaral. PhD, State University of Londrina, Londrina, Brazil. Thesis title: Identification and characterization of effective rhizobia strains for enhanced N fixation in Mozambique Supervisor: Dr Steve Boahen. Status: Ongoing.
- Hacholi, Kaubi N. MSc, University of Zambia. Thesis title: Characterization of maize germplasm for resistance to *Striga* asiatica in southern Africa Supervisor: Dr David Chikoye. Status: Ongoing.
- Kachapulula, Paul. PhD, University of Arizona, USA. Thesis title: Aflatoxin contamination and aflatoxin-producing fungi related to Zambia Supervisor: Dr Thomas Dubois. Status: Ongoing.

- Muananamuale, Carlos Pedro. MSc, Tshwane University of Technology, Pretoria, South Africa. Thesis title: Interactive effects of nitrogen and phosphorus and inoculant on yield and yield components of soybean Supervisor: Dr Steve Boahen. Status: Ongoing.
- Mucavea, Mônea Lina Adelino. MSc, Bunda College, University of Malawi. Thesis title: Legume cropping systems – Intercropping soybean and groundnuts with maize Supervisor: Dr Steve Boahen. Status: Ongoing.
- Sualei, Fernando João. MSc, Bunda College of Agriculture, University of Malawi. Thesis title: Reaching legume farmers through effective and efficient dissemination strategies Supervisors: Dr Steve Boahen and Dr Anne Turner. Status: Ongoing.
- Tembo, Mathias. MSc, University of Zambia. Thesis title: Survey and molecular characterization of cassava mosaic geminiviruses and their effect on yield of cassava in Zambia Supervisor: Dr Pheneas Ntawuruhunga. Status: Ongoing.
- Ussene, Rachad. MSc, Tshwane University of Technology, Pretoria, South Africa. Thesis title: Evaluation of cowpea genotypes across several agroecologies of Mozambique Supervisor: Dr Steve Boahen. Status: Ongoing.

Natural resource management

- Siyeni, Donald. MSc, Bunda College of Agriculture, University of Malawi. Thesis title: Effect of rhizobium inoculation and phosphorous fertilizer on yield and nodulation of soybean in Dedza, Salima and Kasungu districts of Malawi Supervisor: Anne Turner. Status: Ongoing.
- Yohane, Esnart Nyirenda. MSc, Bunda College of Agriculture, University of Malawi. Thesis title: Assessment of the diversity of cowpea rhizobia in soils from different cropping systems in Central Malawi and evaluation of N-fixation of these strains together with their compatibility with improved cowpea genotypes Supervisor: Dr Anne Turner. Status: Ongoing.

Publications

Peer-reviewed Thomson

Plant protection and health management

Fontem, L.A. and Chikoye, D. 2012. Efficacy of herbicide formulations for weed control in maize in a humid tropical environment. JFAE, Volume 10: 1572-1574.

Peer-reviewed non-Thomson

Social science and agribusiness

Alene, A.D., Khataza, R., Ntawuruhunga, P., Mahungu, N.M., and Jumbo, S. 2012. Economic impacts of cassava improvement in Malawi and Zambia. In Proceedings of the 11th Triennial Symposium of the ISTRC-AB, Kinshasa, DRC, 4-8 October 2010. Okechukwu, R.U. and Ntawuruhunga, P. (Ed.). ISBN: 978-978-50368-9-3. Pp. 68-77. http://biblio.iita.org/index.php?page=publication&kind=single&ID=6979.

Biotechnology and plant breeding

Kanju, E., Ntawuruhunga, P., and Otim-Okello, F. 2012. Progress in screening cassava genotypes for resistance to cassava brown streak Uganda virus. 2012. In Tropical Roots and Tuber Crops and the Challenges of Globalization and Climate Changes. Proceedings

of the 11th Triennial Symposium of the ISTRC-AB, Kinshasa, DRC, 4-8 October 2010. Okechukwu, R.U. and Ntawuruhunga, P. (Ed.). ISBN: 978-978-50368-9-3. Pp. 125-128. http://biblio.iita.org/index.php?page=publication&kind=single&ID=7852.

Ntawuruhunga, P., James, B., Sanni, B., Sandifolo V., Tarawali G., Okechukwu R.U., and Abass, A. 2012. Inter-project linkages to create cassava enterprises for expanded markets and utilization. In Tropical Roots and Tuber Crops and the Challenges of Globalization and Climate Changes. Proceedings of the 11th Triennial Symposium of the ISTRC-AB, Kinshasa, DRC, 4-8 October 2010. Okechukwu, R.U. and Ntawuruhunga, P. (Ed.). ISBN: 978-978-50368-9-3. Pp. 344- 353. http://biblio.iita.org/index.php?page=publication&kind=single&ID=7865.

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Moyo, C.C., Jumbo, S., Mahungu, N.M., Benesi, I.R.M., Ntawuruhunga, P., and Sandifolo, V. 2012. Evaluation of commercially available herbicides for weed control in cassava. In Tropical Roots and Tuber Crops and the Challenges of Globalization and Climate Changes. Proceedings of the 11th Triennial Symposium of the ISTRC-AB, Kinshasa, DRC, 4-8 October 2010. Okechukwu, R.U. and Ntawuruhunga, P. (Ed.). ISBN: 978-978-50368-9-3. Pp. 269-274. http://biblio.iita.org/index.php?page=publication&kind=single&ID=7861.

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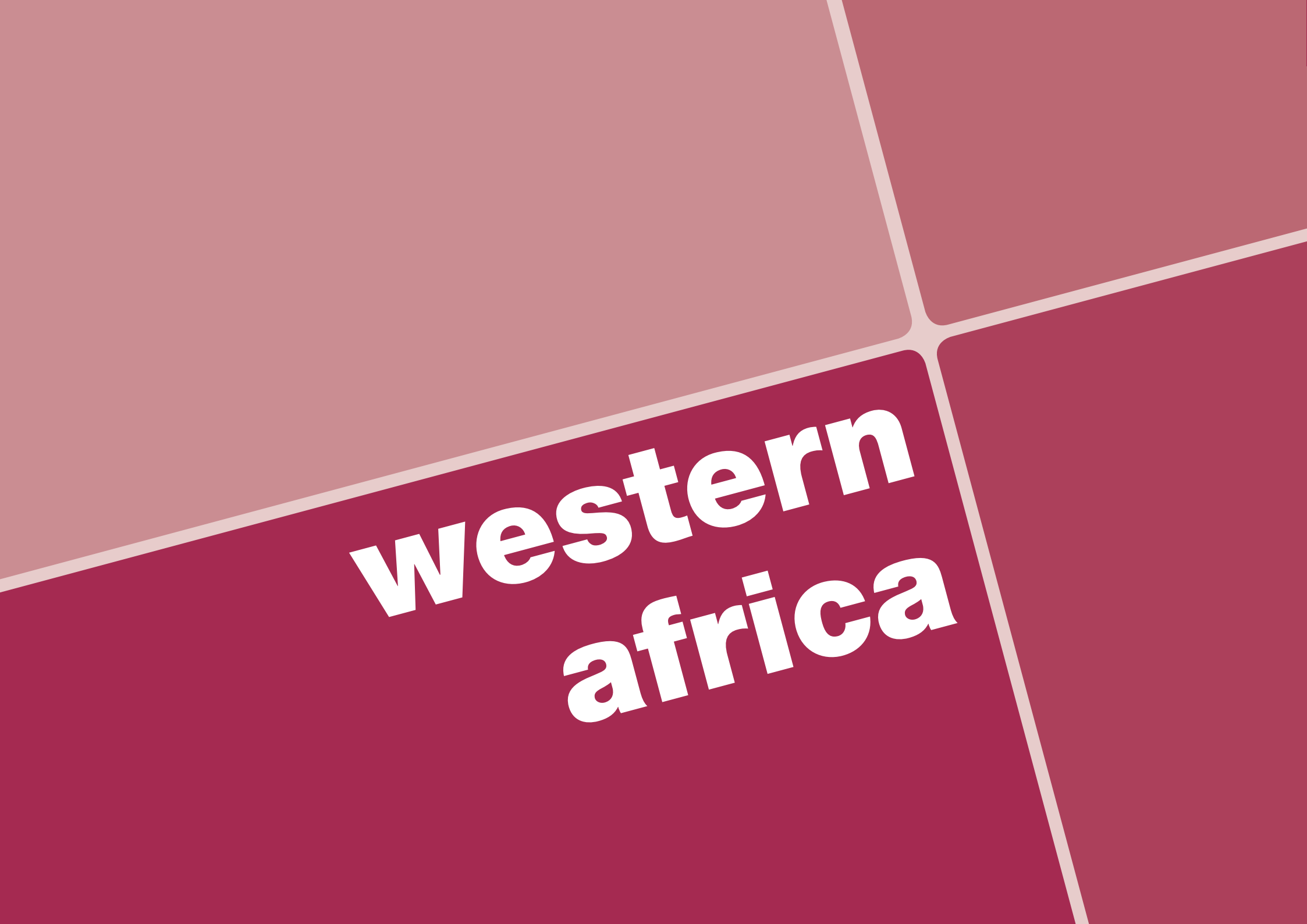
western
africa

From the Regional Director

Dr. Robert Asiedu
Director
Western Africa Hub

The West Africa Hub made significant progress during 2012 in the implementation of research-for-development (R4D) projects with a broad range of partners working towards the achievement of our principal objectives:

- Sustainable productivity growth and intensified production systems in the humid and sub-humid areas;
- More resilient agro-ecosystems, improved and less vulnerable livelihoods of rural communities;
- Enhanced and equitable agricultural innovation systems that link to policy and improve the impact of research and development investments; and
- Enhanced nutrition and food safety.

Ninety-two research projects were implemented wholly or in part in IITA-West Africa during the year. Of these 26 have life budgets above one million US dollars. The major development investors included the Bill and Melinda Gates Foundation (BMGF) (directly and through other agencies), the CGIAR Consortium, the US Agency for International Development (USAID), the Global Crop Diversity Trust (GCDT), the Nigeria Federal Ministry for Agriculture and Development, and the World Bank. Key examples include the project on Yam Improvement for Incomes and Food Security in West Africa (YIIFSWA,) funded by the BMGF and managed by Norbert Maroya, Drought Tolerant Maize for Africa (DTMA), funded through a sub-contract from the International Maize and Wheat Improvement Center (CIMMYT) and managed by Abebe Menkir, and Achieving sustainable *Striga* control for poor farmers in Africa, funded by the BMGF and managed by Mel Oluoch.

The search for additional resources continued. Of the 40 grant proposals and concept notes submitted to development investors during the year, 14 proposals were funded, five were not funded, and we are waiting for decisions on the others. One concept note was approved for development into a full proposal and several new concept notes and proposals were in the pipeline of development.

The releases of new varieties of cassava, maize, cowpea, and soybean by our partner institutions during the year continue to demonstrate the benefits of our collaborative efforts in genetic improvement. The released varieties included three drought tolerant and three pro-vitamin A varieties of maize. The local names given to the varieties at the time of release in Ghana portray their key characteristics or expectations of impact on the lives of their users. For instance the three Cowpea

varieties released were named Hewale meaning 'strength', Asomdwee meaning 'peace', and Videfuu which means 'profitable'.

IITA root crop scientists in West Africa collaborated with the Federal University of Agriculture, Abeokuta, Nigeria in hosting the 16th Symposium of the International Society for Tropical Root Crops (ISTRC), a global triennial event, 23-28, September. IITA research fellow T.F. Adaramola was awarded the Pat Coursey Prize for Yam Research for her paper Ploidy level, morphological traits, and metabolite profile of *Dioscorea dumetorum* to determine breeding strategy. I was also given a special award for contributions to yam research. The symposium was followed by a meeting of the Management Committee of the CGIAR Research Program (CRP) on Roots, Tubers, and Banana and a workshop on genomics at IITA-Ibadan.

Increased interaction of IITA scientists with policy makers at state and federal government levels in Nigeria led to formal agreements and funding for collaborative projects on maize, cassava, and soybean, especially in relation to the government's agenda for the transformation of agriculture.

It was a pleasure to receive the positive recommendation and constructive suggestions from an external review of IITA's work within our previous programs on Agrobiodiversity and Root and Tuber Systems, with a focus on activities in West Africa. This was part of the Monitoring of CGIAR Projects, co-funded by the European Commission in 2010. The panel's general assessment was: "Very valuable contribution to science, food security, and other development benefits with work focusing on under-researched species". Through relevant CRPs we are already addressing the panel's recommendations, for instance, to:

- enhance incorporation of gender issues in project design and implementation;
- expand our collection and management of plant genetic resources of wild relatives of our mandate crops;
- develop more measurable outcome indicators for efficiency and effectiveness of germplasm collection, conservation, and use; and
- promote the genebank contents more widely using diverse communication strategies and tools with a view to further increasing its utilization.

The increasing consolidation of our project activities in the central and northern parts of Ghana during the year is in line with, and supports, our focus on achieving very significant impact in this important agricultural zone of the country. Active in this zone during the year were three major projects funded by BMGF Drought Tolerant Maize for Africa (DTMA), Putting Nitrogen Fixation to Work for Smallholder Farmers in Africa (N2Africa), and Yam Improvement for Incomes and Food Security in West Africa (YIIFSWA) as well as Africa RISING, the USAID-funded project on the sustainable intensification of cereal-legume systems. Similarly, partnership arrangements and other plans were made for active work in Ghana of the projects on Tropical Legumes and Aflatoxin Management, both funded by the BMGF, as well as the maize systems

component of the Support to Agricultural Research for Development on Strategic Commodities in Africa (SARD-SC), a project funded by the African Development Bank (AfDB).

The maize systems component of the SARD-SC project will also be implemented in Nigeria; the cassava systems component will be implemented in Sierra Leone. The N2Africa project started in Sierra Leone and Liberia with initial focus on building partnerships through scoping missions and workshops. A senior root crop breeder was stationed in Sierra Leone under the West Africa Agricultural Productivity Program (WAAPP) with a focus on cassava systems. This program is funded by the World Bank under the auspices of the Economic Community of West African States (ECOWAS).

The recruitment of a Regional Administrator, Sylvia Oyinlola, late in the year was a most welcome addition to the Hub. Among other things, she will contribute to our systematic efforts to upgrade field and laboratory facilities in support of our research.

The IITA campus in Ibadan houses the institute's Headquarters as well as the Western Africa Hub office. Photo by JT Oliver, IITA.

The Western Africa Hub at a glance

The Guinea and Sudan savanna zones in the north of West Africa are characterized by sub-humid ecologies that rely annually on a single rainy season and a single growing period which does not generally exceed 225 days. IITA's target areas generally receive between 300 and 1200 mm of rainfall annually. The more southern humid forest zone receives ample rainfall (>1000 mm) and is characterized by the absence of long dry seasons. Rainfall is often spread over two rainy seasons per year and the length of the growing period generally exceeds 225 days (Fig. 1).

The key disciplinary groupings of the 64 scientists (63 full time equivalents - FTE) working for IITA in West Africa are Biotechnology & Crop Improvement (22 scientists), Social Science and Agribusiness (10), Natural Resource Management (6), and Plant Production & Health (22). Four scientists (e.g., the biometrician) work across these categories or bring unique skills, such as medical entomology.

Our scientists also are involved in the new CRPs such as: HumidTropics; Policies, Institutions and Markets; Maize; Roots, Tubers, & Bananas; Grain Legumes; Agriculture for Nutrition & Health; Water, Land, Ecosystems; Climate Change; and Genebank. Most contribute their disciplinary expertise and experience to two or three CRPs. This multiple membership enhances a broader understanding of the CRPs as well as the sharing or transfer of results from one CRP to others where they are needed.

IITA staff work in most countries of the sub-region from stations/offices in six countries: Bénin, Burkina Faso, Ghana, Liberia, Nigeria and Sierra Leone. Of the 50 IITA scientists in Nigeria, 47 are based at Ibadan station, which serves as the regional Hub, and 3 at the Kano station, with Alpha Kamara as Station Representative, where they are hosted by the Institute of Agricultural Research (IAR). Six of the scientists are based at the Cotonou station in Bénin Republic where Manuele Tamo

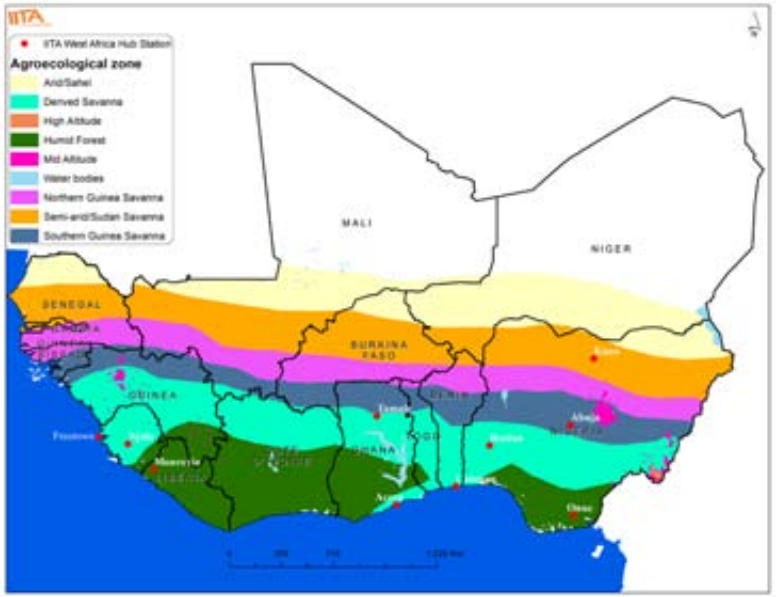

Figure 1. Agroecological map of West Africa.

is our Country Representative. In Ghana, two scientists are based in Accra -- one in Kumasi, and another, the Country Rrepresentative, Asamoah Larbi, is based in Tamale, where he is hosted by the Savannah Agricultural Research Institute (SARI). One scientist, Haruki Ishikawa, works for IITA from his base in Burkina Faso, while another, Amare Tegbaru, is based in in Monrovia, Liberia. In Sierra Leone, there are two IITA scientists: one based at the Njala Agricultural Research Center and the other at the headquarters of the Sierra Leone Agricultural Research Institute (SLARI) in Freetown. The distribution of nationally recruited technical, research staff working with these scientists are as follows: 157 in Nigeria, 21 in Bénin, 2 in Ghana, 4 in Sierra Leone, and 9 in Liberia. The administrative support team is led by the Regional Administrator, Sylvia Oyinlola, with 37 staff in Nigeria, 3 in Bénin, 9 in Ghana, 9 in Liberia, and 5 in Sierra Leone.

Our partners

Our research-for-development work is characterized by partnership with other research institutes (national, regional, and international), service providers and supporting organizations, such as extension agencies and NGOs, and value chain operators in the private sector, such as producers, processors, and traders. These partnerships are important for bringing together the necessary critical mass of skills, as well as the experience and knowledge to ensure delivery of research outcomes and significant demonstrable impact on the ground.

Partnerships with other Advanced Research Institutes (ARI) give IITA access to additional skills, experience, materials, and facilities which enhance the efficiency of our research efforts while we also contribute to international efforts based on our comparative advantage. Examples include our collaboration with Cornell University, USA, in the genotyping of hundreds of cassava accessions at high-density using genotyping-by-sequencing; with Iwate Biotechnology Research Center, Japan, on whole genome sequencing of selected accessions of white yam (*Dioscorea rotundata*); with the Natural Resources Institute (NRI), UK, in yam postharvest systems; and with USDA-ARS Southern Regional Research Center in New Orleans, on the biological control of strains of Aspergillus flavus that produce aflatoxin. Working with USDA-ARS we have also developed several lines of maize that combine good resistance to aflatoxin production with desirable agronomic and adaptive traits. Several of these lines were used in further bi-parental crosses during the year.

IITA collaborates with the National Agricultural Research Institutes (NARI) and universities in 12 countries in the sub-region in the training of new scientists and the design and execution of research projects. Many of our research projects include degree-related studies conducted by students from African universities *(see section on graduate and post-graduate studies)*. Such studies are co-supervised by IITA scientists and university lecturers. The benefits from these activities include the strengthening of R4D capacities and the delivery of new technologies in the sub-region. Examples of these technologies are the new varieties released during the year by the National Root Crops Research Institute (NRCRI) and the Institute of Agricultural Research and Training (IAR&T) in Nigeria, as well as the CSIR-Crops Research Institute (CRI) and the CSIR-Savannah Agricultural Research Institute (SARI) in Ghana *(see section on New Varieties Released)*. The mutual benefits of active support from host country governments and collaboration with selected public and private sector agencies are best exemplified by our R4D activities, especially on cassava, under the Agricultural Transformation Agenda of Nigeria during the year.

Implementation of several of our research projects that target key value chains of our mandate crops involves private sector agencies and NGOs. Among other things, this enhances adoption potential and the scaling out of the results. Working with Nestlé, the West Africa Seasoning Company (WASCO), and cassava farmers in Nigeria has led to increased volumes and stability of supply of storage roots to factories of the two companies, based on significant increases in productivity from using improved technologies. The significant knowledge from many years of experience with farming systems in Southeast Nigeria by the NGOs Diocesan Development Services (DDS) and the Missionary Sisters of the Holy Rosary (MSHR) is an asset to our major collaborative effort in improving yam seed systems through the YIIFSWA project.

IITA's partnerships with the sub-regional organization West and Central African Council for Research and Development (CORAF/WECARD), and the regional economic communities (ECOWAS and the West African Economic and Monetary Union (WAEMU) enable us to contribute to, and benefit from the collaborative design of regional R4D projects and the regional harmonization of relevant regulations, e.g., seed laws.

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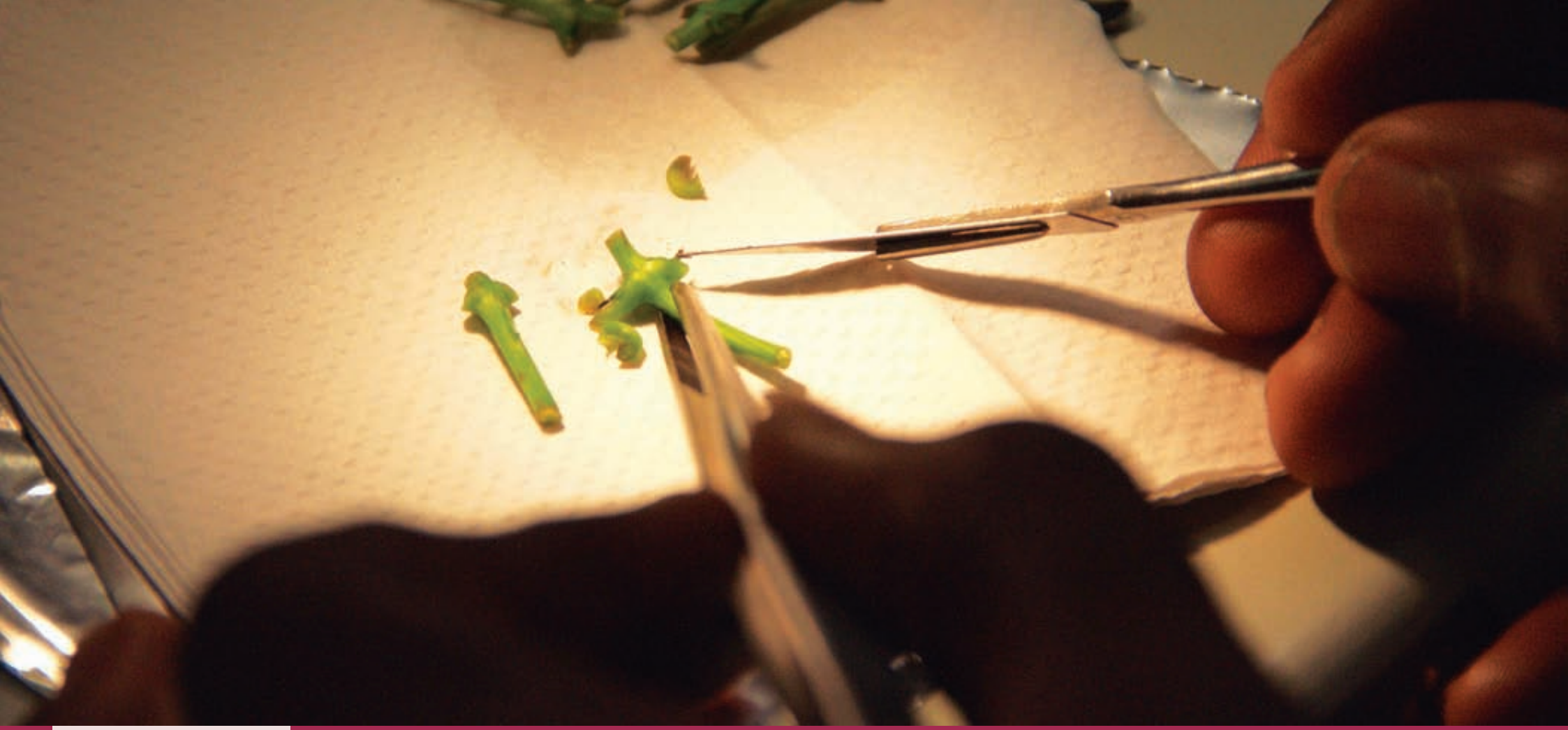
Satellite imagery of the IITA campus in Ibadan, Nigeria.



Preparing a cassava plantlet for in vitro conservation at the Genetic Resources Center in IITA-Ibadan. Photo by JT Oliver, IITA.

Research Highlights

A "cottage industry" in Bénin for the production of natural enemies of *Maruca vitrata*, a major pest of cowpea

Manuele Tamo

Maruca vitrata, popularly referred to as the pod borer, is an endemic pest of cowpea in West Africa. From the initial larval to the adult phase, this pest attacks the cowpea plant. The larva starts off by boring into the flower, leading to shedding. As the plant matures and starts to produce pods, the grown up larva now bores into the pods, using the developing grain as feed and causing the entire pod to rot. This translates to a partial or a total loss of crop for the farmer. This tiny pest has been responsible for over 80% of losses in both indigenous and high yielding varieties. With funds from both USAID (through the Dry Grain Pulses Collaborative Research Support Program) and GIZ/BMZ (through the World Vegetable Center - AVRDC) we have investigated developing and implementing biological control as one of the most effective, sustainable, and economically viable options for managing this major pest.

We used a novel approach for producing the specific virus (MaviMNPV) for *M. vitrata* by soaking cowpea grains until germination, and subsequently rearing the insect host on those cowpea sprouts. Two technicians of the self-help communal enterprise Bio-Phyto in Glazoue, Central Bénin, spent their industrial attachment period at IITA-Bénin to acquire the necessary knowledge and skills to produce the virus in a commercial quantity with their group. A local student also carried out his MSc thesis on the optimization of the methodology to make it more efficient. The work is still ongoing, but early results clearly indicated that soaking the grains for 48 h and subsequently infesting the sprouts with neonate *M. vitrata* larvae at the appearance of the first green parts of the germinating seeds allowed optimal pod borer rearing. Infesting two layers of sprouting cowpea seeds with the larvae, and subsequently inoculating the virus at the third instar, gave the highest yields in terms of virus production. Also, using the advanced sprouting stages of the seeds made it easier to separate the moribund larvae for harvesting the virus.

Maruca vitrata *damage to a cowpea pod. Photo by SP-IPM.*

Following up on the successful field deployment of the combination of neem oil and MaviMNPV observed last year, more detailed studies were carried out to assess the nature of these interactions. The effect of the compounds, alone or in combination, on key insect pests of cowpea, (aphids, thrips, and pod borers) was investigated in the laboratory. Second-instar aphids and thrips nymphs, and third-instar pod borer larvae reared in the laboratory, were treated with various concentrations of the control agents, either separately or in combination. The combination of neem oil and MaviMNPV resulted in a significantly higher larval mortality than treatment with either virus or botanical insecticide alone at the corresponding concentrations. Co-infected insects died sooner than those infected with only one control agent. Combinations between MaviMNPV and botanical oils produced both additive and synergistic effects. No evidence of antagonistic effects was noted. Larval as well as pupal development was significantly delayed and the emergence of adults was reduced in the combined treatment of MaviMNPV and neem oil.

Meanwhile, neem oil has been re-formulated as an emulsifiable mixture of neem and essential oil from lemon grass, which is planted by women groups and sold to the self-help enterprise together with the neem seeds, thus providing additional household income. This mixture is sold commercially by the Bio-Phyto communal enterprise under the brand name, Top-Bio. IITA scientists and their partners have been assessing the viability of the MaviMNPV virus kept in Top-Bio for several months, to determine if the two components can be pre-mixed and sold in the same container. At the same time, Top-Bio has been dispatched with the virus to our collaborators in Burkina Faso, Niger, and Nigeria for proper multi-locational field testing. There is clearly an enormous potential and synergy working with self-help communal enterprises such as Bio-Phyto. A second self-help enterprise producing bio-pesticides should be established soon in Northern Bénin, and IITA scientists have been invited to participate in setting up the strategy for future directions in biopesticide production.

Nutritional enhancement research and better stress tolerance in maize

Abebe Menkir

In the team, we have devoted attention to the continual infusion of new and diverse germplasm towards the expansion of the genetic base of adapted inbred lines with high pro-vitamin A content. This work is mainly funded by the BMGF through HarvestPlus, an interdisciplinary program coordinated by the International Center for Tropical Agriculture (CIAT) and the International Food Policy Research Institute (IFPRI). The micronutrient target that HarvestPlus has determined would improve poor people's nutrition and health is 15 µg /g beta-carotene. Seed samples of 18 inbred lines received from Thailand and 52 inbred lines introduced from the US were self-pollinated at Ibadan, Nigeria, and sent to the University of Wisconsin, USA, for carotenoid analysis. Seven inbred lines with low-to-medium contents of ß-cryptoxanthin (2.2 to 6.3 µg /g) and of pro-vitamin A (5.5 to 8.3 µg /g) were selected for use as parents of bi-parental crosses to broaden and diversify the genetic base of alleles controlling pro-vitamin A content in adapted maize. Six of the inbred lines with desirable agronomic traits and low –to-medium levels of ß-cryptoxanthin (3.5 to 6.3 µg /g) were crossed with IITA's adapted inbred lines having medium-to-high levels of ß-carotene (8.6 to 26.8 µg /g) during the 2012 dry season to form bi-parental crosses.

Harvest of yellow maize. Photo by IITA.

The resulting 18 F1s were planted during the main growing season at Saminaka, Nigeria to generate F2 bulk seeds. At least five plants were self-pollinated in each F1 cross to produce the F2 bulk seeds for planting in 2013.

In an effort to identify maize inbred lines that combine high pro-vitamin A with high sulfur- containing amino acids, methionine and cysteine, that are considered to be promoters of iron and zinc bio-availability in humans, 40 maize inbred lines with yellow and orange endosperm containing medium-to-high levels of pro-vitamin A (10.0 to 21.2 µg/g) in their grain were grown at Ibadan during the 2012 dry season. Seed samples produced by self-pollinating each line were analyzed for amino acid content by the Grain Quality Laboratory in Pretoria, South Africa. Significant differences were found in both methionine and cystine content. The team found some lines that combined high levels of methionine with high levels of cysteine and others that were high in cysteine but were intermediate or low in methionine. The best inbred lines selected from this study will be used as parents of bi-parental crosses to develop new inbred lines with much higher levels of pro-vitamin A and the two sulfur-containing amino acids.

In recognition of the importance of the adaptation of the nutritionally enhanced maize lines to the challenging environments in which they have to perform, we have been working to incorporate drought tolerance and *Striga* resistance into them. Forty-three hybrids, progenies from maize inbred lines with yellow endosperm, were evaluated under controlled drought stress along with a commercial hybrid check with orange endosperm during the dry season in 2012. In this trial, hybrids formed from 26 inbred lines produced grain yields under drought stress that exceeded the mean grain yield of the commercial hybrid check by up to 126%. In an effort to develop *Striga*-resistant maize inbred lines with yellow and orange endosperm that also have high pro-vitamin A levels, 270 S2 plants derived from crosses between *Striga*-resistant and high pro-vitamin A inbred lines, selected in 2011 for desirable agronomic traits, were planted under artificial *Striga* infestation. Out of these, 168 S3 lines with desirable agronomic traits as well as bright yellow or orange kernel color and flint or semi-flint texture (hard and shiny kernels) were selected for further inbreeding. Ninety-nine of the 168 S3 lines also showed high levels of resistance to *Striga hermonthica*. The S3 lines will be screened once again for consistency of their performance under *Striga* infestation in 2013.

New approaches in genetic improvement of cassava

Ismail Rabbi

Researchers at IITA have played a major role in the genetic improvement of cassava for the African continent over the last 40 years. Hundreds of improved varieties that are not only high-yielding but also nutritious and tolerant to biotic and abiotic stresses have been developed and extensively deployed in sub-Saharan Africa. Most of these advances were achieved through conventional breeding, which is often a lengthy process due to cassava's long growth cycle and low rate of multiplication. For example, it takes an average of 5-6 years from the time cassava is crossed to generate new recombinant progenies and go through field evaluations to the time new parents are selected for the next crossing cycle.

Scientists are now working to cut short this lengthy breeding process through the use of cutting-edge genomic tools. In collaboration with researchers from Cornell University, USA, we are developing and adapting the rapidly advancing next-generation sequencing

Improved cassava gives farmers better yields. Photo by IITA.

technologies by generating high-density molecular markers, unravelling the crop's genetic diversity and structure, and locating genomic regions that control quantitative and qualitative breeding traits.

Lack of high-density molecular markers has been a major constraint in cassava breeding. Through partnership with Cornell University, we have genotyped-by-sequencing (GBS) bi-parental mapping populations (i.e., first-generation progenies generated from crossing two genetically divergent clones) segregating for a number of attributes related to productivity (fresh root yield and dry matter content), plant health (resistance to virus diseases) nutritional qualities (increased pro-vitamin-A accumulation in storage roots), and plant morphology. This new genotyping approach, based on the use of restriction enzymes to reduce genome complexity and ligation of DNA barcodes (unique DNA sequences) for multiplexing many samples, yields thousands of single nucleotide polymorphisms (SNPs) markers at a cost of less than 20 USD.

We have used the SNP data from GBS to develop the most dense genetic linkage map of cassava with more than 2500 markers. Genetic maps are essential in guiding researchers to genomic locations that contain genes that underlie variation at traits of interest –just as cartographic maps guide travellers to their intended destinations. The current genetic maps have less than 700 markers, which limits their mapping resolution when trying to locate genes of interest. We are also part of an international consortium led by Steve Rounsley of Dow Agrosciences – Indianapolis, USA, that seeks to develop a consensus genetic linkage map of cassava. This will assist in developing a better assembly of the cassava reference genome sequence that is currently made of more than 12000 different pieces. Other researchers contributing to this effort are from University of California – Berkeley, and the US Department of Energy – Joint Genome Institute.

We have used the GBS approach to genotype more than 1000 improved clones and landraces from the breeding collection. These improved clones were developed and selected over a period of 40 years, but until now, very little was known about their genetic structure. The researchers are using between 4000 and 20,000 SNP markers as well as various cluster analysis methods, including the Bayesian model-based clustering algorithm implemented in the program STRUCTURE, and Principle Co-ordinate Analysis. So far, preliminary results indicate a limited level of genetic differentiation in the breeding collection, suggesting the need to broaden the available gene-pool by introducing exotic germplasm. This is critical if the objectives of raising the yield frontier and improving tolerance to biotic and abiotic stresses as well as culinary traits are to be achieved.

In addition to conducting basic genetic studies researchers from IITA, in partnership with scientists from Cornell University, the National Root Crops Research Institute of Nigeria, and the National Crop Resources

Research Institute (NaCRRI) of Uganda have embarked on the use of next-generation markers in genomic selection, a new breeding method that uses statistical modelling to predict how a plant will perform, even before it is field-tested. Genomic selection uses novel statistical models and bioinformatics tools, combined with the increasingly abundant genomic information, which has enabled the deployment of prediction-based breeding methods in crop breeding programs. The first generation of recombinant seeds is already in the field at the IITA station in Ibadan and more information about this new project can be found at www.nextgencassava.org.

In conclusion, cassava breeding at IITA is being redefined, thanks to the increasing availability and deployment of genomic resources. Combining these resources with IITA's long standing conventional breeding pipeline means that the best days of cassava lie ahead. These efforts will ultimately satisfy the increasing need for more healthy and nutritious food produced in environmentally sustainable ways.

New varieties released

Two varieties of cassava, three of cowpea, three of soybean, and 15 of maize were released by our partner institutes (Table 1) based on germplasm provided as part of our collaboration in the genetic improvement of these crops. The lead institutes involved are the National Root Crops Research Institute (NRCRI), Nigeria; the Institute of Agricultural Research and Training (IAR&T), Nigeria; the CSIR-Crops Research Institute (CRI), Ghana; and the CSIR-Savannah Agricultural Research Institute (SARI).

TABLE 1. New crop varieties released by IITA partners in 2012

Crop	Country	Lead Partner	IITA/ Partner Accession No.	Release Name
Cassava	Nigeria	NRCRI	IITA-TMS 1982132	UMUCASS 42
		NRCRI	IITA-TMS 1011206	UMUCASS 43
Cowpea	Ghana	CRI	IT93K-192-4	*Hewale*
		CRI	IT94K-410-2	*Asomdwee*
		CRI	IT95K-142-20	*Videfuu*
Soybean	Ghana	SARI	TGx 1834-5E	*Afayak*
		SARI	TGx 1145-3E	*Songda*
		SARI	TGx 1799-8F	*Suong-Pungun*
Maize	Nigeria	IAR&T	LW0618-42	Ife Maizehyb-1
		IAR&T	LW0904-13	Ife Maizehyb-2
		IAR&T	A0905-28-Provitamin A	Ife Maizehyb-3
		IAR&T	A0905-32-Provitamin A	Ife Maizehyb-4
	Ghana	SARI	DT Syn-1-W	*Sanzal-sima*
		SARI	IWD C3 Syn F2	*Ewulboyu*
		SARI	TZE-Y DT STR C4	*Bihilifa*
		SARI	GH120 DYF/D Pop	*Tigli*
		SARI	TZE-W DT STR C4	*Wang Data*
		CRI	MO826-4	*Aseda*
		CRI	MO826-7	*Opeaburoo*
		CRI	MO826-12	*Tintim*
		CRI	A0804-5	*Owanwa*
		CRI	A0806-2	*Odomfo*
		CRI	PVA Syn 6	*Honampa*

Molding future scientists. Children keen on learning about science and trying their hands on some scientific equipment during IITA's annual Open Day. Photo by JT Oliver, IITA.

Capacity Building and **Publications**

Seminars

The seminars organized and attended at IITA-Ibadan during the year related to, staff recruitment, and reviews of staff contracts and others which were given on invitation by IITA staff and visitors. Table 2 shows the seminars presented by scientists based in IITA-Western Africa.

TABLE 2. Seminars presented at IITA-Ibadan.

Presenter	Seminar title
Peter Kulakow, IITA	Cassava Research Programs: Varieties for West Africa
Mbaye Yade, IITA	Informing African Agricultural Development Planning and Implementation in the context of CAADP
Manuele Tamo, IITA	Insect-Smart Cereal-Legume Cropping Systems for Africa
Amare Tegbaru, IITA	A Project Manager, Social Scientist, and Gender Expert's Contributions to African Development and Future Plans
Alpha Kamara, IITA	Increasing Cropping System Productivity in the West African Savannas through IAR4D: Some Examples from Northern Nigeria
Ranajit Bandyopadhyay, IITA	Aflatoxin Biocontrol in Africa: Progress and Prospects
Antonio Lopez-Montes, IITA	Yam Breeding, Food Security, and Value Chains: Progress, Challenges, and Next Phase
Badara Gueye, IITA	Plant Genetic Resources Conservation & Use: Backbone for Research to Nourish Africa
Ranjana Bhattacharjee, IITA	Harnessing NextGen Technologies for Dynamizing Plant Genetic Resources at IITA
Samuel Ajala, IITA	Accelerating Maize Transformation Agenda in sub-Saharan Africa
Sylvester Meseka, IITA	Maize Value Chain for Transforming Agriculture in Sub-Saharan Africa: moving improved technologies from shelves to Farmers' Fields

Training workshops

The workshops and training courses conducted during the year (Table 3) related to stakeholders' consultation and information exchange, group training of scientists, technicians, and extension workers (including Training of Trainers), as well as the group training of other value chain actors, such as farmers, seed producers, traders, etc.

TABLE 3. Workshops and training courses organized.

Course title	Location	No. of pax	IITA staff involved
Experimental design and data analysis	Tamale, Ghana	16	Asamoah Larbi
Stakeholder consultation on yam production systems	Tamale, Ghana	60	Antonio Lopez-Montes

Seed Health Testing	Ibadan, Nigeria	4	Lava Kumar; Oluwole Oguntade
Harmonization of Analytical Methods for Fertilizers	Ibadan, Nigeria	27	Joseph Uponi
Group training of technicians in maize production and research	Ibadan, Nigeria	36	Baffour Badu-Apraku
Training on seed production techniques, Fertilizer use, soil improvement technologies and *Striga* biology and control for Field supervisors, Extension agents and Seed producers	Ndjamena, Chad	15	Alpha Kamara
Training on seed production techniques, Fertilizer use, soil improvement technologies and *Striga* biology and control for Field supervisors, Extension agents and Seed producers	Maroua, Cameroon	16	Alpha Kamara
Pre-season training on *Striga* management and control and safe use of pesticides for extension agents, lead farmers and seed producers	Bauchi, Nigeria	657	Alpha Kamara
Pre-season training on *Striga* management and control and safe use of pesticides for extension agents, lead farmers and seed producers	Kano, Nigeria	593	Alpha Kamara
Community mobilization training of extension agents	Kaduna State, Nigeria	15	Alpha Kamara
Pre-season and field plot training of extension agents and seed producers,	Kaduna State, Nigeria	60	Alpha Kamara
Training on Seed Marketing of Input Dealers and Stockists	Kano State, Nigeria	69	Alpha Kamara
Training of trainers workshop for technicians and researchers at the Sierra Leone Agricultural Research Institute (SLARI) in field crop techniques	SLARI, Sierra Leone	20	Alpha Kamara
Training of farmers in group management and leadership and in cowpea crop management	Sierra Leone	200	Alpha Kamara
Training for enumerators in household field survey in Jigawa State	Jigawa State, Nigeria	19	Alpha Kamara
Crop production training of field trial managers in N2Africa project	SLARI-Njala, Sierra Leone	25	Alpha Kamara
Development of illustrated learning materials	Kenema, Sierra Leone	63	Braima James
Cassava flour production training	Kpandebu, Sierra Leone	12	Braima James
Business development and financial literacy for cassava producers, processors, and marketer entrepreneurs	Kambia, Bo, and Kenema Sierra Leone	79	Braima James
Attieke production	Kpandebu, Sierra Leone	45	Braima James
Cassava planting techniques	10 districts, Sierra Leone	1284	Braima James
Planting techniques for fuelwood lots	10 districts, Sierra Leone	420	Braima James
Economic use of cassava waste in mushroom production	Koribondo, Sierra Leone	105	Braima James
Gari production techniques	Robis Bana, Sierra Leone	34	Braima James

Production of soya fortified *gari*	Kpandebu, Sierra Leone	16	Braima James
Training of bag vendors for Purdue Improved Cowpea Storage (PICS) project (North Central)	Abuja, Nigeria	12	Tahirou Abdoulaye
Workshop for Extension agents in Agricultural Development Programs (ADP) on Purdue Improved Cowpea Storage (PICS) (North West)	Gusau, Nigeria	17	Tahirou Abdoulaye
Workshop for Extension agents in Agricultural Development Programs (ADP) on Purdue Improved Cowpea Storage (PICS) (North East)	Gombe, Nigeria	17	Tahirou Abdoulaye
Workshop for Extension agents in Agricultural Development Programs (ADP) on Purdue Improved Cowpea Storage (PICS) (North Central)	Abuja, Nigeria	21	Tahirou Abdoulaye
Training of bag vendors for Purdue Improved Cowpea Storage (PICS) project (North West)	Gasau, Nigeria	23	Tahirou Abdoulaye
Training of bag vendors for Purdue Improved Cowpea Storage (PICS) project (North East)	Gombe, Nigeria	27	Tahirou Abdoulaye

Graduate and post-graduate studies

A total of 35 students (24 male and 11 female) conducted research towards PhD degrees under the co-supervision of IITA scientists with university lecturers during the year. In addition to 38 students (23 male and 13 female) on MSc programs, 34 technicians a¬nd scientists from partner agencies (25 male, 9 female) made study visits to IITA. In Nigeria, 57 (30 male, 27 female) worked at IITA under the National Youth Service Scheme and 110 (49 male, 61 female) under the Student Industrial Work Experience Scheme. Below is a list of selected PhD students who have started and those who have completed their degree programs in 2012, categorized by research area:

Biotechnology and genetic improvement

- Salaudeen Muhammadu. PhD, University of Ibadan, Nigeria. Thesis title: Studies on mechanisms and genetics of maize streak virus (MSV) resistance in maize. IITA supervisor: Dr Lava Kumar. Status: completed.
- Ayalew Desalegne Belayneh. PhD, Addis Ababa University, Ethiopia. Thesis title: Genetic and morpho-physiological basis for drought tolerance in cowpea (*Vigna unguiculata* L.) genotypes and its potential for adaptation to the changing climate in Ethiopia. IITA supervisors: Dr Melaku Gedil and Dr Ousmane Boukar. Status: completed.
- Atanda Samuel Oladejo. PhD, University of Ibadan, Nigeria. Thesis title: Breeding for insect resistance to thrips in cowpea. IITA supervisors: Dr Ousmane Boukar and Dr Christian Fatokun. Status: commenced.
- Victor Okechukwu Azuh. PhD, University of Ibadan, Nigeria. Thesis title: The use of genome-wide association mapping to identify maize

steak virus resistance genes in maize (*Zea mays*). IITA supervisors: Dr Lava Kumar, Dr Abebe Menkir, and Dr Melaku Gedil. Status: commenced.

- Olaniyi Oyatomi. PhD, University of Ibadan, Nigeria. Thesis title: Genetic diversity in wild *Vigna*. IITA supervisors: Dr Ousmane Boukar and Dr Christian Fatokun. Status: commenced.

Natural resource management

- Odon Clement Ncho. PhD, University of Abobo-Adjame, Côte d'Ivoire. Thesis title: Role of selected microbial and chemical commercial products for improving the growth and nutrition of cereal and legume crops across agroecologies in Niger and Nigeria. IITA supervisor: Dr Robert Abaidoo. Status: completed.

Plant production and plant health

- Elizabeth Ifeoluwa Oketade. PhD, University of Ibadan, Nigeria. Thesis title: Evaluation of the effects of fertilizer types and rates, plant spacing, and ratooning on yield of cassava. IITA supervisors: Dr Peter Kulakow and Dr Marie Octavie Yomeni. Status: commenced.
- Chukwuemeka Kanu Nkere. PhD. Thesis title: Assessment of the genetic diversity of viruses infecting yams in West Africa and development of simple and low-cost diagnostic tools. IITA supervisor: Dr Lava Kumar. Status: commenced.

Publications

Thirty-eight papers were published in peer-reviewed journals on the Thomson list with average impact factor (IF) of 1.845. Seventeen of the papers had impact factors above 2, with the highest being 9.68. Twenty-seven papers were published in peer-reviewed journals that are not on the Thomson list, 56 in conference proceedings (full papers and abstracts) and Newsletters, 1 as a book chapter and 10 articles in IITA's R4D Review publication. Six technical reports and guides and three booklets were also published. Below is a list of selected publications according to research area:

Biotechnology and genetic improvement

Bart, R., Cohn, M., Kassen, A., McCallum, E., Shybut, M., Petriello, A., Krasileva, K., Dahlbeck, D., Medina, C., Alicai, T., Kumar, P. L., Moreira, L., Neto, J., Verdier, V., Santana, M., Kositcharoenkul, N., Vanderschuren, H., Gruissem, W., Bernal, A., and Staskawicz, B. 2012. High-throughput genomic sequencing of cassava bacterial blight strains identifies conserved effectors to target for durable resistance. Proceedings of the National Academy of Sciences (PNAS) 109, E1972-E1979. http://biblio.iita.org/index.php?page=publication&kind=single&ID=7918.

Badu-Apraku, B., Akinwale, R., Fakorede, M., Oyekunle, M., and Franco, J. 2012. Relative changes in genetic variability and correlations in an early-maturing maize population during recurrent selection. Theoretical and Applied Genetics 125(6), 1289-1301. http://biblio.iita.org/index.php?page=publication&kind=single&ID=7816.

Badu-Apraku, B. and Oyekunle, M. 2012. Genetic analysis of grain yield and other traits of extra-early yellow maize inbreds and hybrid performance under contrasting environments.

Field Crops Research 129, 99-110. http://biblio.iita.org/index.php?page=publication&kind=single&ID=7574.

Chen, Z., Brown, R., Menkir, A., and Cleveland, T. E. 2012. Identification of resistance-associated proteins in closely-related maize lines varying in aflatoxin accumulation. Molecular Breeding 30, 53-68. http://biblio.iita.org/index.php?page=publication&kind=single&ID=7600.

Pottorff, M., Ehlers, J. D., Fatokun, C., Roberts, P. A., and Close, T. J. 2012. Leaf morphology in cowpea [Vigna unguiculata (L.) Walp]: QTL analysis, physical mapping and identifying a candidate gene using synteny with model legume species. BMC Genomics 13, 1-12. http://biblio.iita.org/index.php?page=publication&kind=single&ID=7801.

Natural resource management

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, M. T. 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.

Plant production and plant health

Omane, E., Oduro, K. A., Cornelius, E., Opoku, I., Akrofi, A., Sharma, K., Kumar, P. L., and Bandyopadhyay, R. 2012. First report of leaf blight of Taro (Colocasia esculenta) caused by Phytophthora colocasiae in Ghana. Plant Disease 96, 292-292. http://biblio.iita.org/index.php?page=publication&kind=single&ID=7700.

Senghor, A. L., Sharma, K., Kumar, P. L., and Bandyopadhyay, R. 2012. First report of mango malformation disease caused by Fusarium tupiense in Senegal. Plant Disease 96, 1582-1582. http://biblio.iita.org/index.php?page=publication&kind=single&ID=7970.

Social science and agribusiness

Tambo, J. A. and Abdoulaye, T. 2012. Smallholder farmers' perceptions of and adaptations to climate change in the Nigerian savanna. Regional Environmental Change (DOI) 10.1007/s10113-012-0351-0. http://biblio.iita.org/index.php?page=publication&kind=single&ID=7987.

Warth, B., Parich, A., Atehnkeng, J., Bandyopadhyay, R., Schuhmacher, R., Sulyok, M., and Krska, R. 2012. Quantitation of mycotoxins in food and feed from Burkina Faso and Mozambique using a modern LC-MS/MS multitoxin method. Journal of Agricultural and Food Chemistry 60, 9352-9363. http://biblio.iita.org/index.php?page=publication&kind=single&ID=7995.

Acronyms and abbreviations

5CP	New Cassava Varieties and Clean Seed to Combat CBSD and CMD Project
AATF	African Agricultural Technology Foundation
ACMV	Africa Cassava Mosaic Virus
ADISCO	*Association Appui au Développement Intégral et la Solidarité sur les Collines*
AfDB	African Development Bank
Africa RISING	Sustainable Intensification of Key Farming Systems in East and Southern Africa
AGRA	Alliance for a Green Revolution in Africa
AGRF	African Green Revolution Forum
ARIs	Advanced Research Institutes
AVRDC	Asian Vegetable Research and Development Center (World Vegetable Center)
AYT	Advanced Yield Trial
BBTD	Banana Bunchy Top Disease
BBTV	Banana Bunchy Top Virus
BeCA	Biosciences East and Central Africa
BMGF	Bill & Melinda Gates Foundation
BoT	Board of Trustees
BXW	Banana *Xanthomonas* Wilt
CAADP	Comprehensive Africa Agriculture Development Program
CAH	Central Africa Hub
CARBAP	*Centre Africains de Recherche sur Bananiers et Plantains*
CCARDESA	Center for Coordination of Agricultural Research and Development for Southern Africa
CBO	Community based organization
CBSD	Cassava Brown Streak Disease
CBSV	Cassava Brown Streak Virus
CCAFS	Climate Change, Agriculture, and Food Security
CDAs	Conservation Development Agreements
CEGA	Center of Evaluation for Global Action
CFC	Common Fund for Commodities
CGIAR	Consultative Group on International Agricultural Research
CIALCA	Consortium for Improving Agriculture-based Livelihoods in Central Africa
CIAT	*Centro Internacional de Agricultura Tropical* (International Center for Tropical Agriculture)
CIBe	*Caritas International Belgique*
CICs	Camp Agricultural Committees
CIFOR	Center for International Forestry Research
CIMMYT	*Centro Internacional de Mejoramiento de Maíz y Trigo* (International Maize and Wheat Research Center)
CIP	*Centro Internacional de la Papa* (International Potato Center)
CIRAD	*Centre International de Recherche Agronomique pour le développement*
CMD	Cassava Mosaic Disease

CORAF	*Conseil ouest et centre africain pour la recherche et le développement agricoles*
COSTECH	Commission for Science and Technology, Tanzania
CRI	Crops Research Institute
CRP	CGIAR Research Program
CRS	Catholic Relief Service
DDPSC	Donald Danforth Plant Science Center
DDS	Diocesan Development Services
DGDC	Directorate-General for Development Cooperation, Belgium
DRC	Democratic Republic of the Congo
DTMA	Drought Tolerant Maize for Africa
EAH	Eastern Africa Hub
EAC	East African Community
EACMV	East Africa Cassava Mosaic Virus
ECOWAS	Economic Community of West African States
ESA	East and Southern Africa
FAO	Food and Agriculture Organization
FHIA	*Fundacion Hondurena de Investigacion Agricola*
FtF	Feed-the-Future Initiative
GCDT	Global Crop Diversity Trust
GCP21	Global Cassava Partnership for the 21st Century
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit
GIZ/BMZ	German Agency for International Cooperation/ Federal Ministry for Economic Cooperation and Development
GRZ	Government of the Republic of Zambia
HIV/AIDS	Human Immunodeficiency Virus/ Acquired Immune Deficiency Syndrome
Humidtropics	Consortium Research Program on Integrated Systems for the Humid Tropics (CRP1.2)
IAR	Institute of Agricultural Research, Kano
IARCs	International Agricultural Research Centers
IAR&T	Agricultural Research and Training
ICRAF	International Center for Research in Agroforestry (World Agroforestry Center)
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
ICT	Information and Communication Technology
IF	Impact Factor
IFAD	International Fund for Agricultural Development
IITA	International Institute of Tropical Agriculture
INERA	*Institut de l'Environnement et de Recherches Agricoles* (National Institute for Agronomic Study and Research)
IP	Innovation Platform
IRAD	Institute of Agricultural Research for Development
IRS	internationally recruited staff
ISBN	International Standard Book Number
ISFM	Integrated Soil Fertility Management
ISTRC	International Society for Tropical Root Crops
ITC	International Transit Centre
KIPI	Kenya Industrial Property Institute

KWF	German Development Bank
LUWES	Land use planning for low emission development strategies
MAFC	Ministry of Food Security and Cooperatives
MIRACLE	Making Agricultural Innovations Work for Smallholder Farmers Affected by HIV and AIDS in Southern Africa
MOU	Memorandum of Understanding
MSHR	Missionary Sisters of the Holy Rosary
N2Africa	Putting Nitrogen Fixation to Work for Smallholder Farmers in Africa
NARES	National Agricultural Research and Extension System
NARI	National Agricultural Research Institutes
NARO	National Agricultural Research Organization
NARS	national agricultural research system
NGO	Non-governmental organization
NRCRI	National Root Crops Research Institute
NRM	Natural Resources Management
NRS	Nationally recruited staff
NSIR	National Institute for Scientific and Industrial Research
PACA	Partnership for Aflatoxin Control in Africa
PADAP	*Projet d'Appui au Développement Agricole de la Province*
PAIOSA	*Programme d'Appui Institutionnel et Opérationnel au Secteur Agricole*
PLWA	People living with HIV/AIDS
PPCDR	*Programme Post Conflit de Développement Rural*
PVS	Participatory variety selection
R&D	Research and Development
R4D	Research-for-Development
REALU	Reduced Emission from all Land Uses
REDD+	Reducing Emissions through Reduced Deforestation and Forest Degradation.
RTB	Roots, Tubers, and Banana
SADC	Southern Africa Development Community
SAH	Southern Africa Hub
SARD-SC	Agricultural Research for Development on Strategic Commodities in Africa
SARI	Savannah Agricultural Research Institute
SCCI	Seed Control and Certification Institute
SIDA	Swedish International Development Agency
SIMLEZA	Sustainable Intensification of Maize and Legume Systems in the Eastern Province of Zambia
SLARI	Sierra Leone Agricultural Research Institute
SUA	Sokoine University of Agriculture, Tanzania
TFDA	Tanzania Food and Drug Agency
TLC	Total Land Care, Zambia
TL II	Tropical Legumes Project, Phase 2
TOT	Training of Trainers
TPRI	Tropical Pest Research Institute
UNIKIN	University of Kinshasa
UNIKIS	University of Kisangani
UNZA	University of Zambia

USAID	United States Agency for International Development
USDA-ARS	United States Department of Agriculture - Agricultural Research Service
UYT	Uniform Yield Trials
VCG	Vegetative Compatibility Grouping
WAAPP	West Africa Agricultural Productivity Program
WAEMU	West African Economic and Monetary Union
WAH	Western Africa Hub
WASCO	West Africa Seasoning Company
WECARD	West and Central African Council for Research and Development
YIIFSWA	Yam Improvement for Incomes and Food Security in West Africa
ZARI	Zambia Agriculture Research Institute

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