



IITA

Research to Nourish Africa

regional
highlights

20
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2013 regional highlights



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On the cover: Children at a public school in Nkhamba, Swaziland playing with cowpea harvested from their school's garden established through IITA's SIDA-funded MIRACLE Project.

The introduction by MIRACLE of a variety of nutritious vegetables and legumes -- and the delicious dishes that can be made from them -- in the school has helped improve the health of pupils. *Photo by Jeffrey Oliver, IITA.*

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message from the **DDG-R4D**



Dr Ylva Hillbur

Deputy Director General
Research for Development

“There is a lot of buzz around IITA these days”, someone said to me a while ago – and I agree, there certainly is a lot of positive buzz!

2013 has been a year of expansion and of growth, manifested in a rapid increase in number of staff, number and types of projects and partnerships, as well as in infrastructural investments and upgrades, which has significantly strengthened IITA’s regional capacity and presence.

This report presents selected highlights from 2013 from our regional hubs in Central Africa (CA), Eastern Africa (EA), Southern Africa (SA) and Western Africa (WA). The hubs are led by Drs Bernard Vanlauwe (CA), Victor Manyong (EA), David Chikoye (SA), and Robert Asiedu (WA). The regional hubs oversee the operation of our R4D work in the respective regions (Figure 1).

The regional directors also lead IITA’s core competence areas: Dr Vanlauwe for natural resource management (NRM), Dr Manyong for social science and agribusiness, Dr Chikoye for plant production and plant health, and Dr Asiedu for biotechnology and crop improvement. A major achievement in 2013 was the development/revision of strategies for the four competence areas that will lead and guide the efforts of the respective hubs in the coming years.

The science stories in this regional highlights reflect the depth and breadth of IITA’s expertise, ranging from molecular plant breeding over agronomy and plant pathology to social science and systems research.

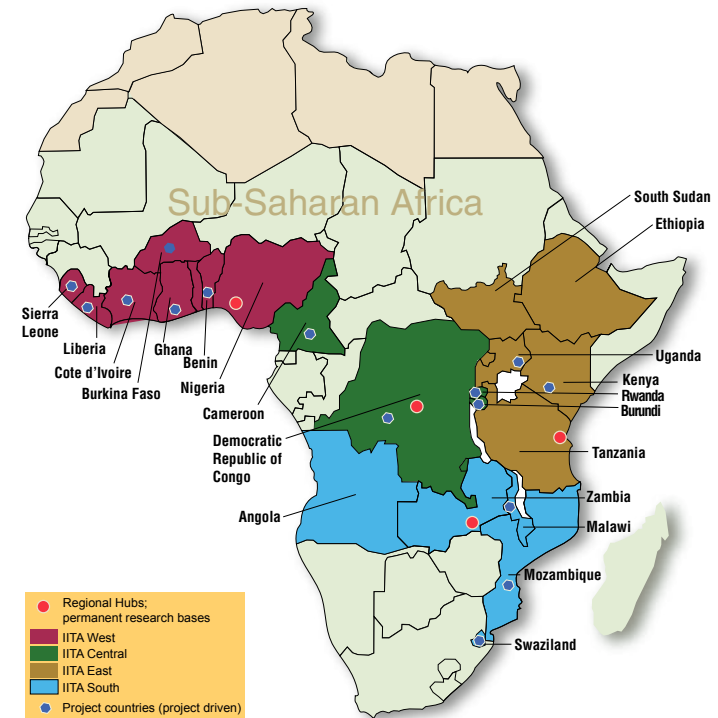


Figure 1. Where we work: our operational map showing hub locations, regional coverage and project countries.

Through work on intensification of maize-based systems using protein-rich and soil improving legume crops, bio-fortification of staple crops, increased profitability for small-holder crops, soil fertility improvement, and adaptation to climate change of key cropping systems IITA supports the CGIAR efforts to meet the global challenges. More details

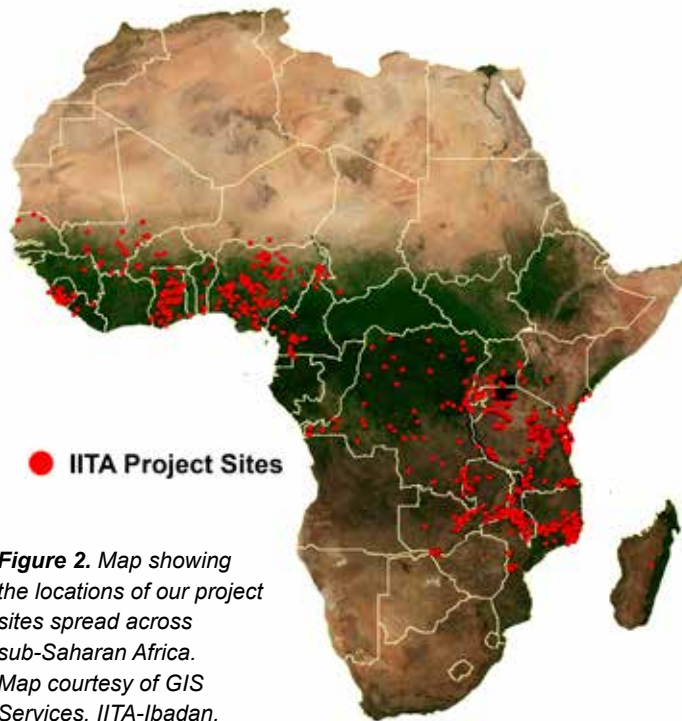


Figure 2. Map showing the locations of our project sites spread across sub-Saharan Africa. Map courtesy of GIS Services, IITA-Ibadan.

on our contribution to the CGIAR Research Programs are presented in the 2013 IITA annual corporate report.

Our hubs are also well-placed to support the operations of our various programs and projects spread across sub-Saharan Africa (SSA) (Figure 2). Our project sites are strategically and deliberately located to represent the different agroecologies in the SSA. This enhances the efficiency and relevance of our R4D work as results of

research carried out in a specific agroecology in one region can be applied in the same zone in another region with just minor adaptation.

IITA also actively invests in scientific infrastructure. Most notably in 2013 we inaugurated a new state-of-the-art science building in Dar-es-Salaam in the Eastern Africa hub and we also broke ground and laid the foundation stone for the Southern Africa Research and Administration Hub – or SARA – facilities in Lusaka, Zambia. These investments are part of IITA’s strategy and shows our commitment to create strong regional nodes for agricultural research, partnership and capacity development throughout sub-Saharan Africa.

IITA’s most valuable asset, however, is – and will always be – its human resources. During the year, our scientists have engaged in debates in workshops and at meetings, reported on their findings at seminars and in scientific journals, developed and strengthened partnerships, and contributed to capacity development through training and mentorship. In short, they have relentlessly continued their efforts to deliver science-based solutions to hunger and poverty in Africa.

It is with great pleasure that I present you the IITA Regional Highlights 2013!

message from the **regional director**

The Central Africa Hub, established through the IITA 2012-2020 Refreshed Strategy, has been active for one and a half years. Farming families in Central Africa are facing major challenges while the region is under-resourced in terms of science for development capacity and presence of the international scientific research community. Our increased research capacity in the region, up from 8 scientists in 2012 to 14 in 2013, is an important step in setting up the required capacity to tackle these challenges.

Major outputs and outcomes were generated in 2013 across the various research areas of IITA with some of these highlighted in this report. An important event was the launching of the East and Central African Action Area of the Humidtropics in Bukavu in May 2013. Delegates from 6 countries, including the Governor of South-Kivu Province of DR Congo, attended the meeting hosted in Bukavu, East – DR Congo, and master plans were drawn up to kick start activities in the various action sites. In the Congo Basin, the African Root and Tuber Scale (ARTS), *Stictococcus vayssierei*, is a soil insect pest than can result in 70% yield loss in cassava. IITA research demonstrated the high genetic diversity in ARTS populations in the Congo Basin, contrary to established knowledge. A better understanding of host utilization and host plant factors affecting scale populations and diversity can be exploited for the development of cassava resistance to the scale. In Burundi and Rwanda, over 90 (64 with financial support from the Belgium Technical Cooperation) banana macro-propagation units produced over 70 000 banana seedlings and generated approximately

US\$ 96 000 in income to 9 farmer associations with 344 members (118 female and 226 male). With the increasing demand for improved banana varieties, this multiplication technique is expected to grow in importance, in combination with the supply of tissue culture bananas. In DR Congo, six cassava varieties have been released that produce high yields, are resistant to the cassava mosaic virus, and have a good level of tolerance to cassava brown streak disease, recently observed in Western DRC.

Many of the above results were obtained through effective partnerships with various stakeholder groups, as illustrated with examples from Burundi, DR Congo, and Cameroon. A total of 19 PhD and 24 MSc students were engaged in scientific programs in 2013 and 20 scientific papers were published in high impact journals. In short, the current report reflects the excellent science for impact that is being generated in Central Africa, and underscores the potential for moving to greater heights over the coming years towards delivery of impacts.

I would 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 for their cooperation with IITA to deliver products to the end-users, the farmer organizations that have continuously provided a reality check on those products, the national support staff for providing a conducive environment for science to flourish, and last-but-not- the least, the donor community that has retained interest in investing in Central Africa.



Dr Bernard Vanlauwe
Regional Director
Central Africa

central africa **research highlights**

The East and Central Africa Action Area of the Humidtropics CRP launched in the DR Congo

*Chris Okafor, Action Area Coordinator for
the Humidtropics CRP, IITA-DR Congo*

The Humidtropics Action Area for East and Central Africa (ECA) was launched successfully on 20 May 2013 by the Governor of South Kivu Province, His Excellency Marcellin Chishambo Ruhoya, who commended the initiative and added that his attendance with his Minister of Agriculture for South Kivu was a demonstration of his support to the Humidtropics CGIAR Research Program (CRP) and his desire to know more about the program. The event was

attended by Humidtropics partners including Bioversity, CIP, ILRI, CIAT, ICRAF, IWMI, AVRDC, ICIPE, FARA, and Wageningen University, regional and national organizations and farmer organizations. The ECA Action Area, which constitutes a Flagship Project of Humidtropics, covers Rwanda, Burundi, East DR Congo (Kivu), southern Uganda, western Kenya and western Ethiopia. The area is home to 78 million people, mainly smallholder farmers who live on approximately 29 million ha, and provides a significant potential to the

Humidtropics program to generate lasting positive changes in the poverty status, and food and nutritional security of the people without destroying the environment.

Towards the realization of the Humidtropics' goal of strengthening research and stimulating innovation that increases economic and social returns to rural households, a number of coordinating activities were initiated in 2013.

Following the launching and inception workshop in May, start-up activities including consultations and sensitization of key stakeholders were carried out in three of the focal countries, DR Congo, Burundi and Rwanda, and inception workshops were organized in each country. The workshops, which were attended by Humidtropics key partners and other stakeholders, provided a forum for participants to develop a shared understanding of the program and to agree on key start-up issues such as the process of mobilizing national and local support for the program.

Also, during the inception workshops, potential field sites within the action sites and broad entry themes were identified for further investigation. Some of the common entry themes include soil fertility management, integration of leguminous trees into agricultural production systems, crop diversification, *Striga* management, strengthening of seeds systems, crop-livestock integration, agro-forestry-livestock mixed enterprises, value chain development of priority crops, sustainable land use systems and water management. Measures to enhance coordination and next steps such as field site (field locations where research will

*Participants at ECA Action
Area Launching. Photo by
Baly Kabike, IITA, Bukavu.*





Partners discussing with a farmer during a field visit to Kayonza, Rwanda. Photo by Paul Dontsop, IITA, Bukavu.

be implemented) visits, situation analysis (planning workshop and implementation), and platform inception meetings were also discussed.

Field site visits were organized to allow partners and core stakeholders gain better understanding of the potential field sites and to interact with farmers (primary

stakeholders) in five countries (Uganda, Kenya, Rwanda, Burundi and DR Congo). The visits were also meant to complement the situation analysis as a primary component of the system analysis that will guide validation of field sites, entry points and establishment of R4D platforms. The visits enabled participants to connect the Humidtropics agenda to farm realities and further review and refine the broad entry themes identified at the respective inception workshops. R4D teams were constituted to develop discussion notes around the themes to be presented at platform inception workshops. Participants in the visits included CGIAR partners, officials of government ministries, NARS, NGOs, and farmers' organizations.

In preparation for the situation analysis in Uganda and Kenya, a planning workshop led by ILRI was organized for partners from the two countries. Following the workshop, action site supervisory committees were constituted in each country to oversee the process of data collection, focus group discussion, data analysis and report writing. Initial screening of key players that will form the bedrock of each R4D platform was also started during the year and will continue in 2014, leading to establishment of platforms which are critical instruments to manage collaboration, ensure synergy and achieve scale with proven technologies.

About the author



Chris Okafor is the Action Area Coordinator/Flagship Manager for the East and Central Africa action area of the Humidtropics CRP. He is based in Bukavu, Democratic Republic of Congo, from where he coordinates the implementation of activities of the Humidtropics CRP in the DRC, Uganda, Rwanda, Burundi, western Kenya, and western Ethiopia. Prior to joining the Humidtropics CRP team, while working with IITA and TechnoServe, he had provided leadership in developing and managing research and development programs built around partnerships to improve the livelihoods of cocoa-farming communities in Nigeria and Tanzania.



A farmer answering a question during a field visit. Photo by Chris Okafor, IITA, Bukavu.

Deciphering the diversity of the African Root and Tuber Scale – an insect pest of cassava in the Congo Basin – and implications for its management

Rachid Hanna, Entomologist, IITA-Cameroon;
and **Armand Doumtsop**, Post-doctoral Fellow
(Agricultural Economics), IITA-DR Congo

Cassava is a key food security crop in Africa and has enormous potential for the economic growth to the continent. The crop's productivity continues to be constrained, however, by several widespread diseases and pests, one of which is the African Root and Tuber Scale (ARTS) *Stictococcus vayssierei*, a soil insect pest restricted to the Congo Basin where it can be locally important in forest areas located between 300 and 1400 m above sea level. ARTS was described and named in 1971 and was recognized as an agricultural pest in the early 1980s. ARTS can be found on over 16 host plants, which were identified by IITA and its partners through exhaustive surveys in several countries in the Congo Basin. Cassava remains the

most infested host plant, followed by cocoyam and yam, while scale infestations on wild host plants are generally very low.

The scale feeds by sucking plant sap and can be found on all underground cassava shoots, stems, and roots. Previous exclusion experiments (unpublished data) showed that severe scale infestations can reduce cassava root yield by over 70% with nearly equal loss in above ground biomass, thus exacerbating the effect of scale infestations through additional losses of available cassava stems on which farmers depend for replanting their crop, as well as loss of cassava foliage widely used as vegetable (such as *Kpwem* in Cameroon and *Pondu* in DR Congo). Further losses can occur due to reductions in market value caused by the presence of the scale and the necrotic feeding spots under the cassava skin.

IITA, with national and international partners, has been conducting research on ARTS biology and ecology with the aim of developing an integrated and sustainable management strategy to reduce ARTS infestations and its impact on cassava productivity. Substantial emphasis has been placed on understanding the distribution and diversity of ARTS in the Congo Basin as this knowledge is central to the development of management options such as host plant resistance and biological control.

Extensive surveys established the presence of ARTS in an area stretching from western Uganda to Equatorial Guinea and from northwestern Cameroon to southwestern DR Congo. Until 2010, when a new species, *Stictococcus*

(Main photo) ARTS on base of cassava stems. Photo by Rachid Hannah, IITA-Cameroon.





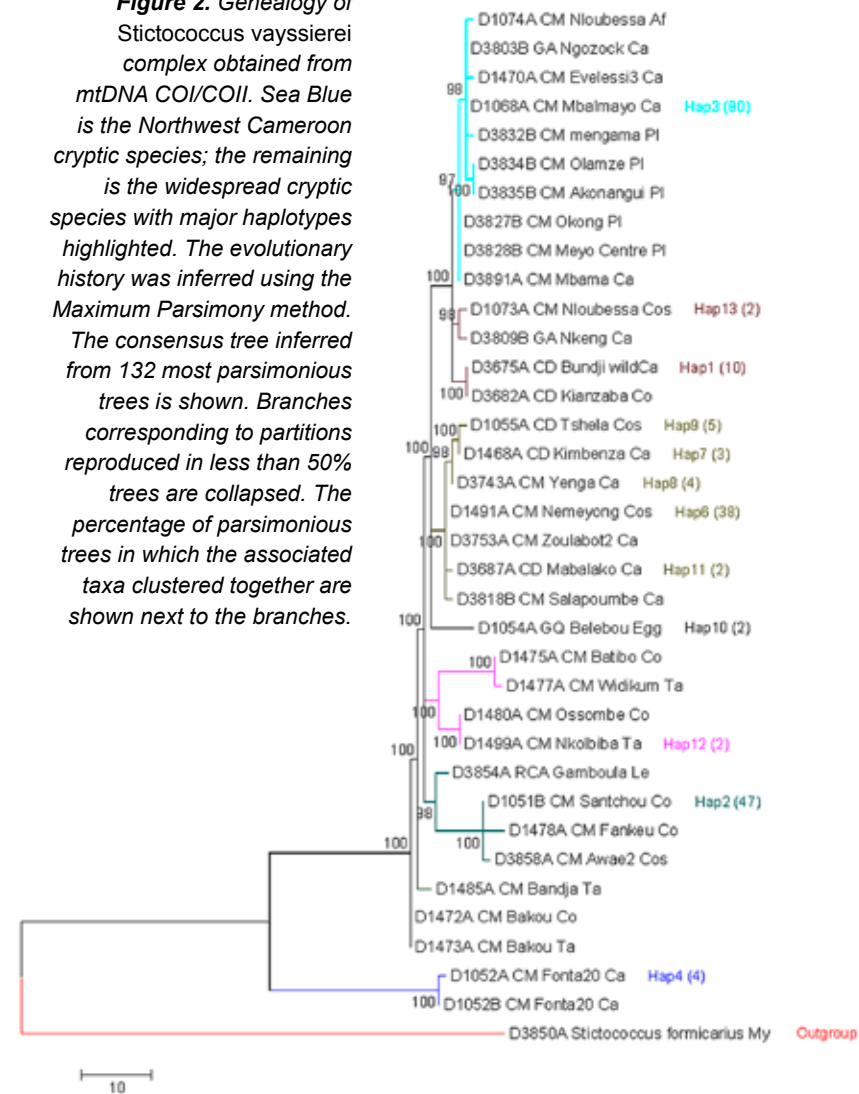
Figure 1. *Stictococcus vayssierei* collection sites (14 host plants, 128 locations, and seven countries in the Congo Basin).

subterreus, was described, ARTS has been considered as the only subterranean species in the family Stictococcidae. The description of a new subterranean species along with the breadth of ARTS distribution, its wide host range and the presence of ARTS ‘hot spots’ provided the basis for the hypothesis of the existence of host/geographic-adapted biotypes or cryptic species with substantial implications for the development of sustainable management options – particularly host plant resistance.

With the University of Massachusetts, USA, we conducted morphological and molecular analyses on 213 ARTS samples collected from 14 host plants in 128 locations in seven Congo Basin countries – comprising of the largest collection of the species. Morphological data showed consistent levels of variation among specimens from different geographic areas, but without clear and significant association

between morphotypes and host plants (Figure 1). What emerges from molecular analysis – using rRNA 28S and mtDNA COI/COII gene sequences – is much clearer, with the two techniques respectively identifying 40 and 32 haplotypes and up to 4 and 32% genetic difference in the various ARTS populations. This comparatively high diversity indicates that the species is going through significant levels of diversification (Figure 2). At present, the data support the existence of two cryptic species in the ARTS complex: one from Fonta in northwest Cameroon (to be described as a new species) and one widespread species with high genetic diversity – consisting of at least four biotypes – and found throughout the Congo Basin. Furthermore, at least

Figure 2. Genealogy of *Stictococcus vayssierei* complex obtained from mtDNA COI/COII. Sea Blue is the Northwest Cameroon cryptic species; the remaining is the widespread cryptic species with major haplotypes highlighted. The evolutionary history was inferred using the Maximum Parsimony method. The consensus tree inferred from 132 most parsimonious trees is shown. Branches corresponding to partitions reproduced in less than 50% trees are collapsed. The percentage of parsimonious trees in which the associated taxa clustered together are shown next to the branches.





Farmers showing cassava plants and roots with severe ARTS infestation. Photo by Rachid Hannah, IITA-Cameroon.

one of the biotypes is associated with ‘hotspots’ of severe scale infestations in the areas bordering Cameroon, Equatorial Guinea, and Gabon. These can help our understanding of the invasion biology of this species and support the development of specific control options, in particular limiting the movement of infested planting materials from hotspots to other areas.

To further understand the ecological factors that are associated with ARTS diversity, screening of the ARTS collection for endosymbionts, microorganisms living inside the scale insects, showed

the presence of three secondary endosymbionts (*Rickettsia*, *Sodalis* and a Gamma proteobacteria) in addition to the primary endosymbiont *Uzinura diaspidicola*. These organisms are likely to play an important role in plant utilization as well as genetic differentiation of the host scale insect. Primary endosymbionts are known to make up food deficits in insect feeding and secondary endosymbionts manipulate the reproductive system, altering fecundity and reproduction and in some instances causing mating incompatibility. Additional research on the interactions of the various scale genotypes with their associated endosymbionts may help us understand the causes of genetic differentiations in scale populations and provide clues to their host utilization and host plant factors that affect scale population growth and dynamics, which can be

exploited for the development of cassava resistance to ARTS.

This work was supported by the CRP Root, Tubers and Banana (CRP RTB), the International Fund for Agricultural Development (IFAD), and a Borlaug-LEAP Fellowship to A. Doumtsop. M. Tindo of the University of Doula, Cameroon, provided some Cameroon samples.

Acknowledgement

The authors also wish to acknowledge the contributions of the following: Benjamin Normark, University of Massachusetts Amherst, USA; Abraham Fomena, University of Yaounde 1, Cameroon; Willy Tata-Hangy, IITA-DR Congo; and Kerry Oliver, University of Georgia, USA.

About the authors



Rachid Hanna is an Entomologist and IITA-Cameroon Country Representative. He holds an MSc in Plant Protection and Pest Management and a PhD in Entomology, both from the University of California Davis. He has extensive experience in arthropod biodiversity, arthropod-host plant interactions in natural and agricultural systems, vector biology, biological control and crop utilization. In addition to his work on integrated management of ARTS, Dr Hanna specializes in developing biological control options for insect and mite pests of annual and perennial crops

ARTS on a cassava root. Photo by Rachid Hannah, IITA-Cameroon.



including such examples as the successful biological control of cassava and the ongoing programs on biological control of mites on coconuts, the fruit fly *Bactrocera invadens* on mango and other fruits, whiteflies on cassava, and aphids on vegetables. His work on banana aphid biology and epidemiology of banana bunchy top disease (BBTD) – with Lava Kumar and Cornell University researchers – is paving the way to the identification of BBTD-tolerant plantain varieties and sources of resistance to banana aphid in *Musa* germplasm, as well as understanding the interactions between the banana aphid, tending ants, and generalist natural enemies and their consequences for aphid population dynamics and BBTD epidemiology.



Armand Doumtsop received his Bachelor of Science in Animal Biology Degree from the University of Douala, Cameroon, in 2001; an MSc in Entomology from the University of Yaounde I, Cameroon in 2008; and he is currently following a PhD program in Entomology at the same university while conducting his research at IITA-Cameroon.

He is an Assistant Lecturer since 2012 in the Department of Agriculture, Husbandry and Products of the Higher Institute of the Sahel, University of Maroua, Cameroon. In addition to his PhD research on the biology and ecology of ARTS, Mr Doumstop assists the IITA-Cameroon team in a number of other activities such as surveillance and forecasting of crop pests and diseases and mass rearing of economically important insects. His current research focuses on detection of cryptic species in pest populations using morphological and molecular techniques. Mr Doumtsop was awarded the Norman E. Borlaug fellowship 2011-2012 and had a new scale insect species, *Diaspis doumtsopi*, named after him.

Enhancing legume productivity in Eastern DR Congo with N2Africa technologies

Christopher Ngosong, Post-doctoral Fellow (Systems Agronomy), IITA-DR Congo

The N2Africa project, “Putting nitrogen fixation to work for smallholder farmers in Africa”, is supported by the Bill & Melinda Gates Foundation and the Howard G. Buffett Foundation, and operates in East DR Congo, Nord and South Kivu provinces, as well as in Nigeria, Ghana, Liberia, Sierra Leone, Rwanda, Kenya, Malawi, Zimbabwe, and Mozambique. The overall vision of success of N2Africa by 2013 is to raise average grain legumes yields by about 950 kg per hectare in the four legumes: groundnut, cowpea, soybean, and common bean, to increase average biological nitrogen fixation by 46 kg per hectare, and to increase average household income by US\$465 per annum.

In DR Congo, local partner organizations include the National Agricultural Research Institute (INERA), the Catholic University of Bukavu, and the University of Goma. Field implementation of project activities was facilitated by local NGOs, including Women for Women International (W4W) and Diobass in Nord Kivu Province, and W4W, Initiative Paysanne pour Lutter Contre l’Ignorance (IPLCI) Kamanyola, and Centre de Développement Communautaire de KIRINGYE (CDC Kiringye) in South Kivu Province. Especially W4W focuses on improving the livelihoods of



Cassava-soybean trials in DRC. Photo by Despines Bamuleke, IITA-DRC.

women although all other partners also have a specific focus on women, especially in the post-conflict situation of East DR Congo.

The vision of success of N2Africa is addressed via the deployment of improved legume varieties, integration of legumes into existing rotational or intercropping arrangements, use of appropriate fertilizer and Rhizobium inoculants. Rhizobia are bacteria that help nitrogen fixation in leguminous crops thus increasing both yields and soil benefits.

In South Kivu, soybean production was enhanced by over 500 kg per hectare after application of Rhizobium, while fertilizer had minimal impact on the yield. At a value of approximately US\$1 per kg of soybean, these extra returns are substantial in relation to an investment of about US\$5-10 per kg for inoculant application. The returns to fertilizer application are obviously minimal to nil. Soybean aboveground biomass also demonstrated an average increase of about 400 kg per hectare per farming season for soils inoculated with rhizobium compared to non-inoculated soils. This represents an important contribution to animal feed for the production of dairy products. Eastern DR Congo is known for animal husbandry with smallholder farmers involved in integrated farming systems, combining

crop production and animal rearing. Besides the importance of grain legumes for human nutrition, the smallholder farmers thus consider the production of aboveground biomass to serve as animal feed as an important parameter in their agricultural activities.

The N2Africa technology was exposed to about 17 000 smallholder farmers in both South and North Kivu provinces over four farming seasons. The direct beneficiary farmers were trained in relation to various N2Africa interventions, including the application of Rhizobium inoculant, improved agronomic practices, and legume participatory variety selection. Another 2500 smallholder farmers were trained on postharvest transformation of soybeans to local diet specialities (i.e. soya milk, yoghurt, fufu, sauce, balls, benye, meat or tofu, etc.), which enhances preservation and add value to the produce.

Future interventions should focus on: (i) the sustainable supply of inputs, including improved varieties, appropriate fertilizer, and high quality Rhizobium inoculants; (ii) access to profitable grain legume output markets; and (iii) the facilitation of effective partnerships with development initiatives to expose the best N2Africa technologies to the largest number of interested smallholder farmers.

The project also addresses capacity development for scientific and development partners. In East DR Congo, four female and two male students have completed their BSc dissertation while two MSc students, one male and one female, are in the process of finalizing their thesis.

Acknowledgement

This report would not have been completed without the support and valuable contributions from Juma Rehani, Despines Bamuleke, and Jean-Marie Sanginga, all of IITA-DR Congo.

About the author



Christopher Ngosong is a Post-doctoral Fellow (Systems Agronomy) based at IITA-DR Congo in Bukavu. He also coordinates the N2Africa project on putting nitrogen fixation to work for smallholder farmers in sub-Saharan Africa. The research focus of the project is on soil biota (legume-rhizobia interactions) and fertilizer amendments.

Dr Ngosong previously worked at McGill University, Canada, as a post-doctoral fellow, and also as assistant lecturer at University of Buea, Cameroon. Before that he worked in various capacities at the University of Hohenheim, Germany.

In Burundi and Rwanda, banana planting materials provide additional income to smallholder farmers

Emmanuel Njukwe, Associate Scientist, IITA-Burundi

Banana production in Burundi and Rwanda is constrained by factors such as limited availability of quality planting material. To help overcome these challenges, IITA has been promoting and facilitating access to new high-yielding, pest and disease resistant, improved hybrid banana cultivars with good consumer acceptability. As prelude to the widescale distribution of these hybrids, macro-propagation technology is promoted for the production of healthy planting material. The method is simple and cheap, but requires investment, which makes it suitable for enterprising farmers. The objective of the project is to develop a cost-effective and sustainable system for continuous multiplication and timely distribution of quality planting material.

Planting material production and sale

For smallholders to move from small-scale production to agriculture enterprise development, seedling nurseries are required for regular supply of healthy suckers. Specialized



Banana macro-propagation facilities of Behar Bidasoa Association in Kamonyi, Rwanda. Photo by Emmanuel Njukwe, IITA.

seed producers in Burundi and Rwanda establish tissue culture mother gardens to back up the supply of healthy suckers for macro-propagation. Mother gardens are rejuvenated with new stocks of tissue-cultured plants or replenished with new varieties every 3 to 4 years.



FLORESTA Farmers' Association nursery in Rutana. Photo by Emmanuel Njukwe, IITA.

Farmers in Burundi and Rwanda have installed macro-propagation units for the production of healthy planting materials both to expand their own fields and for sale to generate income. Five farmer associations with 209 members (70 female and 139 male) in Burundi are able to provide a consistent supply of over 30 000 plantlets, which allows them to plant between 15 and 20 hectares annually and to collectively make over US\$ 24 000 to raise their standard of living and purchase new plant stock when needed. Member-farmers benefit from free healthy planting material to establish

fields and sell bunches, while profit from quantity sold is reinvested in the association and serve as loan to members at small interest rates. The situation is similar in Rwanda where, during the 2013 agricultural show, over 20 farmer associations exhibited banana plantlets derived from macro-propagation. UCODE Farmers' Association in Ngozi utilized money from the sale of banana plantlets to initiate a micro-finance scheme for its members.

Financial and technical support

In the framework of the Belgian Technical Cooperation and Rwanda Agricultural Board (BTC/RAB), 64 macro-propagation units were installed in four provinces, all managed by farmers' cooperatives. Similarly in Burundi, the FLORESTA Farmers' Association, with technical and scientific support from IITA, received financial support from the Governments of Belgium, the Netherlands, and USA, while another farmer association, CADEK, received financial support from the Government of Italy to expand macro-propagation activities. The private tissue culture lab, Phytolabu, based in Bujumbura, also received material and technical support from the government of Belgium to expand and produce more planting material as starting stocks to establish mother gardens.

With external resources, our partners/farmers were able to initiate the production of healthy planting material on their own rather than depending on IITA for the provision of starting stocks and materials, as was the case in 2006 to 2009. In 2012, IITA received €10,000 from PPCDR to promote macro-propagation technology and leverage for additional investments for outscaling.

Looking forward and moving ahead

Although macro-propagation can be appropriate for small and medium scale enterprises, there are challenges – the most critical being lack of initial capital investment and technical skills. Other limiting factors include climatic conditions, sucker quality, proximity to the propagator

Group training of farmers on establishing banana nursery organized by IITA in Gitega, Burundi. Photo by Emmanuel Njukwe, IITA



for regular shoots monitoring, availability of materials, and water. Labor requirements are also often overlooked. Additional problems encountered during macro-propagation may include access to appropriate sucker type and substrate, poor sprouting rate, premature rotting of corms, low plantlet survival rates, pest and disease attack and varietal mix-up.

To help farmers overcome some of these challenges and to ensure successful technology out-scaling, training workshops are organized and training materials disseminated. Lead farmers are often involved in the training. Communication tools such as factsheets and videos are produced and distributed to farmers.

To support further development of an effective system for continuous production of healthy banana planting

material, cost benefit analysis studies will be conducted and options to market banana planting material will be promoted through market information networks and innovation platforms in the Great Lakes region. Regarding this, IITA has contacted Burundi and Rwanda National Universities for students to carry out cost-benefit analyses in 2014 and we plan to install macro-propagation facilities in the Kalambo Office for youth entrepreneurs and economic studies. In addition, market information network will be established through the Humidtropics CRP field sites' IPs. The effectiveness and efficiency of various methods for healthy banana planting material production will also be assessed and improved.

About the **author**



Emmanuel Njukwe is an Associate Scientist at IITA-Burundi. He coordinates partnerships in the African Great Lakes region with local research, farmer and development partners with a special focus on out-scaling technologies and training tools to the end-users. Emmanuel is experienced in participatory germplasm introduction and evaluation and has facilitated IITA improved germplasm (cassava, banana and yam) in East and Central Africa, where some have been released. Emmanuel has been working at IITA since 2001. His communication skills, technical expertise, and experience in building and maintaining partnerships have helped to further improve and expand the R4D approach in the Consortium for Improving Agriculture-based Livelihoods in Central Africa" (CIALCA) project.

New varieties released

IITA, in collaboration with INERA, released six improved cassava varieties in DR Congo with an official release ceremony held on 1 November 2013 at the Research Center of INERA at Mvuazi, Bas Congo province.

The Minister of Agriculture and Rural Development, Hon John Chrysostome Vahamwiti, and the Minister of Higher Education and Scientific Research, Bonaventure Chelo, graced the ceremony. Dr Nzola Mahungu, who represented IITA at the ceremony, presented the IITA Cassava project funded by USAID since 2001, which was adding another range of six new cassava varieties, making a total of 20 varieties since the project's inception.

These varieties have so far been used by farmers and other producers. They are resistant to CMD, with a good level of tolerance to CBSD, high yielding, early to late bulking, and adapted to different environments in the country.

Dr Mahungu further described the morphological and agronomic traits of these six varieties as a requirement for them to be registered in the national catalog of the "National Seed Systems". Two of the six new varieties were introduced from IITA: Mutiene (I 92/326) and Bomengo (M98/115), while the other four were selected locally: Lito (2006/114), Muzuri (2006/073), Kansakako (MV2007/102) and Ilona (MV2007/126). These varieties have harvest periods varying from 12 to 20 months after planting, with root yield of 21 to 47 t/ha. All varieties are good for *fufu*, *lituma*, *chikwangu* and *pondu* (cooked cassava leaves).



(Left photo) INERA DG, Prof Paul Mafuka, handing over cuttings of the new varieties to the Minister of Higher Education and Scientific Research who, in turn, handed them over to the Minister of Agriculture (right photo) who, then, officially announced their release.

Crop	Country	Lead partner	IITA accession number	Release name
Cassava	DR Congo	INERA	M98/115	Bomengo
			2006/114	Lito
			2006/073	Muzuri
			MV2007/102	Kansakako
			MV2007/126	Ilona
			I 92/326	Mutiene

capacity building, seminars and publications

Training

In 2013, the Central Africa hub organized 25 training workshops covering a wide spectrum of research themes and benefitting more than 2500 individuals. Below is the list of training activities by country:

DR Congo (Kinshasa)

- Cassava R4D project: annual planning workshop and capacity building (training) for NARS (INERA) researchers and technicians, about 50 participants, August.
- Regional launch of SARD-SC project cassava component, Kinshasa, about 35 participants, 13-14 February.
- National launch of SARD-SC project cassava component in Bas Congo province, Matadi, about 35 participants, 15 March.
- National launch of SARD-SC project cassava component in Oriental Province, Kisangani, about 35 participants, 22 March.
- Statistical training course on the use of SAS software, Kinshasa, 35 participants, 21-25 October.
- Training of trainers (ToT) on cassava multiplication, cultural practices and diseases/pests identification, one week each in Bas-Congo (Kinza-Vuete), Kisangani and Bukavu held on 18-20 September, 26-28 September, and 1-3 October, respectively, with total of 86 participants.

DR Congo (Bukavu)

- Research methodology in social science, 30 participants.
- Integrated soil fertility and farm management, 100 participants.
- Seed multiplication and preparation, 80 participants.
- Establishment of field trials, 500 participants.
- Application of farm input (fertilizer and rhizobium), 500 participants.
- Harvest and postharvest transformation, 600 participants.
- Objective project reporting, 30 participants.

Cameroon

- Extension and farmer training (identification and management of fruit flies), 13 participants (2 female and 11 male), 3 days.
- Extension and farmer training (aphids and their natural enemies), 15 participants, 3 days.
- Extension and farmer training (macropropagation), 47 participants (11 female, 36 male), 2 days.
- Extension and farmer training (plantain IPM and ISFM), 38 participants (9 female, 29 male), 7 days.
- Participatory variety assessment workshops in Buea, Manfe and Mudemba, 320 participants (83 male, 237 female), April-May.

- Student workshops on qualitative methods, research techniques and analysis of qualitative data. Four female students from Leipzig and Buea Universities, Yaounde and Buea, October.
- National Workshop (Restitution of the ended Phase II of REALU Project) with about 50 participants from REDD+ system in Cameroon, 2 days.

Burundi and Rwanda

- ToT on banana disease identification, prevention and management, 60 participants (18 female and 42 male), 5 days.
- ToT on improved banana and cassava field management practices, IPM and NRM, 30 participants (9 female and 21 male), 5 days.
- ToT on rapid multiplication of health banana planting material, 60 participants (22 female and 38 male), 5 days.
- TOT on post-flask management of cassava and banana field management and evaluation, 20 participants (8 female and 12 male) , 3 days.
- TOT on post-flask management of cassava and banana, 5 participants (2 female and 3 male), 1 day.

Seminars

Natural resource management

- Effectiveness of rhizobia isolated from South Kivu soils on nodulation of soya beans. Bintu Ndusha (MSc student), IITA Kalambo station, DRC, 1 February.
- Productivity in banana legume intercropping systems. Ir Jules (MSc student in agronomy), IITA Kalambo station, DRC, 8 February.
- Profiling nutrients limiting soya bean productivity in high degraded soils of South Kivu DRC. Eric Sika (MSc student), IITA Kalambo station, DRC. 27 March.
- Climate change and agriculture: a back-and-forth relationship. Patrick Mutuo (CIAT Scientist), IITA Kalambo station, DRC. 3 June.
- Effectiveness of rhizobia isolated from South Kivu soils on nodulation of soya beans. Bintu Ndusha (MSc student), IITA Kalambo station, DRC. 7 June.
- Erosion control in South Kivu. Audrey Muke (CIALCA), IITA Kalambo station, DRC, 8 June.
- Effects of mycorrhizae rhizobia inoculation on phosphorus and nitrogen availability and soybean performance in Walungu District, DR Congo. Liliane Shukuru (MSc student), IITA-Kalambo, DRC. 19 July.
- Assessment of quality control of legume inoculant on bean and soybean in East and central Africa. Isaac Balume (MSc student), IITA Kalambo station, DRC. 5 September.

- Potential of local rhizobia strains to enhance nitrogen fixation by bio-fortified beans in South Kivu Eastern DRC. Noël Mulinganya (MSc student), IITA Kalambo station, DRC. 10 September.
- Survey results on the short-term impact of the N2Africa project in eastern Democratic Republic of Congo. Jean-Marie Sanginga (N2Africa Focal Point person), IITA Kalambo station, DRC. 4 October.
- Heterogeneous quality of commercial inputs and learning through experimentation: implications for technology adoption and agricultural productivity. Moses Thuita (Postdoc), IITA CA hub office, Kenya. 8 October.
- COWBIA: Multi-purpose cowpea inoculation for improved yields in small holder farms in Kenya. Sam Mathu (PhD student), IITA CA hub office, Kenya. 29 October.
- Effect of improved variety and inorganic fertilizer on cassava yield, agronomic efficiency and economic returns in DR Congo. Nyi Thandar (PhD student), IITA CA hub office, Kenya. 3 December.

Social science and agribusiness

- Impact of marketing strategies on farmers' income and input commercialization. Valéry Kasereka (PhD student), IITA Kalambo station, DRC. 15 February.
- *Activités non agricoles et adoption des nouvelles technologies dans les sites d'action de CIALCA.* Serge

Amato (BSc student), IITA Kalambo station, DRC. 14 June.

- *Impact des technologies N2 Africa sur la production et le revenu agricole.* Grácia Kahasha (MSc student), IITA Kalambo station, DRC. 19 August.
- Cassava investment in DR Congo: Challenges for value chains improvement. Dr. Nzola Mahungu, IITA Kinshasa office, DRC. 16 May.
- The contribution of yams in food security in DR Congo. Ir. Toussain Kendenga (IITA Research Associate – Socio-economy). 19 July.
- Challenges on environmental factors from emerging small scale cassava processing units: Case of DR Congo. Ir. Lukombo Singi (IITA Research Associate - Food Technology), Kumbikumbi Hotel, Mbuji-Mayi, Kasai Oriental Province, DR Congo. 2 September.
- *Effet du labour et de la position de bouturage sur le rendement en racines tubéreuse et en feuilles de manioc : Cas des zones de savane et des jachères forestières de la RDC.* Ir. Ndonda Adrien (IITA Research Associate - Agronomy), Kumbikumbi Hotel, Mbuji-Mayi, Kasai Oriental Province, DR Congo. 2 September.

Plant production and plant health

- Cassava breeding activities in the DR Congo by INERA and IITA. Ir. Ndombo Delo (IITA Research Associate – Plant Breeding), IITA Kinshasa office, DRC. 26 July.

Graduate and post-graduate studies

During the year, a total of 10 MSc students (6 female and 4 male) commenced their studies under the supervision of IITA scientists based in the Central Africa hub. During the same period, 6 MSc students (3 male and 3 female) completed their studies. Details of PhD students who commenced or completed their studies in 2013 are presented below:

Name	Affiliation	Title of thesis	IITA supervisor	Status
Natural resource management				
Nibasuba Anaclet	Catholic University of Leuven	Arabica coffee x banana intercropping and its impact on yield, postharvest quality and farm revenue in Burundi	Piet Van Asten	Completed
Marlene Saidi Mariam	<i>Université du Benin</i>	<i>Etat de l'agrobiodiversité et sa conservation dans la réserve biosphère de Luki au Bas Congo</i>	Nzola Mahungu	Commenced
Nathalie Ewane Nonga	University of Kinshasa	Developing tree management model for enhancing carbon stock and productivity in cocoa agroforest	Martin Yemefack	Commenced
Adoph Kemga	University of Kinshasa	Investigating for appropriate remote sensing tools for evaluating and monitoring carbon stock from all land uses in the humid forest of southern Cameroon	Martin Yemefack	Commenced
Plant production and plant health				
Michel Dogmo	Department of Animal Biology, University of Yaounde I	Diversity and resilience of the butterfly <i>Bicyclus dorothea</i> under climate change	Rachid Hanna	Commenced

Social science and agribusiness

Kasereka Bishikwabo	University of Nairobi	Impact of market linkage strategies on agricultural productivity, farm incomes, and poverty in South Kivu	Paul Dontsop	Commenced
Scarlett Apfelbacher	University of Leipzig, Germany	The impact of climate change on agriculture and gender relations	Holger Kirscht	Commenced
Kerstin Schopp	University of Bayreuth, Germany	Local knowledge and gender	Holger Kirscht	Commenced
Mbuh Quinta Wonjih	University of Buea	Access to and control over agricultural resources	Holger Kirscht	Commenced

Selected publications

Natural resource management

Dewitte O, Jones A, Spaargaren O, Breuning-Madsen H, Brossard M, Dampha A, Deckers J, Gallali T, Halletti S, Jones R, Kilasara M, Le Roux P, Michéli E, Montanarella L, Thiombiano L, Van Ranst E, Yemefack M, and Zougmore R. 2013. Harmonization of the soil map of Africa at the continental scale. *Geoderma* 211–212.

Gentile RM, Vanlauwe B, and Six J. 2013. Integrated soil fertility management: Aggregate carbon and nitrogen stabilization in differently textured tropical soils. *Soil Biology and Biochemistry* 67: 124-132.

Ndabamenye T, Van Asten PJA, Blomme G, Vanlauwe B, Uzayisenga B, Annandale JG, and Barnard RO. 2013. Nutrient imbalance and yield limiting factors of low input East African highland banana (*Musa* spp. AAA-EA) cropping systems. *Field Crops Research* 147: 68-78.

Otinga AN, Okalebo JR, Njoroge R, Emong'ole M, Six L, Vanlauwe B, Pypers P, and Merckx R. 2013. Partial substitution of phosphorus fertilizer by farmyard manure and its localized application increases agronomic efficiency and profitability of maize production. *Field Crops Research* 140: 32-43.

Paul BK, Vanlauwe B, Ayuke F, Gassner A, Hoogmoed M, Hurisso TT, Koala S, Lelei D, Ndabamenye T, Six J, and Pulleman MM. 2013. Medium-term impact of tillage and residue management on soil aggregate stability, soil

carbon, and crop productivity. *Agriculture, Ecosystems and Environment* 164: 14-22.

Vandamme E, Renkens M, Pypers P, Vanlauwe B, Smolders E, and Merckx R. 2013. Root hairs explain P uptake efficiency of soybean genotypes grown in a P-deficient Ferralsol. *Plant and Soil*. In press.

Vanlauwe B, Wendt J, Giller KE, Corbeels M, Gerard B, and Nolte C. 2013. A fourth principle is required to define Conservation Agriculture in sub-Saharan Africa: the appropriate use of fertilizer to enhance crop productivity. *Field Crop Research*. In press.

Plant production and plant health

Agboton BV, Hanna R, Onzo A, Vidal S, and von Tiedemann A. 2013. 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* 60: 205-217.

Bothon FTD, Gnanvossou D, Noudogbessi JP, Hanna R, and Sohounhloue D. 2013. *Bactrocera cucurbitae* response to four *Cymbopogon* species essential oils. *Journal of Natural Products* 6: 147-155.

Onzo A, Bello IA, and Hanna R. 2013. Effects of the entomopathogenic fungus *Neozygites tanajoae* on the predatory mite *Typhlodromalus aripo* on cassava green mite: greenhouse experiments. *BioControl* 58: 397-405.

message from the **regional director**

The year 2013 has been another special year for us here at the Eastern Africa hub. It saw us launch our new science building, one of our staff received a prestigious international award and our research scope increased and spread to more countries in the region through new exciting projects.

Launch of new science building

The long-awaited launch of our new science building was held on 13 May 2013 by the President of the United Republic of Tanzania, His Excellency Dr Mrisho Jakaya Kikwete. The colorful event was also attended by the country's former president, HE Benjamin Mkapa, and the IITA Ambassador

and former President of Nigeria, Chief Olusegun Obasanjo. Others dignitaries on hand were agriculture ministers from Tanzania and Uganda and other top government officials, heads of diplomatic missions and donors organizations, the Chair and CEO of the CGIAR Consortium, the Directors General of several CGIAR Centers, members of civil society, and the media. From IITA, all members of the Board of Trustees, Dr Nteranya Sanginga, IITA Director General, all senior management team, and the staff in Tanzania took part. The building, with its state-of-the-art laboratories, will strengthen our research capacity and that of partners as we help find solutions to the agricultural challenges facing smallholder farmers in the region.



Dr Victor Manyong
Regional Director
Eastern Africa



(Left photo) President of the United Republic of Tanzania, His Excellency Dr Mrisho Jakaya Kikwete (in red tie), with former Nigerian President Chief Olusegun Obasanjo (in blue traditional attire), Dr Victor Manyong, and other dignitaries during the ribbon cutting ceremony of the new IITA science building. (Right photo) The new science building at the IITA-Tanzania premises in Dar es Salaam. Photos by C Njuguna and JT Oliver, IITA.

Staff recognition

One of our staff, Dr Charity Mutegi, who is based in Kenya, won the prestigious 2013 Norman Borlaug Award for Field Research and Application for her efforts to tackle aflatoxins – toxic chemicals produced by naturally occurring fungi, *Aspergillus* sp which attack important staple crops.

International conferences

During the year we hosted and supported the organization of several high-level international conferences such as the International Plant Virology Epidemiology (IPVE) Symposium and an international workshop on the Banana Bunchy top disease, both held in Arusha, Tanzania, the Pan Africa Control Aflatoxin (PACA) Platform Meeting in Dar es Salaam, Tanzania, and the 6th International Nitrogen Conference in November in Kampala, Uganda.

Spreading our wings

We expanded our research activities into Ethiopia and South Sudan. In Ethiopia, we signed Memoranda of Understanding with the Ethiopian Institute of Agricultural Research (EIAR) at the federal level and with Southern Agriculture Research Institute (SARI) based in Hawassa at the regional level. We also initiated capacity building activities in collaboration with Hawassa and Mekele Universities in Ethiopia and the University of Juba in South Sudan within a new project funded by the Norwegian Program for Capacity Development in Higher Education and Research for Development (NORHED) of the Norwegian Agency for Development Cooperation (NORAD).

We are also extending our successful biotechnology research to tackle the destructive banana bacterial wilt disease on cooking banana in Uganda to 'enset' in Ethiopia. Enset is important to the livelihoods of millions of smallholder farmers for food and livestock feed. Similar to banana, its production is also threatened by bacterial wilt.

Building our human resources capacity

In response to the increase in new projects, the number of scientists increased from 14 at the beginning of the year to 22 by year end (14 in Tanzania, four in Kenya, and four in Uganda).

New projects

We increased our project portfolio this year bringing in an additional US\$11 million. This has seen our research financial resources at the hub doubling to US\$20 million.

Revamping banana research

Banana is a very important food and income crop in the region and at IITA we are revamping our banana program in both Tanzania and Uganda and also in West Africa through the efforts of two new experts recruited in 2013. We are happy to note that after many years of neglect, this crop is now being considered a priority by development investors and action has been initiated for increased funding support in the coming years.

All these would not have been possible without the good support of our staff, partners and donors and we say a big thank you to all of you. *Asanteni sana*. I wish you all happy reading!

eastern africa **research highlights**

Soil, crop and livestock experts seeking a mixed basket of solutions for smallholder farmers' challenges: lessons from the Africa-RISING experiences in Babati

Mateete Bekunda, Chief Scientist, Africa-RISING, East Africa, IITA-Tanzania; and **Irmgard Hoeschle-Zeledon**, Coordinator, Africa-RISING, East and West Africa, IITA-Ibadan, Nigeria

Most of the farmers in sub-Saharan Africa practice mixed farming on mostly small parcels of land – they grow different crops, cereal, grain legumes, vegetables and fruit trees, and keep livestock. The research program Africa-RISING, led by IITA, brings together many different partners to develop integrated science-based technologies and management practices that better integrate these different components. The overall objective is to increase whole-farm productivity, improve nutrition, and increase farm incomes while at the same time maintaining natural resources base. Here we share some of the successes and achievements so far in one of the project sites, Babati district in northern Tanzania.

Low productivity and high poverty rates is the bane of small-holder farming systems in Africa. However, if well-managed, smallholders systems can be very productive and their diversified methods of production can lead to more

sustainable agricultural systems. To achieve this, investment in science, technology and people is crucial. The IITA-led program Africa Research in Sustainable Intensification for the Next Generation (Africa-RISING), funded by the USA Government under the Feed the Future (FtF) Initiative, brings together multi-disciplinary teams of research and development partners to address challenges faced by different typologies of small-holder farmers. It aims to increase overall farm productivity, profitability and food security, with minimal negative impact on natural resources.

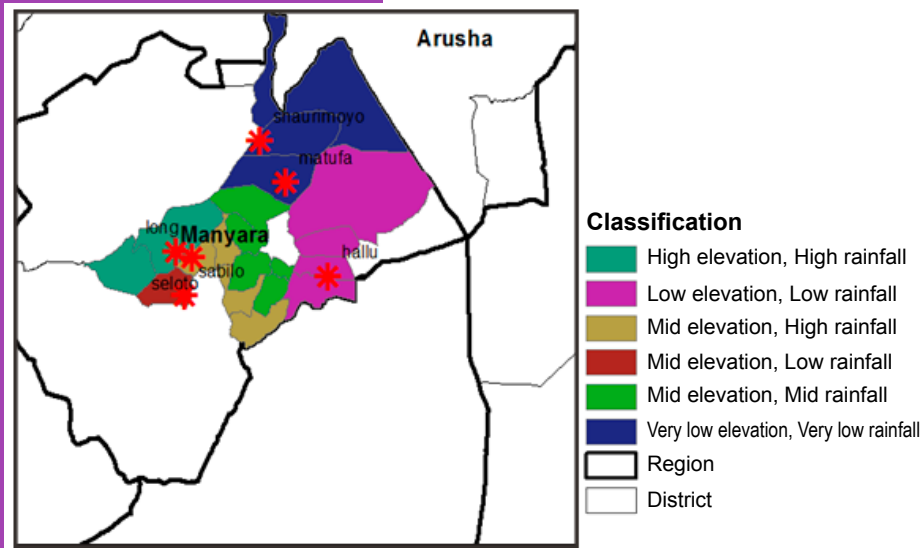
The program aims at providing integrated science and technologies encompassing components ranging from the use of improved seed varieties and livestock breeds to pre- and post-harvest management skills. Regional components/ characteristics that set the framework for the program are nutritional needs, marketing and social institutions, and maintenance of the integrity of natural resources.

The researchers are evaluating a wide array of existing technologies at local levels to identify the most appropriate ones for adoption and scaling up in areas with similar agro-ecologies.



Africa-RISING farmers with their climbing beans introduced by CIAT.

Figure 1. Africa-RISING intervention villages in Babati (red stars) are located in different agroecological zones classified according to elevation and rainfall.



Location and approaches

Babati District in northern Tanzania is one three action sites of the Africa-RISING program in East and Southern Africa. Due to the wide altitudinal range within the area (950-2450 m above sea level; Figure 1), the site provides an opportunity for comparisons along a diverse set of agroecologies.

The project team working in Babati District is multidisciplinary, and sourced from different institutions including five CGIAR centers: IITA, International Livestock Research Institute (ILRI), International Maize and Wheat Improvement Center (CIMMYT), International Centre for Tropical Agriculture (CIAT), International Crops Research Institute for the Semi-Arid-Tropics (ICRISAT) and

International Food Policy Research Institute (IFPRI). Other partners include the World Vegetable Centre (AVRDC) and Wageningen University. Scientists from these organizations are working in partnership with local research institutions including the Selian



Agriculture Research Institute (SARI), Tanzania Livestock Research Institute (TALIRI), Nelson Mandela African Institute of Science and Technology (NM-AIST), Sokoine University of Agriculture (SUA) and University of Dodoma. The project is also working with the District Agricultural Irrigation and Cooperative Officers (DAICOs).

The competences and expertise represented by the partners in the team include biophysical production and constraints, improved food and feed crop varieties, fodder species for land management, intercropping and fertilizer application, mycotoxin management, postharvest technologies, integration of vegetables, baseline surveys and farming system analysis.

In 2012/2013, the Africa-RISING research team engaged farmers through baseline surveys and focus group

discussions to understand and focus the research to address the local needs. Concurrent field research, mainly field trials of new crop varieties and integration of technologies based on the researchers' expert knowledge, were also initiated. In addition, two studies were commissioned - one on the maize lethal necrosis disease and the other on the successes and challenges of related projects/research activities conducted in Babati in the past.

Key results

Agronomists identified large and variable yield gaps between and within farmers' fields. While over 81% of the farmers used maize hybrids, only 3% applied fertilizers on maize. As a consequence, the majority of the farmer fields had negative nutrient balances, indicating mining of the soil nutrients. A classification tree was used to attribute the magnitude of different factors to the yield gap. It showed that plant density in the field, field slope, proximity to the homestead and frequency of manure application were important factors. Fields located on flat land close to the homestead and with high plant density had significantly higher yields. The team is aware that socio-economic factors play a very important role and need to be considered in the analysis and for developing recommendations.

The project's agronomic trials demonstrated to farmers the value of adding fertilizers to increase crop yields. The experiments were done in a maize-pigeon pea intercrop and different types of fertilizer were tested. All had a positive effect on the yield, improving the less than 1 ton per

hectare yields that were obtained under farmer's practice to between 3.8 and 4.6 ton per hectare, depending on the fertilizer (Table 1). Fertilizer application combined with introduction of a new climbing bean variety also increased yields significantly. Currently, only 3% of the farmers use fertilizers and one of the challenges for the project is to support farmers to adopt the use of these inputs.

Table 1. Impact of fertilizer micro-dosing on maize yields from a maize/pigeon pea intercrop in Sabilo village.

Treatment	Yield (t/ha)
Diammonium phosphate (DAP)	4.618
Minjingu Mazao (a fertilizer blend)	4.149
Minjingu Phosphate Rock (granular)	3.853
Farmer's practice	0.71
LSD (n=9)	0.62
CV (%)	19.3

Hungry livestock

Using an assessment tool (Feed Resource Assessment Tool, FEAST), it was estimated that the feed sources at best met up to 65% of the cattle feed needs during the wet season (mainly grazing) and only 12-30% during the dry season (mainly crop residues) (Figure 2). Extensive grazing is dominant and the other common feed resources are crop residues, e.g. dry maize stover, green maize stover, bean haulms, pigeon pea residue, sugarcane tops and sweet potato vines. Planted forages, especially legumes, are largely absent from the system.

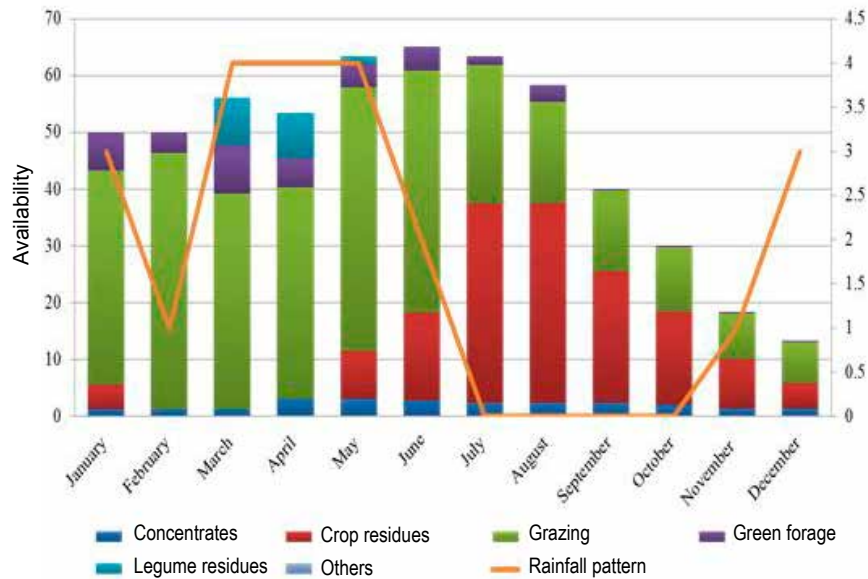


Figure 2. Cattle feed availability in Babati during a calendar year.

Therefore, improved grasses and forage legumes have been introduced and integrated in the farming systems to increase feed productivity and quality. These plants will also improve the landscape quality, especially by controlling erosion and introducing nitrogen to the soils through biological nitrogen fixation. Increasing crop yields of currently grown crop varieties will

also increase crop residue quantities that can be used to increase livestock feed.

Implications on future activities

The research team has developed a research strategy to address multi-discipline integration. The research components are layered so that products from one activity can benefit from or be a resource to another activity. Sometimes such products are “wastes”, e.g. vegetable residues are being proposed as a local feed resource for poultry and poultry manure is proposed as a nutrient resource for vegetables. In such a scenario,

“wastes” are eliminated, farm productivity is increased and environmental integrity is upheld.

Each year, the technologies prioritized through participatory evaluation with farmers will be subjected to a randomized evaluation. The results will be analyzed through models to estimate the causal effects of these technologies on several key agricultural and human development outcomes, and their potential for adoption and diffusion. The phosphate rock fertilizer and maize x pigeon pea intercropping technology, and the climbing beans are pioneering this exercise during 2013/14.

About the authors



Mateete Bekunda is currently employed as Farming Systems Agronomist at IITA. His responsibility as Chief Scientist to the Africa RISING is to guide the design, planning and implementation of integrated natural resource, crop and livestock management studies to address farmers’ needs in different intensification gradients in the project target regions of Tanzania, Malawi and Zambia. Dr Bekunda has had long-term research and capacity building experience in soil and natural resources directed toward crop nutrient management, agronomy and environmental dimensions of sustainable smallholder low-input farming systems in East Africa. He has worked with national and international researchers and institutions in promoting agricultural science, the latest example being his convening of the 6th International Nitrogen Conference during November, 2013.



Irmgard Hoeschle-Zeledon is the coordinator of the Africa-RISING projects in East & Southern Africa and West Africa. She has vast international experience in management and implementation of agricultural research and development projects around the globe. She gained her first international experience from 1984-1986 as a research assistant of the

*University of Hohenheim in Germany, working in a horticulture program in Ethiopia and studying control options for the parasitic weed *Orobanche*. She then worked in various capacities in integrated pest management and postharvest protection projects in Ecuador, Nicaragua, Myanmar, Germany, and Malawi. In 2002, she was seconded to Bioversity International in Rome, Italy to establish a Global Facilitation Unit for Underutilized Species (GFU) and act as its global coordinator. Mid-2008, she joined IITA in Ibadan, Nigeria, as the new Coordinator of the CGIAR System-wide Program on Integrated Pest Management (SP-IPM), a position she held until end of 2013 when the Program officially came to an end.*

IITA leads regional exchange of elite cassava varieties to combat deadly viral diseases

Edward Kanju, Cassava Breeder, and **Silver Tumwegamire**, Postdoctoral Fellow (Cassava Breeding), IITA-Tanzania

The success of any breeding program comes from having a diversity of genetic material. As part of efforts to intensify the development of cassava varieties with dual-resistance to two diseases destroying the crop in countries in Eastern and Southern Africa, IITA is spearheading an initiative to facilitate the exchange of the most promising material between the countries in the region to enrich the gene pool.

Five countries — Kenya, Malawi, Mozambique, Tanzania, and Uganda – have joined efforts to speed up the search for cassava varieties that are tolerant to both cassava brown streak disease (CBSD) and cassava mosaic disease (CMD), the two viral diseases that are currently the most important constraint to the production of the crop. Each country will share its five most promising cassava germplasm in terms of tolerance to the two diseases and all 25 varieties will be tested in all CBSD-affected zones in each country to identify those that have the best combination of dual virus resistance and acceptability to local farming communities.

The efforts are under a project launched in 2011, “New Cassava Varieties and Clean Seed to Combat CMD and

Dr Edward Kanju inspecting some tissue-cultured cassava plantlets. Photo by IITA.



CBSD” (5CP) funded by the Bill & Melinda Gates Foundation and led by IITA. The project offers a unique opportunity for the breeders and virologists to work together for a common goal of combating these major cassava diseases.

The following progress has been made so far under this initiative:

Collection and cleaning of germplasm

By the end of 2012, each partner country had submitted samples of their five best elite cassava clones and one susceptible control to the Natural Resources Institute (NRI), University of Greenwich, UK, and the Kenyan Plant Health Inspectorate Services (KEPHIS) for virus cleaning and indexing. All the clones were cleaned of both cassava mosaic

Gemini-viruses and cassava brown streak viruses, and initiated into tissue culture (TC) for better preservation and shipment. The cleaning is critical to avoid possible spread of the diseases through exchange of materials and also to provide disease-free material as a starting point for multi-location testing.

Mass micro-propagation of clean tissue culture plants

Genetic Technologies International Limited (GTIL), a commercial tissue culture lab based in Nairobi, received 75 TC plantlets for each of the 28 clones

from NRI and right away started the mass micro-propagation. Two other clones that were recently cleaned will be sent to GTIL by end of January 2014. Other clean clones at KEPHIS will be maintained as a backup to complement mass micro-propagation needs at GTIL. The target is to raise a total of 45 000 plantlets (300 per clone per country). To date, GTIL has raised 17 420 plantlets (38.7% of the target) through five sub-cultures. This rate of progress is sufficient to achieve the germplasm exchange milestone within the first quarter of 2014 for all the countries.

Verification for the virus free status and genotype identity

To ensure quality, leaf samples have been collected for all the clones at both KEPHIS and GTIL for virus diagnostics and fingerprinting. The virus verification is being done by Mikochei Agricultural Research Institute (MARI) and IITA, while genotyping is being carried out by the Ugandan National Agricultural Crop Resources Research Institute (NaCRRRI) and IITA. Results from the two verification exercises will inform the decisions for material distribution to countries.

Post-flask management training

To address the human capacity challenges at national programs level, field and lab-based technicians from the five project countries attended a practical training on how to handle and harden the delicate TC plantlets for the field at NaCRRRI, Uganda. The trainees have since embarked on

infrastructural and logistical preparations to receive, handle and manage the tissue culture plantlets.

Moving forward

The exchange of the clean and virus-indexed elite germplasm between the five partner countries is scheduled for the first quarter of 2014. Further research of the exchanged germplasm will follow. First, the clones will be tested in multi-location trials in all five countries to: (a) determine the response of the different genotypes to different environments as estimated by root yield and CBSD and CMD infestation levels; and (b) identify the superior clones for CBSD and CMD resistance in each site. A study protocol has been developed to ensure proper implementation of the multi-location trials. Secondly, the countries will in the future use the clones to generate new breeding populations for further selection for CMD/CBSD resistance in combination with other key farmer-preferred agronomic and culinary traits. Lastly, the selected superior clones will further be tested on-farm and tabled for variety release in different countries.

About the authors



Edward Kanju is regional cassava breeder for Eastern Africa based in Dar es Salaam, Tanzania. He has over 15 years' experience in cassava breeding. He is the leader of the SCP and involved in many other projects in East and Southern Africa in collaboration with NARS in Burundi, DR Congo, Kenya,

Mozambique, Rwanda, Tanzania and Uganda. His research is focused on developing new cassava varieties that combine dual resistance to CMD and CBSD for the eastern African region. Dr Kanju obtained his PhD in Plant Breeding from the University of Free State, South Africa. He was by then employed by the Ministry of Agriculture, Food Security and Cooperatives, Tanzania. His research background includes cassava and sweet potato improvement that combine resistance to major biotic and abiotic stresses along with end-user-preferred characteristics.



Silver Tumwegamire is a Postdoctoral Fellow – Cassava Breeding. He assists Dr Kanju in overseeing the implementation of SCP. Dr Tumwegamire holds a PhD in Crop Science (Breeding), MSc in Crop Science (Breeding), and a BSc in Agriculture, all completed at Makerere University in Uganda. He joined IITA from CIP where he worked for 11 years on sweetpotato breeding programs for sub-Saharan Africa. Previously, he also worked at CARE International in Uganda under a project to protect one of the few remaining world natural habitats (Bwindi Impenetrable Forest) for mountain gorillas through community-based agricultural interventions. He also worked for a short while at Uganda's national bean breeding program.

Saving Africa's coffee from the heat through climate-smart technologies to improve smallholders' income and resilience in the East African highlands

Piet Van Asten, Agronomist, IITA-Uganda

Coffee is a primary source of foreign exchange revenue for Uganda, Burundi, Rwanda, Tanzania and Kenya. The crop is mainly produced by over two million smallholders who own less than two hectares of land on which they also grow a diverse mixture of food crops, such as bananas, cassava, maize and beans. With declining soil fertility, increasing pest and disease pressure, an increasing population, and consequently decreasing land availability, the coffee production systems are already under severe pressure. For example, Africa's share of Robusta coffee production in the global market has gone from above 80% to below 20% in the past 50 years. In addition to these constraints, climate change is adding pressure to an already vulnerable situation.

Within the next 40 years, the average temperature is predicted to increase by at least 2°C in the East African highlands and rainfall patterns are predicted to become more erratic. If coffee systems remain unchanged – using the current varieties and cropping practices – the temperature increase will significantly

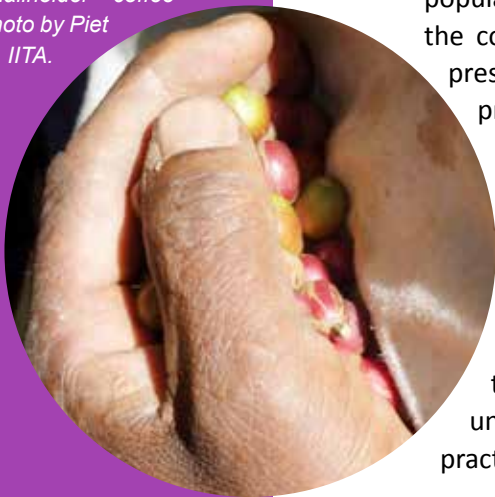
decrease the suitability for coffee production, particularly for Arabica coffee in altitudes below 1500 m. Arabica coffee needs the cooler temperatures that are characteristic for its region of origin, the Ethiopian highlands. With an increase in temperatures, coffee production may need to shift up the slope to cooler altitudes, but as these higher grounds cover a much smaller area, the total production area will decrease. New technologies and approaches are thus needed to prevent loss of production and income.

In search of a sustainable solution

IITA and partners have for the past six years been conducting research on coffee-based cropping systems in Rwanda, Uganda, Burundi and recently, Tanzania, to find out how best to adapt to the changes in climate, so as to reduce smallholder farmer vulnerability and ensuring their food security. The researchers first wanted to understand the current diversity in cropping practices in an effort to identify those practices that could increase farmers' capacity to adapt to climate change and shocks. The results were surprising, with some practices showing high positive effect on productivity and resilience, while others appeared detrimental.

Results from around the region show that modest shading does not negatively affect average coffee yields, but rather, it reduces inter-annual yield variations because it protects the crop from weather shocks such as drought and hail. In particular, banana intercropping looked promising; at the appropriate banana spacing (700-1000 plants/ha), the

Coffee beans in the hand of a smallholder coffee grower. Photo by Piet van Asten, IITA.



income from the intercropped fields increased by over 50% (Figure 1).

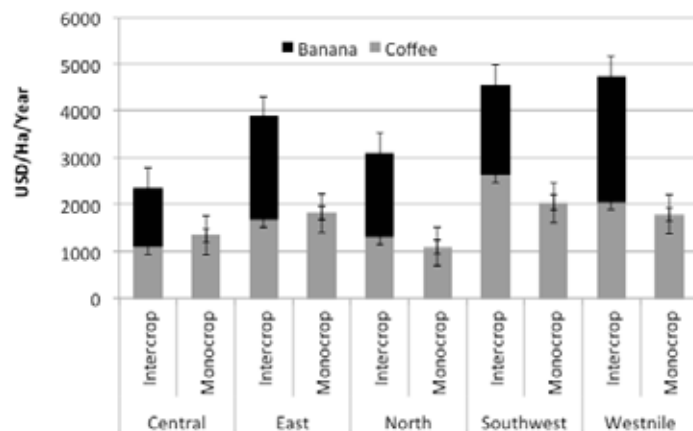


Figure 1. On-farm surveys in nearly 400 farms revealed total revenue from intercropped banana-coffee fields in Uganda often doubles that of coffee mono-cropped fields across a wide-range of agro-ecological regions in both Robusta-growing areas (Central, North) and Arabica-growing areas (East, Southwest, West Nile). Similar trends were observed in the other countries.

Coffee yields do not decrease under shading and results from both Uganda and Burundi showed that there is a slight improvement in bean size and cup quality. This is considered particularly important by e.g. Rwanda and companies that wish to tap into the lucrative specialty coffee market. In addition, the incidence of coffee leaf rust (*Hemileia vastatrix*) which is strongly increasing with temperature was 50% lower in Ugandan coffee farms at flowering when intercropped with bananas.

On-farm and on-station research in Uganda, Burundi, and Rwanda confirmed that most farmers consider the intercropping practices beneficial. However, recommendations to monocrop coffee that originated from the colonial era still persisted among the coffee authorities, national extension bodies, and private-sector actors in the coffee area. IITA has been engaging the industry and the authorities in the region in discussions regarding changing this practice and has made significant progress. Policy makers in Rwanda and Burundi, where intercropping had been discouraged, have approached

IITA for more information on the banana-coffee intercrop. In Rwanda, the coffee sector actors came together and decided to test the intercropping in large farmer field school trials run by the government.

Not all shades are equal

While IITA and its partners were excited by the positive effect of banana intercropping, the surveys revealed a more worrying trend in Uganda's Robusta areas. Here, the black coffee twig borer (*Xylosandrus compactus*) had rapidly developed into a severe pest over the past decade. After a disastrous outbreak of coffee wilt in the 1990s, coffee farmers were now again observing yield losses of



Farmers walking past coffee-banana intercropped fields in Mbale, Uganda. Photo by IITA.



A little girl in a field with coffee-banana intercrop in Mbale, Uganda. Photo by IITA.

tens of percent due to twig borer. Twig borer incidence and severity appeared particularly severe in those farms that had shade trees, in particular *Albezia* spp., which had been promoted as a shade tree to farmers to adapt to climate change because of its light permeable canopy and N-fixing abilities. NARO entomologists supported by IITA further dug into this phenomenon and observed that *Albezia* proved to be a perfect alternative host for the twig borer. Consequently, NARO has now instructed the extension partners to put a hold on recommending this shade tree.

Another challenge in the quest for climate-smart coffee systems is soil fertility. While the increased production of banana-intercropping brings more money in farmers' pockets, the practice does put more pressure on soil nutrient stocks and integrated soil fertility management (ISFM) is critical to sustain these systems. IITA developed software to rapidly diagnose banana and coffee nutrient deficiencies (Figure 2) which have been shared with the national systems and the coffee sector actors.

IITA and partners will continue to investigate, develop and test climate-smart technologies for smallholder farmers in 2014 with its partners in the CGIAR research program on Climate Change, Agriculture and Food Security (CCAFS).

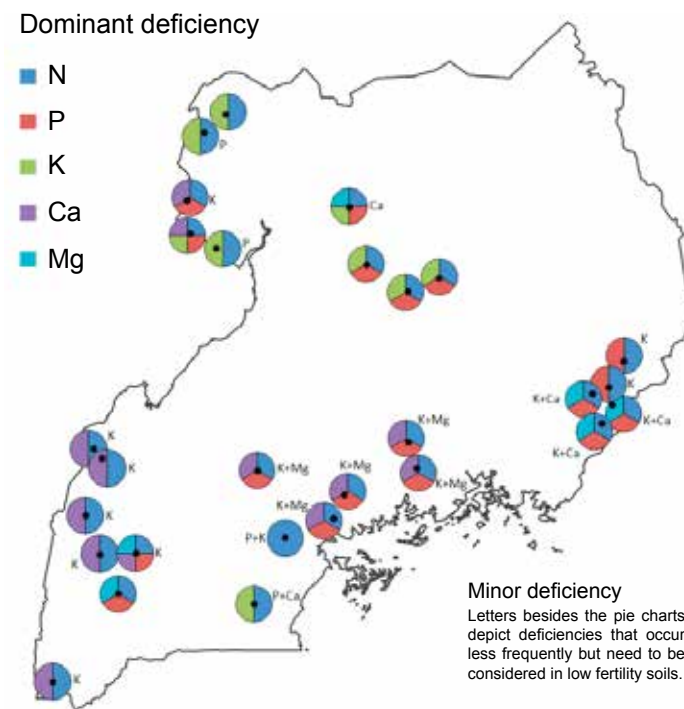


Figure 2. Map with the coffee plant nutrient deficiencies in Uganda based on foliar analysis, soil analysis, and compositional nutrient diagnosis.

Acknowledgement

Supporting research projects were Agricultural Productivity Enhancement Program (APEP) (2007-2009) and LEAD (2010-2013) funded by USAID in Uganda, the Consortium for Improving Agriculture-based Livelihoods in Central Africa (CIALCA, www.cialca.org) project (2006-2013) funded by the Belgian directorate for development (DGD) with activities in Burundi and Rwanda, and the BMZ-funded project (2013-2016) on coffee and climate change in Uganda and Tanzania.

NARS partners are in particular National Agriculture Research Organization (NARO) in Uganda, *Institut des Sciences Agronomique du Burundi* (ISABU) in Burundi, *Institut des Sciences Agronomiques du Rwanda* (ISAR) now Rwanda Agriculture Board (RAB) in Rwanda, and Tanzania Coffee Research Institute (TaCRI) in Tanzania.

About the **author**



Piet van Asten is a Systems Agronomist at IITA-Uganda working on sustainable intensification of perennial-based cropping systems (coffee, banana, cocoa) in Africa's humid zones for the past 10 years. He has over 17 years of professional research experience in Sub-Saharan Africa varying from peri-urban vegetable gardening in South Africa to irrigated rice schemes in West Africa and more recently agricultural systems in the eastern Africa highlands. He holds a PhD degree in soil science and agronomy from Wageningen University with a strong emphasis on soil quality and farming systems research. Over the

past years he has been increasingly involved in managing and supporting research for development projects on a regional scale, with a strong focus on interdisciplinary research ranging from the soil pit to household economics, linkages to input-output markets, and climate change mitigation and adaptation. His main interests are the development of more productive, profitable, and resilient crop and soil management systems for African smallholder farmers through sustainable intensification.

Tackling a hidden danger: efforts to introduce Aflasafe in Kenya get boost from promising efficacy trials

Charity Mutegi, East Africa Coordinator, APPEAR Project; and **Ranajit Bandyopadhyay**, Plant Pathologist and Project Leader, Aflasafe Project, IITA-Ibadan, Nigeria

IITA and their national and international partners are making very good progress in their efforts to avail to farmers in Kenya an affordable yet highly effective solution, a biopesticide codenamed Aflasafe KE01™, to reduce contamination of key staple crops by aflatoxins, a cancer causing chemical produced by naturally-occurring fungi found in soils. Efficacy trials of the biopesticide in different

parts of the country have yielded very promising results building a strong case for its registration.

Aflatoxins are highly toxic, cancer-causing chemicals that suppress the immune system, retard growth, and cause liver disease and death in both humans and domestic animals. They also cause huge economic losses by affecting trade.

IITA researchers partnering with the United States Department of Agriculture - Agricultural Research Services (USDA-ARS) and the African Agricultural Technology

Foundation (AATF) have developed Aflasafe, a natural safe biocontrol product for controlling aflatoxins. It makes use of native atoxigenic strains of the fungus *Aspergillus flavus*, which do not have the capacity to produce aflatoxins. Aflasafe products are being pilot tested in many countries in Africa to reduce the aflatoxin menace and improve the health and livelihoods of farming communities.

One such country is Kenya, which is considered a hotspot for aflatoxin contamination and has had incidences of acute contamination of the toxic poison resulting in loss of lives as well as destruction of hundreds of thousands of tons of contaminated maize—a key staple crop highly vulnerable to aflatoxin—found unfit for human and even livestock consumption. The biopesticide solution with the trademark ‘Aflasafe KE01™’ is composed of four isolates belonging to 4 distinct genetic groups of atoxigenic *A. flavus* that were isolated from maize produced in Kenya and are both widespread in and adapted to the country’s ecosystems.

On-farm testing of aflasafe KE01™

The sites and farmers to take part in the trials were selected. The main focus was in eastern Kenya, which is considered a hot spot for aflatoxicoses outbreaks, and Bura and Hola in Coastal Kenya, where maize is frequently contaminated with high levels of aflatoxin.

Aflasafe KE01™ was tossed by hand on soils in the selected maize fields at the appropriate time - between the 7 leaf and 9 leaf growth stages of the crop. Two treatments (rates of 10 kg/ha and 20 kg/ha) of the biopesticide were

Dr R Wanjogu of National Irrigation Board sensitizing farmers in Bura-A . Photo by IITA.



evaluated in each region. All treatments were applied to entire fields. Each treated field was paired with a nearby untreated (control) field. The crop was harvested after maturity and dried for two weeks, cobs shelled, and grains milled to fine flour. Samples of the flour were shipped to the USDA-ARS Aflatoxin Laboratory - University of Arizona with appropriate KEPHIS and USDA-APHIS permits for aflatoxin analysis.

A cost effective solution to a hidden danger

Overall, the results from the 2012/2013 farmer's field tests show that Aflasafe KE01™ is highly effective at preventing aflatoxin contamination with just one application per season. In all three areas, concentrations of aflatoxins in maize from treated farmer's fields were significantly lower than in the untreated ones. In the Hola, Bura, and Makueni trials respectively, 88%, 60% and 33% of maize produced in farmer's fields that were not treated with Aflasafe KE01™ contained aflatoxin concentrations above 10 parts per billion (ppb)—the maximum level permitted by the Kenyan government - compared with 38%, 20%, and 0% of maize from the treated farmer's fields.

AflasafeKE01 was even more effective in reducing aflatoxin concentrations in fields that are more prone to high levels of aflatoxin contamination. Maize with higher than 100 ppb total aflatoxins was produced in 56%, 40%, and 27% of field fields in Hola, Bura, and Makueni, respectively, that were not-treated, compared to 6%, 0%, and 0% in treated fields.

Maize produced in the untreated fields in the three areas

frequently had acutely dangerous aflatoxin concentrations, more than 50 times the accepted limits, building a case to urgently avail this technology for wide spread use.

More is not (necessarily) better

In the current studies, we also evaluated application rates of 10 kg/ha and 20 kg/ha for efficacy in reducing aflatoxin contamination. In all three treatment areas, the 20 kg/ha application rate did not provide any greater reduction in contamination than the 10 kg/ha rate. From these results, there is therefore no benefit in increasing the application rates at additional costs for farmers.

In conclusion, our work demonstrates the high efficacy of Aflasafe KE01™ in reducing aflatoxin levels in maize. Furthermore, area-wide, and long-term/additive influences of atoxigenic strain applications observed in Nigeria and Senegal, have showed even greater benefits from both treating a larger proportion of maize fields in an entire area and treating over multiple years.

Moving forward, this data forms a crucial component of the dossier to Pest Control Products Board (PCPB) to enable the registration of Aflasafe KE01™, so that it is accessible to farmers.

Partners

Kenya Agricultural Research Institute (KARI), United States Department of Agriculture-Agricultural Research Services (USDA-ARS), ACDI-VOCA, African Agricultural Technology Foundation (AATF); and the Bill & Melinda Gates Foundation.

Acknowledgement

The research, and this report, would not have been possible without the valuable contributions of Peter Cotty, Senior Scientist, USDA-ARS and School of Plant Sciences, University of Arizona, Tucson; and Ramon Jamie, Plant Pathologist, School of Plant Sciences, University of Arizona, Tucson.

About the authors



***Charity Mutegi** is the East Africa Coordinator for the APPEAR project that deals with aflatoxin control. She graduated with a Bachelor of Science degree in Food Science and Postharvest Technology from Jomo Kenyatta University of Agriculture and Technology in Juja, Kenya in 1998; obtained her MSc degree in Food Science and Technology from the University of Nairobi, Kenya in 2002 and her PhD in Food Security in 2010 from University of Kwa Zulu Natal. Her research focused on the extent of aflatoxin contamination on groundnut from households in western Kenya and the causative factors of contamination. She has been working as a Senior Research officer with the Kenya Agricultural Research Institute (KARI) from 2001 to 2010. She also doubled up as a Co-Principal Investigator and Project Director (Kenya activities) in the Peanut Collaborative Research Support Program (CRSP) Project that sought to improve the health and livelihoods of people in East Africa by addressing aflatoxin and gender-related constraints in peanut production, processing and marketing. She also held the post of National Post-Harvest Consultant – Kenya Aflatoxin Intervention Program at the Food and Agriculture Organization of the United Nations (FAO) from 2004 – 2005. In 2000, she was a Research Assistant with the Food Research Project, funded by the European Union, University of Nairobi, Kenya and taught*

Food Microbiology on a part time basis at The Kenya Polytechnic, Nairobi, Kenya from 1999 – 2000, while pursuing her MSc. Charity is the recipient of the Norman Borlaug Award for Field Research and Application conferred by the World Food Prize Foundation in 2013.



***Ranajit Bandyopadhyay** is a plant pathologist at the International Institute of Tropical Agriculture (IITA), Ibadan, Nigeria. He obtained his BSc and MSc degrees from GB Pant University of Agriculture and Technology, Pantnagar, and PhD degree in plant pathology in 1980 from Haryana Agriculture University in India. He has been working in international agriculture research centers since 1980 – first as a sorghum pathologist at the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT, India) from 1980 to 2001, and then as a plant pathologist at IITA from 2002 to present. Ranajit has 35 years of extensive experience in agricultural research in Asia, Africa, North America and Latin America. He leads IITA's Africa-wide research on mycotoxins and biological control of aflatoxins. His research on mycotoxins focuses on developing an understanding of their occurrence, bio-ecology of toxigenic fungi, policy and institutional issues, and methods to manage mycotoxins with focus on biological control, diagnostics and integrated management of aflatoxins. He also conducts research on diseases of maize, soybean, cowpea, cassava, banana and yam. He has 175 publications as refereed journal articles, edited books, book chapters, newsletter articles, conference proceeding articles. He serves on editorial board of two journals and international advisory committees of a series of international conferences on mycotoxins organized by the European Union. He has been invited to give lectures in scientific meetings in Asia, Africa, Europe and the Americas.*

capacity building, seminars and publications

Training

In 2013, we conducted or organized over 30 capacity building activities for our staff and partners, sent staff for in-house training in various institutions, and our researchers supervised or co-supervised several PhD and MSc students.

Plant production and plant health

- Integrated Pest Management of soybean, 19 participants (Catholic Relief Services field staff), Songea- Ruvuma, Tanzania; 7-10 September 2013.
- Cyanide analysis, 7 participants (Tanzania NARS), Analytical Services Lab, IITA-Ibadan, Nigeria. Funded by the Common Fund for Commodities (CFC).

Biotech and plant breeding

- Post-flask handling of tissue cultured cassava plantlets; 14 participants (researchers from 5CP project member countries), National Crops Resources Research Institute (NaCRRI), Namulonge, Uganda; 3-13 September 2013.
- Digital field data capture (12 participants), Naliendele Agricultural Research Station, Tanzania; 8-10 October 2013 .
- Integrated Breeding Platform's 'Fieldbook', 10 participants, Nairobi, Kenya; 21-22 September 2013.
- Individual training:
 - ◊ Hellen Opiyo, NaCRRI Uganda. 5 June to 4 September 2013, IITA-Kenya. Research topic:

Genetic transformation of Ugandan farmer-preferred cassava cultivars for virus resistance.

- ◊ Rajesh Patti, Jain Irrigation, India. 1-31 August, 2013, IITA-Kenya. Research topic: Tissue culture of African varieties of banana and genetic transformation.
- ◊ Irene Njagi, KARI, Kenya. Nov 2013 to May 2014, IITA-Kenya. Research topic: Development of genetic transformation protocols for Kenyan cassava landraces.

Social science and agribusiness

- Data entry and record-keeping, 18 participants, Bukomansimbi, Uganda; 20 August 2013.
- Data entry and record-keeping, 21 participants, Luwero, Uganda; 22 August 2013.

Other major R4D training-related events

- Multi-center Planning on Banana/Plantain Improvement, Development of *Musa* Breeding Project Proposal, Douala, Cameroon; 28-30 October 2013
- Statistics and Statistical Computing Course with Statistical Analysis System (SAS), 18 participants (IITA EA Hub and partner research institutions' staff); 9-13 December 2013. Conducted by the IITA Capacity Development Office and Biometrics Unit, IITA-Ibadan.

Seminars

Scientific conferences

- “Evolution, Ecology and Control of Plant Viruses”, the 12th International Symposium on Plant Virus Epidemiology, 28 January to 1 February 2013, Arusha, Tanzania, .
- Partnership for Aflatoxin Control in Africa (PACA) Strategy Development Stakeholder Consultation Workshop, 10-12 April 2013, Dar es Salaam, Tanzania.
- Inception workshop for Rwanda project to evaluate cost benefit of mycotoxin mitigation strategies and SPS priorities, 6-10 May, Kigali, Rwanda.
- “Grow Africa and the role of agricultural research by national systems, IITA, and its partners”, 13 May 2013, Dar es Salaam, Tanzania (during launch of IITA science building).
- Cassava Germplasm Collection Process and Action Plan for South, East and Central Africa, 4-6 June 2013, Dar es Salaam, Tanzania.
- Inception workshop for BMZ-funded project on coffee/cocoa and climate change, 12-13 June 2013, Nairobi, Kenya.
- 6th International Nitrogen Conference, 18-22 November 2013, Kampala, Uganda. The conference was hosted and supported by the International Nitrogen Initiative, Makerere University, Uganda’s National Agricultural Research Organization (NARO), and IITA.

Keynote addresses at international conferences

- The International Congress of Plant Pathology (ICPP2013), 25-30 August, 2013, Beijing, China. Fen Beed, “The biological environment”; and Leena Tripathi “Banana *Xanthomonas* wilt in East and Central Africa”.
- The American Association for the Advancement of Science (AAAS) Annual Meeting, 14-18 February, 2013, Boston, USA. Dr. Leena Tripathi, “Genetic Transformation of Bananas for Resistance to *Xanthomonas* Wilt Disease”.

Eastern Africa Hub R4D seminar series

IITA-Tanzania

Month	Presenter(s) and affiliation(s)	Topic
February	Gerald Rusulabeza, IT Specialist, IITA-Tanzania	IITA Tanzania Information System overview
March	Hillbur Ylva, DDG-R4D, IITA-Ibadan	R4D: the way forward
April	Yabeja Juma, Research Associate, IITA-Tanzania	Statistical models for yield, insect pest abundance and disease incidence in tomato

Month	Presenter(s) and affiliation(s)	Topic
May	Fen Beed, Plant Pathologist, IITA-Tanzania; Julian Smith, FERA; and Phil Abrahams, CABI	Crop pest prevention–better than cure: a webinar presentation
June	Carly Giggs, BBC Media Action-Tanzania	The role of community radio in building citizen resilience
July	Edward Kanju, Cassava Breeder, IITA-Tanzania	Cassava improvement at IITA's Eastern Hub: achievements, challenges and way forward
August	Ephraim Nkonya, Research Fellow, IFPRI	Trends and patterns of land use change and international aid in SSA
September	Thomas Wobill, M&E Specialist, IITA-Ibadan	IITA's Monitoring and Evaluation Strategy for results-based performance management
October	Joseph Rusike, Impact Assessment Specialist, IITA-Tanzania	Global, regional and local drivers of change in cassava value chains in Africa: implications for upgrading smallholder systems

Month	Presenter(s) and affiliation(s)	Topic
November	Emmanuel Koyano, Research Associate, IITA-Tanzania	Mycotoxins: detection and control strategy for food safety
December	Adebayo Abass, Value Chains Specialist, IITA-Tanzania	Missing Food... how it happens

IITA-Uganda

Month	Presenter(s) and affiliation(s)	Topic
January	Wanyama Ibrahim, IITA	Mapping and evaluating improved intercrop and soil management options for Ugandan coffee farmers
February	Tricia Caffrey, Sylwia Trzaska, Rita Ojok-Laker, and Tim Finan, USAID/ African and Latin American Resilience to Climate Change (ARCC) Project	Vulnerability assessment for adaptation in Uganda's agricultural sector

Month	Presenter(s) and affiliation(s)	Topic
February	Laurence Jassogne and Piet van Asten, IITA	Coffee smallholders in Rakai: their vulnerability and entry points to adapt to climate shocks and climate change
February	Kristof Titeca, Research Foundation, Flanders University of Antwerp and the University of Ghent	The informal economy or 'smuggling': a quantitative analysis of a smuggling group's activities in Uganda's borderlands
March	E Were, I Ramathani, GV Nakato and S Olal, Kyambogo University; and Fen Beed, IITA	Potential of banana weevil, <i>Cosmopolites sordidus</i> (Germar), to transmit <i>Xanthomonas campestris</i> pv. <i>Musacearum</i> , the causative agent of Banana <i>Xanthomonas</i> Wilt
April	Haruna A. Sekabira, IFPRI, Kampala	Capital structure and its role on sustainability of micro finance institutions – the case of Uganda

Month	Presenter(s) and affiliation(s)	Topic
May	Leah Bevis, Cornell University	Soil-to-human micronutrient transmission: a health-based poverty trap in rural Uganda?
June	Els Lecoutere, Conflict Research Group at Ghent University, Belgium / Research consultant for SNV, Netherlands Development Organisation	A gendered approach to cooperative farming in Uganda: the impact on empowerment and gender roles
July	Stella Namanji, Uganda Martyrs University	Participatory community development through agriculture: an assessment of the National Agriculture Advisory Services Program's performance in Kalangala District, Uganda

Month	Presenter(s) and affiliation(s)	Topic
September	Marguerite Duponchel, International Growth Centre, Uganda	Investigating the gender gap in agricultural productivity: evidence from Uganda
November	Helen Byamugisha, Makerere University, Uganda	Information seeking and use among urban farmers in Kampala district Uganda
December	Lucy Billings, Research Analyst, Poverty Health and Nutrition Division, IFPRI	Impact evaluation of the HarvestPlus project on developing and delivering biofortified crops in Uganda: baseline report

IITA-Kenya

Month	Presenter(s) and affiliation(s)	Topic
January	John Hu, Professor in Plant Pathology, University of Hawaii-USA	Detection, characterization and control of banana bunchy top virus (BBTV)

Month	Presenter(s) and affiliation(s)	Topic
February	PV Sane, Principal Scientific Advisor, Agri Biotech at Jain Irrigation Systems Ltd, Jalgaon, India	Studies on Flowering Locus T: the Florigen in banana
March	Kristina Roing de Nowina, Proposal Development Coordinator, IITA-Ibadan	Proposal development
April	Evans Nyaboga, Postdoc (Cassava Transformation), IITA-Kenya	Cassava transformation technologies: progress and challenges
May	Kenneth Mburu, PhD graduate fellow, IITA-Kenya	An integrated approach for the control and management of the banana bacterial wilt disease
June	Samuel Kariuki, PhD Graduate Fellow, IITA-Kenya	TALENs for banana streak virus and CENH3 silencing

Month	Presenter(s) and affiliation(s)	Topic
July	Esther Kahariri, PhD Graduate Fellow, IITA-Kenya	Optimization of genetic transformation protocol for selected banana and plantain (<i>Musa</i> spp.) cultivars preferred in Africa
July	Jaindra Tripathi, Banana Transformation Specialist, IITA-Kenya	Control of <i>Xanthomonas</i> wilt in banana through genetic engineering
August	Sarah Macharia, Research Assistant, IITA-Kenya	Genetic transformation of banana with extracellular secreted plant ferredoxin-like protein (ES-PFLP) gene
September	Hellen Beatrice Apio, National Crops Resources Research Institute (NaCRRI), Namulonge, NARO, Uganda	Genetic transformation of Ugandan farmer preferred cassava cultivars for virus

Month	Presenter(s) and affiliation(s)	Topic
October	Joshua Njiru, PhD Graduate Fellow, IITA-Kenya	Genetic engineering for the control of cassava brown streak virus and cassava bacterial blight
October	June Micheka, Trainee at IITA-Kenya	Tissue culture of yam: Progress and challenges
November	Abubaker Muwonge, PhD Graduate Fellow, IITA-Uganda	A fight against the banana wilt disease

Graduate and post-graduate studies

In 2013, four students from various institutions being supervised by IITA researchers finalized their PhD studies. Six new PhD students came on-board. The number of MSc students being supervised increased to 37 by end of 2013 with 23 new students joining the hub.

The following PhD students initiated and/or completed their studies in 2013:

Name	Affiliation	Title of thesis	IITA supervisor(s)	Status
Natural resource management				
Telesphore Ndabamenye	University of Pretoria, South Africa	Effects of high planting density on nutrient dynamics and banana productivity in banana (<i>Musa spp</i>)-based cropping systems	Piet Van Asten	Completed
Anaclet Nibasumba	University of Louvain la Neuve, Belgium	Banana x coffee intercropping	Piet Van Asten and Promoter Laurence Jassogne	Completed
Jamson Mawazo Shitindi	Tuskegee University, USA	Developing an integrative soil fertility management package for improved nitrogen and phosphorus use efficiency under smallholder maize production in the northern zone of Tanzania	Bekunda Mateete	Commenced
Ibrahim Wanyama	University of Freiburg, Germany	Assessing mitigation options to reduce greenhouse gas emissions from agriculture at farm and landscape level in the CCAFS Rakai block – Uganda	Piet van Asten	Commenced

Name	Affiliation	Title of thesis	IITA supervisor(s)	Status
Biotechnology and plant breeding				
Evans Nyaboga	University of Nairobi	Genetic transformation of cassava for abiotic stress tolerance	Leena Tripathi	Completed
Moses Nyine	Palacky University, Olomouc, Czech Republic	Genotyping by sequencing of related triploid and diploid banana hybrid population: first steps toward genomic selection for efficient banana breeding	Rony Swennen and Brigitte Uwimana	Commenced
Plant protection and plant health				
Simon Boniface	University of Dar es Salaam	Whitefly vectors of cassava viruses in Tanzania	James Legg	Completed
Ewaut Kissel	Catholic University of Leuven, Belgium	The quest for drought tolerant varieties: multivariate phenotyping at plant level	Piet van Asten	Commenced
Mpoki Shimwela	University of Florida, USA	Spatio-temporal analysis and modeling of the spread of BXW and citrus HLB: implications for disease control	Fen Beed	Commenced
Social science and agribusiness				
Matema Lileko Emily Imakumbili	Sokoine University of Agriculture, Tanzania	Influence of some plant nutrients in reducing cassava cyanogenic glucoside levels in selected areas of Eastern and Southern Tanzania	Adebayo Abass	Commenced

The following students initiated their MSc studies in 2013:

Name	Affiliation	Title of thesis	IITA supervisor(s)	Status
Natural resource management				
Anne Kleene	Wageningen University, The Netherlands	The effect of UTz certification on sustainable land management practices	John Herbert Ainembabazi and Laurence Jassogne	Commenced
Siri Rene Pisters	Wageningen University, The Netherlands	Problematic lands in sub-Saharan irrigation schemes	Piet van Asten and John Herbert Ainembabazi	Commenced
Benten Anders	Texas University	Understanding farmers' decision-making regarding climate change	Piet Van Asten	Commenced
Ruben Ortiz	Catholic University of Leuven, Belgium	Coffee and climate change in East Africa: analyzing mitigation and adaptation trade-offs from the smallholder and industry's perspective	Piet Van Asten	Commenced
Plant protection and plant health				
Evans Were	Makerere University	Characterization of a novel orange colored bacterium from banana, and its possible utility as a prospective biocontrol agent for <i>Xanthomonas campestris</i> pv. <i>Musacearum</i>	Fen Beed	Commenced

Name	Affiliation	Title of thesis	IITA supervisor(s)	Status
Myrtle Verhaeven	University of Ghent, Belgium	Nematode microbial suppressants on tomato seedlings	Danny Coyne	Commenced
Mushobozi Baitani	Sokoine University of Agriculture, Morogoro, Tanzania	Distribution, variance and impact of <i>Ralstonia solanacearum</i> on tomato and peppers along coast of Kenya and Tanzania	Fen Beed and Danny Coyne	Commenced
Chacha Joseph Nyangi	Sokoine University of Agriculture, Morogoro and University of Nelson Mandela, Arusha, Tanzania	Risk assessment of aflatoxins and fumonisins on maize and beans grown in Tanzania: a case study of Babati District	Fen Beed	Commenced
Juma Chacha	Sokoine University of Agriculture, Morogoro, Tanzania	Incidence of <i>Aspergillus flavus</i> in stored dried cassava chips	Adebayo Abass	Commenced
Alex Msongore Christopher	Sokoine University of Agriculture, Morogoro, Tanzania	Post-harvest technologies	Adebayo Abass	Commenced
Firaol Taressa Ugfa	University of Catania, Italy	Effects of contrasting temperature on the developmental biology of <i>Bemisia tabaci</i> (Hemiptera, Aleyrodidae), with influence on the transmission of cassava mosaic and cassava brown streak viruses in Tanzania	James Legg	Commenced

Name	Affiliation	Title of thesis	IITA supervisor(s)	Status
Mathew Muinde Mumo	Pwani University	Incidence, distribution and characterization of tomato begomoviruses in Kenya	James Legg	Commenced
Biotechnology and plant breeding				
Sarah Macharia	Kenyatta University, Kenya	Genetic transformation of banana with extracellular secreted plant ferredoxin-like protein (es-pflp) gene	Leena Tripathi	Commenced
Social science and agribusiness				
Gwamaka Mlekwa	Sokoine University of Agriculture, Tanzania	Cassava value chain in Tanzania	Joseph Rusike and Adebayo Abass	Commenced
Ofro Sanga	Sokoine University of Agriculture, Tanzania	Cassava value chain in Tanzania	Joseph Rusike and Adebayo Abass	Commenced
Alex Msongore Christopher	Sokoine University of Agriculture, Tanzania	Post-harvest technologies	Adebayo Abass	Commenced

Selected publications

In 2013, the hub published 22 articles in peer reviewed Thompson indexed journals. A selection of some of these papers include:

Natural resource management

Ndabamenye T, Van Asten PJA, Blomme G, Vanlauwe B, Swennen R, Annandale JG, and Barnard RO. 2013. Nutrient imbalance and yield limiting factors of low input East African highland banana (*Musa* spp. AAA-EA) cropping systems. *Field Crops Research* 135:126-136.

Ndabamenye T, Vanlauwe B, Van Asten PJA, Blomme G, Swennen R, Uzayisenga B, Annandale JG, and Barnard RO. 2013. Influence of plant density on variability of soil fertility and nutrient budgets in low input East African highland banana (*Musa* spp. AAA-EA) cropping systems. *Nutrient Cycling in Agroecosystems* (DOI 10.1007/s10705-013-9557-x).

Plant production and plant health

Nakato V, Beed F, Ramathani I, Kubiriba J, Rwomushana I, and Opio F. 2013. Risk of banana *Xanthomonas* wilt spread through trade routes and practices. *Journal of Crop Protection* 2: 151-161.

Wagacha JM, Mutegi C, Karanja L, Kimani J, and Christie ME. 2013. Fungal species isolated from peanuts in major Kenyan markets: Emphasis on *Aspergillus* section *Flavi*. *Crop Protection* 52: 1-9.

Adikini S, Beed F, Tusiime G, Tripathi L, Kyamanywa S, Lewis Ivey ML, and Miller SA. 2013. Spread of *Xanthomonas campestris* pv. *musacearum* in banana plants: implications for management of banana *Xanthomonas* wilt disease. *Canadian Journal of Plant Pathology*. DOI:10.1080/07060661.2013.845856.

Paparua P, Dubois T, Coyne D, and Viljoenc A. 2013. Differential gene expression in East African highland bananas (*Musa* spp.): Interactions between non-pathogenic *Fusarium oxysporum* V5w2 and *Radopholus similis*. *Physiological and Molecular Plant Pathology* 82: 52-63.

Biotechnology and plant breeding

Kawuki RS, Herselman L, Labuschagne MT, Nzuki I, Ralimanana I, Bidiaka M, Kanyange MC, Gashaka G, Masumba E, Mkamilo G, Gethi J, Wanjala B, Zacarias A, Madabula F, and Ferguson ME. 2013. Genetic diversity of cassava (*Manihot esculenta* Crantz) landraces and cultivars from Southern, Eastern and Central Africa. *Plant Genetic Resources available on CJO2013*. Doi:10.1017/S1479262113000014.

Ndabamenye T, van Asten PJA, Blomme G, Vanlauwe B, Swennen R, Annandale JG, and Barnard RO. 2013. Ecological characteristics and cultivar influence optimal plant density of East African highland bananas (*Musa* spp. AAA-EA) in low input cropping systems. *Scientia Horticulturae* 150: 299-311. <http://dx.doi.org/10.1016/j.scienta.2012.11.037>

Social science and agribusiness

Ainembabazi JH, Shively G, and Angelsen A. 2013. Charcoal production and household welfare in Uganda: a quantile regression approach. *Environment and Development Economics* 18(5): 537-558.

Romijn E, Ainembabazi HJ, Wijaya A, Herold M, Angelsen A, Verchot L, and Murdiyarso D. 2013. Exploring different forest definitions and their impact on developing REDD+ reference emission levels: a case study for Indonesia. *Environmental Science and Policy* 33: 246-259.

message from the **regional director**

First, I would like to say a ‘big thank you’ for your continuing and strong support of the southern Africa Hub. Your belief in us and what we do is vital validation of our research for development activities.

As you know, the entire southern Africa region experienced a dramatic ending of the rainy season in February last year, when the staple crop – maize and other crops – had not yet matured. This experience was yet another reminder to us that our research agenda should be more geared towards generating technologies, products and services that are more responsive to the challenges posed by climate change.

Despite this challenge, the year 2013 saw some landmark achievements both in infrastructure development and research. During the year, we broke ground for our Southern Africa Research and Administration Hub (SARAH) facilities and initiated its construction. Research facilities in Malawi were also upgraded while designing of the research facilities for Mozambique has commenced. On the R4D front, the southern Africa Hub achieved the following:

- We continue to implement 20 R4D projects across the region with a total value of approximately US\$10 million. We are concerting more effort to attract additional research funding to continue addressing the needs of smallholder farmers in southern Africa
- Our hub-based scientists are training and supervising over 20 students at graduate and post-graduate levels, 30 undergraduates, and we have facilitated the training of more than a thousand farmers in crop

production and processing technologies, particularly of cassava, soybean, and cowpea, through our various projects in the region

- Over 500 genotypes of cassava and legumes were evaluated for adaptability to the region.
- Thirty-eight yellow-fleshed and high-yielding cassava varieties have been identified and are in advanced performance trials
- Three self-nodulating varieties of soybean have been submitted to Variety Release Committee for consideration in Zambia.
- We have increased our awareness activities, with IITA being awarded a prize for its technology exhibition at the Zambia Agricultural and Commercial Show held in Lusaka in August
- A hub retreat was organized during which the R4D strategy for the region was developed.

Though we have had some significant achievements in the region during the year, we endeavor not sit back and rest on laurels. Instead, we will continue to consolidate our R4D strategy, building on our strengths and comparative advantage, and create more awareness of the results from our work. Together, let us develop more initiatives that will make IITA a more influential partner in developing more improved varieties, products, and technologies that will better serve the needs of our farmers and the agricultural sector and translate into future agricultural impacts.



Dr David Chikoye
Regional Director
Southern Africa

southern africa **research highlights**

Scientists + farmers = improved cassava

*Pheneas Ntawuruhunga, Cassava Breeder, IITA-Zambia;
and James Legg, Plant Virologist, IITA-Tanzania*

Cassava is the second most important staple food crop after maize in southern Africa. Most rural people grow and depend on cassava roots as a staple food while using also the leaves as relish. Cassava, therefore, has a central role in IITA research activities in the region. At Chitedze Research Station in Zambia, more than 3000 cassava seedlings from 26 families were screened for resistance to the cassava mosaic disease (CMD), cassava brown streak disease (CBSD), and cassava bacterial blight [CBB] as well as the pests cassava green mite and cassava mealy bug in 2012/13. The year after, approximately 190 clones were advanced for evaluation. One year after evaluation, 55 clones were selected for further evaluation in preliminary yield trials in 2014.

Evaluation of yellow-fleshed clones

Yellow-fleshed cassava has higher beta-carotene content and is thus more nutritious than the common white/cream-fleshed one. In 2011/12, more than 200 yellow-fleshed clones were evaluated for beta-carotene content as well as for reaction to diseases and pests, root yield, dry matter content and taste. Beta carotene levels ranged from 0.38 to 7.2 µg /g, with more than 195 of them (>97%) being free of CMD or CBSD symptoms. Thirty (30) clones gave

high average yields of 21.3 t/ha), with about 21 (68.6%) of them having higher dry matter content than the control Mbundumali. Based on these results, 131 clones were selected for re-evaluation in 2012/13 at Chitala where the pest and disease pressure is very high. Out of those 131 evaluated during 2012/12, 38 performed well and were advanced for preliminary yield trials in 2014.

Drought tolerance studies

During the 2012-2013 cropping season, we evaluated about 160 genotypes for drought tolerance at two sites: Chitala and Ngabu in Malawi. Ngabu, located in the Shire Valley, is the dryer of the two areas with an average rainfall of 635.6 mm and average temperature of 26.7°C over the last 4 years. On the other hand, Chitala is characterized by an average of 967.4 mm of rainfall and mean temperature of 23.4°C over the same period.

The clones that withstood the moisture stress to some extent – or had high “stay green” ability – were cultivars Chisalanzo, Kantawira, IITA TMS L100115, Manyimanyi, and Nyajogwa at Chitala; and IITA TMS L100060 and IITA TMS L100055 at Ngabu.

We also found during the evaluations that CMD and CBSD were the major diseases, although a relatively low levels (damage score of <2). Among the pests, cassava mealybug dominated at Ngabu and cassava green mite at Chitala. Root yields were also generally low (<10 t/ha) in both sites due to termite damage to the crop stand.

*Selection of high yielding clone
with high dry matter and potential
resistance to CMD and CBSD
at Chipata, Malawi. Photo by
P Ntawuruhunga, IITA.*



Promoting improved cassava varieties through participatory variety selection in Zambia

The “Mitigating Cassava Disease Threats for Improved Cassava Production in Zambia” – one of the six component projects under the Zambia Feed-the-Future Research and Development Program funded by USAID – is using the participatory variety selection approach to identify market preferred improved varieties for promotion and to understand factors behind adoption. Five improved cassava varieties were evaluated in farmers’ fields in six districts of Luapula, Northern and Eastern Provinces, using local cultivars used as controls. The results showed that the districts of Mambwe and Petauke in Eastern Province had significantly better yields (20 and 18 t/ha respectively) than the districts of Mansa (9 t/ha), Kasama (9 t/ha) and Luwingu (8 t/ha) in the Luapula and Northern Provinces respectively. The results showed that improved supplied

The improved Nalumino variety being peeled for culinary test. Photo by P Ntawuruhunga, IITA.



varieties performed significantly ($p < 0.001$) better than the local cultivars at farm levels. The improved varieties Mweru, Kampolombo and Nalumino were the overall best yielding and were also resistant to diseases. However, the culinary results revealed that most of the local cultivars were still preferred by the farmers. Only one of the improved varieties, Nalumino, was among those that the farmers liked. The results thus present a challenge to breeders to double their efforts in identifying and selecting high yielding, disease-resistant varieties that also respond to the farmers’ culinary preferences in order to enhance adoption and boost production in the country.

Super-abundant whiteflies in Zambia calls for urgent action

The pathology team of the cassava disease mitigation project have been conducting several surveys of cassava viruses and whiteflies in the main cassava-growing regions of Zambia. These have always shown low abundances of the whitefly, *Bemisia tabaci* (Genn.). However, during a recent germplasm evaluation work in Mambwe, Eastern Province which was undertaken through participatory variety selection, unusual symptoms were observed on the lower leaves of cassava plants being evaluated. Photos were taken and reviewed by the project team members in IITA and ZARI. Blackening of lower leaves suggested the occurrence of sooty mould and subsequent pictures of the undersides of affected leaves confirmed the presence of large populations of *B. tabaci* nymphs. Results of the routine disease diagnostics surveys confirmed that such



Whiteflies and sooty mould on lower leaves of cassava plant in Zambia. Photo by James Legg, IITA.

symptoms had been widely observed during recent survey activities in different parts of the country.

It is known that *B. tabaci* is the vector of the cassava mosaic viruses that cause CMD, and the cassava brown streak viruses that cause CBSD. It is also known that the super-abundant whitefly populations increase the frequency of virus spread from field to field, village to village and ultimately region to region. This situation of super-abundant *B. tabaci* in Zambia represents therefore a major threat to the future cultivation of cassava in the country; the scientists' team collaborating on this

project decided that a rapid molecular characterization of whiteflies in Zambia be done. But this calls also to do more efforts in developing dual resistant varieties in readiness of eventual explosion of the CBSD or CMD spread in the country.

About the **authors**



Pheneas Ntawuruhunga is a Plant Breeder/ Agronomist based at IITA-Zambia. He was also the Regional Coordinator of the now-defunct Southern Africa Root Crop Research Network (SARRNET) which covers SADC countries. Before joining IITA, he was based in Uganda as the Regional Coordinator of the East Africa Root Crop Research Network (EARRNET) covering Burundi, Democratic Republic of Congo, Kenya, Madagascar, Ethiopia, Rwanda, Southern Sudan, Tanzania, and Uganda. EARRNET, a

sister network to SARRNET, was coordinated in collaboration with the Association for Strengthening Agricultural Research in Eastern and Central Africa (ASARECA).

Dr Ntawuruhunga obtained his PhD in Agronomy/Breeding from Makerere University while working with IITA in Uganda. After completion of his studies in 2000, he worked as a consultant at IITA/ESARC for the breeding program with responsibility of implementing the cassava mosaic disease project and restoration of the cassava national program project in the Democratic Republic of Congo.



James Legg is a Plant Virologist at IITA with more than 20 years' experience of working on plant viruses and their insect vectors. He graduated in Pure and Applied Biology from St. Catherine's College, University of Oxford, before completing his MSc and PhD studies at the University of Reading. Dr Legg's PhD research examined the role of the whitefly, *Bemisia tabaci*, in vectoring cassava mosaic geminiviruses in East Africa. Most of his professional career has focused on strengthening understanding of cassava viruses, and using that improved understanding to develop and facilitate the promotion of control strategies.

His extensive research portfolio covering aspects such as detection and molecular characterization of cassava viruses; field epidemiology; virus-vector interactions; development and deployment of host plant resistance; field surveillance strategies; vector molecular characterization, vector population dynamics/bionomics; vector-natural enemy interactions, biological control; and cultural approaches for the management of both viruses and their vectors.

Better soybean for Africa

Hesham Agrama, Soybean Breeder, IITA-Zambia

Since the mid-1970's, IITA has been undertaking soybean improvement in Africa in response to poor yields, low seed viability, poor nodulation with native *Rhizobium* available in the soil, high pod shattering, and lack of knowledge on postharvest utilization suitable for smallholder farmers. IITA's work has contributed to significantly developing the crop and increasing its production from average yields of 0.5 t/ha in the 1970s to 1.1 t/ha in 2012. Over the last 5 years, soybean production area has been expanding at an average of 5% per year while total production has been on the rise at 7% annually. In 2012, total African soybean production was two million tons, but only six countries in sub-Saharan Africa produced more than 91% of the soybean consumed in Africa (Figure 1). However, despite these gains, demand for soybean in Africa still surpasses supply. In 2010 Africa imported about US\$2 billion worth of soybean grain and soybean-derived products.

The main drivers for increased soybean demand in Africa include increased market demands deriving from a rapidly growing use in poultry feeds, edible oils, and human foods in urban markets, a high demand for soybean as feedstock and for biodiesel, and a growing and expanding regional export market. IITA has identified a large area of climatic zones suitable for soybean production (Figure 2, next page). Furthermore, the crop's ability to fix high amounts of

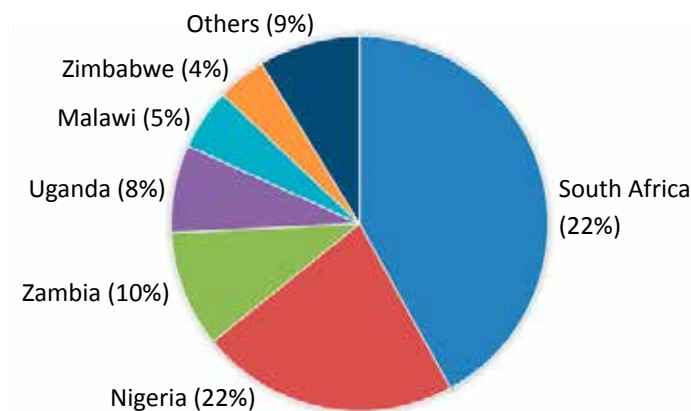


Figure 1. Soybean production in Africa (FAOStat, 2012).

atmospheric nitrogen (N₂), which, when used in rotational cropping systems, improves soil fertility thereby permitting farmers to use less fertilizer and reduce farm costs and its ability to reduce *Striga* infestation by promoting suicidal germination in cereal-based systems contribute to the soybean demand.

The main goal of the soybean breeding program is to develop high yielding and stable varieties that are tolerant or resistant to biotic and abiotic constraints. This report highlights progress made in the past two years.

During the 2011/12 season, segregating populations of F₂ to F₆ were grown in the field to select for earliness in maturity, disease resistance, high biomass, pod load and minimal pod shattering. In screenhouse trials, F₁ plants from 28 crosses were raised and their F₂ seeds were

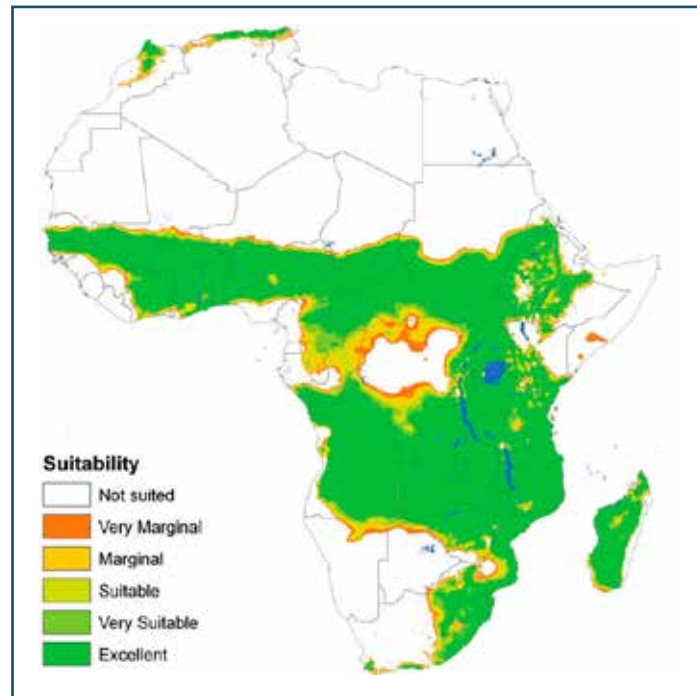


Figure 2. Climatic zones in Africa suitable for soybean production.

evaluated during the 2012/13 rainy season. In 2013, a total of 99 crosses were made to incorporate rust resistance, lodging resistance, improved seed size and yield of the released varieties and some breeding lines. Released varieties (Tikolore, Makwacha and Nasoko) were also used as parents to incorporate traits into the elite IITA breeding lines. Segregating materials were planted in non-replicated 1 m row plots under natural disease infestations and single plant and row selections were made. The selected materials

were planted during the dry season under irrigation in 2013 for generation advancement to shorten the breeding period. These populations are currently under further evaluation.

Drought tolerance

In a series of ongoing experiments we screen for genotypes that are drought tolerant and produce good yield when subjected to drought treatments. In 2012 and 2013 two sets of trials were subjected to three drought treatments (DT): DT1 = fully watered until physiological maturity, DT2 = drought imposed just before first flower opens (V7) for 2-3 weeks, DT3 = drought imposed at beginning pod formation stage (R3). It can be concluded that drought stress was not severe in some of the drought treatments. Analysis of variance showed that genotypes were highly significant ($P \leq 0.01$) for grain yield, signifying that there is high genetic variability for drought stress in the tested lines.

Preliminary variety trials

During the 2011/12 growing season, three sets (sets 1, 2, and 4) of preliminary variety trials (PVT) comprising 25 genotypes each were evaluated. The main objective was to compare the field and yield performance of the selected genotypes with the check genotypes. Set 1 comprised 17 soybean lines, set 2 had 16 introduced genotypes and two newly generated lines, and set 4 had 17 recently generated lines. Results revealed significant differences ($P < 0.05$) among the varieties with respect to days to 50% flowering, harvest index, 100 seed weight, fodder and grain yield (set

1, 2 and 4), plant height (set 2 and 4), days to 50% podding and days to maturity (set 1 and 4). No significant differences ($P>0.05$) were recorded for plant height at harvest (set 1), days to 50% podding and days to 95% maturity (set 2). Evaluation of the test varieties continued during the 2012/13 season.

Advanced variety trials

Sixteen introduced IITA soybean lines were evaluated and compared with released varieties at five research stations in advanced variety trials (AVT) in the 2011/12 and 2012/2013 seasons. The main objective of the trial was to assess the adaptability and yield performances of the IITA lines compared to the released varieties. In 2011/12, results showed significant differences ($P<0.05$) among the test genotypes for grain yield across locations with TGx 1989-60F and TGx 1987-62F giving the highest mean yields (1940 kg/ha and 1921 kg/ha, respectively). The soybean check varieties Nasoko, Makwacha, Tikolore produced 1683, 1378, 1651 kg, respectively.

From the two seasons, the results showed four genotypes with consistently high yields that can be earmarked for release. These genotypes include TGx 1989-60F, TGx 1987-62F, TGx 1988-18F, and TGx 1991-22F. The performance of these lines was verified under evaluation both on-station and on-farm in different agro-ecological zones of Malawi.

On-farm farmer participatory variety selection

Five promising genotypes were evaluated under farmer-managed conditions during the 2011/12 season in

Lilongwe and Dowa districts of Malawi. The objective was to compare the adaptability and yield performance of the promising varieties with checks (Makwacha, Magoye and Tikolore) and identify new superior genotypes that can be considered for release for commercial production. The check variety Tikolore and the test genotype TGx 1989-60F outperformed the rest of the genotypes in terms of grain yields. Above mean grain yields were also noted in test genotypes TGx 1987-62F and TGx 1987-11F. In terms of yield, Lilongwe district appeared to be a favorable location for soybean.

In 2012/13, 24 farmers (18 women and 6 men) were engaged in participatory variety selection (PVS). During the exercise, farmers were given “positive” ribbons to select their favorite variety and “negative” ribbons for their less-preferred variety. Male and female farmers were given different colors for positive ribbons and negative ribbons in order to segregate the results for male and female farmers’ preferences. At the end of the exercise, farmers discussed and agreed that the best variety was TGx-1989-60F because it is high yielding.

Seed production

It is the mandate of IITA’s Soybean Breeding Program to make sure that breeders and basic seed of released varieties is available in required quantities. During 2012 off-season, a total of 3550 kg of breeders’ seed was harvested of Tikolore. Similarly, 1500 kg was harvested during the 2012/2013 main growing season.

*Since the 1970’s, IITA has been working to improve the production of soybean in Africa and the lives of millions of smallholder farmers who depend on it for their livelihoods.
Photo by JTOliver, IITA.*



About the **author**



Hesham Agrama, an Egyptian, is Soybean Breeder based at IITA-Zambia. He obtained his PhD in Genetics from Alexandria University, Alexandria, Egypt in 1992, and his MSc and BSc in Genetics degrees from the same university in 1986 and 1979, respectively.

Dr Agrama worked on maize research with the Agricultural Research Center in Egypt from 1981 to 1996. He started his career as a Visiting Scientist with CIMMYT in Mexico. Prior to his appointment at IITA, he worked as a Research Geneticist at the Agricultural Research Center, Egypt (2010–2011) and as a Research Associate at the Rice Research and Extension Center, University of Arkansas, and DB National Rice Center, USA, from 2004 to 2010.

He has extensive experience and training in plant genetics and application of modern research tools in molecular breeding including genotyping germplasm accessions, gene mapping, marker-assisted selection, association mapping, genomic selection, and development of innovative experimental designs. His techniques were applied to identify economically important quantitative trait loci associated with biotic and abiotic stress traits in many crops such as drought tolerance and nitrogen use efficiency in corn and arsenic problems in rice.

Boosting soybean yields in Mozambique through rhizobium inoculation

Steve Boahen, Legume System Agronomist and Country Representative, IITA-Mozambique; and **Robert Abaidoo**, Soil Microbiologist, IITA-Ghana

Legumes have unique ability to fix atmospheric nitrogen (N) through symbiotic association with root nodule bacteria. This ability reduces the need for fertilizer N application. The bacteria, collectively called *Rhizobium* must be present in the soil to infect the root of the plant and develop the symbiotic plant organ called “nodules”, the housing for the nitrogen fixation process. To ensure that large, effective populations of rhizobia are available to facilitate effective nodulation and nitrogen fixation it is essential to add appropriate *Rhizobium* strains (inoculants) to the soil in fields where legumes are grown. With support from the Bill & Melinda Gates Foundation through Wageningen University and from USAID, the N2Africa



Root of soybean plant grown in an inoculated field showing good nodulation (white outgrowth on the roots). Photo by Steve Boahen, IITA.

and Platform Mozambique projects are developing, disseminating and promoting appropriate nitrogen fixation technologies focusing on soybean for smallholder farmers in Mozambique.

Mozambique does not have an inoculant production facility and therefore inoculants used in the country are imported. In 2013, field trials were established across four sites in Mozambique: Nkhame and Ntengo Umodzi in Tete Province, Ruace in Zambezia province and Sussundenga in Manica province, with the objective of testing five imported peat-based inoculant products and the liquid formulations of two of the peat-based products. The products performed consistently across sites and significantly improved nodulation. The peat-based inoculants increased soybean grain yield by 334-695kg/ha when averaged across sites. Two of the products, Biagro and Biofix consistently produced the highest grain yield across the four sites. The grain yields for the liquid formulations did not differ from that for the non-inoculated plants.

In another field trial, we evaluated the responses to inoculation of the promiscuous (cultivars which will produce nodules in the presence of indigenous strains of *Rhizobium* species) variety Zamboane (TGx 1904-6F) and the non-promiscuous variety Storm as well as the interactive effects of phosphorous and starter N application (40 kg N/ha) on nodulation and grain yield. A split-plot design arranged in a randomized complete block with zero and 40 kg P/ha as main plots was used. The sub-plots consisted of a factorial combination of the two varieties, 40 kg N/ha, a peat-based inoculant applied at planting, and a combination of 40

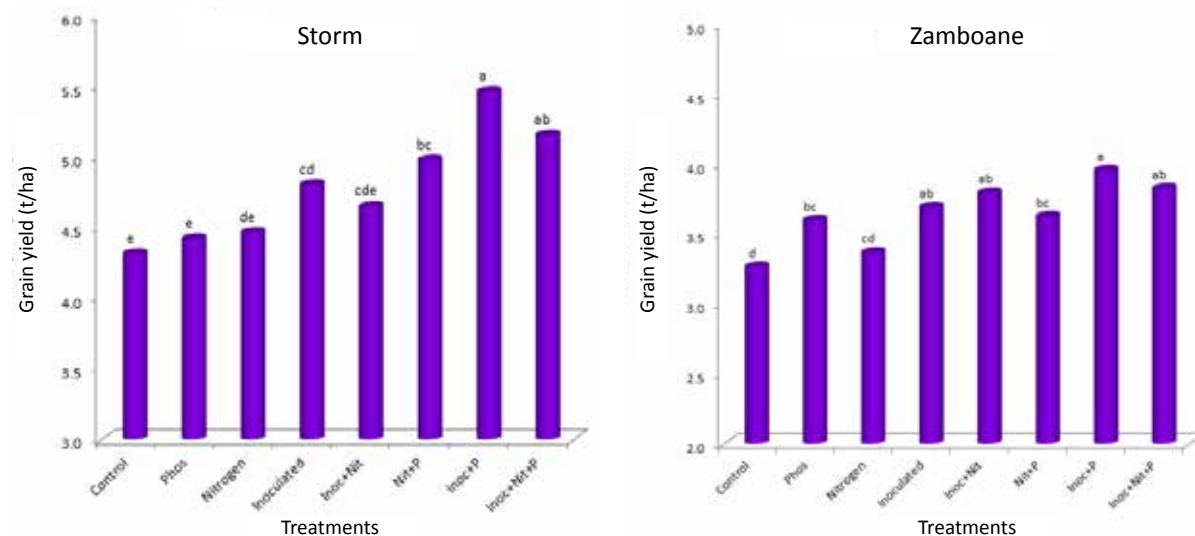


Figure 2. Yield responses of soybean varieties to inoculation, phosphorous, nitrogen, and a combination of the inputs during the 2012/2013 growing season in Mozambique.

kg N/ha and inoculant. Inoculation increased nodulation in both soybean varieties across sites but the effect of P on nodule formation was not consistent across sites and variety. Starter N generally depressed nodulation across sites and varieties when applied alone. Overall, inoculation plus P application produced the highest grain yields of both varieties (Figure 2). Similar results were obtained in on-farm demonstration trials managed by farmers across several soybean growing regions in Mozambique.

The average farm gate price for soybean grain in Mozambique for the 2013 harvest was 14 MZN/kg

when decomposed, add to the soil nitrogen reserves. On the other hand, yield increases due to P application cannot compensate for the high cost of P fertilizer in Mozambique. Our results show that due to the high cost of phosphorus fertilizer, it is more economical for farmers to use inoculant alone to maximize return on investment.

About the **authors**



Steve Boahen is a Legume System Agronomist based in IITA-Mozambique. His main research interests include the development of improved crop management technologies for legume-based cropping systems with a focus on identifying physiological and management constraints to soybean and cowpea productivity, developing efficient nutrient management, inoculation methods for enhanced nodulation and N₂ fixation and community-based seed system. He is involved in participatory research and works with university staff, students, farmers and farmers' associations and NARES partners. Dr Boahen also serves as IITA's Country Representative in Mozambique.



Robert Abaidoo is a Soil Microbiologist based at IITA's research station in Ghana. He has experience spanning over 25 years of soil microbiology research on soil fertility improvement, natural resource management, plant nutrient use efficiency, evaluation of biological and chemical products for improved crop and soil productivity and graduate student training in close collaboration with national institutions in sub-Saharan Africa. He coordinates and manages R4D-oriented projects in Ghana.

Raising the yield bar through better soybean agronomy

Steve Boahen, Legume System Agronomist and Country Representative, IITA-Mozambique

For many resource-poor farmers in Mozambique, soybean is relatively a new crop but it is one of the most profitable smallholder crops in parts of Zambezia, Lichinga, Nampula and Tete provinces, in areas where mean annual rainfall is above of 1400 mm. The demand for soybean is high and this is driven by the growing domestic poultry industry. The inadequate domestic supply, available regional market and attractive farm gate prices make soybean a crop with a huge growth potential. However, farmers have not taken full advantage of the situation due to low productivity largely resulting from lack of access to good quality soybean seeds and poor crop management practices.

In collaboration with national and international partners, IITA recently introduced five high-yielding and drought tolerant varieties (the first batch of soybean varieties released in Mozambique) and supplied foundation seed to community-based seed producers, start-up seed companies and other partners to produce certified seeds. This intervention in combination with other initiatives that multiply or import soybean seeds from neighboring countries has minimized the problem of seed accessibility. While introducing the new varieties is the first essential step for successful soybean production, the key to closing the



Soybean farm with variety Wàmini (TGx 1740-2F), one of the varieties released in Mozambique. Photo by Steve Boehn, IITA.

yield gap is capitalizing on the yield potential of the varieties available and managing them to maximize productivity under challenging smallholder farming environments. With USAID support, the Platform Mozambique project is developing agronomic systems that integrate soybean genetics, environment and balanced crop nutrition with crop management practices.

A major emphasis is being placed on determining the best time to plant soybean in several agro-ecologies. Planting date studies have shown that yields of up to 5.0 tons/ha could be obtained in high potential soybean growing areas in Gurue and Angonia districts in Zambezia and Tete

provinces, respectively, when seeds are planted early in the growing season (around mid-December). Yields decreased consistently across all agro-ecologies when planting was delayed, and the decline increased further when planting occurred after mid-January (Figure 1). For example, in the 2012-2013 growing season, average yield losses of 65 kg/ha and 31 kg/ha, respectively, occurred for every day that planting was delayed after mid-December until end of

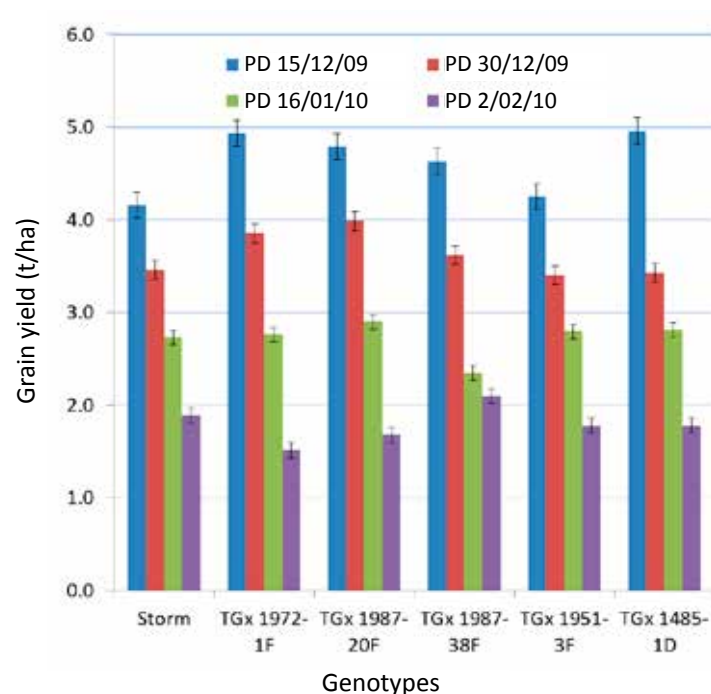


Figure 1. Grain yield of soybean genotypes as influenced by planting date in Zambezia province of Mozambique



A soybean farmer in her seed multiplication field in Mozambique. Photo by Steve Boahen, IITA.

December. Delayed planting affected the late maturing varieties more since the long duration varieties were not able to fully complete pod-filling before terminal drought began. The data suggested that the growth and development of early planted soybeans occur under favorable environmental conditions and that the plants have more time for seed-filling and maturation resulting in the production of bigger seeds.

Through this study, we are matching varieties with varying maturity duration to specific environments and to provide farmers options that will enable them to match varieties to the length of the growing season. For example, when rain delays in a particular year or if for some reason farmers could not plant early, they can select short-maturing varieties that can fit into the remaining growing period. Currently, we have enough data to conclude that the best time to plant soybean in the major soybean growing agro-ecologies of Mozambique is within the first three weeks of December; however even within this window, better yields can be achieved when planting is done early.

Another important approach to exploit yield potential of available varieties is combining appropriate row spacing with optimum plant population. In this study, narrow spacing of 33 and 50 cm in addition to wide spacing of 75 cm commonly used by farmers were evaluated. Grain

yields for the 33 and 50 cm row spacing were not different but on average both were 20% higher than that for the 75 cm row spacing. In terms of plant population, the 33 cm spacing had 28% more plants per m² area than the 50 cm row spacing suggesting that 28% of the seed cost for the 33 cm spacing could have been saved if planted at 50 cm. Furthermore, the 33 and 50 cm row spacing plots were weeded two times, whereas that for the 75 cm row spacing plots were weeded three times during the season. Using appropriate row spacing and plant population ensured early canopy cover, which control weed and minimize the amount of water loss from the soil surface.

These results in addition to other recommended management practices on inoculation, phosphorous application and crop rotation are being disseminated to farmers in different ways. Demonstration plots are established with the direct participation of farmers and they are responsible for the day-to-day maintenance of the plots to encourage hands-on learning. Several field days are organized during the growing season for individual farmers and farmers' groups to create awareness about the technologies. Information is also disseminated through training to improve the skills of farmers to facilitate the proper application of the technologies.

The project is filling the void in providing soybean foundation seeds to partners to produce certified seeds. Our current model is provision of seeds at low cost to start-up companies like MozSeeds, Phoenix Seeds Ltd and Lozane

Farms to help build the commercial seed sector. At the same time the project through partnerships with NGOs, Farmers Associations and individual farmers is scaling up seed multiplication to strengthen and sustain the community-based seed system in order to enhance accessibility of improved and good quality seeds. The seed sector is making steady progress since large quantities of seeds are presently being produced. Farmers are increasingly depending on seeds produced by others instead of using their own saved seeds. Thus, more farmers are buying seeds but mostly on credit through community-based organizations, farmers' groups and development organizations.

We believe that the model is working successfully but will require more time to be self-sustaining. These interventions have played a major role in raising the national average yield from 800 kg/ha two years ago to 1200 kg/ha. Farmers who have adopted improved technologies and implement them appropriately typically obtain over 2000 kg/ha in years with good rainfall. The seed companies are expanding and establishing their businesses, the knowledge and skills gained by farmers through training and the release of high-yielding and drought tolerant varieties are contributing to accelerate the process of adoption and sustainability of the new technologies. It is expected that the interventions will continue to boost soybean productivity and expand production to encourage full participation of the private sector at all levels along the value chain and ultimately enhance the family income and food security of the smallholder farmers.

Acknowledgement

The author wishes to acknowledge the contributions of Carlos Muananamuale, Rachad Ussene, and Canon Engoke in the completion of this report.

capacity building, seminars and publications

Training

DR Congo

- Cassava R4D Project annual planning workshop and training, 50 participants (INERA researchers and technicians), 26-30 August, Kinsasha, DRC.

Malawi

- Tropical Legumes II Project Socioeconomic Survey Methodology Workshop, 5 participants, 6-9 May 2013, Lilongwe, Malawi.
- Resource mobilization: essentials of project implementation cycle, 22 participants, 23-26 July 2013, Lilongwe, Malawi.
- Resource mobilization: Guiding principles of proposal development, 22 participants, 27-28 July 2013.

Zambia

- Disease management and agronomy, 12 participants, 26-28 January 2013, Eastern and Luapula Province.
- Gender mainstreaming and the use of Participatory Research and Extension Approaches (PREA) in Malawi, Mozambique, Swaziland, and Zambia. 215 participants. Various dates.

Mozambique

- Tropical Legumes II Socioeconomic Survey Methodology Workshop, 8 participants, 2-4 July 2013, Nampula, Mozambique.

Seminars

Natural resource management

- Effectiveness of rhizobia isolated from South Kivu soils on nodulation of soya beans, Bintu NDUSHA (MSc student), IITA-Kalambo station, 1 February 2013.
- Cassava productivity opportunities and challenges in southern Africa and the role of a breeder in the cassava value chain. Pheneas Ntawuruhunga, Lusaka, Zambia, 11 November 2013.
- IITA working partnerships and capacity building initiatives, Kenton Dashiell, DDG-Partnerships and Capacity Building, 15 October 2013, University of Zambia, Lusaka, Zambia.

Social Science and agribusiness

- Overview of socioeconomics research at IITA-Malawi, Arega D. Alene, Makaiko Khonje, and Julius Manda, 5 March 2013, Chitedze Research Station, Lilongwe, Malawi.
- Strategic assessment of cassava research priorities in Africa, Arega D. Alene, Joseph Rusike, Jofrey Oleke, and Tahirou Abdoulaye, 12-14 Nov 2013, International Potato Center (CIP), Lima, Peru.

Graduate and post-graduate studies

Below is a list of PhD students that have either initiated or ongoing studies in 2013 supervised by scientists based at the southern Africa hub:

Name	Affiliation	Title of thesis	IITA supervisor(s)	Status
Social science and agribusiness				
Julius Manda	IITA (APO)	Adoption and impacts of maize-legume system technologies in eastern Zambia	Arega Alene	Ongoing
Grace Chikowi	University of Malawi	Knowledge, attitude and practices of farm families on processing and utilization of soybean: case of Chitekwere EPA	Penina Muoki	Ongoing
Biotechnology and plant breeding				
Arnold Aibu Muimui	University of Zambia	Assessment of farmer's preferences on characteristics of cassava through PVS across agro-ecological regions in Zambia	Pheneas Ntawuruhunga	Ongoing
Mathias Tembo	University of Zambia	Characterization and identification of cassava viruses causing CMD	James Legg and Pheneas Ntawuruhunga	Ongoing
Tiuzeyan Zulu	University of Zambia	Characterization of cassava varieties resistant to cassava mosaic virus in Zambia	Pheneas Ntawuruhunga	New

Name	Affiliation	Title of thesis	IITA supervisor(s)	Status
Paul Kachapulula	University of Arizona	Biocontrol for maize and groundnuts	Juliet Akello	New
Amaral Chibeba	Tshwane University of Technology, Pretoria, South Africa	Identification and characterization of effective rhizobial strains for enhanced N fixation in Mozambique	Steve Boahen	Ongoing

Also in 2013, the following MSc students had ongoing studies supervised by scientists based in the region:

Name	Affiliation	Title of thesis	IITA supervisor(s)	Status
Malawi				
Donald Siyeni	Bunda College of Agriculture, University of Malawi	Effect of <i>rhizobium</i> inoculation and phosphorous fertilizer on yield and nodulation of soybean in Dedza, Salima and Kasungu districts of Malawi	Anne Turner	Ongoing
Esnart Nyirenda Yohane	Bunda College of Agriculture, University of Malawi	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	Anne Turner	Ongoing

Name	Affiliation	Title of thesis	IITA supervisor(s)	Status
Willard Kamowa Mbewe	Chancellor College	Distribution of CBSD and characterization of CBSV (<i>Potyviridae: Ipomovirus</i>) in Malawi	Pheneas Ntawuruhunga	Ongoing
Mozambique				
Carlos Pedro Muananamuale	Tshwane University of Technology, Pretoria, South Africa	Interactive effects of nitrogen and phosphorus and inoculant on yield and yield components of soybean	Steve Boahen	Ongoing
Rachad Ussene	Tshwane University of Technology, Pretoria, South Africa	Evaluation of cowpea genotypes across several agro-ecologies of Mozambique	Steve Boahen	Ongoing
Gersonia Catine	Catholic University, Nampula	Administration and human resources management	-	Ongoing
Mônea Lina Adelino Mucavea	Bunda College of Agriculture, University of Malawi	Legume cropping systems – Intercropping soybean and groundnuts with Maize	Steve Boahen	Ongoing
Fernando João Sualei	Bunda College of Agriculture, University of Malawi	Reaching legume farmers through effective and efficient dissemination strategies	Anne Turner and Steve Boahen	Ongoing
Zambia				
Kaubi N Hacholi	University of Zambia	Characterization of maize germplasm for resistance to <i>Striga asiatica</i> in southern Africa	David Chikoye	Ongoing

Name	Affiliation	Title of thesis	IITA supervisor(s)	Status
Pride Cheelo	University of Zambia	Genotype X environment interaction and stability analysis for yield and other components in soybean in Zambia	Hesham Agrama	Ongoing
Tiuzeyani Zulu	University of Zambia	Molecular characterization of cassava genetic variation for CMD resistance in landraces and improved varieties in Zambia	Pheneas Ntawuruhunga	Ongoing
Mudenda M Hampango	University of Zambia	Evaluation of yield performance of cassava germplasm under water stress	Pheneas Ntawuruhunga	Ongoing

Selected publications

Natural resource management

Dewitte O, Jones A, Spaargaren O, Breuning-Madsen H, Brossard M, Dampha A, Deckers J, Gallali T, Halletti S, Jones R, Kilasara M, Le Roux P, Michéli E, Montanarella L, Thiombiano L, Van Ranst E, Yemefack M, and Zougmore R. 2013. Harmonization of the soil map of Africa at the continental scale. *Geoderma* 211-212.

Social science and agribusiness

Alene A, Khataza R, Chibwana C, Ntawuruhunga P, and Moyo C. 2013. Economic impacts of cassava research and extension in Malawi and Zambia. *Journal of Development and Agricultural Economics*, Vol. 5(11), pp. 457-469. DOI10.5897/JDAE2013.0496

Ntawuruhunga P, Dixon AGO., Kanju E, Ssemakula G, Okechukwu R, Obiero H, Bigirimana S, Gashaka G, Lukombo S, Mkamilo G, Ndyetabura I, Tata H, Otim Okello Fand Schofield. 2013. Successful innovations and lessons learnt in cassava improvement and deployment by IITA in the Eastern African Region. *African Journal of Root and Tubers Crops*. Vol. 10 No. 1. Page 41-54.

Plant protection and plant health

Legg J, Somado EA, Barker I, Beach L, Ceballos H, Cuellar W, Elkhoury W, Gerling D, Helsen J, Hershey C, Jarvis A, Kulakow P, Kumar L, Lorenzen J, Lynam J, McMahon M, Maruthi G, Miano D, Mtunda K, Ntawuruhunga P, Okogbenin E, Pezo P, Terry E, Thiele G, Thresh M, Wadsworth J, Walsh S, Winter S, Tohme J, and Fauquet C, 2014. A global alliance declaring war on cassava viruses in Africa. *Food Sec.* (2014) 6:231–248, DOI 10.1007/s12571-014-0340-x.

message from the **regional director**

The year 2013 is another landmark period for the Western Africa Hub, highlighted by a number of significant achievements in our R4D work in the region and contributing towards the realization of the institute's mission and vision as stated in our 2010-2020 Refreshed Strategy. Of course, these would not have been made possible without the continued support and trust of our donors and partners who continue to believe that IITA makes a difference in the lives of smallholder farmers not only in West Africa but also across the continent.

This year, the release in Nigeria of two extra-early maturing white maize hybrids that we developed that combined drought and low N tolerance with *Striga* resistance will contribute to more stable maize production in the country in the face of increasingly unpredictable rainfall. Two improved cowpea varieties bred by IITA and tested locally with farmers were released in Burkina Faso. The released varieties have been selected for dissemination in the country by a World Bank project (WAAPP). Planting materials for 444 improved genotypes of cassava were delivered to the Sierra Leone Agricultural Research Institute for evaluation and selection of those adapted to the farming systems and market preferences in the country.

Resistance to cassava mosaic disease (CMD) obtained from African landraces of cassava has been used by many breeding programs owing to its effectiveness in different genetic backgrounds. Our scientists, working those from Cornell University and USDA-ARS, have demonstrated a

narrow genetic basis for this resistance in the crop's African gene pool and a need for diversification of sources of resistance. Currently breeders depend on the protection provided by the combination of this monogenic resistance with the polygenic resistance derived from a wild cassava relative, *Manihot glaziovii*.

Technologies for more rapid propagation of yam were established at IITA-Ibadan station by the project 'Yam Improvement for Income and Food Security in West Africa' (YIIFSWA), funded by the Bill & Melinda Gates Foundation. Hundreds of yam minitubers are produced from vine cuttings in the aeroponics system — an air environment with regular supply of nutrients to the roots by misting. We have capacity for production of 19 200 *in vitro* plantlets in a single batch from a bioreactor system. This can also be used for production of yam microtubers.

Georg Goergen, head of the Biodiversity Center at our Cotonou station, Benin was honoured by the Royal Museum for Central Africa, Tervuren, Belgium (MRAC) and the Natural History Museum, London, England for his work on the West African insect fauna which recently led to the discovery and description of a new species of fruit fly in Benin and Togo. The new species has been named after him, as *Dacus goergeni*. Goergen also leads the team that is managing the spread and damage of the papaya mealybug (*Paracoccus marginatus*) in West and Central Africa through biological control (funded by the Swiss Agency for Development and Cooperation).



Dr Robert Asiedu
Regional Director
Western Africa



Satellite imagery of the sprawling IITA-Ibadan campus, which hosts both IITA headquarters and the Western Africa hub. Image courtesy of Google Maps.

Tahirou Abdoulaye received the Purdue University Agricultural Economics APEX Award for his effectiveness in the transfer of new technologies. The Purdue Improved Cowpea Storage (PICS) program that he led has reached farmers in more than 12 000 villages in Nigeria, providing them with information on how to effectively store cowpea in the triple layer plastic bags to protect them from insect damage. Ijeoma Akeaogu, IITA PhD Research Fellow, placed

3rd in the Science competition held during the 6th Africa Agricultural Week organized by FARA.

Accra, Ghana was the venue for three key international meetings. IITA staff, including Richardson Okechukwu and Elizabeth Parkes, led the organization of the 12th Triennial Symposium International Society for Tropical Root Crops-Africa Branch (ISTRC-AB). Lava Kumar led the organizing committee for a successful Global Yam Conference. The launch of the Ghana National Yam Strategy by the Deputy Minister for Food and Agriculture, Hon. Ahmed

Yakubu Alhassan, was another important milestone. IITA, represented by Dr. Antonio Lopez-Montes, and the International Trade Center (ITC) based in Switzerland, provided technical backstopping to the private sector led effort to develop this roadmap to guide improvements in the yam sector.

These are but just a sampling of our achievements in 2013. As you go through the pages of the Western Africa section of these regional highlights, know that it is the smallholder farmer who is foremost in our collective hearts and minds. To them we dedicate this report.

western africa **research highlights**

Adaptation to climate change and adoption of drought-tolerant maize varieties by smallholder farmers

Tahirou Abdoulaye, Socio-economist, IITA-Ibadan, Nigeria

There is a general consensus that the climate is changing and that this change has a significant impact on agricultural production worldwide. Africa is expected to be particularly hard hit by climate change because of the geographical challenge, high dependence on agriculture, and with limited capacity to adapt due to poverty and low level of technological development. Smallholder farmers are among those who will suffer most.

Under the Drought Tolerant Maize (DTMA) project, funded by the Bill & Melinda Gates Foundation, a survey on farmers' perceptions on climate change was carried out in the Northern Guinea Savanna and the Sudan Savanna areas of Nigeria (Tambo and Abdoulaye, 2013). The study also investigated the impact of climate change on farmers and how they are adapting. The results/information will inform development practitioners on farmers' adaptation strategies and possible interventions to help them improve their livelihood. A total of 200 farm households were interviewed (100 households from each region).

Farmers' perception of climate change

A high proportion of the farmers interviewed, 92%, had perceived changes in temperature over the past 20 years

and over 75% had noticed an increase in temperature. Very few farmers indicated a decrease in temperature (8%) or no changes in temperature (6.5%). These perceptions are stronger when one moves to the north with almost all farmers interviewed (94%) in the Sudan Savanna zone arguing that the temperature has increased over the last 20 years.

Regarding long-term changes in average rainfall, about 24% had noticed a decrease in the volume of rainfall or a shorter rainy season, while 12% had observed that the timing of rainfall fluctuates from year to year. The majority of the respondents (60%) had noticed both a decrease in rainfall and changes in the timing of the rains. Only 3% of the farmers reported an increase or no changes in rainfall. The farmers noted that there is more erratic rainfall with seasonal changes in the pattern and unpredictable starts and stops. The farmers asserted that they constantly commenced planting/sowing in May, but in the past few years, they are unable to determine when to plant because of the unpredictable rains. They also reported that over the past 5 years, rainfall in the area has not been uniform with cases of rainfall only in parts of a village.



A woman farmer in her maize field. Photo by IITA.

Farmers giving their thoughts about drought-tolerant maize as IITA scientist, Dr Tahirou Abdoulaye (in blue, seated), listens as another IITA staff records their responses. Photo by IITA.



Adapting to climate change

Farmers who responded that they had observed changes in climate over the past 20 years were asked to indicate adjustments they had made in their farming activities in response to the perceived changes in temperature and rainfall. Although many farmers perceived changes in temperature, about 46% had not undertaken any adaptation measures. Among those who did, most of the respondents took up measures in order to adapt to decreasing volumes or changes in the timing of rainfall. Only 15% of the 184 farmers who perceived changes in rainfall did not take up any form of adaptation.

The main adaptation methods were the use of drought tolerant or early maturing maize varieties (52%) and a shift

in dates of planting (47%). The high use of these two adaptation measures can be attributed to two projects in the study area: Drought Tolerant Maize for Africa (DTMA) and Promoting Sustainable Agriculture in Borno State (PROSAB) both implemented by IITA and funded by the BMGF (Bill & Melinda Gates Foundation) for DTMA and CIDA (Canadian International Development Agency) for PROSAB. Because drought has always been one of the main problems affecting farming in the area, the two projects developed and disseminate early maturing and drought tolerant varieties of some major crops, particularly maize. Due

to the availability of drought tolerant and early maturing maize varieties, most of the farmers are able to delay the time of planting until there is stable rainfall.

Another study, estimated potential benefits of adoption of drought tolerant maize varieties and hybrids in the 13 countries included in the DTMA project. It was concluded that, for Nigeria alone, benefits from adoption of drought tolerant maize will range from US\$ 0.05 to 1.63 million, depending on the scenario chosen. The study also showed that drought tolerant maize varieties may be an effective tool for reducing household risk, especially for the poor who face high drought risk and are highly dependent on cereal production. Considering changes in production due to climatic change, the findings suggest that drought tolerant maize can be a viable option for reducing food crises caused by drought and climate change and can decrease poverty in general. Policies and investment that set up appropriate infrastructure for production and dissemination of drought tolerant maize may prove to be very beneficial in both the short and long term.

About the author



Tahirou Abdoulaye, a national of Niger, obtained his BSc in Economics from the University of Niamey, Niger, and his MSc and PhD in Agricultural Economics degrees from Purdue University, USA. He has been involved in evaluation and impact assessment of several projects mainly in West Africa.

He has produced papers on impact assessment of research activities in several African countries including Niger, Ghana, Mali, Senegal, Nigeria, and Benin. His research work covers a wide range of rural economic issues including seed systems, farm-level efficiency and also technology evaluation and transfer. His more recent research interest focuses on innovation systems and how they can help increase technology uptake by small farmers.

Prior to joining IITA in 2007, he was a research fellow with JIRCAS (2005–2006), Scientist at INRAN (2004–2005), graduate research assistant and postdoctoral research associate at Purdue University (1997–2003) and Economist at INRAN (1989–1993, 1994–1996).

Maximizing profitability of yam production

Stefan Hauser, Root and Tuber Systems
Agronomist, IITA-Ibadan, Nigeria

At IITA major efforts are focused on increasing crop production through sustainable intensification, i.e. to increase crop yields through measures that are affordable to farmers and that maintain or improve natural resources. Profitability of crop production and the use efficiency of inputs usually decline with increased input quantities, because costs increase and the biological or physiological use efficiencies eventually levels out or decline. For yam, a highly appreciated staple crop in most of West and Central Africa, our knowledge on input use efficiency is still limited.

Input costs in relation to yam production are numerous. Most yams are grown after long bush fallow leading to high cost for land clearing, subsequent nutrient losses at biomass burning, labor intensive tillage and mounding and costs related to the procurement of stakes. Furthermore, seed yams are expensive and often of poor quality and, later on during the season, weed control, prevention of rodent damage and theft are additional cost factors in the production chain

Yam being arranged on a truck for transport to markets in Nigeria. Photo by IITA.



of yam. To increase the long-term profitability of yam production, it is thus important to determine which of the major production factors can contribute to sustainable yield increases without compromising the natural resource base.

With the objective of estimating the relative importance of the different production factors and to identify possible synergistic effects within the inherent complexity of the varying yam cropping systems used by farmers, a four factorial on-station experiment was conducted at IITA-Ibadan. The experiment was set up so as to mimic the on-farm situation and the effects of four key production factors were studied: tillage, intercropping yam with maize, fertilizer application and planting density of the yam. This approach is the first in which the effect of these production factors and their interactive effects have been tested simultaneously. Approximate on-farm costs were used to estimate the profitability of the studied factors for yam production.

Impact on tuber yields

Contrary to our expectations, tillage by ridging using a tractor (75 cm spacing between 35-40 cm high ridges, which flattened out during the season) produced lower tuber yields (16 tons per hectare) compared to leaving the land surface flat (17 tons per hectare). Intercropping with maize at a high maize density also significantly reduced yam tuber yields (from 21 to 12 tons per hectare), indicating that the common system of maize-yam intercropping might not always be ideal for sustainable intensification

of yam production. However, the maize yield in itself and as a compensation for the decrease in yam yield needs to be considered. Maize yields were also significantly lower in yam intercrop than when grown alone and increased significantly when fertilizer was applied .

Yam was planted at eight densities ranging from 10 025 to 33 333 plants per hectare and tuber yields increased with increasing plant density (Figure 1), both when grown alone and when intercropped with maize. However, yield increases leveled out at higher yam plant densities (marked

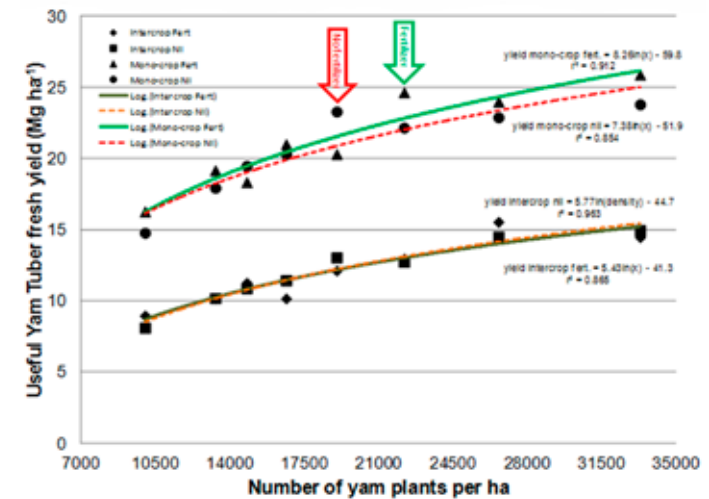


Figure 1. Yam tuber yields at different yam plant densities in fertilized and unfertilized yam grown alone (upper curves) versus yam intercropped with maize (lower curves), Ibadan, 2013. Vertical arrows indicate at which densities the yield increase levels out, with (green arrow) and without fertilizer (red arrow).

by arrows in Figure 1) and yields were significantly higher at all densities when yam was grown alone, as mentioned above (the top curves).

Fertilizer application (200 kg per ha NPK 15:15:15 at 4 weeks after planting, 65 kg/ha urea at 8 weeks after planting and 100 kg/ha potassium chloride at 18 weeks after planting) only caused an increase, although not significant, in tuber yields when yam was grown alone (the top curves in Figure 1).

Costs and benefits

In this on-station experiment tillage with tractor led to a significant decrease in yield and, given the related costs, tillage was clearly not profitable. Furthermore, tillage is perceived as potentially damaging to the natural resource base as it has been shown in previous studies to lead to negative changes in soil organic matter (SOM) (Al-Kaisi and Yin, 2005) and nutrient concentrations (Spiegel *et al.* 2007), as well as increased erosion and mixing of weed seeds into deeper soil layers (Shrestha *et al.* 2006). However, it should be noted that ridging might lower labor cost for harvesting as well as damage to tubers during the process because it is easier to harvest tubers sitting above ground level. It could thus be interesting to further explore different row distances and ridging heights, possibly by addition of mulch, as ways of increasing profitability of yam production.

Fertilizer application did not result in significant yield increases either. The yield increase when fertilizer was applied to yam was limited (780 kg per hectare) and the value

of the increase was only half of the cost for the fertilizer. In the intercropped system, yam had no response to fertilizer application and the estimated value of the increase in maize yield was also only about half of the fertilizer cost. Consequently, under the on-station conditions, fertilizer use was thus not an option to intensify yam and maize production in a profitable manner. However, on other soils and under other rainfall conditions the crop yield response to fertilizer could be more positive. To develop fertilizer use in yam production into a reliable measure to conserve or improve the natural resource base, e.g. the soil nutrient status, more research will be needed to determine fertilizer application rates and to fine-tune the timing of fertilizer application.

Among all factors tested in our experiment, increased crop density was the most efficient factor of intensification. Crop density can easily be controlled and is therefore also a tool that is likely to be applied by farmers. However, given the relative price differences between seed yam and ware yam (the yam sold/used for consumption), the farmer has to do a trade-off analysis to determine the optimum yam plant density, and whether to intercrop with maize or not, for maximum yield/profitability. There are two options for obtaining seed yam, either to buy it or to use own, stored seed. In Nigeria, an average ware yam price would be 30 naira/kg at harvest time, whereas purchasing seed at planting could typically cost three times more, 90 Naira/kg (about US\$0.56/kg). If the farmer instead uses own, stored seed the cost would be equal to the lost revenue for not

selling it as ware yam, i.e. 30 Naira/kg (about US\$0.19/kg). Applying those numbers to the yields obtained at different yam densities and with or without intercropping with maize in our experiment, shows that the seed cost has a stronger impact on the profitability than the cropping system. The monocrop system using stored seed yam attained the highest revenue at medium plant density (22 222 plants per hectare) under the given conditions. The potential of intercropping should however further be explored in terms of optimal proportions, arrangements, and timing of planting of the companion crops, and even plant architecture of the varieties of the two crops.

About the **author**



Stefan Hauser is a Root and Tuber Systems Agronomist based at IITA-Ibadan in Nigeria with 25 years of research experience in West and Central Africa. His background is in soil science and soil biology in the humid forest zones of Nigeria and Cameroon. He was previously based in DR Congo after formally establishing the IITA-DR Congo station and conducting an academic training program for the Congolese national agricultural research system. He currently works on cassava and yam agronomy and plant nutrition in Nigeria, Ghana, Cameroon, and DR Congo.

Multiple stress-tolerant early and extra-early maize to boost maize production in West and Central Africa

*Baffour Badu-Apraku, Maize Breeder/
Geneticist, IITA-Ibadan, Nigeria*

Extra-early and early maturing maize cultivars developed by IITA and partners has made it possible for the crop to spread fairly rapidly into the savannas because of its high productivity, wide adaptation and relative ease of cultivation, processing, storage and transportation. This has increased the potential of the crop to combat the food security challenges posed by population increase in West Africa. Maize has a higher yield potential and is more responsive to fertilizer application than the staple cereal crops sorghum and millet, traditionally grown in the savanna agro-ecosystem. However, production in the savanna agro-ecology is severely constrained by low levels of soil nitrogen (N), recurrent drought, and *Striga hermonthica* parasitism. The occurrence of drought can cause about 90% reduction in grain yield (Figure 1, next page). Estimated yield losses from N-stress alone can be as high as 50% while severe *Striga* infestation may cause complete crop loss. Therefore, the development and commercialization of maize cultivars with tolerance to multiple stresses are crucial for increased productivity. Consequently, over the last two decades, the IITA strategy to stabilize maize yield in the sub region has

been to breed for drought tolerant cultivars with resistance to *Striga* and tolerance to low N.

Breeding methodology for adaptation to multiple stress environments

Two approaches have been adopted for breeding for adaptation to drought. The first is to breed for drought escaping through early and extra early maturing cultivars that reach maturity before the onset of drought. Selection for these traits is carried out in the savannas of West and Central Africa and induced drought stress is achieved by withdrawing irrigation water 3-4 weeks after planting until maturity. The second approach is to breed cultivars that possess drought tolerant genes and can withstand a drought which occurs during the flowering and grain-filling periods. The selected lines are also used as sources of tolerance genes for introgression into early and extra-early breeding populations.

In terms of *Striga*, breeding efforts can both be focused on resistance and tolerance. A resistant maize plant stimulates the germination of *Striga* seeds, but prevents the attachment of the parasite to its roots and/or kills it when attached. The resistant genotype thus supports significantly fewer *Striga* plants and produces a higher yield than a susceptible genotype. A *Striga*-tolerant genotype, on the other hand, germinates and supports as many *Striga* plants as the susceptible genotype, but produces more grain and stover and shows fewer damage symptoms.

Evaluation for tolerance to low nitrogen is conducted under conditions of low soil N and in plots with optimum levels of nitrogen (N). To create low soil N conditions, soil fertility is depleted to levels well below 1.5 g/kg by continuous cultivation of maize or other non-leguminous crops and no application of fertilizers. Uniformity of screening sites is required to reduce experimental error and identify genotypes that truly owe their superiority to ability to excel under conditions of nitrogen stress. Genotypes with high grain yield, large number of ears per plant, delayed leaf senescence, good ear aspect and low Anthesis-Silking Interval (delay in silking) under nitrogen stress are considered tolerant to low soil nitrogen.

Using this combined strategy, several early and extra-early, *Striga* resistant/tolerant and low N tolerant cultivars with enhanced adaptation to drought-prone environments have been bred. Recurrent selection methods are used to increase the frequency of alleles enhancing adaptation to drought and low N stresses as well as *Striga* resistance. Inbreeding is also adopted to fix favorable alleles.

Impact through DTMA project

During the past decade, IITA and the national programs of West and Central Africa have released several of these improved cultivars and inbred lines. There is, however,



Figure 1. Spotty seed set as a result of drought. Photo by IITA.

(Top) Drought tolerant versus susceptible hybrids in Ikenne, Nigeria; (bottom) Striga resistant versus susceptible hybrids in Abuja, Nigeria. Photos by IITA.



tremendous opportunity for improving the overall performance and suitability of these cultivars by incorporating even higher levels of adaptation to drought. A major strategy of the Drought Tolerant Maize for Africa (DTMA) project, funded by BMGF and executed by CIMMYT and IITA, has therefore been to screen early and extra-early inbred lines also for drought tolerance. Promising inbred lines with better adaptation to drought, as well as low-N tolerance and *Striga* resistance, are then evaluated in hybrid combinations. The most promising hybrids are subsequently evaluated in regional and on-farm trials in several contrasting environments in collaboration with partners in Nigeria, Ghana, Mali and Benin and then released for production by farmers. Consequently, not only low-N and *Striga* resistant/tolerant inbred lines and hybrids, but also drought-tolerant early and extra-early inbreds and hybrids that are drought escaping and also carry genes that are tolerant to drought at

flowering and grain-filling periods are now available in the region. Two such early maturing hybrids, TZE-Y Pop STR C4 x TZEI 13 and TZEI 60 x TZEI 83, and the extra-early hybrids, TZEE-W Pop STRC 5 x TZEEI 6 and TZEEI 21 x TZEEI 29, were released in Mali and Nigeria in 2013. The availability of these inbreds and hybrids should contribute to reducing the instability of maize yields in sub-Saharan Africa.

About the **author**



Baffour Badu-Apraku has a PhD in Genetics and Plant Breeding from Cornell University, Ithaca, USA. He was the Coordinator of IITA's West and Central Africa Collaborative Maize Research Network (WECAMAN) from 1992 to 2006. Before joining IITA, he was the leader of the Ghana National Maize Program and also the Joint Coordinator of the Ghana-CIDA

Grains Development Project (GGDP) from 1987 to 1992. Under his leadership a QPM laboratory was established for the screening of maize genotypes for high lysine content in Ghana. The QPM variety, Obatanpa GH, was developed and released, and has been widely adopted in Ghana and in Benin, Togo, Mali, Senegal, Cameroon, Côte d'Ivoire, Burkina Faso, Nigeria, Chad, Guinea, Uganda, Malawi, Swaziland, Zimbabwe, Mozambique, South Africa, and Ethiopia. In addition, appropriate recommendations for maize and legume-based cropping systems and several maize, cowpea, and soybean varieties were released and widely adopted in Ghana.

Developing innovative drying solution for smallholder cassava industries

Braima James, Country Representative, IITA-Sierra Leone

Value addition constitutes a huge step in the preparation of farm commodities for markets and nutrition. Amongst value added cassava products are fermented cassava flours and the unfermented High Quality Cassava Flour (HQCF). HQCF is gaining market popularity for its suitability as wheat flour substitute in bakery and pastry products. The production of cassava flours involves grating fresh roots into mash, pressing the mash into wet cakes, sieving the wet cakes into granules/particles, drying the particles to approximately 5% moisture content and milling particles into flour. The process from root harvest to drying should be completed quickly, in 24 hours for HQCF, to assure product quality. Drying technology is therefore a major lynchpin in the process.

Traditionally the production of cassava flour relies on sun-drying which is slow, inefficient and, impractical for year-round drying, and of limited value where premium is on volume and quality of products. Sun-drying is mostly reduced to one batch a day and it may take 3 to 5 days, depending on prevailing weather, to thoroughly dry the same batch. High-end dryers, such as flash driers, are unaffordable, motorized and expensive to sustain by smallholders.

The main objective of this project was thus to provide the smallholder industry with a drying solution that is independent of sunny/dry season for its operations; rural-friendly and uses available renewable energy sources; devoid of moving parts and not prone to operational problems caused by friction; fast enough to assure adequate supply of cassava flour in quality and market demands; hygienic to prevent product contamination; gender-friendly and labour saving; and good for business in terms of daily output to assure a steady market. The technology targets smallholder cassava factories, mostly women-run, and the functioning of the dryer is amenable for use in different countries.

The steam dryer was designed to serve as a key machinery to help beneficiaries respond to trade opportunities.

In Sierra Leone the steam dryer is currently used by seven smallholder cassava factories, constructed and supported by USAID and UNIDO in selected pilot areas in the northern, eastern and southern provinces. It is expected that when organized into associations, smallholder cassava factories using steam dryers would compete with flash dryers with daily outputs of 1 to 3 million tons of flour.

The steam dryer consists of a boiler (= steam generator) with a pressure release valve and is connected to one

Loading sample trays into the steam dryer cabinets. Photo by Braima James, IITA.





Loading trays laden with wet cake particles into the steam dryer cabinets. Photo by Braima James, IITA.

to four drying chambers. The boiler can hold up to 250 litres of water and is filled once a day without re-filling. An insulating housing is built around the sides of the boiler to minimize heat loss and reduce firewood or charcoal consumption for boiling the water. For operational safety, a pressure release valve is fitted on the boiler.

The boiler is connected to the steam dryer cabinets through copper tubes that takes steam from

the boiler and circulates it through the cabinet to heat sample trays loaded with wet cake particles.

Water in these particles will be driven off by a convection current of ambient air through very narrow horizontal vents at the top and bottom of the cabinet doors. A glass inspection window fitted on each cabinet door would be misty during drying and clear when the product is dry. The window helps to prevent heat loss caused by frequent opening and closing of the doors to inspect the samples. Two cabinets with 11 sample trays each operating over an eight to ten-hour working day can produce approximately 350 kg of HQCF. The boiler can operate up to of four such drying chambers to double the production capacity.

This steam dryer will greatly reduce technology problems faced by rural-based smallholder enterprises wishing to

participate in cassava flour business. The primary fuel this far used for heating the boiler is firewood. The next step to pursue in Sierra Leone is to experiment with solar energy as an alternative to firewood. A prototype system with solar panels of sufficient surface area to provide the projected energy required for drying flours is expected to be developed in 2014 through inter-project collaboration between USAID/IITA UPoCA project and AfDB SARD SC cassava project in Sierra Leone.

Acknowledgement

The steam dryer was developed in Sierra Leone by IITA and Fourah Bay College, University of Sierra Leone (USL) collaborating on the USAID funded project “Unleashing the Power of Cassava in Response to Food Price Crisis in Africa” (UPoCA). Additionally, UNIDO supported Growth Centres in Sierra Leone and provided end-user testing sites for the dryer.

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About the **author**



***Braima Dama James** is currently IITA Country Representative to Sierra Leone, prior to which he was Director of the IITA Station in Cotonou, Benin, West Africa (2004 to 2008). He obtained his PhD in Agricultural Biology (specializing in applied entomology) from the University of Newcastle Upon Tyne, UK, in 1980.*

Braima's work focuses on the development/implementation of inter-institutional projects for capacity building in efforts to put research knowledge/results to use for increased agricultural productivity and income of smallholder groups.

In March 1993, he joined IITA as Regional Coordinator of the Africa component of the bi-continental UNDP-funded project "Ecologically Sustainable Cassava Plant Protection (ESCaPP) in Africa and Latin America (1993-1998). He has worked with a range of organizations (e.g., FAO, 13 IARCs, BioNET INTERNATIONAL, USAID, ECOWAS, CropLife International, UNIDO, International Association for the Plant Protection Sciences/IAPPS, Rotary International, and NGO networks) to identify and analyze actual and potential bottlenecks to agricultural productivity; and propose technical resources, partnerships, and funding opportunities that hold promise to effect the desired change.

New varieties released

In 2013, nine new varieties of cowpea and maize -- two and seven, respectively -- developed by IITA and partners were released in three West African countries: Burkina Faso, Nigeria, and Mali. Details of these varieties are shown below:

Crop	Country	Partner institution	IITA/ Partner accession number	Release name
Cowpea	Burkina Faso	<i>Institut National de l'Environnement et de Recherches Agricoles (INERA)</i>	IT99K-573-2-1	Yiis yande
			IT98K-205-8	Niizwe
Maize	Nigeria	Institute for Agricultural Research (IAR)	IITA synthetic PVASYN2	Sammaz 38
			IITA synthetic PVASYN8	Sammaz 39
			DTSTR-Y SYN2	Sammaz 40
	Mali	Institute for Agricultural Research and Training (IAR&T)	TZEEI 29 x TZEEI 21	Ife Hybrid 5
			TZEE-W Pop STR C5 x TZEEI 6	Ife Hybrid 6
	Mali	<i>Institut d'Economie Rurale (IER)</i>	TZE-Y DT STR C4 x TZEI 13	Sanu
TZEI 60 x TZEI 83			Mata	

capacity building, seminars and publications

Training

During the year, the West Africa hub organized and/or coordinated about 60 training workshops in Nigeria, Benin, Burkina Faso, Ghana, and Sierra Leone on various agriculture-related topics. These workshops benefitted about 9000 individuals from various sectors of society. Details of these training workshops are presented below:

Title of training	Location	No. of participants
Training seed producers for improved seed production	Saria, Burkina Faso	26
Training for cowpea production at farmers' field school	Pouni, Loango, Samboaga and Yako, Burkina Faso	230
Training for cowpea production farmers' at farmers field school	Pouni, Burkina Faso	150
Practical guidelines for enumerators on community, household and field levels' questionnaire for YIIFSWA additional baseline survey in Ghana	Ejura-Seykedumase Municipal, Ghana	6

Title of training	Location	No. of participants
YIIFSWA cross-objective workshop and community capacity building	Kintampo, Ghana	505
Capacity building of SME seed company personnel in WCA on marketing and selling directly to smallholders and business management	Tamale, Ghana	29
Capacity building of SME seed company personnel in WCA on marketing and selling directly to smallholders and business management	Zaria, Nigeria	50
Capacity building of SME seed company personnel in WCA on marketing and selling directly to smallholders and business management	Bamako, Mali	47
Pre-season training of extension agents	Kaduna, Nigeria	68

Title of training	Location	No. of participants
Weed control strategies and fertilizer application on CAP Farm	Osun state, Nigeria	12
Training of Nestle farmers from Delta, Imo, Anambra, Enugu and Abia States on weed control and best farm management practices	Delta, Imo, Anambra, Enugu and Abia States, Nigeria	203
Training of trainers on application and management of aflasafe and best practices in planting and post-harvest management of maize	Ibadan, Nigeria	8
Training of farmers on cluster formation from Odigbuetue, Uhiere and Omigie villages	Edo State, Nigeria	120
<i>In situ</i> hands-on training in harvesting and postharvest processing to meet quality standards	Kano, Zaria, and Funtua, Nigeria	17

Title of training	Location	No. of participants
Sampling protocol for Year 1 verification of aflasafe prevalence in maize and criteria for incentive payments	Kaduna, Nigeria	10
Field day /training on improved cassava varieties and agronomic practices	Ikoyi, Iddo, Kogi, Okete, Igboga, Okana, Obaniku, Kwali, Iseyin, and Owiwi, Nigeria	1083
Production of breeder and foundation seed yam	Umudike, Nigeria	22
Training workshop for youth empowerment through sustainable agriculture in Nigeria: problems and prospects	Lagos, Nigeria	69
<i>In situ</i> hands-on training in seed production planning and the establishment and management of seed fields especially maize hybrids	Kano, Zaria, Funtua, Kaduna, Gusau, and Saminaka, Nigeria	29

Title of training	Location	No. of participants
Training of extension agents on data collection, pest management and <i>Striga</i> control practices	Kano and Bauchi, Nigeria	88
Good laboratory practices and laboratory information management system (GLP-LIMS)	Ibadan, Nigeria	14
Farmer's field day for sustainable cassava seed system	Ibarapa and Atisbo, Nigeria	398
Community seed production for OPV maize and soybean	Cross River, Akure, and Ekiti states, Nigeria	75
Sampling protocol for Year 1 verification of aflasafe prevalence in maize and criteria for incentive payments	Abuja, Nigeria	7
Training of enumerators for SARD-SC baseline survey using electronic means	Ilorin, Nigeria	21

Title of training	Location	No. of participants
YIIFSWA cross-objective workshop and community capacity building	Abuja, Nigeria	228
Training of enumerators for SARD-SC baseline survey	Kaduna, Nigeria	17
Training of enumerators for SARD-SC baseline survey	Nasarawa, Nigeria	17
Training of enumerators for SARD-SC baseline survey using electronic means	Oyo, Nigeria	24
Training of enumerators for SARD-SC baseline survey	Katsina, Nigeria	14
Seed entrepreneur and service provider training on cassava variety and cassava disease identification and NASC Seed Quality Protocol	Benue and Oyo, Nigeria	61
Rhizobiology training	Ibadan, Nigeria	11

Title of training	Location	No. of participants
Training of enumerators for DT maize monitoring survey	Kano, Nigeria	16
Pre-season training of farmers	Kano and Bauchi, Nigeria	2567
Maize and soybean seeds and cassava planting materials production and marketing	Ibadan, Nigeria	16
Training workshop WASCO Phase III farmers	Lokoja, Nigeria	35
Training of trainers on minisett technology	Abuja, Nigeria	60
Seed protocol review and NASC certification officers training workshop	Ibadan, Nigeria	22
Training of extension agents for community and social mobilization exercise	Kano and Bauchi, Nigeria	94

Title of training	Location	No. of participants
Training of farmers on basic agronomic practices in cassava production and best farm management practices	Umuaja, Ukwani LGA, Delta state, Nigeria	236
Training on basic agronomic and best weed management practices in cassava production and to distribute improved varieties of cassava stems to farmers	Delta State, Nigeria	236
Genomics and bioinformatics training	Ibadan, Nigeria	31
Training of enumerators for PICS depot study	Kano, Nigeria	13
Soil and plant analysis training	Ibadan, Nigeria	24
Training of farmers on basic agronomic practices in cassava production and best farm management practices	Abraka, Delta state, Nigeria	384

Title of training	Location	No. of participants
Control of invasive insect pest	Cotonou, Benin	3
Training course on conduct and management of field trials and techniques of variety testing and seed production of OPVs and hybrids	Cotonou, Benin	24
Cassava <i>gari</i> production	Lower Saama, Lugbu chiefdom, Bo district, Sierra Leone	35
Best-bet cassava planting techniques	Kailahun, Kenema, Pujehun, Bo, Moyamba, Bombali, Kono, Tonkolili District, Sierra Leone	596

Title of training	Location	No. of participants
Cassava <i>gari</i> production	Gbangbatoe Junction, Bagruwa Chiefdom, Moyamba district, Sierra Leone	44
Refresher training in <i>attieke</i> production	Pujehun Growth Center, Pujehun town, Kpanga Kabonde chiefdom, Pujehun district, Sierra Leone	18
Best-bet agronomic practices in soybean production including land preparation; lay-outing, seed rate calculation, fertilizer application and crop management	Kailahun, Kenema, Bo, Moyamba, Bombali, Tonkolili District, Sierra Leone	153
Experimental design and data analysis for young female scientists	Accra, Ghana	18

Title of training	Location	No. of participants
Rapid farm characterization training workshop	Tamale, Ghana	26
Detailed farm characterisation training workshop	Tamale, Ghana	25
Community analysis workshop	Tamale, Ghana	25
Sorghum/millet-legume cropping and crop-livestock planning workshop	Bolgatanga, Ghana	20

Seminars

Under the R4D Seminar Series this year, the West Africa hub hosted 29 seminars at IITA-Ibadan presented by IITA scientists and visiting partners. Details below:

Title of seminar	Presenter(s) and affiliation(s)	Date
Natural resource management		
Which farmers benefit most from growing legumes? Tools to unpack variability among farmers and improve targeting of agricultural technologies	Linus Franke, Wageningen University	13 March
Biotechnology and crop improvement		
Progress in Genetic Enhancement of Maize for the Lowlands and Mid-altitudes	Abebe Menkir, IITA	8 February
Genetic Analysis and Molecular Characterization of Early-maturing Maize Inbred Lines for Drought Tolerance	Muhyideen Oyekunle, IITA	13 February

Title of seminar	Presenter(s) and affiliation(s)	Date
Delivering the crop breeding revolution to smallholders: results of the convening on increasing genetic gains in crop improvement for South Asia and sub-Saharan Africa	Gary Atlin, Bill & Melinda Gates Foundation, Seattle, USA	4 April
Next Generation Breeding and Cassava Genomics	Lukas Mueller, Boyce Thompson Institute, USA, and Jessen Bredeson, University of California, Berkeley, USA	23 April
Yam: Tools for accelerated breeding and propagation	Yukiko Kashihara, IITA	19 June
Potential application of marker assisted selection in breeding for high provitamin A	Girum Azmach Mekonnen, IITA	26 July

Title of seminar	Presenter(s) and affiliation(s)	Date
Genetic Analysis of Early Maturing Maize Inbred Lines under Low Soil Nitrogen and Striga Stress and Non-stress Environments	Beatrice Ifie, IITA	31 July
Genetic mapping using genotyping-by-sequencing in cassava	Ismail Rabbi, IITA	14 August
Cocoa: The Sweet and Bitter Truth About Chocolates	Ranjana Bhattacharjee, IITA	23 September
Mainstreaming Omics into IITA's Crop Improvement Programs	Melaku Gedil, IITA	4 November
Plant production and plant health		
Characterization of <i>Colletotrichum gloeosporioides</i> populations responsible for anthracnose on yam (<i>Dioscorea alata</i>)	Christian O. Nwadili, IITA	18 February

Title of seminar	Presenter(s) and affiliation(s)	Date
Global Cassava Partnership and the War on African Cassava Viruses	Claude Fauquet, GCP21, CIAT, Colombia	21 March
Prevalence and biological control of aflatoxin in groundnut in Senegal and maize in Kenya	Lamine Senghor, National Crop Protection Directorate, Senegal, and Henry Sila Nzioki, Kenya Agricultural Research Institute, Kenya	12 May
Germes, Bugs and Germplasm: Understanding the Interplay for Plant Health Improvement in Sub-Saharan Africa	Lava Kumar, IITA	10 June
Current molecular detection methods in plant virus research	Vincent Fondong, Delaware State University, USA	23 September
Integrated approach to manage aflatoxins and improve crop quality for better health and income	Joseph Atehnkeng, IITA	4 October

Title of seminar	Presenter(s) and affiliation(s)	Date
Viruses in plants: How to find it and how to get rid of it! The works of the DSMZ Plant Virus Department	Stephan Winter, Head, Plant Virus Department, Leibniz-Institut DSMZ Germany	10 October
Drosophila olfactory neuroecology	Marcus Stensmyr, Lund University, Sweden	20 October
The cocoyam root rot disease pathogen: characterization and control strategies	Monica Hofte, Department Crop Protection, Ghent University, Belgium	21 August
Molecular characterization of begomoviruses and associated satellites in Cameroon – implications for plant virus research in Africa	Walter Leke, Visiting Scientist, IITA	23 October
Social science and agribusiness		
Transaction Costs and Threshold Behavior in Spatial Market Analysis: The Case of Ethiopian Wheat Markets	William Bowser, IITA	27 February

Title of seminar	Presenter(s) and affiliation(s)	Date
Food Consumption Trends in West Africa	Mbaye Yade, IITA	5 June
M&E System for an Agricultural Research Project: RAC (Reaching Agents of Change) CIP (International Potato Center)	Godfrey Mulongo, CIP, Tanzania	28 June
Introducing IITA's Monitoring and Evaluation Strategy for Results Based Performance Management	Thomas Wobill, IITA	7 August
Analysis of the policy options for expanding output and improving performance of the rice milling sector in Nigeria	Michael Johnson, IFPRI, Washington DC, USA	5 September
Issues influencing Agro-dealers participation in the loan market in Nigeria	Ade Olomola, IFPRI, Abuja, Nigeria	31 October

Graduate and post-graduate studies

In 2013, 23 MSc and 14 PhD students started their studies supervised by IITA scientists based at the Western Africa Hub. Details of the new MSc students are as follows:

Name	Affiliation	Title of thesis	IITA supervisor(s)
Isaiah Oluwafemi Obisesan	Obafemi Awolowo University, Ile-Ife, Osun State, Nigeria	Comparative performance of synthetic double-cross and synthetic three-way maize hybrids under stress and non-stress conditions	Baffour Badu-Apraku
Latifah Bimpe Abdulyekeen	University of Ibadan, Nigeria	Yam virus cleaning process	Badara Gueye
Midori Iino	Tokyo University of Agriculture, Japan	Induction of artificial-polyploid plant by colchicines processing of yams	Yukiko Kashiwara
Ibukun O. Ayoola	University of Ibadan, Nigeria	In-vitro propagation and molecular genetic validation of anticholinesterase plant- <i>Musa sapientum</i>	Badara Gueye
Hameedat Balogun	Obafemi Awolowo University, Ile-Ife, Osun State, Nigeria	In-vitro selection for salinity tolerance in some cassava lines (<i>Manihot esculenta</i> Crantz) through organogenesis and somatic embryogenesis	Badara Gueye
Jane Ijeoma Awah	Michael Okpara University of Agriculture, Umudike, Nigeria	Isolation and characterisation of bacteria from cassava	Lava Kumar
Temitope Damian Ademulegun	Federal University of Agriculture, Abeokuta	Combining ability and heterotic grouping of early maturing inbred lines derived from <i>Zea diploperennis</i> under contrasting environments	Baffour Badu-Apraku

Name	Affiliation	Title of thesis	IITA supervisor(s)
Sayibu Alhassan	Kwame Nkrumah University of Science & Technology, KNUST, Ghana	Integration of farmers' agro-ecological knowledge, morphological characterization and molecular tools to identify yam nutrient use efficient varieties	Antonio Lopez-Montes
Oluchi Lawrence Odom	University of Ibadan, Nigeria	Screening protocol of different yam accessions (<i>Dioscorea</i> species) for resistance to yam nematode (<i>Scutellonema bradys</i>) and root-knot nematodes (<i>Meloidogyne incognita</i> and <i>Meloidogyne enterolobii</i>)	Antonio Lopez-Montes
Temitayo O. Aremu	University of Ibadan, Nigeria	A reaction of <i>Dioscorea rotundata</i> accessions to <i>Meloidogyne</i> spp. and <i>Scutellonema bradys</i>	Antonio Lopez-Montes
Sylvia U. Echefu	University of Ibadan, Nigeria	Quantitative trait loci mapping analysis associated to cassava mosaic disease (CMD) in cassava	Ismail Rabbi
Oiza Rebecca Enesi	University of Ibadan, Nigeria	Yam tuber yield response to planting density, intercropping and fertilizer	Stefan Hauser
Opeyemi Olubukola Ogedengbe	University of Ibadan, Nigeria	Establishment of true-to-type virus-free clones of yam landraces in Nigeria	Lava Kumar
Abdulwahab S. Shaibu	Federal University of Agriculture, Abeokuta, Nigeria	Combining ability and heterotic patterns of extra-early yellow maize inbreds derived from <i>Zea diploperennis</i> (Iltis) under stress and non-stress environments	Baffour Badu-Apraku

Name	Affiliation	Title of thesis	IITA supervisor(s)
Nnaemeka Innocent Korie	University of Ibadan, Nigeria	Drought tolerance and nutrient use efficiency in yam (<i>Dioscorea</i> spp.) species induced by Arbuscular Mycorrhizal Fungi (AMF)	Martin Jemo
Ikechukwu Valentine Ugbor	University of Ibadan, Nigeria	Technology adoption in agricultural and economic growth in Africa	William Bowser
Ndubisi Albert Anopume	University of Ibadan, Nigeria	Assessing technical efficiency of small- holder yam producers in Nigeria	DB Mignouna and William Bowser
Marien Obiageli Nwabueze	Obafemi Awolowo University, Ile-Ife, Osun State, Nigeria	Genetic variances for grain yield and components in an early-maturing tropical white maize population under stress and non-stress environments	Baffour Badu-Apraku
Oluwatosin Anuoluwapo Olomide	University of Ibadan, Nigeria	Nitrogen use efficiency of selected drought tolerant cowpea varieties under low phosphorus soils of Nigeria	Ousmane Boukar
Ndenum Suzy Shitta	University of Ibadan, Nigeria	Diversity analysis in African yam bean using microsatellite markers	Michael Abberton
Victoria Doyin Ade-Oni	University of Ibadan, Nigeria	Comparative study of the timber yield of some indigenous and exotic tree species in the secondary forest for IITA	Stefan Hauser
Daniel Osabhie Aihebhoria	University of Ibadan, Nigeria	Response of yam (<i>Dioscorea</i> spp.) genotypes and tuber portions to positive selection for quality seed yam production	B Aighewi
Olufunmilayo Ladejobi	University of Ibadan, Nigeria	Mapping of quantitative trait loci controlling resistance to maize streak virus disease using an F ₂ population	Abebe Menkir and Melaku Gedil

The following initiated their PhD studies in 2013:

Name	Affiliation	Title of thesis	IITA supervisor(s)
Bello Muhammad Hassan	University of Kwazulu-Natal Pietermaritzburg, South Africa	Farmers' perceptions and economic assessment of sustainable <i>Striga</i> control technologies for poor farmers in Northern Nigeria	Tahirou Abdoulaye
Rekiya Otuchu Abdulmalik	Ahmadu Bello University, Zaria, Nigeria	Assessment of gain from marker assisted recurrent selection for resistance to <i>Striga hermonthica</i>	Abebe Menkir and Melaku Gedil
Sourou Angelot Paterne Agre	University of Abomey-Calavi, Benin	Genetic resources and plant breeding	Ranjana Bhattacharjee
Harriet Amaka Achi	Federal University of Agriculture, Abeokuta, Nigeria	Geospatial evaluation of coastal erosion management in the Niger-delta area of Nigeria	T. Alabi
Celestina Ibitayo Omohimi	Federal University of Agriculture, Abeokuta, Nigeria	Hazards characterization and safety assessment of traditional dried yam chips (<i>Gbodo</i>), flakes (<i>Kunube</i>) and flour (<i>Elubo</i>) produced in South West Nigeria	Ranjit Bandyopadhyay
Akaogu Ijeoma Chinyere	Ahmadu Bello University, Zaria, Nigeria	Genetic diversity assessment, combining ability and heterosis of early maturing white maize inbreds under contrasting environments	Baffour Badu-Apraku
Olugboyega Success Pelemo	University of Ibadan, Nigeria	Evaluation of improved varieties of yam (<i>Dioscorea</i> spp) under high ratio seed production technologies	Norbert Maroya

Name	Affiliation	Title of thesis	IITA supervisor(s)
Agbetiamah Daniel	Kwame Nkrumah University of Science & Technology, KNUST, Ghana	Biological control of aflatoxins in crops via the use of atoxigenic strains of <i>Aspergillus flavus</i> for enhanced food safety and income in Ghana	Ranjit Bandyopadhyay and Joseph Atehnkeng
Muibat Abiola Laditi	University of Ibadan, Nigeria	Diversity of communities of arbuscular mycorrhizal fungi colonization: association and importance to yam (<i>Dioscorea</i> spp.) growth in Sub-Saharan savannas of Ghana and Nigeria	Martin Jemo
Imuwahen Priscilla Aigbedionn	Federal University of Agriculture, Abeokuta, Nigeria	Application of SWAT-GIS model for water resources management in Ogun River basin	Stefan Hauser
Priscilla Adofo Boateng	University of Ghana, Legon, Ghana	Combining ability and heterotic groupings of intermediate maturing tropical maize (<i>Zea mays</i>) inbreds and hybrid performance under low-and high-soil nitrogen environments	Baffour Badu-Apraku
Lovina Nkantol Iyandu	University of Ibadan, Nigeria	Genetic architecture of pro-vitamin A content (B-Carotene) in cassava (<i>Manihot esculenta</i> Crantz)	Ismail Rabbi and Melaku Gedil
Ademola Ogundapo	Ladoke Akintola University of Technology, Ogbomoso, Nigeria	Economic impact of conservation and improvement of cowpea germplasm in Nigeria	Tahirou Abdoulaye, Michael Abberton, and Badara Gueye
Ugochi Esther Amazue	University of Nigeria, Nsukka, Nigeria	Genetic analysis of resistance to aphids (<i>Aphis craccivora</i>) in cowpea (<i>Vigna unguiculata</i> [L.] Walp.)	Ousmane Boukar

Selected publications

Natural resource management

Tueche J, Norgrove L, Hauser S, and Cadisch G. 2013. Tillage and varietal impacts on tomato (*Solanum lycopersicum* L.) production on an ultisol in central Cameroon. *Soil and Tillage Research* 128: 1-8.

Wendt J and Hauser S. 2013. An equivalent soil mass procedure for monitoring soil organic carbon in multiple soil layers. *European Journal of Soil Science* 64: 58-65.

Plant production and plant health

Agunbiade TA, Sun W, Coates BS, Djouaka RF, Tamo M, Ba MN, Binso-Dabire L, Baoua I, Olds BP, and Pittendrigh BR. 2013. Development of reference transcriptomes for the major field insect pests of cowpea: a toolbox for insect pest management approaches in West Africa. *PLOS ONE* 8: 1-14.

Adegbola RO, Ayodeji O, Awosusi O, Atiri G, and Kumar PL. 2013. First report of banana bunchy top virus in banana and plantain (*Musa* spp.) in Nigeria. *Plant Disease* 97: 290-292.

Zandjanakou-Tachin M, Ojiambo P, Vroh Bi I, Tenkouano A, Gumedzoe YM, and Bandyopadhyay R. 2013. Pathogenic variation of *Mycosphaerella* species infecting banana and plantain in Nigeria. *Plant Pathology* 62(2): 298-308.

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Muchero W, Roberts PA, Diop NN, Drabo I, Cisse N, Close TJ, Muranaka S, Boukar O, and Ehlers JD. 2013. Genetic architecture of delayed senescence, biomass, and grain yield under drought stress in cowpea. *PLOS ONE* 8: 1-10.

Badu-Apraku B, Yallou C, and Oyekunle M. 2013. Genetic gains from selection for high grain yield and Striga resistance in early maturing maize cultivars of three breeding periods under *Striga*-infested and *Striga*-free environments. *Field Crops Research* 147: 54-67.

Huynh B-L, Close TJ, Roberts PA, Hu Z, Wanamaker S, Lucas MR, Chiulele R, Cisse N, David A, Hearne S, Fatokun C, Diop NN, and Ehlers JD. 2013. Genepools and the genetic architecture of domesticated cowpea. *The Plant Genome* 6: 1-8.

Social science and agribusiness

Tambo JA and Abdoulaye T. 2013. Smallholder farmers' perceptions of and adaptations to climate change in the Nigerian savanna. *Regional Environmental Change* 13(2): 375-388.

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notes

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