IITA
Transforming African Agriculture
50
1967 - 2017

IITA 2016
Annual Report

Transforming African agriculture through research

Transforming African agriculture through research
IITA 2016 Annual Report
Published by the International Institute of Tropical Agriculture (IITA), 2017

PMB 5320, Oyo Road
Ibadan, Oyo State, Nigeria

ISSN 0331 4340

International mailing address
IITA, 7th floor, Grosvenor House, 125 High Street, Croydon CRO 9XP UK

Development and Production

Communication Unit: Katherine Lopez, Jeffrey Oliver, Rose Umelo, Yvonne Olatunbosun, Bright Godson, Olusegun Adebayo, Sade Oyedokun, Tunde Ajayi

With support from: Kwasi Asiedu,
Ezekiel Bolarinwa, Christopher Adeyemi

Correct citation: IITA. 2017. Transforming African agriculture through research. IITA 2016 Annual Report. Ibadan, Nigeria. International Institute of Tropical Agriculture (IITA). Available online at www.iita.org/annual-reports

Cover photo: Teresa Augusto from Mozambique has benefited from IITA's improved soybean seeds and complementary crop management practices, which have helped boost legume production and food security in the community. Every day, Teresa sells 500 loaves of soybean bread, made from local harvests, in her community. Photo by Ana Filipa Couvinhas, Feed the Future, Mozambique Improved Seeds for Better Agriculture (SEMEAR). which won 3rd prize in the Feed the Future photo contest in 2017.

IITA 2016

Annual Report

Transforming African agriculture through research

Contents

From the **Director General**

Dr Nteranya Sanginga
Director General

In 2017, we are celebrating our Golden Jubilee. IITA will be only one of four CGIAR centers to reach that milestone, and the first Africa-based center to do so. I am very excited and extremely proud to be at the helm when IITA reaches that landmark.

Going towards our 50th anniversary—and together with our partners, supporters, and donors—we continue to toil hard to achieve impact from our research-for-development (R4D) work to help our smallholder farmers create a better life for themselves and their families. To this end, 2016 has been another exciting and productive year for us.

We concluded an institutional reorganization and realignment by creating the Partnerships for Delivery (P4D) Directorate to replace the Partnerships and Capacity Development Directorate to enable us to better achieve our goals of increasing the productivity and wealth of African farm families and improving their health. We also streamlined and decentralized many of our processes and procedures to make our Hubs more autonomous, and make the delivery of our R4D and P4D efforts across the continent more efficient.

We developed a new institutional tagline "Transforming African Agriculture", which more aptly reflects our aspirations, mission, and vision as stipulated in our Refreshed Strategy 2020 and clearly describes our work and how we respond to the ever-changing landscape of agriculture in Africa.

In 2016, IITA was instrumental in the development of the "Zero Hunger in Nigeria" Strategy—a roadmap that outlines what the country needs to do to achieve a hunger-free status by 2030, in line with one of the United Nations Sustainable Development Goals (SDGs). We continued to build on the success of our Youth Agripreneurs program, which has its roots in Nigeria but has now spread to many other African countries and is supported by various international donors, national programs, and governments.

We also advanced on many of our research fronts across the continent. We documented success stories from our R4D projects particularly on crop breeding, seed systems development, biodiversity conservation, pest and disease management, nutrition and health, natural resources management, seed and postharvest storage, ICT in agriculture, technology upscaling, gender equity, and agricultural mechanization.

On the P4D front, we have consolidated our strengths in partnership, technology delivery, multi-stakeholder platforms, mega project management, mechanization, and commercializing technologies through our Business Incubation Platform to ensure that IITA's research outputs reach small farmers and businesses, as in the case of Aflasafe, NoduMax, and GoSeeds. Aflasafe is now being marketed in three countries in Africa, making food supplies safer for Africans; NoduMax is ensuring higher yields in soybean for enhanced nutrition; and breeder and foundation seeds are more readily available for seed companies when they need them.

We continued to build Africa's next generation of agricultural researchers, coaching and producing several MSc and PhD graduates. We also organized and facilitated training courses to build the capacities and upgrade the skills of our own staff, to keep pace with the advances in related technologies and the dynamic nature of agricultural research.

We reached out and explored new partnerships, while nurturing existing ones. Partnerships have been, and will always be, one of the cornerstones of our operations. We achieve our goals because of the backing of our donors and supporters.

As we move towards our 50th anniversary, we look forward to better and brighter things ahead. I hope you enjoy going through this Annual Report.

From the **Board Chair**

IITA sees a bright future for Africa, a continent that can become a world leader in agriculture and sustainability. The Institute's 2012–2020 Strategic Plan established an ambitious goal of lifting 11 million people out of poverty and revitalizing 7.5 million hectares of degraded land by 2020. The Board of Trustees is committed to providing leadership and oversight to the Institute in the achievement of this goal.

IITA has undergone a period of unprecedented growth over the last five years. Its budget has tripled since 2011, resulting in a doubling of the number of internationally recruited scientists. State-of-the-art science buildings have been constructed in the eastern, southern, and central African hubs in Tanzania, Zambia, and DR Congo, as well as in Mozambique. The increased science capacity, improved infrastructure, and updated scientific equipment have greatly increased IITA's capacity to conduct research to deliver on its mission and strategic plan.

IITA has been the lead center on the CGIAR Research Program (CRP) on Integrated Systems for the Humid Tropics, which has been the focal point for the Institute's R4D programs. This CRP ended in December, 2016, and will not be a stand-alone program in the second round of CRPs, starting in 2017. However, several projects in the CRP have been incorporated in the new Agri-Food Systems CRPs. In the new CRP portfolio, IITA is a key partner in five CRPs—Roots, Tubers and Bananas, MAIZE, Climate Change, Agriculture for Nutrition and Health, and Policies, Institutions and Markets, as well as three Platforms. IITA's research programs are well aligned with the CRPs to achieve the CGIAR's system-level outcomes.

To support the delivery and impact of technologies developed from its research programs, IITA established a Business Incubation Platform (BIP) at its main headquarters in Ibadan, which is being extended to other IITA locations. Three products are now being produced and distributed from this facility: Aflasafe, which greatly reduces poisonous aflatoxin in cereals and legumes; NoduMax for nodulating soybeans; and GoSeed, a facility to produce breeder and foundation seed of new IITA cultivars. Aflasafe is now being used in several countries to improve food safety and a production facility has been constructed in Kenya, with plans for facilities in other countries. BIP is also involved in capacity development, including the Youth Agripreneur program pioneered by IITA, which has now been extended to many African countries under the ENABLE Youth Program, funded by the African Development Bank under IITA's technical assistance. The goal is to get African youth more involved in agriculture, driving innovation in the sector, and addressing youth unemployment.

A highlight of 2016 was DG Sanginga's acceptance of the Board's offer of a second five-year term as head of IITA. Sanginga's vision and leadership have been key to the recent growth in the research capacity of IITA and we are very pleased that he will continue to lead the Institute's growth as the leading agricultural research partner in Africa.

I am pleased serve as chair of the Board of this well managed Institute and would like to thank my colleagues on the Board for their dedication to IITA's success. The Board expresses its appreciation to DG Sanginga and his senior management team for the significant accomplishments over the past five years and for their vision for the future. We congratulate the scientists and support staff for the excellent research being conducted. Finally, we express our appreciation to our funders who recognize the importance of the work being done and have confidence in the Institute's ability to do it.

Dr Bruce Coulman
Chair, Board of Trustees

Transforming African agriculture through research

Research is undertaken to address development needs.
Photo by IITA.

IITA will mark its 50th year of founding in 2017. Almost 50 years ago, IITA's founders established the Institute as one of the first four major international agricultural research centers across the globe addressing food security and poverty. In 2016, the Institute reiterated its commitment to support partners, including the national programs to help transform African agriculture, and thus facilitate agricultural solutions for hunger, malnutrition, poverty, and natural resource degradation.

Through its research-for-development efforts and strategic initiatives, IITA continues to focus on four big-picture outcomes that are aligned with the new sustainable development agenda and the 17 Sustainable Development Goals: increase in food security, reduction in rural poverty, reduction of undernutrition, and more sustainable management of natural resources.

To ensure success in meeting these goals, IITA partners with various science and development stakeholders that include advanced research institutions, national agricultural research and extension systems, governments and policymakers, civil society, the private sector, development partners, farmers and farmer's organizations, investors, and media.

We continue to strengthen our regional hubs and 15 research stations across sub-Saharan Africa, operating decentralized but integrated regional research programs focused on major constraints to agriculture in the various regions. We participate in several CGIAR Research Programs (CRP) that cut across our major research themes: biotechnology and genetic improvement, natural resource management, plant production and health, nutrition and health, and social science and agribusiness. The IITA-led CRP on Integrated Systems for the Humid Tropics officially closed in 2016, but IITA continues to use an integrated systems research approach and unique partnership platforms to ensure impact on poverty and ecosystems integrity.

Since its inception, IITA has been in the forefront of ensuring rural communities are transformed into thriving, progressive, and profitable agribusiness centers. Photo by Clement Ono-Raphael, IITA.

Improving crops

IITA's research in maize improvement showed that for every dollar invested in research, additional food worth US$21 is generated. Photo by IYA.

Sowing the seeds of success in West Africa

Baffour Badu-Apraku, Abebe Menkir, N'Tji Coulibaly, Tahirou Abdoulaye, Silvestro Meseka, and Robert Asiedu, IITA, Ibadan, Nigeria

Seed companies play a key role in enhancing the production and productivity of maize in West Africa as they provide farmers access to higher yielding and more stress-tolerant hybrids and open-pollinated varieties (OPVs).

For the past five years, public and private sector entities have regularly delivered and disseminated seeds of IITA-improved maize hybrids and OPVs that have been formally released in West African countries (Table 1). The adoption of these hybrids and varieties has helped improve the lives and livelihoods of farmers, traders, and consumers dependent on maize in the region.

Although access to quality seed of improved maize varieties has been of the upswing in recent years, the production and supply of sufficient quantities of early generation seeds (breeder and foundation seeds) still pose a challenge particularly to emerging and small-scale seed companies in West Africa that rely heavily on varieties bred by national agricultural research systems (NARS) and international agricultural research centers. Until such time that policies and scales of production allow for improved efficiencies to address this constraint, public organizations must shoulder part of the responsibility of providing early generation seeds.

Table 1. Number of IITA germplasm-based maize hybrids and OPVs released by public and private sector entities in West Africa in the last five years.

	Hybrids and open-pollinated varieties released per year (no.)					
Country	2012	2013	2014	2015	2016	Total
Benin	–	–	–	6	4	10
Ghana	11	–	–	10	–	21
Mali	–	2	6	–	6	14
Nigeria	4	5	4	4	8	25

IITA maize breeder Silvestre Meseka interacting with farmers on the benefits of planting stress tolerant maize varieties. Photo by DTMA/STMA.

IITA and partners implementing the Stress Tolerant Maize for Africa (STMA) project—funded by the Bill & Melinda Gates Foundation through CIMMYT—have been making significant strides. Some of the project's notable achievements in 2016 include:

- **Identification of seed companies to produce early generation seeds.** STMA supported the selection of seed companies to produce early generation seeds to hasten the production and marketing of stress-tolerant hybrids and OPVs in West Africa. Ahmadu Bello University-Institute for Agricultural Research (ABU-IAR), Zaria, and Premier Seed Ltd in Nigeria, M&B in Ghana, and *Institut D'Economie Rurale* (IER) in Mali produced a total of 16,600 kg of breeder seeds. On the other hand, ABU-IAR Zaria, Premier Seed Ltd, Maslaha Seed Ltd, Value Seed Ltd, and Gawal Seed Ltd in Nigeria, M&B in Ghana, and Faso Kaba, and IER in Mali collectively produced some 230,800 kg of foundation seeds.

- **Production of breeder seed of stress-tolerant varieties.** STMA facilitated the production of 4,688 kg of seeds of 43 promising stress-tolerant extra-early, early, intermediate/late-maturing inbreds, hybrids, and OPVs for use in on-farm trials, breeder seed production, and community-based seed production.

- **Production of foundation seed of stress-tolerant parental lines.** Five institutions/seed companies identified and selected by the project in Nigeria (ABU-IAR Zaria, Premier Seed Ltd, Maslaha Seed Ltd, Value Seed Ltd, and Gawal Seed Ltd), and one each in Ghana (M&B) and Mali (IER and Faso Kaba) produced 231 tons of foundation seeds of stress-tolerant parental lines.

- **Production of initial hybrid seed for demonstration, registration, and promotion.** The project distributed, on request, about 15,000 kg of breeder seed of promising drought-tolerant, extra-early, early, intermediate, and late-maturing inbreds, hybrids, and varieties to NARS partners and seed companies in Nigeria, Ghana, Benin, Mali, Niger, Burkina Faso, Senegal, and Tanzania. These are currently being used in on-farm trials, breeder seed production, and community-based seed production.

Farmers visiting demonstration plots of stress tolerant maize at Mokwa, Nigeria.
Photo by DTMA/STMA.

- **Maintenance of parental materials.** Under STMA, more than 2,000 kg of breeder/foundation seeds were produced in Nigeria by IAR (2 inbreds) and IITA (15 inbreds), and in Ghana by M&B (3 inbreds).

- **Selection and evaluation of new stress-tolerant hybrids and varieties for seed production characteristics.** The project selected 30 early maturing maize hybrids comprising single, three-way, double, and top crosses and their parental lines based on their superior performance in the regional trials and other previous evaluations. They were then characterized for seed production under contrasting environments. Similarly, the project characterized 40 extra-early maturing maize parental lines and their hybrids.

Success Showcase

Mali and DTMA: *When partnerships work, farmers benefit*

For the past nine years, the Drought Tolerant Maize for Africa (DTMA)/STMA and Mali have worked together to generate, promote, and deliver adapted drought-tolerant maize varieties and hybrids to farmers. This partnership has led to the release of several open-pollinated drought- and *Striga*-resistant varieties and hybrids by Malian scientists in collaboration with IITA (Table 2). The project has relied on the national agricultural research and extension system (NARES) of Mali—including IER and *Institut Polytechnique Rural de Formation et de Recherche Appliquée* (IPR/IFRA)—to promote the adoption of improved varieties through national and local communication and extension networks. It also worked with local seed companies such as Faso Kaba, Comptoir 2000, Coprosem, Coop Kolokoani, and DNA to actively scale up and distribute seeds of improved drought-tolerant maize hybrids and OPVs.

Additionally, through the project, 12 IITA-developed drought-tolerant early, extra-early, and intermediate maturing hybrids (Table 2) as well as six drought-tolerant OPVs have been released in Mali and are now in the

Table 2. Drought-tolerant maize varieties released under DTMA in Mali (2007 to 2015).

Release name	Base-Genetics	Year of release	Type (Hybrid/ OPV)	Maturity range
Jorobana	EVDT97WSTRC1	2009	OPV	Early
Brico	TZEE -Y Pop STR C4	2010	OPV	Extra-early
Tieba	DT-SR-W C0/TZL-COMP3-C2-S2-34-4-1-2-BB	2012	Hybrid	Medium-late
Mata		2012	Hybrid	Medium-late
Diambala		2012	OPV	Medium-late
Sanu	TZE-Y DT STR C4 x TZEI 13	2012	Hybrid	Early
Sahel Kaba	TZEE-W Pop DT STR C5 XTZEEI 6	2014	Hybrid	Extra-early
Sosani	TZEE-Y Pop DT STR C5 X TZEEI 58	2014	Hybrid	Extra-early
Dilika	TZEI 24 X TZEI 17	2015	Hybrid	Early
Apraku	TZEI 11 X TZEI 23	2015	Hybrid	Extra-early
Sahel Kaba Blanc	TZEE-W POP DT STR C5 XTZEEI 6	2015	Hybrid	Extra-early
Sahel Kaba Jaune	TZEE-Y POP DT STR C5 X TZEEI 58	2015	Hybrid	Early
Tamalaka	TZEI 124 X TZEI 25	2015	Hybrid	Early
Duba	IITA TZI1717 X IITA TZI 1528	2015	OPV	Medium/late
Kiban	EV DT Y 2000 STR	2015	OPV	Early
Tieblenke	DTSYN 11 Y	2015	OPV	Medium/Late
Soden	TZL COMP4C3DT	2015	OPV	Early

hands of farmers or seed companies and community seed producers. These efforts have contributed to increased maize productivity in Mali, making the country one of the top maize producers in Africa today (Fig. 1).

Together, Mali and IITA, through DTMA, have used a mix of delivery pathways to sustain and scale up seed production and dissemination to smallholder farmers in the country. In some areas of Mali that are not served by seed companies, the project supported community-based seed production schemes to ensure supply of good quality seeds of improved drought-tolerant maize varieties to farmers. Eventually, these schemes are envisioned to evolve into full-blown private seed enterprises or be linked to small-scale seed production start-ups.

Annually, IITA produces and makes available adequate quantities of breeder seed to Malian scientists through the project to produce breeder and foundation seeds, with the end goal of meeting the demand from seed producers. IITA works with Mali partners on seed-demand creation strategies to ensure sustainability of seed production such as conducting awareness and information campaigns to spur interest among potential development entities, especially seed suppliers.

IITA has also helped build the capacity of national partners to facilitate the release, promotion, and dissemination of drought-tolerant varieties. Through the project, IITA has conducted regular training courses on related areas such as breeding techniques, seed production, and seed marketing involving partners from both the public and private sectors in Mali. In addition, DTMA has also conducted several on-station and on-farm demonstrations and maize field days, and designed and implemented a variety of communication strategies and tactics to generate greater interest and adoption of improved maize seed among farmers, farmers' organizations, seed companies, and policymakers.

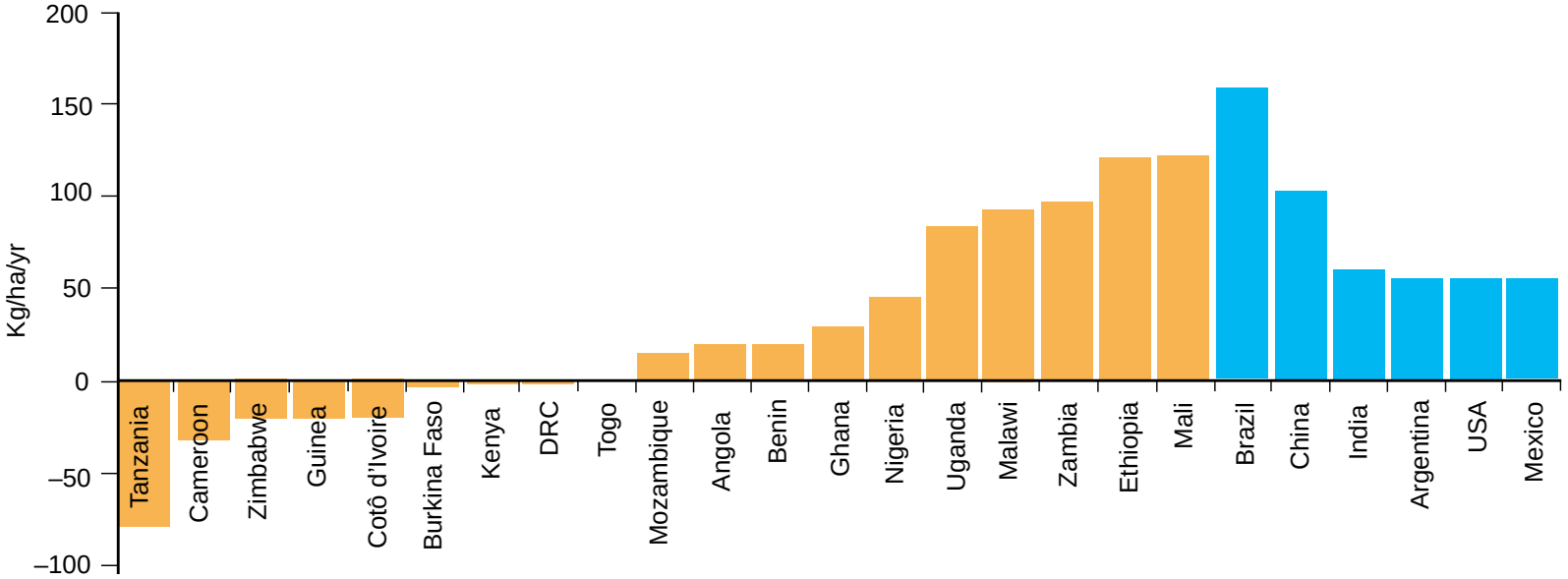


Figure 1. Productivity gains in the top 20 maize-growing countries in sub-Saharan Africa compared to other major global maize-producing countries, 2000-2013 (After Abate et al. 2015).

Improving the "golden pod" in southern Africa

Godfree Chigeza, IITA, Kabangwe, Zambia

Soybean production in southern Africa is complicated by the occurrence of frequent droughts and poor soils, especially those low in phosphorus. During the 2015/2016 season, Malawi, Mozambique, Zambia, and Zimbabwe experienced one of the worst droughts in decades, with very few farmers getting a decent harvest.

Developing soybean varieties with delayed wilting under drought conditions and also early maturing varieties which can escape drought are some of the approaches IITA is taking in its breeding program. In addition, the IITA germplasm which is largely promiscuous nodulating—a trait developed to improve soil fertility in small-scale farms—is apparently showing that nitrogen fixation is the most important trait for delayed wilting, hence it can be used to indirectly develop drought-tolerant cultivars for the region.

To meet farmers' needs such as developing high-yielding and disease-tolerant varieties, as well as large-seeded ones to meet market needs, IITA's Soybean Breeding Program is being supported by two soybean projects: the USAID/IITA Genetic Improvement in Soy W3 CGIAR Research Program on Grain Legumes, and the University of Illinois/IITA, Soybean Innovation Laboratory under USAID's Feed-the-Future initiative. The two projects are complementary; the former focuses on direct variety development, whereas the latter centers on breeding efficiency, capacity building, and integration of USA elite lines into tropical germplasm.

IITA's work on improving soybean in the Southern African region has recorded significant strides in 2016. Table 1 summarizes these achievements to date.

Figure 1. Drought-tolerant and drought-susceptible varieties evaluated under random drought conditions at the Chitedze Research Station in Malawi during the 2015/2016 season.

Yield trials in 2015/2016 season

During the 2015/2016 season, preliminary variety trials and advanced variety trials were planted in Malawi, Mozambique, Nigeria, and Zambia to examine the performance of varieties under different environmental conditions which included drought and low soil phosphorus conditions. Due to the severe drought experienced during the 2015/2016 season, data from several trials could not be used for Malawi. Some of the results of the advanced trials are shown in Table 2 and Figure 1, presenting the reaction of some of the lines under drought conditions at IITA's Research Station at Chitedze in Malawi.

Table 1. Activities and highlights of achievements of the Soybean Breeding Program, Southern Africa region.

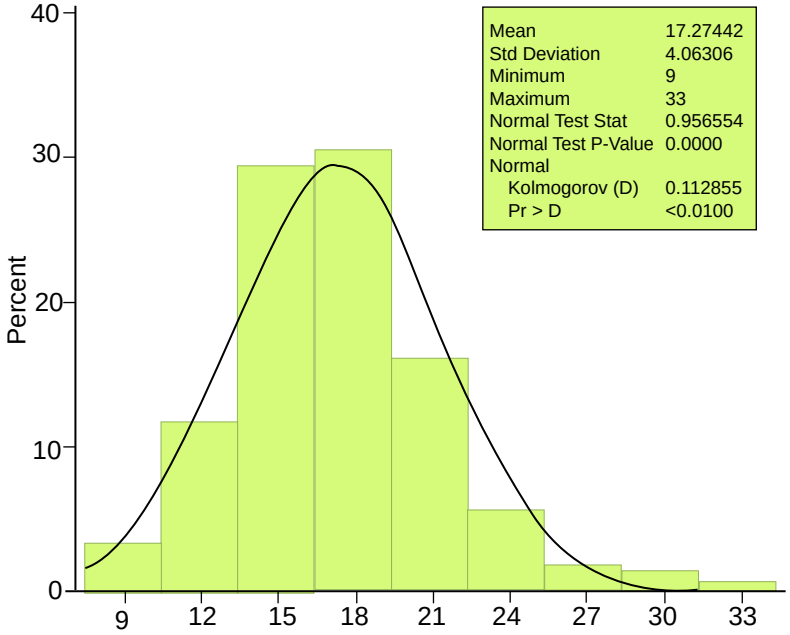
Program activities	Highlights
Develop high-yielding, drought-tolerant, and early maturing soybean lines	Evaluation of yield trials planted in Malawi, Mozambique, Zambia, and Nigeria.
Exotic germplasm evaluation	462 accessions evaluated in an observation nursery in Zambia. The accessions consisted of lines from the USA plant variety protection lists and advanced breeding lines.
Participatory Variety Selection in Malawi	Participatory variety selection trials planted in three districts in Malawi and farmers given the opportunity to select varieties of their choice during field days.
Breeders' and basic seed production	1000 kg of breeder seed of TGx1740-2F (Kafue in Zambia, Tikolore in Malawi) distributed to the MISST Project in Malawi (600 kg). In Zambia, 1.5 tons of breeder seed of Kafue and 3 tons of Mwembeshi were produced. The seed will be used in a private−public partnership between IITA and Good Nature Seed (Zasaka) in Zambia.
Soybean International Trials	29 trials sent to eight countries: Cameroon, Ethiopia, Ghana, Mali, Nigeria, South Sudan, Togo, and Zambia.

Table 2. Average yield of the 10 top-performing varieties across four locations in the Southern African region under random drought conditions.

Variety	Yield (t/ha)	Days to 50% flowering	Maturity	Plant height (cm)	100-seed weight (g)	Rank*
TGx2001-19DM	1.71	48.0	98.1	53.9	15.5	1
SC Square (check)	1.70	40.0	97.1	55.2	21.2	2
NASOKO (check)	1.55	39.6	95.2	46.7	19.2	3
TGx2002-7FM	1.50	41.0	95.5	44.0	16.4	4
TGx2001-10DM	1.42	45.5	99.2	56.5	15.8	5
TGx2001-11DM	1.39	41.8	94.0	46.4	14.4	6
TGx2002-5FM	1.36	44.3	94.2	48.1	16.9	7
TGx1989-52F	1.33	42.3	96.7	44.6	15.0	8
TIKOLORE (check)	1.30	41.7	91.4	52.0	13.8	9
nreps	3	3	3	3	3	
Locations	4	4	4	4	4	
Location variance	0.86	50.43	251.03	99.85	2.25	
Genotype variance	0.02	10.88	7.79	3.18	2.23	
Loc × Genotype variance	0.06	9.17	6.13	6.95	0.55	
Residual variance	0.24	2.02	2.26	65.80	5.06	
Grand mean	1.23	42.70	94.55	47.22	15.98	
LSD	0.69	5.61	4.70	12.58	2.36	
CV	27.72	6.49	2.46	12.68	7.36	
Heritability	0.28	0.77	0.77	0.18	0.80	

** Ranking based on yield in descending order*

Figure 1. Drought-tolerant and drought-susceptible varieties evaluated under random drought conditions at the Chitedze Research Station in Malawi during the 2015/2016 season.



Exotic germplasm screening and introgression

Infusing germplasm from the University of Illinois' soybean breeding program into IITA breeding populations is one of the key objectives to increase genetic diversity and also yield potential in African tropical germplasm. A total of 462 genotypes from the Soybean Innovation Lab (SIL), USA (Table 3) were requested and planted at the IITA Research Station in Kabangwe, Zambia, during the 2015/2016 season.

Due to the drought, planting was done late in the season. Twenty-five seeds per genotype were planted in single-row plots in an augmented design, which included six checks from Seedco, SC Samba, SC Sepa, SC Safari, SC Square, and SC Spike. MRI-Syngenta check MRI Dina was also included. Table 3 summarizes the number of genotypes planted.

Observation data collected included days to flowering, plant aspect, and 100-seed weight. Figure 2 summarizes the distribution of the 100-seed weight among the genotypes, a key trait to be introgressed into the IITA germplasm. From the observation nursery a total of 40 genotypes were selected as potential parents to initiate pedigree breeding from IITA genotypes with an emphasis on increasing seed size.

Table 3. Number of genotypes planted in the observation nursery at the Southern Africa Research and Administration Hub (SARAH) Station, Lusaka, Zambia, during the 2015/2016 season.

Germplasm type	Genotypes (no.)	Days to 50% flower	Plant aspect 1 - good 5 - poor	Seed weight (100 seeds)	Materials selected for use in IITA breeding program
Accessions (Genebank materials, old varieties)	256	28–54	1–5	9–33	4
Advanced breeding lines/elite lines/segregating lines	206	30–36	1–5	12–24	36
Checks	6	40–52	2–4	10–20	
Total	462				

The 100-seed weight of accessions from the genebank ranged from 9 to 33 g with a mean of 17.3 g. The majority of the large-seeded genotypes were of Asian origin, namely, Akiiyoshi and Sudoi No 1, and some USA maturity group 3, Saturn. Mean 100-seed weight for the elite breeding material ranged from 10 to 24 g with a mean of 16.6 g.

Participatory variety selection in Malawi

The soybean breeding technology transfer and scaling up is done through demonstration plots using Participatory Variety Selection (PVS) trials and field days during the growing season. During the 2015/2016 season, three field days were held in Malawi at Chitekwere EPA, Nkhoma, Lilongwe; Kaphuka EPA, Dada District; and Nachisaka EPA, Dowa District. In total, 183 participants attended the field days with 95 males and 88 females. Table 4 summarizes the number of participants for each district.

Table 4. Number of participants in the soybean Participatory Variety Selection in Malawi during the 2015/2016 season.

District	Male	Female	Total
Chitekwere EPA, Nkhoma, Lilongwe	25	44	69
Kaphuka EPA, Dada	23	27	50
Nachisaka EPA, Dowa	47	17	64
Total participants	**95**	**88**	**183**

Partnerships and the Soybean International Trials

In addition to the breeding trials, Soybean International Trials (SIT) were also sent out to collaborating partners on request from various institutes, including the Syngenta Foundation and the Seeds2B program for trials in Mali. Table 5 summarizes the recipients of SIT during the 2015/2016 season. In total, eight countries participated in the 2015/1016 SIT. Results from these trials will be used to identify key lines by collaborating partners for use as direct variety release or parental lines for use in the breeding programs.

Table 5. Participating countries and institutes in the Soybean International Trials during the 2015/2016 season.

Country	Institutions	Type of trial	Number of entries per trial	Number of trials
Cameroon	Institute of Agricultural Research for Development	Early, Medium	17	3
Ethiopia	Institute of Agricultural Research	Early, Medium	17	2
Ghana	CSIR	Early	17	2
Mali-Bamako	*Foundation Syngenta Delegation du Mali*	Early	17	3
Nigeria-Kwara State	Kwara State University	Early, Medium	28	2
Nigeria-Abeokuta	FUNAAB	Early	17	2
Nigeria-Delta State	Delta State Polytechnic	Early	17	1
Nigeria-FCT Abuja	SeedCo	Early, Medium	28	6
Nigeria-Ogbomoso	University of Technology	Early	17	1
South Sudan	Dept of Agricultural Science	Early	17	1
Togo	ITRA/CRASS	Early, Medium	17	4
Zambia	Zamseed	Early, Medium	26	2
Total trials sent				29

Transforming lives through better seeds in Mozambique

Ana Filipa Couvinhas, Alexander Wiredu, and Carlos Malita, SEMEAR, IITA, Nampula, Mozambique

Agriculture is the backbone of Mozambique's economy, with over 80% of the total population depending on agriculture for food, income, and employment. In 2010, agriculture generated approximately 23% of the gross national product, suggesting low returns to labor. Therefore, accelerating agricultural growth is key to eradicating poverty and improving food security especially in the rural areas. However, several biophysical and socioeconomic factors continue to undermine efforts to address these challenges.

Demo plots. Photo by Canon Engoke, IITA.

Mozambique's agricultural sector is characterized mainly by small-scale, rainfed, subsistence production, low mechanization, labor-based production techniques, weak policy support, low-level use of farm inputs, outdated agronomic practices, and poor access to seeds of improved and high-yielding varieties. The latter has been identified as a key challenge, compounded by the lack of an effective and well-coordinated system to produce and supply improved seeds to farmers.

IITA leads the implementation of the 5-year "Improved Seeds for Better Agriculture" project (SEMEAR in its Portuguese acronym) launched in 2015 and funded through USAID's Feed-the-Future (FTF) Initiative in Mozambique. IITA is undertaking the project in partnership with the Mozambique Institute of Agricultural Research (IIAM), ICRISAT, and CIAT. SEMEAR's goal is aligned with PEDSA's, Mozambique's national agricultural development strategy that aims to improve the availability of breeder, pre-basic, basic, and certified seed of improved varieties released in the country and to strengthen technology delivery in the USAID-FTF's Zones of Influence of Manica, Nampula, Tete, and Zambézia provinces in the country.

SEMEAR has three main objectives: (1) increase the production and supply of breeder, pre-basic, basic, and certified seed of common bean, cowpea, groundnut, pigeon pea, sesame and soybean, and strengthen the national seed systems; (2) scale up and enhance the adoption of improved varieties and best management practices through participatory approaches; and (3) enhance national policy dialogue on seed and fertilizer supply. The project is targeting to reach 100,000 households, 35% of them women. Further, SEMEAR looks to achieve intermediate results that directly respond to two of the five PEDSA objectives: increased productivity and improved marketing services.

Only one year into its implementation starting in the planting season of 2015/2016, SEMEAR has already registered some remarkable achievements. SEMEAR's partners have already produced 69 tons of breeder/pre-basic and basic seed of common bean, cowpea, soybean, groundnut, pigeon pea, and sesame; and facilitated production of 479 tons of certified and improved seed of the crops being promoted. Demonstrations established totaled 1,094 for variety and crop management, with more than 120 field days conducted. There were 22 training sessions administered attracting more than 3,677 farmers and extension agents (2,237 men and 1,440 women). Soil samples were collected for soil fertility suitability analysis and mapping.

Left, below: Nametile Nacololo Field day, June 2016.

Right: Malema training, June 2016. Photos by *Ana Couvinhas, IITA.*

"SEMEAR's partners have already produced 68.98 tons of breeder/ pre-basic and basic seed of common bean, cowpea, soybean, groundnut, pigeon pea, and sesame; and facilitated production of 479.03 tons of certified and improved seed of the crops being promoted.."

SEMEAR

The project also actively participates in national platforms for dialogues in the seed and fertilizer sectors in collaboration with the private sector, NGOs, and the Government to lobby and promote the accreditation of independent seed inspectors, provision of capacity building, and training in production of basic seed by the private sector. The foundation seed produced by implementing partners will be supplied to partners and stakeholders to improve certified seed multiplication schemes, directly impacting on the number of farmers using improved seed in these communities. It has also envisaged that the seed systems in the country would operate efficiently.

Within a short period, SEMEAR is already making a difference in the lives of its beneficiaries. Take the case of Cecilia João—a woman-farmer, leader, and the co-founder of a women's association—who is working with SEMEAR to change lives for the better.

An empty sack cannot stand upright

Cecilia João is one of many Mozambican farmers working with SEMEAR in the Meconta District of Nampula. She is a model, inspiring woman-leader, and pioneer in improved seed production and commercialization in her home community of Teterrene. Yet, just three years ago, Cecilia considered herself just a common smallholder farmer struggling to find good-quality seed and facing difficulties to produce enough for her family's needs.

Due to SEMEAR's interventions, Cecilia has increased her cowpea yields five times; and in a couple of years, Cecilia's life started to turn for the better. She is no longer an introverted rural woman as she quickly became confident in "preaching the gospel" of IITA/SEMEAR to other farmers and even the media. Besides being a motivational leader in her community, Cecilia runs a demonstration plot planted with three IITA improved cowpea varieties (IT-16, IT-18, and IT-1062) and one local variety. The field is regularly visited by many farmers eager to see and apply the improved agricultural technologies showcased there.

Due to SEMEAR's interventions, Cecilia has increased her cowpea yields five times; and in a couple of years, Cecilia's life started to turn for the better.

CECILIA

Cecilia's family at the demonstration plot of improved cowpea varieties. Photo by *Ana Couvinhas, IITA.*

With one child and another on the way, Cecilia considers the IITA/SEMEAR project as a blessing. "This project has made me feel proud to be a farmer because being one truly represents food for my own children," Cecilia professes. "An empty sack cannot stand upright," she adds, referring to the importance of having sufficient food since, she says, only well-nourished farmers can produce efficiently, which leads to better incomes. SEMEAR caters to both.

Also, in 2015, Cecilia co-founded the Associação das Mulheres Olhasana (AMO)—a local women's association that is working alongside IITA in fighting aflatoxin in Mozambique using Aflasafe™. Later on, AMO also became a seed business development partner of SEMEAR.

Despite being primarily a women's group, AMO also works with male constituents, particularly members' husbands. Together, AMO members cultivate clusters of farms spanning multiple hectares and encourages investment in high-quality inputs such as improved seed and inoculant. The men perform the more physically laborious tasks such as land preparation.

Blazing the trail for next generation cocoa R4D in West and Central Africa

Ranjana Bhattacharjee, IITA, Ibadan, Nigeria; Richard Asare, IITA, Accra, Ghana; Denis Sonwa, IITA and CIFOR, Yaoundé, Cameroon; Rachid Hanna, IITA, Yaoundé, Cameroon; and Sona Ebai, World Cocoa Foundation, Accra, Ghana

The majority of the world's cocoa, about 70%, is produced in West and Central Africa by Côte d'Ivoire, Ghana, Nigeria, and Cameroon. Around 6 million ha are planted to the crop in the region, mostly in smallholder farms. Despite feeding the global chocolate market, worth an estimated US$98.3 billion, the regional cocoa sector is still besieged by persistent problems such as pests and diseases, ageing trees, outdated farming techniques, and limited research support.

In West and Central Africa, the growth of the cocoa sector has largely been hampered by fragmented research efforts. This is due to the lack of a common regional cocoa research-for-development (R4D) strategy to develop and deploy next generation research-based solutions to both

The Ooni (Yoruba king) of Ife participated in the regional symposium. Photo by Olusegun Adebayo, IITA.

long-standing problems (such as CSSVD) and emerging challenges (such as climate change).

It is in this context that IITA in collaboration with the Cocoa Research Institute of Nigeria (CRIN), within the African Cocoa Initiative (ACI) project funded by the World Cocoa Foundation (WCF), convened a regional symposium in 2016 that focused on bringing cocoa research to the next level and initiating the development of a regional cocoa sector strategy that will guide and synergize R4D efforts by research entities in West and Central Africa. The symposium was the first of its kind ever to be held in West Africa.

The symposium was a key component of the World Cocoa Foundation–African Cocoa Initiative project—and brought together the who's who of the cocoa industry in the region representing a wide spectrum of value chain stakeholders from researchers and farmers to public and private sector players, national program partners, donors, traditional community leaders, and policy and decision-makers. The goal was to find ways to work collaboratively and identify and apply appropriate next generation, cutting-edge research to solve the problems that have been ailing the region's cocoa sector to ensure its sustainability and profitability while benefiting smallholder farmers and protecting the environment.

The symposium provided a platform for scientific interaction, a display of products, and the strengthening of partnerships. It covered several thematic areas such as cocoa genetic resources and breeding; pests, diseases, and risk mitigation including climate change; rehabilitation and intensification; and the related policy and institutional framework. The delegates deliberated on research priorities, shared research experiences, identified research needs, and formed national, regional, and global alliances.

During the discussions on the latest research studies presented at the symposium, several findings were highlighted that could form the basis of a collective regional strategy. For example, it was found that the global demand for cocoa will continue to increase at an annual rate of 3%, buoyed by recent research findings that the consumption of cocoa in its various forms has confirmed health benefits.

To meet this growing demand, researchers must find ways to increase farmers' access to improved planting materials, to rehabilitate ageing farms, and replace old, unproductive trees. This has long been a focus of WCF's engagement on cocoa research—from support for the conservation of genetic resources to propagation and distribution of improved varieties in the field. Although some first- or second-generation improved planting materials with high yield abilities have been developed in the breeding programs of the national research institutes of Cameroon, Côte d'Ivoire, Ghana, and Nigeria, most farmers still use nonselected planting materials. Additionally, the seeds/planting materials are available only when farmers are busy with harvesting of cocoa pods.

The country institutions responsible for cocoa breeding have established a cooperative approach framework by setting up an African Cacao Breeders' Working Group to coordinate and build support for cocoa genetic resources and breeding. The group focuses research on (1) investments in global cocoa collections; (2) development of new varieties that are higher yielding and tolerant of pests and diseases and resilient to climate change; (3) improvements in the genetic diversity in planting materials in the region; and (4) a deeper understanding of the socioeconomic and household behaviors in cocoa-growing areas that create sustainable livelihoods and communities. Issues of land tenure, profitability of farming, and effective extension practices are also critical.

Other important issues highlighted during the symposium included:

- What is the regional strategy for genetic resource conservation of cocoa for its long-term security and use in breeding programs?
- DNA fingerprinting research has shown that about 30–70% of breeders' collections and seed garden materials are mislabeled. What are the steps planned to address this challenge when only 2% of the collection has been fingerprinted and it is not possible to fingerprint every tree in all the seed gardens in the region? What is the strategy to develop a regional true-to-type set of varieties that can be shared between and within countries?

Cocoa pods. Photo IITA.

Cocoa production in West and Central Africa is beseiged by numerous challenges.
Photo by IITA.

- What different propagation strategies should be adopted to avoid the spread of pests and diseases?
- How do we ensure that climate-smart technologies in agriculture are economically profitable for the farmer/producer? What about newly emerging suitable areas? How does the issue of movement of planting material work in the absence of a regional quarantine system?
- Is climate change a bane or boon for cocoa in West and Central Africa? How do we develop regional climate-smart agriculture for cocoa farmers to address the challenges posed by climate change?
- How could we prevent encroachment by cocoa plantations into the remaining forest lands in Nigeria, Cameroon, and the Congo Basin?
- How can the work on pests and diseases, particularly CSSVD, and be more coordinated at regional level for faster resolution?
- What are the demands from the private sector in the region for cocoa sustainability so that value chain actors, including researchers, can position themselves more effectively to meet those demands?
- How could we more effectively attract the youth to engage in cocoa farming? What are the effective ways to soften the blow of price volatility and reduce middlemen's interventions so that young cocoa farmers can get more value for their work and investment?
- How could we actively involve absentee farmer/landowners to enable caretaker farmers to invest in new technology developed/presented to them?
- Africa contributes 74% to global production, although consumption in Africa is less than 5%. What are the national, regional, and continental efforts on training and demand-raising to enhance local consumption of cocoa by Africans?

Answers to these and other questions and issues raised and discussed during the symposium will form the basis of the future regional strategy for the cocoa sector in the region.

Giving hope to cassava farmers in Zambia

Pheneas Ntawuruhunga, IITA, Kabangwe, Zambia

For the last five years, IITA has been intensifying its cassava value chain research in Zambia, supported by different development partners and donors. These include the Mitigating Cassava Disease Threats for Improving Cassava Production in Zambia project, a subcomponent of the Zambia Feed-the-Future research-for-development Program funded by USAID; the Support to Agricultural Research for Development of Strategic Crops in Africa (SARD-SC) in Africa project funded by the African Development Bank (AfDB); and the Smallholder Agribusiness Promotion Program (SAPP)-Cassava Intervention Plan funded by the International Fund for Agricultural Development (IFAD) through the country's Ministry of Agriculture and Livestock (MAL).

These projects point to a common denominator: that the provision of suitable and adapted cassava varieties, and corresponding good agronomic and cultural practices, is key to a sustainable cassava sector. They supported IITA's cassava breeding program, which addresses these research elements.

Developing and deploying new, suitable cassava varieties through conventional breeding has several phases. First, advanced lines generated through breeding schemes are taken through Advanced Yield Trials (AYTs) and Uniformity Yield Trials (UYTs), followed by a series of farmer participatory varietal selection (PVS). Finally, the selected improved varieties are registered and officially released for use.

PVS, in which researchers and farmers evaluate promising genotypes together, has been found to be effective in increasing the chances of newly developed varieties being taken up and used by the intended users—the farmers. In this approach, farmers have a direct say in the selection of the varieties that are well suited for cultivation in their respective agroecologies. This contrasts with the traditional approach in which farmers are mere recipients of technologies handed to them by researchers. It is through this participatory approach that four improved varieties: Mweru, Kampolombo, Nalumino, and Chila have been selected by farmers, popularized, and multiplied for distribution in Zambia. Additionally, three promising varieties coded L9-304/20, L9-304/26, and

A farmer appreciates an improved variety at on-farm trial. Photo by IITA.

TME 579 have also been selected by farmers through PVS and have been submitted to MAL's Seed Control and Certification Institute (SCCI)—the country's seed regulatory body—for official release.

IITA also conducts agronomy trials to investigate the use of fertilizers on cassava—a first in Zambia—and the crop's response to different cultural practices (i.e., plant population density, time of planting, weed management, and crop combinations). The trials conducted on farmers' fields showed that the addition of NPK fertilizer to cassava leads to better root yields, while intercropping cassava in alternate rows with cowpea in moisture-constrained environments, and with soybean in high rainfall areas, were shown to be beneficial. Farmers harvested cowpea/soybean without sacrificing cassava root yield at harvest. Through field days, farmers were able to observe, learn, and differentiate between cassava grown using traditional practices and cassava grown using recommended practices. This has helped farmers to change their mindset on how to grow the root crop better.

For sustainable dissemination and adoption of technologies and innovations, IITA used the Innovation Platform (IP) approach in the SARD-SC and SAPP project areas. The IPs are effective in facilitating long-term interaction and engagement among the different actors in the value chain (producers/farmers, processors, transporters, finance institutions, traders, industrial users, etc.). They strengthen linkages among the actors by providing a platform to seek common solutions to obstacles within the value chain and developing business ideas that support the commodity. This has had a positive impact especially on farmers as they are directly linked to existing and emerging markets.

IITA researchers and partners visiting a SARD-SC multiplication field of improved cassava varieties. Photo by IITA.

The cassava research projects have also benefited communities by creating livelihood opportunities for women and the youth in areas such as value addition and seed multiplication. To this end, capacity building has also been one of IITA's major interventions. For example, in 2016, IITA facilitated two training courses on cassava utilization for 61 participants on producing value-added, cassava-based primary products (such as high quality cassava flour, HQCF) and derivatives such as confectionary (cakes, cookies, biscuits, cocktail tidbits, fritters, and bread), cassava-based dishes including cassava leaves with fish and soy, and cassava leaves with soy paste.

IITA also trained 11 young female members of the Zambia IITA Youth Agripreneurs (ZIYA) on the same topics at the Institute's research campus in Kabangwe. The youth expressed their interest and willingness to start small- and medium-scale businesses based on what they had learned. They have started to use the skills acquired to make cassava products for sale and demonstrate the technologies at agricultural shows.

These projects have also helped rejuvenate the cassava agenda in Zambia and have led to the establishment of strategic alliances and partnerships between IITA and national entities. For example, IITA has partnered with SCCI to facilitate the setting up of seed multiplication fields across the project areas hosted by farmers, following strict guidelines and standards. Through this, all the SARD-SC covered districts recorded a 50% average increase in multiplication of cassava planting material. From 2014 to 2016, a total of 65 ha of multiplication fields has been established under the project that would enable the establishment of approximately 495 ha of cassava.

The cassava projects also supplement each other. Through IPs, multiplication fields of improved varieties have been established by individual farmers, farmers' groups, and cooperatives under SARD-SC, which now supply seed to SAPP project sites. This year, SARD-SC IPs sold 612 bundles of planting material to SAPP as well as to Total Land Care (TLC), which has established an outgrower scheme for cassava.

IITA training participants receive their certificates after completing a 5-day course on cassava value addition at NISR in Lusaka, Zambia.
Photo by IITA.

Because of IITA's initiatives, Zambia's private sector has taken notice of the business potential of cassava. For example, Premier Con Ltd saw an opportunity to promote local commercial production of cassava to extract starch that, in turn, will be used by another company, Kalumbila Minerals Limited (KML), to process copper. According to Lubasa Yuyi, the Chief Executive Officer of Premier Con, the signed off-taker agreement with the mine is to provide 20,000 to 30,000 tons of cassava starch per annum. In the initial phase of the agreement, Premier Con is targeting to produce 7200 tons of starch annually, which requires 28,800 tons of fresh roots per annum. The company has mobilized at least 5,000 small-scale outgrower schemes to meet this huge demand.

ZIYA members processing cassava roots, Kabangwe, Zambia.
Photo by IITA.

The cassava component of SARD-SC has also made strides in linking farmers to markets through the IPs. Farmers in Mansa District, one of SARD-SC's project sites in Zambia, have been linked to Zambian Breweries (ZB), a subsidiary of SABMiller South Africa, which has commenced buying dry chips from the farmers. ZB is using cassava as one main ingredient for its Eagle Lager beer. The company is targeting to buy approximately 1000 tons of dried cassava chips per year.

These developments in the cassava sector of Zambia require significant increases in production alongside the rapid development in processing technologies and marketing of food products derived from the root crop. This, in turn, is pushing the government to effect a favorable policy environment that will support and promote crop diversification as well as enhance the interest of the private sector to invest in cassava. All these will require more and better varieties and a well-established and sustainable clean seed system to meet the exponential demand. IITA and its partners in Zambia such as the Zambia Agriculture Research Institute (ZARI) and SCCI will have to work hand-in-hand with the private sector and other stakeholders.

Reference

Nhamo, N., Kintche, K., Kebede, G., Omondi, J., Chiona, M.*, Chikoye, D., Ntawuruhunga, P. 2016. Adaptation to biophysical stress and improved crop management practices determine cassava (*Manihot esculenta* Crantz) future yield gains. Frontiers in Plant Science, pp. 1−46.

Bringing improved banana hybrids a step closer to farmers' fields

Rony Swennen, IITA, Arusha, Tanzania; Danny Coyne, IITA, Nairobi, Kenya; Allan Brown, IITA, Arusha, Tanzania; Brigitte Uwimana, IITA, Sendusu, Uganda; Inge Van den Bergh, Bioversity International, Leuven, Belgium; Rhiannon Crichton, Bioversity International, Montpellier, France; and Jerome Kubiriba and Robooni Tumuhimbise, NARO, Kampala, Uganda

In East and Central Africa banana cultivation covers over 50% of the area under permanent crop cover, representing around half of the area under banana cultivation across Africa. This is currently annually equivalent to about 21 million tons of banana, valued at $4.3 billion for East and Central African countries (Burundi, DR Congo, Kenya, Rwanda, Tanzania, and Uganda).

Consequently, banana constitutes an indispensable part of life in this region and is strongly interwoven into local customs as well as providing an important nutritional component of the diet. Up to one-fifth of total calorie consumption per capita is provided by banana, amounting to an average daily energy consumption of 147 kcal per person or six times the African average.

Unlike many staple crops, banana delivers food throughout the year and quickly recovers from drought stress at the onset of rains. Cultivation of cooking banana in Uganda and Tanzania is dominated by *Matooke* (East African Highland cooking banana, EAHB) and *Mchare* types, which represent a unique set of *Musa* germplasm found only in East and Central Africa. Some *Matooke* types have a high water content and are used for juice production.

Banana production in the region has stagnated at 9% of the yield potential. Pests and diseases are a key component of this problem and pose a particularly significant threat to the future sustainability of production, with the potential of further destabilizing both food security and household incomes across this region. Diseases, such as Black leaf streak (black Sigatoka) and Fusarium wilt (Panama disease), and pests, such as nematodes and weevils, are especially damaging.

Breeding banana is slow, costly, and fraught with numerous difficulties, largely arising from inherent sterility and the very poor germination of the few seeds that are produced. To optimize efforts and skills, the National Agricultural Research Organization (NARO) of Uganda and IITA joined forces under a combined effort to breed *Matooke* in Uganda. Over a period of 18 years a series of high-yielding EAHB hybrids were jointly

Three stages in NARITA breeding. Left: Matooke "Entukura" (starting material); middle (hybrid derived from Entukura; right: NARITA 17 (derived from Entukura hybrid). Photo by IITA.

Farmers participating in a participatory rural appraisal.
Source: Bioversity International.

develo*ped and are now referred to as the NARITA hybrids* (http://www.promusa.org/NARITA+hybrids), embodying the joint contribution.

Banana breeding involves first the identification of seed-producing *Matooke* varieties, which are rare and difficult to find. Twelve such triploid *Matooke* varieties were identified, mass-multiplied in vitro as tissue culture plants, planted in the field, and then carefully hand pollinated using improved diploid banana. This process created tetraploid plants. Although these tetraploid plants had desired attributes, they were not good final products for the end users as they contained residual seed fertility that poses a problem in fruit quality. To circumvent this problem, tetraploids were further crossed with improved diploids to generate secondary triploid NARITA hybrids that are seed-sterile. The resultant NARITAs were then planted in the field and higher yielding hybrids (1–2 plants) were selected once bunches had developed. Planting material from the selected hybrids was then multiplied and the superiority of each hybrid for bunch yield, fruit taste, and reaction to black leaf streak was evaluated from 10 plants of each hybrid.

Over several years of this intensive and laborious breeding process, 27 superior NARITA hybrids were finally selected for delivery to farmers. Their yield ranged from 9.1 t/ha to as high as 37.8 t/ha with bunches weighing up to 30.4 kg, depending on the hybrid. All NARITAs are resistant to black leaf streak (http://www.musalit.org/seeMore.php?id=15482). Seventeen of these NARITA hybrids exhibit high black leaf streak resistance (80–100%), even after three production cycles, demonstrating durable resistance against this disease and possibly against nematodes and weevils. Although 12 *Matooke* cultivars were initially used for breeding, the *Enzirabahima* and *Nakawere* varieties delivered most of the high-yielding and preferred hybrids with minor but significant contributions from *Kabucuragye*, *Entukura*, and *Nfuuka*. Some NARITA hybrids had 16 parents, while others had just four. The noted hybrid vigor is now under investigation. Despite the use of only cooking banana in the breeding program, seven of the hybrids were surprisingly selected as juice banana.

In a next step, yield stability, taste quality, and farmer preference are being evaluated across a range of environments (http://newint.iita.org/

news-item/matoke-east-africa-planned-regional-testing-first-ever-high-yielding-hybrids/) to scale out their use and expand their potential. NARITAs are currently being evaluated in two locations in Uganda (Kawanda and Mbarara), and three in Tanzania (Bukoba, Kilimanjaro, and Mbeya). Private tissue culture laboratories in each country have been subcontracted to produce the desired quantities of plants.

The yield and pest/disease status are being evaluated in a research collaboration led by Bioversity International together with IITA, NARO, and the Agricultural Research Institute, Tanzania (ARI) and Stellenbosch University, South Africa (http://bananabreeding.iita.org/index.php/2017/01/24/work-package-4-empowering-end-user-evaluation/). A barcode labeling system was developed that allows the scientists to identify unambiguously each plant in the trial and follow its development over time; plant performance data are collected with an electronic form uploaded on a tablet or smart phone. This multilocational evaluation of the hybrids also provides the platform from which to investigate farmers' criteria for selection and baseline studies for end-user preferences in EAHB value chains. Such a study paves the way for future participatory breeding and feedback to breeders on the important traits that farmers use for selection.

The team, with partners (CIRAD, France; Makerere University, Uganda; and Clark University, USA), have developed participatory rural appraisal (PRA) tools including an intra-household survey, seasonal and daily calendar exercises, a community wealth ranking exercise, and a trait preference exercise to characterize the target population environments in terms of agroecological and socioeconomic conditions and existing production systems.

The NARITA multilocational trials will also serve as demonstration fields for farmers, while results will provide an important step towards selective breeding and distribution of improved banana. Additional production cycles and farmer responses will continue to be collected towards the generation of a *Musa database* (https://musabase.org/), which will be used to support future breeding activities, among other things. Meanwhile, NARITAs are becoming very popular, with high demand for their testing and distribution elsewhere, such as in Rwanda, Burundi, and DR Congo.

The development of the hybrids to the point of regional testing and generating demand from across the whole of the banana-growing region of ECA demonstrates the success of this collaborative venture between NARO and IITA. The lengthy breeding process is now beginning to bear fruit. However, significant efforts are being undertaken to reduce the length of time, improve the efficiency of the breeding pipeline, and increase the rate of delivery of improved banana within the project "Improvement of banana for smallholder farmers in the Great Lakes Region of Africa" (http://bananabreeding.iita.org/), funded by the Bill & Melinda Gates Foundation. The evaluation of NARITA hybrids in Tanzania and Uganda is a component within the same project.

Pollination of banana flowers to produce seeds of hybrids.
Photo by IITA.

Closing the maize yield gap in Africa:
The TAMASA-Nigeria experience

Ibrahim Baba Mohammad, IITA, Kano, Nigeria; Bernard Vanlauwe, IITA, Nairobi, Kenya; Alpha Kamara and Julius Adewopo, IITA, Kano, Nigeria; Jeroen Huising, IITA, Ibadan, Nigeria; and Jibrin Mohammed Jibrin, Bayero University, Kano, Nigeria

Maize is cultivated by approximately 55 million smallholder farmers in sub-Saharan Africa. Farmers' current maize yields are 50 to 75% lower than attainable yields. The persisting yield gap has been attributed to many biophysical and socioeconomic factors, and are exacerbated by extant weak support systems for wide technology adoption among farmers. Recent advancements in agronomic research have resulted in the development and use of modern tools and analytics to collect and aggregate large volumes of spatially referenced agronomic, socioeconomic, and biophysical data.

Final readiness checks on an unmanned air vehicle (UAV) before deploying for acquisition of fine resolution aerial imagery. Photo by IITA.

This provides a significant opportunity to transform research into widely useable and scalable knowledge products and services, including Decision Support Tools (DST) for farmers, service providers, industry, policy makers, and investors. Information generated through these tools has immense potential to improve existing practices such as blanket recommendations for fertilizer use or varieties across a diverse range of environments.

The *Taking Maize Agronomy to Scale in Africa (TAMASA)* project, funded by the Bill & Melinda Gates Foundation, was designed to engage service providers (i.e., input suppliers, government and private research and extension services, agro-dealers, and others) in a co-development process to address maize yield constraints in sub-Saharan Africa. TAMASA leverages on innovative technologies and data analytics to adapt and co-develop scalable DSTs that can be used to assess maize yield and reduce yield gap at scale. The project, which is being implemented in Ethiopia, Nigeria, and Tanzania, seeks to deliver agronomic intervention to some 600,000 maize farming households.

IITA leads the project in Nigeria, working together with the International Maize and Wheat Center (CIMMYT), the International Plant Nutrition Institute (IPNI), African Soil Information Systems (AfSIS), and other stakeholders. TAMASA is being implemented in Kano, Kaduna, and Katsina states. Delineation of target geography was based on geospatially explicit analyses that incorporated critical factors for maize intensification such as existence of major maize production systems, population density, distance to markets, and presence of scaling partners. The project's activities in the country targets a focal area of about 1.7 million hectares of farmland, within a larger area of interest (AOI) of approximately 14 million hectares.

Assessing stakeholders' needs and co-developing analysis tools

At the onset of TAMASA, IITA convened several roundtable stakeholders' needs assessment and follow-up consultations to identify the most critical innovations/tools that are relevant for near real-time improvement of maize agronomy and yield. Stakeholders included input suppliers such as SeedCo and Notore Fertilizer Company, extension service providers such as Sasakawa Global Association (SG2000), State Agricultural Development Programs (ADPs), and input service providers such as Doreo Partners (also Babban Gona) and Propcom–Maikarfi. Through this extensive engagement process, three tools were identified: (1) Nutrient Expert (NE) for Maize for site-specific nutrient management and fertilizer recommendations; (2) Maize Variety Selector (MVS) for location-specific targeting of appropriate maize varieties; and (3) Fertilizer blending for guiding the fertilizer industry on appropriate elements that should be included in fertilizer blends, based on spatially delineated soil conditions.

Strategic partnership for delivery and strengthening of institutions is a key component of TAMASA. Partners are important in the generation of scientific knowledge through their support in establishment of research field trials, co-development of tools, and capacity building of relevant institutions. In Nigeria, the project partnered with the Center for Dryland Agriculture at Bayero University Kano (CDA-BUK), the Institute for Agricultural Research (IAR), and ADPs of focal states.

Establishing baseline yields through surveys

A comprehensive baseline survey was completed in 2015 with a follow-on Agronomy Panel Survey involving 805 households in 2015 and 2016. The surveys generated uniquely robust and essential spatial data on soil properties, maize yield, and socioeconomic conditions of smallholder farmers within the project's focal AOI, and are currently being translated into knowledge products. By revisiting the same respondent farming households annually until 2018, TAMASA is generating unprecedented volumes of spatio-temporal data on maize smallholder farm and household characteristics. This information is pivotal for ex-ante and ex-post analysis of technology uptake and impact at scale.

Based on the increasing demand for innovative approaches for yield prediction, yield gap assessment, and evaluation of constraints from local to regional scale, TAMASA is pioneering the innovative application of drones (or unmanned aerial vehicles, UAVs) for in-season yield prediction at five locations within the project's focal area. By acquiring high-resolution geospatial imageries (12 cm pixel size) with a multispectral-4C sensor carried aboard the UAVs at low altitude (100 m), TAMASA has successfully demonstrated the possibility of linking plot-level agronomic data (including yield) to remotely sensed vegetation characteristics at field scale.

The initial results obtained from multi-level processing of acquired data offer a promising outlook for in-season prediction of maize yield in farmers' fields. For instance, UAV-derived grain yield predictions, based on a remotely sensed vegetation index, were very close to the measured yield in farmers' fields at Bunkure, Kano ($r2 = 0.87$, Fig. 1). Further, the results suggest that innovative application of UAVs in maize-based systems may complement or replace cost-intensive, ground-based, spatio-temporal yield assessment, which are quite impractical to conduct at scale.

Bridging weather data gap

Implementing agronomic intervention at scale requires near real-time knowledge of weather and weather variability. In partnership with Bayero University, Kano and Kukua. b.V. (a Dutch weather service company), IITA

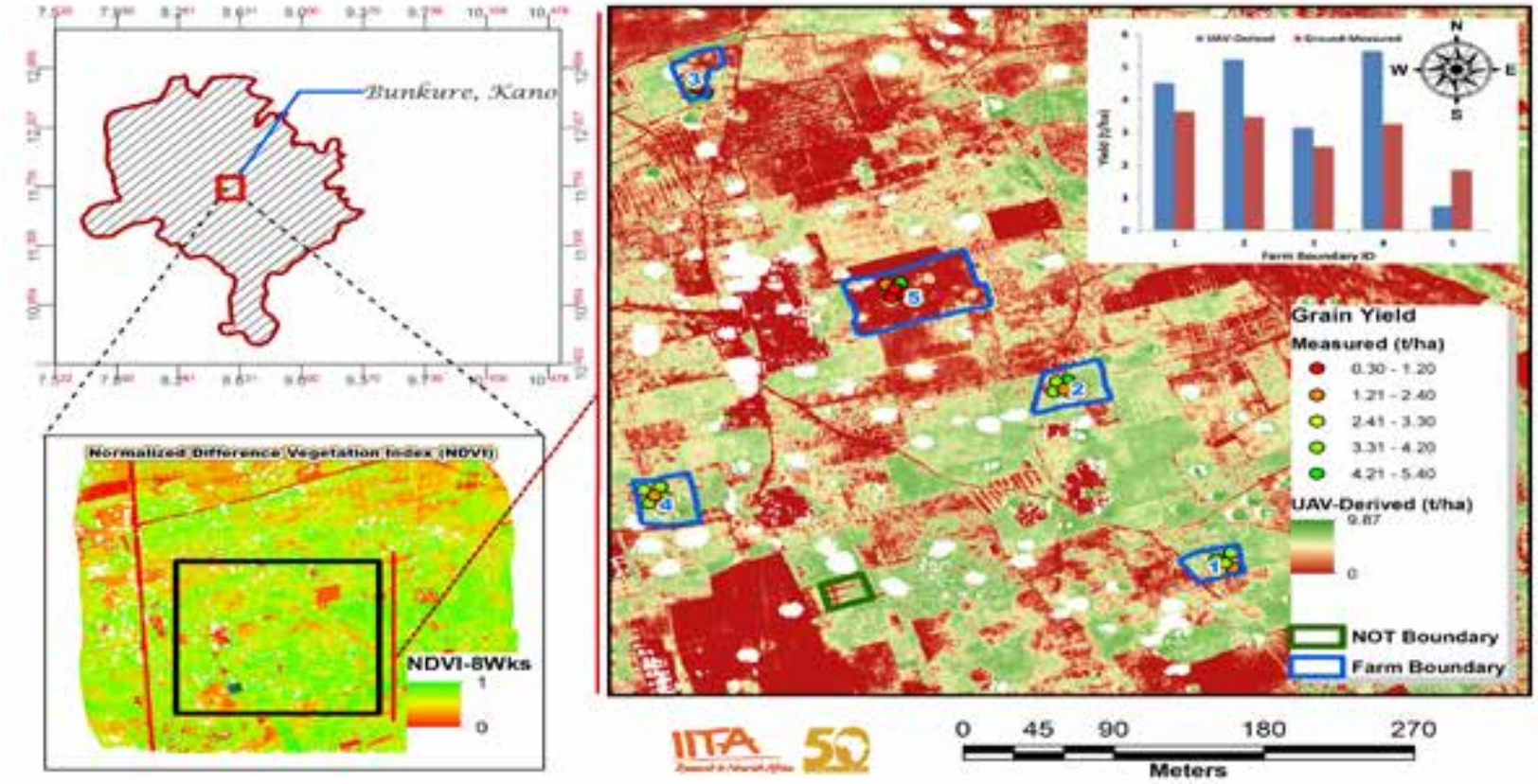


Figure 1. UAV-based assessment of grain yield in maize-based smallholder farmers' field at Bunkure, Kano.

successfully facilitated the installation of 40 weather stations across the focal states. These weather stations are providing real-time and remotely accessible weather data to support research-based predictive agronomy and tool co-development. The data can support national-level weather forecasts by the designated national agency (Nigeria Meteorological Service, NiMET), and become a resource for index-based insurers and financial institutions who require hyper-local weather data to determine the type and magnitude of risks that their prospective and existing clients may be exposed to, including farmers and service providers.

Developing nutrient expert and maize variety selector tools

TAMASA has engaged relevant stakeholders to co-develop both NE and MVS, which is expected to enhance tool ownership, application, and further improvement beyond the lifespan of the project. The first version of the NE (NE v0) was developed based on experimental data obtained from ~200 nutrient omission trials (NOTs) established in 2015, while the second version (NE v1) is a recalibrated version that incorporated

observations from over 100 NOTs experiments which were conducted in 2016 (Fig. 2a and b). As a critical step for rigorous testing of NE value addition, about 200 Performance Trials were established within farmers' fields across 13 LGAs in 2016. The nutrient recommendations generated from NE were compared with soil-test based nutrient recommendations, current regional fertilizer recommendations for maize, and zero-fertilizer control plots. Results strongly point to higher returns on investment accruing to NE tool application and fertilizer recommendations based on the soil test. NE recommended lower amounts of phosphorus (19 kg/ha) and potassium (23 kg/ha) fertilizers, yet maize yields were close to those of soil test-based and regional fertilizer recommendations. Using the available blends in Nigeria, this meant a decrease in the use of NPK fertilizer, resulting in an investment saving of about $80 per hectare.

Matching fertilizer blends to local conditions

Soil properties vary widely within the maize production areas of sub-Saharan Africa, yet farmers are mostly offered singular fertilizer blends (such as NPK 15:15:15), which may be inappropriate to local soil fertility conditions and usually translate to huge financial loss to many farmers. Proper soil fertility management for

Farmers usually just use a singular fertilizer blend in their maize farms that may not be suitable for the soil fertility conditiions. Photo by IITA.

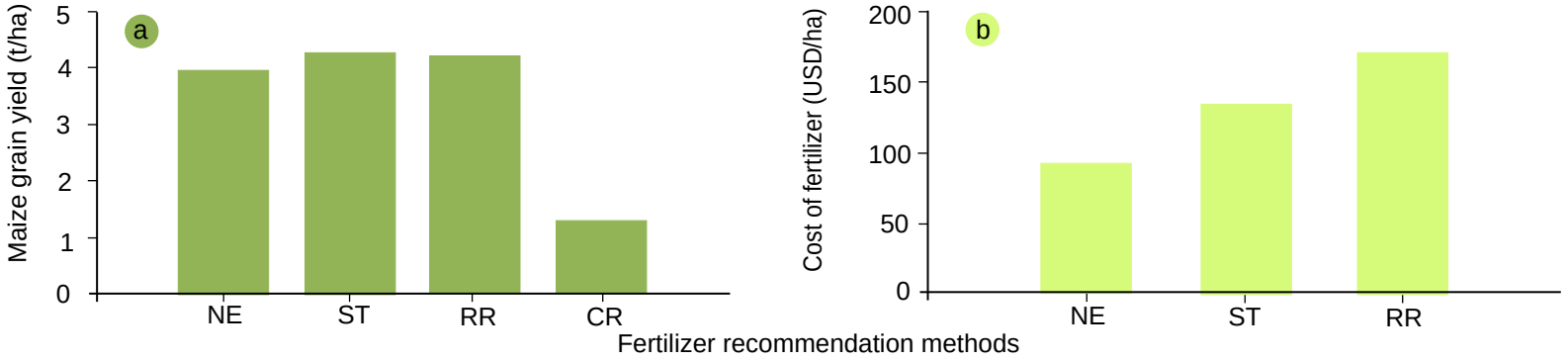


Figure 2. Maize grain yield, t/ha (a) and cost of fertilizer input, US$/ha (b) for fertilizer rates generated with nutrient expert (NE), soil-test based (ST) and regional (RR) recommendation methods. CR (control) is the yield for the no fertilizer input plots. Sample size (N) = 177. Note: exchange rate used – US$1 = 500 Naira.

optimal yield requires appropriate fertilizer blends at the right dosage and applied at the right time and at the right place. To this end and through partnership with OCP, a Morocco-based fertilizer company, the project is evaluating maize response to different fertilizer blends across maize ecologies/fertility domains in Nigeria.

In 2016, the project commenced fertilizer blending activities to facilitate the development of new fertilizer blends appropriate to the soil conditions of the maize belt of Nigeria. This is expected to result in more efficient and affordable products for increased yields and profit of farmers. It is a collaborative project between OCP-Africa, AfSIS, IITA, and national partners in Nigeria. The activities include soil characterization with an emphasis on identifying soil nutrient limitations, formulation and production of new fertilizer products, and regional scale testing of these new products. The maize belt of Nigeria covers an area of ~24 million ha, and 3000 locations have been surveyed and

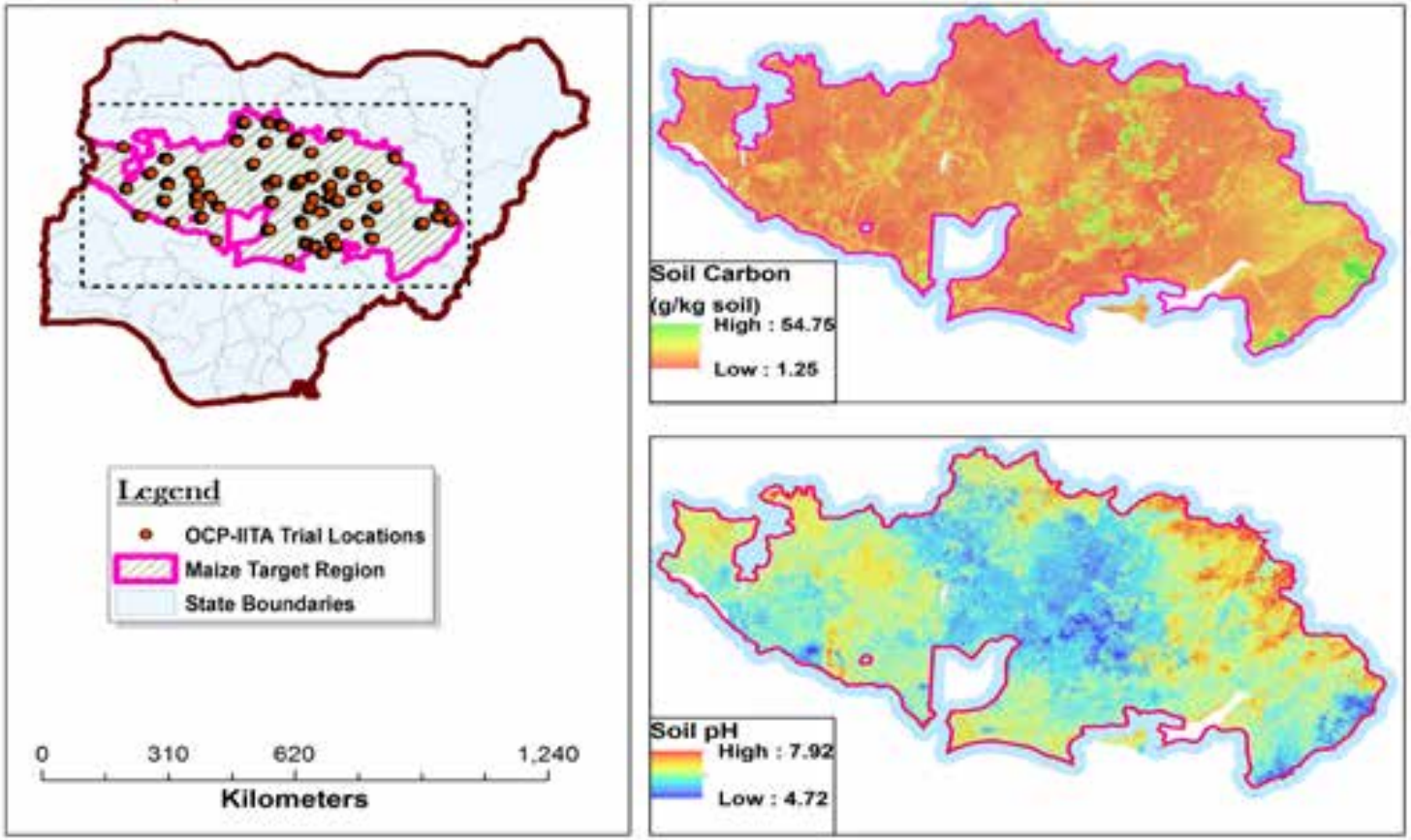


Figure 3. OCP trial locations and underlying spatial variability of soil pH and soil carbon within the maize target region of Nigeria.

sampled for soil characterization. By design, the sampling locations are spread across 60 sentinel sites, with 10 cluster-grids within each sentinel site, and 5 sample locations per cluster (Fig. 3). The survey also provided unprecedented science-based information on the distribution of crop coverage in the area. Top- and subsoil samples have been analyzed for nutrient concentration, organic carbon, total nitrogen, pH, cation exchange capacity (CEC), texture, mineral composition, and elemental composition. This information provides rich insight into inherent soil characteristics and variability at scale within the maize target region (Fig. 3).

Based on the soil characterization and nutrient need assessments, new fertilizer blends are being proposed to the industry. These blends have higher phosphate (P_2O_5) content compared to the commonly available fertilizers, and include additions of sulfur, zinc, and boron to address the inadequacy of these nutrients in the soil. Limitations of available potassium seem to be more localized, therefore, composition of K_2O was increased by 22% in one of the new blends. However, potassium was not included in the second blend. The proposed new blends will be tested during the 2017 cropping season at 1500 locations that have been previously sampled and surveyed. Yield response will be compared with the application of commonly used fertilizer blend in Nigeria (i.e., NPK 15-15-15).

Consequently, testing of the new fertilizer blends in larger areas will provide more insight into their performance and generate more information about the variability in yield response, a critical component in farmer adoption. The knowledge products generated from the extensive soil characterization will be shared with other fertilizer companies such as Notore and Indorama to influence them to produce appropriate (region-specific) fertilizer blends that can help improve return on investment for maize smallholder farmers in the region, particularly Nigeria.

Researcher inspecting maize crop and cob. *Photo* by Ezekiel Onasanya, IITA.

Making crops healthy

Crops being examined for disease and pest damage. Photo by IYA.

Hot on the heels of deadly aflatoxins in southern Africa

Juliet Akello, IITA, Kabangwe, Zambia; Joseph Atehnkeng, IITA, Lilongwe, Malawi; Joao Augusto, IITA, Nampula, Mozambique; and Ranajit Bandyopadhyay, IITA, Ibadan, Nigeria

Aflatoxins are cancer-causing, growth-retarding, and immune system-suppressing poisons produced by *Aspergillus* molds during crop growth or in storage. When aflatoxin-contaminated food and feed are ingested, aflatoxins severely affect human and animal health. Children under five years are particularly vulnerable, with aflatoxin exposure stunting their growth and development and damaging their immune system.

In Mozambique, aflatoxins have been linked to a high prevalence of liver cancer. The high levels of aflatoxin often found in agricultural commodities produced in the southern Africa region have also impeded exports to countries with tight aflatoxin regulations and enforcement.

Research carried out by IITA in Malawi, Mozambique, and Zambia shows that groundnut and maize in farmers' fields, stores, warehouses, and markets have high concentrations of aflatoxins, more so in groundnut. In Malawi, for instance, maize and groundnut from 22 districts collected between the 2014 and 2015 cropping seasons showed that at least 28% of the grains harvested were unsafe for human consumption as per US regulation limits of 20 parts per billion (ppb). Furthermore, groundnut was more prone to aflatoxin contamination than maize, and contamination levels were higher in the southern than the northern part of the country. In Zambia, 30–80% of the groundnut in the sampled sites was also found to be unsafe for human consumption, compared to only 2–5% for maize. In Mozambique, aflatoxin contamination in groundnut and maize was found to be as much as 350 and 30 times higher than the US regulation limits, respectively. Exports of Mozambican groundnut to European Union (EU) countries have, in many cases, been rejected because of exceedingly high levels of aflatoxin contamination. This has

Officials from Malawi including DARS, visit the Aflasafe productin plant in the Business Incubation Platform in IITA/Nigeria.
Photo by IITA.

severely affected the livelihoods of smallholder groundnut farmers who produce almost 100% of the exported crop.

To tackle the challenges posed by aflatoxins in southern Africa, IITA and its partners in Malawi, Mozambique, and Zambia have developed and are testing an innovative biocontrol product called Aflasafe™, which competitively displaces aflatoxin-producing isolates of the *Aspergillus* fungus using non-aflatoxin-producing isolates of the same fungus when applied in the right amounts and at the right time in maize and groundnut fields.

To date, IITA has developed five Aflasafe™ biocontrol products: Aflasafe™ ZM01 and Aflasafe™ ZM02 (Zambia), Aflasafe™ MWMZ01 (regional product for Mozambique and Malawi), Aflasafe™ MZ02 (Mozambique), and Aflasafe™ MW02 (Malawi) and is currently evaluating them in maize and groundnut fields in these countries. IITA is targeting to register at least one Aflasafe™ product in each of these countries by 2017.

A group of farmers demonstrating aflasafe application to fellow farmers.
Photo by IITA.

Evaluating the field efficacy of Aflasafe™ products

In Malawi, evaluation through field demonstrations of Aflasafe™ products is in its second year, covering 11 districts and 22 Extension Planning Areas (EPAs) across three agroecological zones. Six tons of Aflasafe™ products (MWMZ01 and MW02) were imported into the country and are being used for these field and on-station evaluations. For each Aflasafe™-treated field, a corresponding untreated field is being used for comparison. Comparative analyses show a reduction of between 86 and 100% in maize, and 77 and 99.9% in groundnut samples from the Aflasafe™-treated fields.

When aflatoxin-contaminated food and feed are ingested, aflatoxins severely affect human and animal health. Children under five years are particularly vulnerable, with aflatoxin exposure stunting their growth and development and damaging their immune system.

Additionally, the Aflasafe™ component of the Malawi Improved Seed Systems and Technologies (MISST) project has applied the biocontrol product in about 440 maize and groundnut farmers' fields in the 2016–2017 farming season. The 440 farmers (220 maize and 220 groundnut) were spread across selected districts including Mzimba, Lilongwe, Mchinji, Dedza, Ntcheu, Balaka, Machinga, Mangochi, Blantyre, Chikwawa, and Nsanje. Two EPAs from each district were selected for the trials, with each EPA having at least 10 maize and 10 groundnut farmers.

In Mozambique, 312 groundnut farmers and 123 maize farmers from different agroecological zones of Central and Northern regions, covering a total of 435 farmers' fields (312 groundnuts and 123 maize), participated in the Aflasafe™ field efficacy trials. Aflatoxin contamination in non-Aflasafe™-treated control fields were found to range from 3 to 1516 ppb for groundnut, and from 2 to 639 ppb for maize. On the other hand, groundnut fields treated with Aflasafe™ MZ02 showed aflatoxin contamination ranging from non-detectable levels to just 36 ppb, with only five groundnut fields (6%) treated with Aflasafe™ MZ02 exceeding the 20 ppb US regulation aflatoxin threshold. In maize, the Aflasafe™ MZ02-treated fields recorded aflatoxin contamination ranging from non-detectable levels to 24 ppb, with only one Aflasafe™ MZ02-treated field (2%) exceeding the US aflatoxin regulation limits.

Developing a regional aflatoxin solution

During the 2015/2016 crop season, IITA successfully developed and tested the first regional Aflasafe™ biocontrol product (Aflasafe™ MWMZ01) in Malawi and Mozambique. The non-aflatoxin-producing fungal isolates used to develop the regional Aflasafe™ product are specific to Malawi and Mozambique, but have the same lineage. About 200 maize and groundnut farmers' fields each in Mozambique, and 110 maize and groundnut farmers' fields each in Malawi were treated with the regional Aflasafe™ product. Most of the maize (94%) and groundnut (97%) sampled from farmers' fields treated with Aflasafe™ MWMZ01 in each country were found to be safe for human consumption, compared to the maize (50%) and groundnut (30%) sampled from the non-Aflasafe™-treated control fields. These results suggest that a regional Aflasafe product can be registered and effectively deployed across southern Africa.

Extension officer explaining about aflatoxin contamination.
Photo by IITA.

Zambian Aflasafe ZM01.
Photo by IITA.

Enhancing capacities and infrastructure

IITA organized a training in Malawi, Mozambique, and Zambia in collaboration with the District Agricultural Development Officers (DADOs) for maize and groundnut farmers and field extension officers. Participants were briefed on the basics of aflatoxin and efforts to minimize contamination using Aflasafe™, as well as good management practices to improve crop quality. Both farmers and extension officers had the hands-on opportunity to apply Aflasafe™ in the field. A total of 2186 participants (1305 males and 881 females) have been trained on the use of Aflasafe™ and other good management practices. Of these, 350 are agricultural officers while 1836 are farmers. A total of 750 farmers have so far benefited from the use of Aflasafe™ to manage aflatoxin in their fields in the 2015/16 and 2016/17 cropping seasons.

In Mozambique, 579 small-scale farmers (386 men and 193 women), four groundnut and maize associations (each with 50 members), and 49 individuals from the maize private sector received 3 days' training on aflatoxins and Aflasafe™ use for aflatoxin mitigation during the 2016 crop season. The trainees came from Central and Northern Mozambique.

IITA also established and/or rehabilitated aflatoxin research and training laboratories in Malawi, Mozambique, and Zambia to improve support infrastructure and to contribute to building the capacity of research staff. New facilities were established in Mozambique and Zambia, and in Malawi, a research building was donated by DARS which IITA rehabilitated with the required equipment. Technicians were also recruited and trained on surveillance, aflatoxin detection, fungal identification, and related research on aflatoxin in the three countries. In addition, PhD students from the three countries are being trained at the Plant Pathology Department, University of Arizona, USA.

Introducing Aflasafe™ to Zambia's private sector

In Zambia, two aflasafe biocontrol products: Aflasafe™ ZM01 and Aflasafe™ ZM02 have been tested in on-farm conditions under different agroecological zones and have been found to effectively reduce aflatoxins in maize and groundnut by up to 99%.

In 2016, IITA partnered with Profit Plus and Share Africa-Zambia—a private company involved in peanut butter processing. Profit Plus purchased 2 tons of Aflasafe™ from IITA and handed these to Share Africa-Zambia which distributed the product to their farmers. For distribution, trained lead farmers and agro-dealers were identified as channels for Aflasafe™ distribution to farmers while also ensuring the adherence to recommendations and protocols for proper Aflasafe™ application in the field. After crop harvest and the processing of groundnut treated with Aflasafe™ to produce peanut butter, aflatoxin detected in the final product was less than 2 ppb. This was a very positive outcome for the peanut butter processor as their product would meet aflatoxin safety regulations for export.

Furthermore, we demonstrated that farmers receiving a premium price for products meeting EU's aflatoxin safety limits of 4 ppb would make a profit of around $1500 compared to just $280 for non-Aflasafe™ users. With the successful pilot study, this prompted the private sector, Share Africa-Zambia, to invest 25% in importing Aflasafe™ products into the country for the 2016/2017 cropping season.

Strengthening partnerships

Partnerships are key to meeting our aflatoxin eradication targets in the region. In Zambia, IITA partners with the Zambia Agriculture Research Institute (ZARI), the National Institute for Scientific and Industrial Research (NISIR), Profit Plus, and Share Africa-Zambia. In Mozambique, IITA works with the Pesticides' Registration Unit at Mozambique's Ministry of Agriculture, *Novos Horizontes* (a poultry and poultry feed producer based in Nampula), and *Universidade Pedagogica de Mocambique* for capacity building. In Malawi, IITA collaborates with the Department of Agricultural Research and Services (DARS), the Department of Agricultural Extension Services (DAES), the Pesticide Control Board (PCB), the Malawi Program on Aflatoxin Control (MAPAC), and the One Acre Fund (OAF).

Farmers show off aflatoxin-free maize. Photo by Ezekiel Onasanya, IITA.

The nose knows: Managing whiteflies by the way they sense crop scents

Latifa Mrisho and James Legg, IITA, Dar es Salaam, Tanzania; Daniel Maeda, University of Dar es Salaam, Tanzania; and Marcus Stensmyr, Lund University, Sweden

In the battle against crop pests, scientists must take advantage of all available resources. In the case of a novel piece of research by IITA against the whitefly *Bemisia tabaci*, this means learning about the way insects use their sense of smell.

Large population of B. tabaci *adults feeding on the underside of a young cassava leaf.* Photo by IITA.

Close-up of whitefly adults.

B. tabaci is one of the major agricultural pests of vegetable crops in the tropical and subtropical regions. It attacks cassava, which is a staple root crop in sub-Saharan Africa that provides food and income for millions of people. *B. tabaci* is the vector of viruses that cause Cassava Mosaic Disease (CMD) and Cassava Brown Streak Disease (CBSD), which can lead to total crop failure and result in overall crop losses valued at more than $1 billion. Most of the management and control practices for *B. tabaci* are not practical and cost-effective for smallholder farmers. Therefore, new approaches are needed, which require understanding the relationship between the whitefly vector and its host plants, particularly how *B. tabaci* identifies and locates its target plants.

Seeing by smelling

Plant-feeding insects such as *B. tabaci* use color, smell, and taste to detect and identify their host plants for food and egg laying. Smell is thought to be the first signal that plant-feeding insects detect as an indicator of the presence of a nearby host plant. It cues into chemicals emanating from the plant that can be dispersed by wind for long distances. Several scientists have investigated the behavior of the whitefly towards plant-produced chemical odors and have been able to identify some of the chemical compounds that attract insects to plants or repel them.

Studies that have demonstrated the repellent action of some of the plant-produced chemicals towards *B. tabaci* prompted the exploration of the use of such chemicals to manage the whiteflies. A diverse set of plants and plant products have been shown to produce volatile chemicals that repel whiteflies. These include several tomato varieties, extracts from neem, Aframomum and cinnamon spices, as well as the herbs geranium, dill, citronella, litsea, lemongrass, and savory. Several

chemicals thought to be responsible for the attraction or repulsion have been identified but their mechanism of action is not yet known. Understanding this mechanism will enable researchers to identify the active chemical compounds that can be used to make cassava less appealing to whiteflies.

To attract or not to attract, that is the question

An innovative study being undertaken by IITA-Tanzania aims to generate an understanding of the odor-guided response of the cassava whitefly *B. tabaci* by identifying chemicals emitted by different plants and investigating the behavioral response of the whitefly towards these chemicals. This research also aims to determine the mechanism by which whiteflies can detect and identify the plant-produced chemical signals.

Preliminary results on the behavioral response of cassava whiteflies towards chemical odors produced by cassava (the host plant for feeding and laying eggs), tomato (host plant for feeding), and lemongrass (nonhost plant) showed that the whitefly can indeed identify its host plant based on plant-produced and emitted chemical odorants. The whiteflies were shown to be repelled by the chemical odorants from both lemongrass and tomato but not those from cassava. They were also not attracted by the chemical odorants from cassava. A variety of chemical compounds were identified from the chemical odors produced by cassava, tomato, and lemongrass, and these differed in number, type, and concentration. Of the identified chemical compounds, cymene, terpinene, and phellandrene, as well as citral and geraniol, were obtained from tomato and lemongrass. These compounds have been reported to have repulsive effects towards whiteflies; however, it is not known how the whiteflies can detect and identify these chemicals from among the wide range of chemicals being produced by the plants.

Further studies using different varieties of cassava and other plants are being done to confirm the observed behavior of the whiteflies. In addition, the mechanism by which the whitefly can detect and smell the variety of chemicals it encounters will also be determined. Once these volatile chemicals have been identified, they will be used in field studies to determine their effectiveness in attracting or repelling whiteflies in the environmental conditions used to cultivate cassava plants. This will generate a baseline for developing management strategies to prevent whitefly colonization of cassava plants either through intercropping with plants that repel the whiteflies or developing organic insecticides and traps for whiteflies. The chemicals that repel the whiteflies can also be used with transgenic approaches to produce whitefly-repelling cassava; thereby, reducing its likelihood of being infected by the viruses that cause CMD and CBSD.

Latifa Mrisho conducting whitefly behavior assay at the IITA laboratory in Tanzania.
Photo by IITA.

Managing natural resources

Emblematic red-bellied monkey, critically endangered, but doing well in Drabo – mother and baby. Photo by P. Neuenschwander, IITA.

A patch of protection: Helping to safeguard threatened biodiversity in Bénin

Peter Neuenschwander, IITA, Bénin

At the Rio Summit of 1990 two major problems threatening humanity were identified: climate change and loss of biodiversity. The latter has largely remained an academic topic although the former has been given huge amounts of attention and action is being taken to address its effects. Even so, scientists agree that biodiversity is a key requisite for sustaining life on earth.

In the domain of agriculture, IITA was among the first within CGIAR to look into biodiversity for increasing and stabilizing crop yields, particularly through its work on the biocontrol of pests and diseases.

In the last 20 years, IITA has been researching well-defined beneficial taxa, not only for use in insect and weed control but, in particular, to conserve local biodiversity for basic studies. For example, the secondary forest within the IITA campus in Ibadan, Nigeria, has recently been upgraded with the goal of making it a prime research site for biodiversity. Three years ago, IITA became the recipient of 14 ha of long-time fallow land that lies in a disjointed belt of rainforest in Drabo, southern Bénin. This paved the way for the Institute to carry out a project to rehabilitate this patch of rainforest and to document and conserve the threatened biodiversity found within.

Monkey sanctuary: Entrance to monkey sanctuary with children, carrying food for the monkeys and one of the red-bellies. Photo by P. Neuenschwander, IITA.

Rehabilitating a forest, or a patch of it

The Drabo Rainforest Rehabilitation is an initiative led by IITA in collaboration with the National Herbarium of the University of Abomey-Calavi and other partners. It aims to protect the highly threatened fauna and flora of the historically separated patches of rainforest in southern Bénin, most of which today are sacred forests with difficult access. These forests harbor species of Lower Guinean/Congolese origin that invaded Bénin from Central Africa after the ice Age, while those of Upper Guinean origin sought refuge from the Ice Age in today's Côte d'Ivoire and Liberia.

In Drabo, inhabitants of adjacent villages used to see the forest merely as a source of fuelwood, medicinal plants, or wild game for food. This highly extractive perception of the forest among the people living near it is what IITA first wants to change by showing the advantages of living with the forest rather than living from it.

Secondly, IITA wants to observe the transformation of agricultural land, from young fallow to secondary forest, looking at changes in the flora and fauna, particularly insects, as well as physico-chemical factors of soil and water resources.

Until now, these activities have been the outcome of private initiatives and not of a structured IITA program. They relate, however, very well with IITA Bénin's vision of linking biodiversity with bio-risk management under a climate–change scenario. The forest in Drabo houses a field station and is linked with the renowned IITA insect collection—the biggest and best curated in the whole of West and Central Africa—that backs the Institute's entire plant protection program and serves the whole region.

The project will help to enhance and protect biodiversity within this patch of rainforest for the benefit of the local farming communities. It supports local NGOs active in environmental education, contributes to the research of the Béninois National Herbarium, and provides field sites for research on insects, plants, and monkeys.

Yes, monkeys! In the course of 20 years, two free-living groups (about 20–25 individuals) of the critically endangered, endemic red-bellied monkey, *Cercopithecus erythrogaster,* have come to call this forest— Sanctuaire des Singes de Drabo Gbo—their home.

Being used to humans observing them, these red-bellied monkeys are arguably the easiest to see as the remaining 500 or so documented animals live in small groups in remnants of forests in other parts of Bénin where they are being hunted and are therefore very reclusive. IITA considers studying these monkeys as significant because they are key indicators of the sustainability of forests with an impact on related agroecosystems. Additionally, through this initiative, we partnered with many nature NGOs and conservationists, resulting in the production of a book on nature conservation in Bénin (Neuenschwander et al. 2011) that is now standard reading in universities and high schools across the country.

The journey so far

One of the more obvious results of a study of four rainforest sites in Nigeria and southern Bénin is that threatened plants and animals have found refuge. The long-term prospects looked better the farther away the forest was from population centers, if land ownership was secure, and a conservation "champion" was at hand as well as a rare animal or plant inhabitant to make the forest attractive for conservation and ecotourism. Protection by local communities was beneficial, but unfortunately not sufficient in the long term.

Additionally, because of this project, the forest continues to grow, with the adjacent communities accepting responsibility, with IITA, for the forest's protection. The resident red-bellied monkeys are commonly admired when they curiously follow meetings at the communal central square. The forest gives many people, particularly children, a special feeling of living in a pristine environment.

Scientifically, this project culminated in the 20-year floristic study on the rehabilitation of this 14-ha forest reserve (Neuenschwander & Adomou, submitted). Forest regrowth was encouraged by managing the natural growth of the local fallow vegetation and by bringing in seeds and other propagules from forest islands of Bénin in close collaboration with specialists of the National Herbarium.

The succession to shade-tolerant woody forest species of Guineo–Congolian origin at the expense of extra-regional herbs, the coexistence of species with slightly different requirements and the fate of exotic trees in this natural forest were studied. A quantitative assessment of a homogeneous lot indicated 397 trees/ha, 43.7% of them with stems below 20 cm, and a rich undergrowth of 72,600 smaller plants/ha, proof of active rejuvenation. Only 4.2% of all plants resulted from the 1041 introduction events of 222 plant species that were new to Drabo.

A total of 635 species were recorded. In June 2016, the total of 581 surviving species included 224 trees. Among all plants, 244 hailed from the Guineo–Congolian zone and 113 from the three savanna zones; 224 were of extraregional origin. Altogether, 72.8% of all woody plants were of forest and tree–savanna origin, whereas 70.4% of all herbs came from regions outside forested West Africa. Only 70% of all species from the forest zone were in decline but the farther away the origin of the plants, the larger the decline in numbers and vigor. In particular, pan-tropical herbs became ever rarer, with 80% of them declining and remaining confined to the few remaining open spaces along paths.

Stakeholders: People from Drabo Gbo at the handing over ceremony – many and difficult to convince about the wisdom of having a forest next to their home.
Photo by P. Neuenschwander, IITA.

Caption here IITA.

The forest harbors 52 threatened species out of the 73 IUCN-listed species that could possibly survive in Drabo, with threat categories ranging from extinct in the wild, critically endangered, or endangered, to vulnerable on the Red List of Bénin. Some of these species occur in only one or two other locations in Bénin, making Drabo a sanctuary not only for monkeys but also for plants.

The richness in biodiversity of the rehabilitated forests of Drabo now rivals that of the remnant natural rainforests that dot the region, making it a prime site for research in biodiversity and related topics. As the surrounding landscape becomes increasingly impoverished because of high human population, the maintenance of such islands of biodiversity becomes even more critical for the survival of plant and animal species.

By establishing a protective area that will enable rare and endangered species to establish and propagate themselves, we can help compensate for the impact of human intrusion and the resulting loss of species in the highly fragmented forest landscape of Bénin.

References

Neuenschwander P, Sinsin B, Goergen G. 2011. Protection de la nature en Afrique de l'Ouest : Une Liste Rouge pour le Bénin. Nature Conservation in West Africa: Red List for Benin. IITA, Ibadan, Nigeria, 365 pp.

Neuenschwander P, Bown D, Hèdégbètan GC, Adomou A. 2015. Long-term conservation and rehabilitation of threatened rain forest patches under different human population pressures in West Africa. Nature Conservation 13: 21–46.

Neuenschwander P, Adomou A (submitted) Reconstituting a rainforest patch in southern Bénin for the protection of threatened plants. Nature Conservation.

Rich traditions are part of the quality of life. Here the 'paillottes' *(thatched huts) are dancing.* Photo by P. Neuenschwander, IITA.

A concerted effort against weeds in cassava

Alfred Dixon, Friday Ekeleme, Godwin Atser, and Stefan Hauser, IITA, Ibadan, Nigeria; David Chikoye, IITA, Zambia; and Kenton Dashiell, IITA, Ibadan, Nigeria

Weeds are major constraints to the productivity of cassava with a negative impact on millions of African farmers that depend on the root crop for their livelihoods. Yield losses vary between 50 and 90% depending on the level of infestation in the fields.

In Nigeria, home to an annual production of about 54 million tons, the yield is less than 8 t/ha, which is paltry compared to cassava-producing countries in Asia such as India and Thailand where yields average more than 20 t/ha. Several studies point to poor control of weeds as a major contributor to this low yield performance in Nigeria and similar results across Africa. But beyond reducing yields, such infestation also undermines the health and social life of farmers, especially the women and children. Weeding is generally done manually using a hand hoe in Nigeria and is back-breaking work. Farmers, mostly the women, spend an average of 500 hours yearly weeding their cassava fields. And in many cases, children are drafted or pulled out of school to assist them.

The Cassava Weed Management Project to the rescue

To address the weed menace in cassava cropping systems, the Cassava Weed Management Project (CWMP) was conceived in 2014 with funding support from the Bill & Melinda Gates Foundation. The project aims to improve the agronomy of cassava, looking at practices such as tillage versus no tillage, cassava varieties, planting density, fertilization, and intercropping. Closely linked to agronomy is the identification and adaption of mechanical weed control methods. The project also screens environmentally friendly herbicides, evaluates their use, and integrates all the weed control options in one package. It builds the capacity of extension and spray service providers on implementing weed control measures while ensuring the equal participation of men and women in the process.

Women and children generally do the weeding—manually—in cassava fields in Nigeria. Photo by IITA.

Getting partners on board

Before its commencement in 2014, the project invited chemical companies such as Bayer AG, Syngenta, SaroAgroSciences, BASF, Valent, FMC, and Monsanto to a participatory planning meeting. The meeting sought the buy-in of the chemical companies for sustainability of the project's interventions. Other partners that attended the pre-inception meeting were CropLife Nigeria, the National Agency for Food and Drug Administration and Control (NAFDAC), the Standards Organization of Nigeria (SON), the Federal Ministry of Agriculture and Rural Development (FMARD), and the National Environmental Standards and Regulation Enforcement Agency (NESREA). The meeting, among other things, drew up a list of candidate herbicides for screening in cassava farming systems. Because these companies were involved at the initial stage it became easier for them to take part in the subsequent training of extension workers and farmers in the safe use and handling of herbicides.

Weeding in cassava fields does not have to be a back-breaking chore! Photo by IITA.

During its first two years, the project conducted trials on agronomy and mechanical weeding, and screened more than 41 herbicides across three of the agroecological zones of Nigeria (derived savanna, southern Guinea savanna, and humid forest). The project worked with existing and new partners such as FMARD, cassava producer associations, agro-dealers, chemical companies, the Federal University of Agriculture at Makurdi, the Federal University of Agriculture Abeokuta, the National Root Crops Research Institute, NAFDAC, SON, Agricultural Development Programs, and Extension Service Providers, i.e., contract sprayers, (also referred to as spray service providers or SSPs). The project established synergistic links with other IITA-led projects such as the African Cassava Agronomy Initiative (ACAI) and the COMPRO II Project that similarly use partnerships to develop, commercialize, and diffuse agricultural products that increase crop yields.

CWMP: The journey so far

The initial partnerships established by the project with the signing of memoranda of understanding with the diverse stakeholders brought several benefits. For instance, six companies provided herbicides free of charge for screening. In all, the project screened and analyzed herbicides of 41 different types under transparent and controlled conditions, leading to the selection of those best performing for on-farm demonstration. The involvement of regulatory agencies such as NAFDAC, NESREA, and SON enabled the easy shipment of the identified herbicides into Nigeria from abroad; this was also facilitated through IITA's own Supply Chain Unit.

Year 3 of CWMP was a transition phase to on-farm trials but this time with researchers managing the trials and farmers playing an active role in observation and the mobilization of fellow farmers. The project recorded

Spray service providers undergoing practical training on knapsack calibration.
Photo by IITA.

success on this front. The collaboration with the ADPs, NRCRI, universities, and farmers was the key in establishing the trials and ensuring that they were safe from outbreaks of fire or attacks by cattle. This collective action that brought on-board SSPs and agro-dealers at the village level also helped pull in much-needed financial and in-kind resources from other stakeholders, thereby contributing towards the sustainability of the project's initiatives.

In 2016, the project organized several farmers' field days and other related activities. During these field days farmers were mobilized to participate, learn, and understand improved methods of cassava cultivation. The field activities also provided an opportunity to share knowledge on herbicide safety and other aspects of cassava production. In all, the project has directly reached 7121 farmers through its activities (2229 females and 4892 males).

During the same period, CWMP produced 13 project-related articles, which were shared with more than 200 journalists. The stories were also published in the project's newsletter and website. The newsletters were shared with 3005 individuals via email; a limited number of copies were printed and handed to people in face-to-face meetings. The newsletter, *Cassava Matters*, has become a platform for sharing information not only of CWMP activities but also of ACAI and Building a Sustainable, Integrated Seed System for Cassava in Nigeria (BASICS).

Regarding its Web and social media presence, the project's website (http://www.cassavaweed.org/) recorded 1851 downloads, while 21 documents and videos were uploaded. The CWMP Twitter account (CassavaWeedMgt) produced a total of 2080 tweets in 2016 and has 753 followers. The project's Facebook page (https://www.facebook.com/cassava.weedmgt) has 728 followers and registered 710 likes

for the page (https://www.facebook.com/Sustainablecassavasystems). Its LinkedIn account (https://www.linkedin.com/in/cassava-weed-management-project) has 1,565 contacts. The project also has accounts on Slideshare (http://www.slideshare.net/CassavaWeed14), with 18 uploaded documents and 7962 views; on Pinterest with 5427 views; as well as on Flickr and Google+. The YouTube channel houses 10 videos, with a total of 760 views. A Facebook group was also created with 372 members by the end of 2016. Through social media, CWMP reached about 110,000 individuals.

The Project's mobile WhatsApp application was a game changer for reaching farmers. We created a WhatsApp group also called *Cassava Matters* that has consistently been fully subscribed. The platform provides an interface in real time, connecting farmers with extension service providers, researchers, and processors, among others. Farmers are provided with information relating not only to weed control but also to other aspects of cassava cultivation. The platform currently has 256 members. The success of *Cassava Matters* is making other similar projects adopt the innovation.

Farmers at Aba Dapo Farmers' Field Day in Oyo State.
Photo by IITA.

Soil Health Consortiums: Making soil fertility management more relevant to farmers

Elzo Jeroen Huising, IITA, Ibadan, Nigeria

The West Africa Soil Health Consortium (WASHC) project started three years ago with the aim to establish and provide support to Soil Health Consortiums in five West African countries. This would facilitate wider uptake of Integrated Soil Fertility Management (ISFM) practices and technologies with visible impact on rural livelihoods. The project was funded by the Alliance for a Green Revolution in Africa (AGRA) as an initiative of the Soil Health Program.

The project is based on the rationale that even though a lot of research on ISFM has been done in the past, little has been achieved in the way of farmers adopting these sustainable soil and land management practices. Farmers have low awareness of ISFM stemming from little or non-availability of related information or they do not have access to the information.

The solutions to soil fertility problems are rather complex in that integrated practices are required to improve productivity in a sustainable manner, especially against the backdrop of degraded soils that is prevalent in African agricultural landscapes. The use of improved crop varieties or the enhanced use of fertilizer, on their own, will not solve the problem if they are not accompanied by measures to improve soil organic matter management and adapt management practices to local conditions. This requires results from research to be translated, better communicated, and delivered to farmers in the form of practical and practicable recommendations. It requires engagement with stakeholders involved in the delivery process as well as building capacity in creating appropriate communication and awareness creation tools. The facilitation can only be done at national or subnational level but it is complex because of the many thematic aspects, the many parties involved, and the institutional arrangements this requires.

Researcher preparing field for planting.
Photo by IITA.

Caption here
Photo by IITA.

Irrigating field.
Photo by IITA.

Under WASHC, IITA facilitated the establishment of six soil health consortia in five countries: one each in Ghana, Mali, Burkina Faso, and Niger; and two in Nigeria, one for the northern region and another for the south. These consortia brought together a wide range of partners from research organizations and development and outreach partners to farmer organizations, input providers, and financial institutions.

These also provided a platform for exchange of data and information, as well as for streamlining and harmonizing the approach to scaling of ISFM and for advocacy on ISFM and more sustainable agricultural production practices. The consortia have put great effort in sensitization and raising awareness on ISFM and in reaching out to farmers through the delivery partners. Much progress has been made with compiling data and information from research trials on various aspects of ISFM and with compiling and developing information materials on several soil fertility management practices and productivity enhancing technologies.

An outstanding achievement of this project is that, for the first time ever in West Africa, a central location or address where information on ISFM can be obtained has been established. The implementing institution in each participating country has taken on the role of hosting that country's soil health consortia. Although the project itself is closing, the consortia are now in the process of registering and getting official recognition such that they could operate in a formal institutional structure to further promote and facilitate the scaling of ISFM.

Mix and match: Choosing best crop combinations and densities for optimum banana production in the Great Lakes Region

Emmanuel Njukwe, IITA, Kigali, Rwanda; Leon Nabahungu, IITA, Bukavu, DR Congo; Marc Schut and Solange Zawadi, IITA, Kigali, Rwanda; Paul M. Dontsop-Nguezet, Christopher Okafor, IITA, Bukavu, DR Congo; and Bernard Vanlauwe, IITA, Nairobi, Kenya

Banana (*Musa*) is a key component of farming systems in the Great Lakes Region with annual per capita consumption in Rwanda, Burundi, and DR Congo estimated at 250 to 400 kg/year (Kilimo Trust 2012). Apart from being a key staple, banana is also a principal source of income for farmers. It has also become an important component of mixed production systems, intercropped with perennial and annual crops such as coffee and beans.

However, banana production in this region is constrained by several factors such as limited access to and use of healthy and improved planting materials and inefficient agronomic practices resulting in low yields (IITA/FAO 2014; Schut et al. 2016). The introduction of improved and elite varieties in smallholder production systems can overcome these challenges, but they are seldom deployed in appropriate combinations with other crops.

In 2006, IITA played a crucial role in initiating the Consortium for Improving Agriculture-based Livelihoods in Central Africa (CIALCA – www.cialca.org). CIALCA conducted research that could support smallholder production systems in becoming both highly

Banana–pumpkin intercrop.
Photo by Emmanuel Njukwe, IITA.

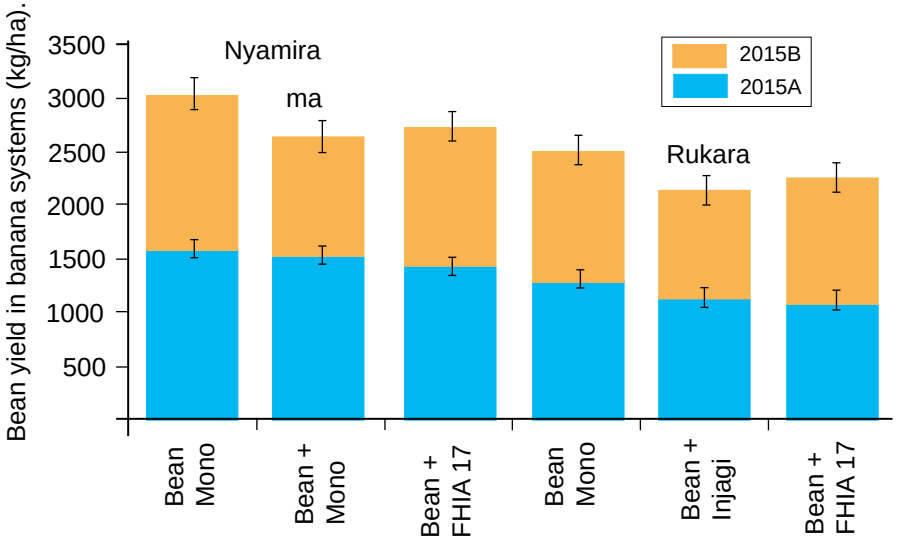


Figure 1. Bean grain yield over two seasons (2015 B, starting in January; and 2015 A, starting in September) in banana cropping system. Injagi and FHIA17 are different banana varieties.

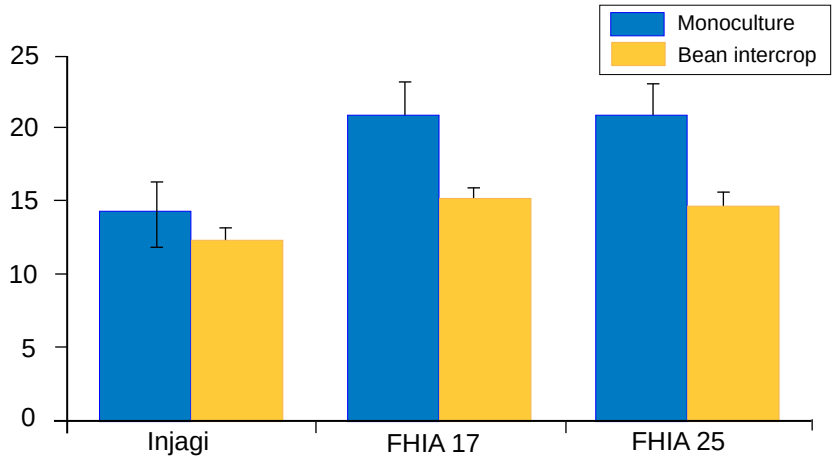


Figure 2. Banana yield (t/ha) in bean cropping system with error bars indicating how the data are spread. Injagi, FHIA 17, and FHIA 25 are different banana varieties.

productive and profitable using intercropping as an option to maintain soil fertility and maximize crop yields. Intercropping is also promoted to mitigate crop failure risk, reduce pest and disease incidence, and to control weeds and soil erosion.

Since its inception, CIALCA has been conducting research for development with a broad focus on increasing food, income, and nutrition security in the Great Lakes Region. CIALCA meets these challenges by building partnerships with research, government, and development partners to access and deliver appropriate agricultural innovations for use by smallholder farmers. One of the innovations that CIALCA is promoting with partners is the intercropping of legumes and vegetables in banana production systems.

Bananas and beans, a likely couple

The intercropping of bananas and beans (*Phaseolus vulgaris* L.) is a common production practice in the Great Lakes Region. In on-farm experiments by CIALCA, a variety of bush bean (RWR2245) was evaluated in sole crop and in association with different banana varieties (Injagi, FHIA 17, and FHIA 25) to determine bean and banana yields in monoculture and as intercrop (Figs. 1 and 2). Trials were established in a randomized complete block design with 3 replicates of 9 banana plants per replication spaced at 3 m × 3 m, and bean intercropped at a spacing of 40 cm × 40 cm.

Results showed that apart from banana cultivar Injagi, yield of improved varieties FHIA 17 and FHIA 25 in the intercrop system was significantly different and could be attributed to competition for soil moisture and nutrients as the improved varieties appeared to be more competitive in the intercrop system. On the other hand, the difference observed in bean yield when intercropped with banana could be attributed to shading. Variety effect showed that FHIA 17 and FHIA 25 gave significantly higher fresh bunch yields compared to the local cultivar Injagi, irrespective of the location, with FHIA 17 performing better.

Banana intercropping: The case of Rwanda

In Rwanda, 200 farmers were observed and interviewed in 2015–2016 to assess the suitability and profitability of intercropping banana (Mukarugwiza 2016). Correspondence analysis showed that there is no structured variation in monoculture banana production in terms of plant density (3 m × 3 m or 1100 plants/ha) but two other production systems were identified: (1) association with coffee and fruit trees; and (2) association with legumes and vegetables during field establishment.

Results of benefit-cost ratio (BCR) analysis indicate that banana intercropped with vegetables is more profitable with a BCR of 5.4, followed by coffee at 4.8, and common beans at 4.4. These imply that the production systems are suitable and profitable, returning $5.4, $4.8, and $4.4 for every $1 invested in vegetable, coffee, and common beans, respectively.

Inclusion of taro, eggplant, and pumpkin with varying degrees of shade tolerance after nitrogen-fixing legumes when banana has already developed a dense canopy is beneficial to smallholder farmers for year-round use of available space, light, and soil moisture. To increase farmer access to healthy and improved banana varieties, over 400 farmers were trained on banana macropropagation techniques.

Banana intercropping pays more, really!

Edward Habinshuti of Uwingando village in Kamonyi District swears by the profitability of banana intercropping. His multicrop farm produces over 1500 seedlings of banana and he harvests about 200 bunches (worth $1200) monthly. His wife intercrops groundnut during the early stage of banana development, harvesting 2–3 cycles of groundnut (worth $1500) before the bananas develop dense canopy. Edward says that he used to harvest about three bags of maize from his farm, but the returns from the banana and groundnut are worth 5 times more. He adds that with the bananas, nothing goes to waste as he uses the peels, leaves, and pseudostems as feed for his goats. In return, he uses the goat manure to fertilize his banana plants—a good deal indeed!

Banana–groundnut intercrop. Photo by Emmanuel Njukwe, IITA.

Better now with better know-how

Irmgard Hoeschle-Zeledon, Manager, and Jonathan Odhong, Communications Specialist, Africa RISING, IITA, Ibadan, Nigeria; and Gloriana Ndibalema, Africa RISING-NAFAKA, IITA, Tanzania

In rural areas, the adoption—or non-adoption—of improved agricultural technologies, skills, and knowledge by farmers could spell the difference between getting stuck in a poverty rut or moving forward to better times. In Africa RISING, building the capacity of farmers is a basic tenet, one that has the potential of improving farmers' lives beyond just the "cash flow".

Since its inception in early 2012, the IITA-led Africa RISING projects in West Africa and East/Southern Africa have so far benefited more than 40,000 farmers with training on agricultural productivity and food security. Halima Mohamed Katumbu and Kassim Lebora are two such beneficiaries of Africa RISING's capacity development efforts in Tanzania whose lives have been improved beyond just the economic.

Tipping the scales of gender equity

Whenever improved agricultural technologies are introduced to rural smallholder farming communities, quite often the focus is primarily on getting better yields. However, this is not—and should not be—the only determinant of the success of such technologies.

When Halima Mohamed Katumbu, from Mkula irrigation scheme, Kilombero District, first heard of a new group in her community that was training farmers on improved rice production techniques, her first instinct was to share this interesting

A happy farm family in one of the project areas. Photo by Michael Dakwa.

information with her husband, Hassan Luheche, who was less than enthused about it.

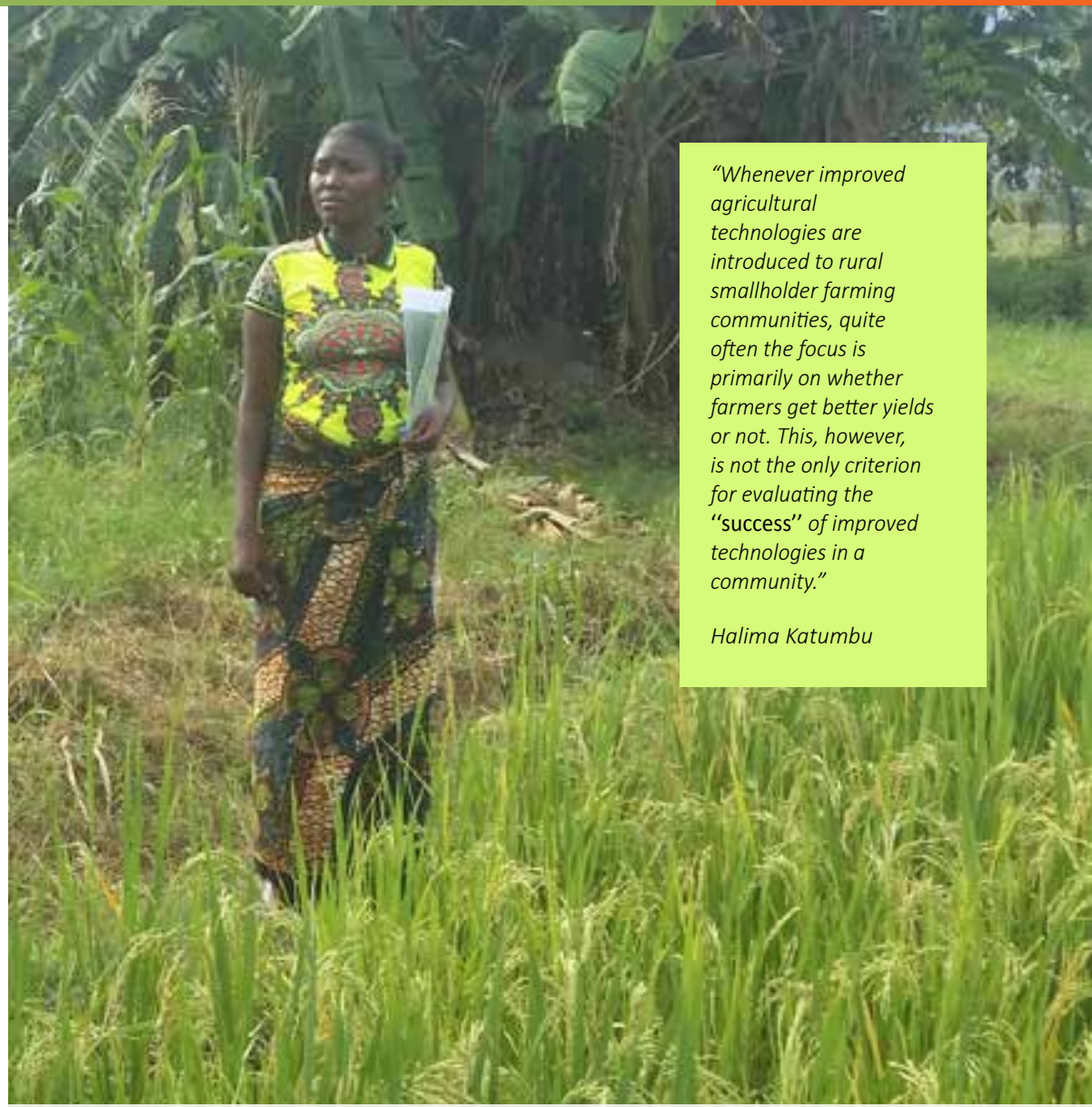
Halima and Hassan, parents of four, had been rice farmers for over 10 years, but despite their best efforts to get optimal yields from their 2-acre paddy, the most they ever harvested was 1440 kg of unmilled rice. They know that they should be getting more, but they did not know how. Furthermore, their earnings became less after having the rice milled, which also cost money.

"My husband and I used to prepare the rice paddy together. However, since we hadn't had any good harvests lately, he's lost interest in growing rice, leaving the task almost entirely to me. I wanted to join the training group, but he did not support the idea as he saw no value in it. But I insisted, so he eventually gave in and allowed me to join," narrates Halima.

After joining the group, Halima got trained on advanced rice production techniques (good agricultural practices) and was introduced to improved rice varieties, which she immediately adopted and planted in her paddy. The combination of adopting the new rice varieties and good agronomic practices produced visible positive results early in the growing season, prompting a change of opinion about the group from her husband.

"After seeing some progress, my husband also got interested and even joined me in the training offered by the group. So far we've been introduced to new rice varieties like TXD 306 and Komboka, which I am now growing. We have also been trained on improved practices that ensure we get the most yields from our paddies such as correct application of fertilizer, the best planting methods, rice paddy management, and proper postharvest practices," says Halima.

After adopting the technologies and recommendations, Halima and Hassan were rewarded with an initial harvest of nearly 2000 kg



"Whenever improved agricultural technologies are introduced to rural smallholder farming communities, quite often the focus is primarily on whether farmers get better yields or not. This, however, is not the only criterion for evaluating the "success" of improved technologies in a community."

Halima Katumbu

Halima standing in her 2-acre rice paddy field. After following the good agronomic practices she was trained on by Africa RISING-NAFAKA project staff, she harvested nearly 2000 kg of unmilled rice, a feat she and her husband had never achieved in the 10 years that they had been rice farmers.
Photo by Gloriana Ndibalema, IITA.

of unmilled rice in the 2015 cropping season. She expects a much better harvest in the coming seasons as they continue to apply and get better at applying the skills she learned and using the best rice varieties to grow.

"My husband and I anticipate that we will see much better harvests ahead, which will be more than enough for home consumption. The surplus we will sell to earn more income," says Halima.

"But for me," Halima adds, "one of the more 'silent' achievements we've made is the fact that our husbands are now getting more involved in rice production and sharing the tasks and resources with us women. We now share responsibilities at the farm because of the positive results of adopting these improved agricultural technologies and practices."

"Our husbands now equally share with us the proceeds from rice sales. The other women in our training group also tell me that their husbands have become less frustrated and conflicts in their households have gone down."

Facilitating women's equitable access to improved agricultural technology can spur their economic advancement and stimulate broader economic growth. In many cases, this is more crucial to the long-term development of a community than just an increase in yields or better incomes.

Halima is just one of the 223 smallholder farmers working with Dakawa Agricultural Research Institute (ARI Dakawa) through the Africa RISING-NAFAKA project in Kilombero District, Tanzania to improve rice production by rural smallholder farming communities. The project is focused on the maize, rice, and vegetable value chains and is introducing and promoting improved varieties, disseminating best-bet agronomic management packages, and introducing and promoting postharvest management technologies.

From shelling to shillings

Kassim Lebora was among a group of 25 farmers from Dihinda Village in Mvomero District, Tanzania, that were trained by the Africa RISING–NAFAKA project partners on improved postharvest management of cereals and legumes.

"That training in November of 2015 exposed me for the first time to various postharvest technologies and opened my eyes to the numerous opportunities therein. It became clear to me that the challenges we had been facing all along in my community particularly with harvesting, shelling, and storage of grains were solvable issues, with ready technologies to overcome them," says Kassim.

At the training, one of the technologies introduced to participants was the motorized maize shelling machine. "After I saw and learned about the motorized maize sheller, it suddenly dawned on me that this machine represented a lucrative business opportunity," Kassim revealed. "There and then, I decided to buy one and start up a shelling business in the village. I had been saving up money to buy a tractor someday, but this idea was quickly replaced by the desire to get that maize shelling machine," he added.

He noted that the motorized sheller, besides reducing farmers' yield losses, also solved the labor demand and workload challenges that have dogged farmers in his village, who over the years have left this laborious postharvest task to women and children.

Kassim turned the postharvest challenge into a business. In one month during the after-harvest season of August 2016, Kassim earned TShs 790,000 (about $350) from the maize shelling business. He charges each farmer TShs 2000 (less than $1 dollar) for a bag of maize shelled. Farmers of Dihinda Village appreciate Kassim's business because of the value it brings to the community.

"Kassim's maize sheller machine takes our village to the next level; it reduces the workload for many farmers, and since he belongs to

our farming group, we are very happy for his development," explains Melkior Mhagama, one of several farmers benefiting from Kassim's business venture.

Kassim plans to save part of his earnings to buy another shelling machine so that he could expand his business to neighboring villages. Having experienced first-hand how modern innovations introduced through projects like Africa RISING–NAFAKA have changed his life, Kassim advises other farmers: "Embrace the opportunities created by new technologies to improve your lives; you have nothing to lose." Over the last two years, the Africa RISING–NAFAKA project has been implementing participatory efforts to boost adoption of viable postharvest solutions by farmers in five regions of Tanzania: Dodoma, Iringa, Manyara, Mbeya, and Morogoro. The project raises awareness by showcasing the value of the technological solutions first-hand to the farmers and communities. Through the initiative, farmers have so far been exposed to the various postharvest technologies such as the Grainpro Super Grain Bag, maize shelling machine, and collapsible drier case.

"The motorized shelling machine, besides reducing farmers' yield losses, also solves the labor demand and workload challenges that have dogged my fellow farmers in the village, who over the years have left this arduous task to women and children after the harvest season."

Kassim Lebora

Kassim Lebora cleans his maize sheller machine in Dihinda Village in Mvomero District, Tanzania. Photo by Frednand Japhet, IITA.

Ensuring impact and delivery

Implementer demonstrating the use of aflasafe with lead farmers. Photo by IYA.

Putting the private sector in the driver's seat to push agricultural innovations

Adebowale Akande, IITA/Deloitte Consulting LLP and Ranajit Bandyopadhyay, IITA, Ibadan, Nigeria

Agriculture in most developing countries is characterized by small-scale farming that relies heavily on the public, rather than the private, sector for its delivery. However, the complex challenges faced by smallholder farmers call for novel approaches to delivering available technologies in appropriate forms to enhance adoption.

Take the case of aflasafe™, an aflatoxin biocontrol technology developed by IITA, the Agriculture Research Service of the United States Department of Agriculture, and several partners for Africa. Aflasafe™ has moved beyond proof of concept: it has been consistently proven to reduce aflatoxins by 80 to 99% during both crop growth and subsequent postharvest storage, and throughout the value chain.

Aflatoxins are dangerous carcinogens produced by fungi when maize and groundnut become naturally infected when growing and/or during storage. Most aflatoxin-producing strains belong to the fungus *Aspergillus flavus*. Aflatoxins cause liver cancer, suppress the immune system, stunt child growth and development, and in some cases, can kill people and animals. It is estimated that in some seasons or regions, up to 40% of maize can be contaminated with aflatoxins. Aflatoxin exposure leads to reduced labor-hours owing to poor health. This leads to compromised productivity, and—in extreme cases—to premature death. Crops with excessive aflatoxin are routinely rejected in premium markets governed by stringent safety requirements on aflatoxin levels.

Although techniques and technologies to reduce aflatoxin contamination have existed for decades, several questions have been raised on the adoption and profitability of biocontrol technology, particularly by and for smallholder farmers.

AgResults and the "pull" mechanism

A model for reducing aflatoxin and creating sustainable market demand for aflasafe™ along the maize value chain is being piloted under the

A farmer examining an aflasafe bag. Photo by IYA.

AgResults Aflasafe Pilot initiative in Nigeria. AgResults develops and implements interventions that address aflatoxin contamination, and that boost socioeconomic benefits at every stage from when the crop is planted, through harvest, and all the way to the market. Through AgResults initiatives, IITA developed an innovative approach to the "pull" mechanism to overcome barriers to adoption of this new technology by smallholder farmers. The project covers 12 states in Nigeria.

This pilot is designed to demonstrate a successful model for increasing smallholder farmers' adoption of biocontrol technology in Nigeria, thereby pulling farmers in. The breakthrough is achieved through reducing barriers that hamper widespread adoption, by offering farmers a premium per-unit payment for maize verified to contain a high content of aflasafe™ strains.

Since its inception in 2012, AgResults has been working with private-sector agricultural enterprises, termed implementers. Currently, implementers are the primary means by which small-scale farmers obtain aflasafe™. In addition, implementers facilitate access to technical knowledge and inputs that farmers require to boost their productivity and move from being solely subsistence to commercial producers. The project provides monetary performance-pegged incentives of $18.75/t to the implementers, with a view to assuring that smallholders produce aflasafe™-treated maize. Through a shared-value approach, smallholder farmers working with the implementers shared from both the performance-pegged incentives and premium received from buyers of the aflasafe™-treated maize after sales.

When the private sector leads the way

The AgResults project has successfully demonstrated that private sector involvement in innovation delivery significantly influences how farmers can be reached with available technologies. It also proves that smallholder farmers can enjoy commensurate premiums from using the innovation. The initiative helps resource-poor farmers to access the technology, and to acquire the knowledge necessary for its beneficial adoption.

Implementer explaining use of Aflasafe.
Photo by IITA.

So far, 24 agricultural enterprises have worked with more than 30,000 smallholder maize farmers in 12 Nigerian states. The enterprises provide farmers with aflasafe™, improve their farm-management practices, aggregate their produce, and ultimately link them to premium markets that command higher prices for aflatoxin-safe maize.

In four years, these smallholders bought 300 tons of aflasafe™, which they applied on 32,000 ha of maize to reduce aflatoxin. Consequently, 96.6% of the maize grain-lots where aflasafe™ was applied saw a dramatic reduction in aflatoxin. In addition, the yield increased by 50% compared to the national average primarily due to the adoption of improved farming practices. Annually, on average, there is 53.6% aggregation of maize for sale, while 22.6% was retained at home, 7% was sold at the farm gate, and 16.8% was sold at different times before aggregation, also given to family members and friends.

Smallholder farmers have benefited greatly from premium payments for aflasafe™-treated maize sold to food and feed industries. Grain lots from aflasafe™-treated fields fetched, on average, a 542% return on investment on aflasafe™ from sale to anchor buyers. The total gross earnings of all implementers from the premium received from anchor buyers (72.4% of total earning) and incentives from AgResults (27.6% of total earning) were nearly 180 million Naira (or about $570,000).

These results demonstrate how AgResults contributes not only to upscaling the technology to improve smallholder livelihoods and health, but also to strengthening local economies through the pull mechanism.

References

AgResults Nigeria Aflasafe Pilot: http://agresults.org/en/283/NigeriaAflasafePilot20

AgResults Nigeria Aflasafe Quarterly Report Technical Report. IITA-Deloitte (Nov-Dec 2016), PJ 1773.

Bandyopadhyay, R., A. Ortega-Beltran, A. Akande, C. Mutegi, J. Atehnkeng, L. Kaptoge, A.L. Senghor, B.N. Adhikari, and P.J. Cotty. 2016. Biological control of aflatoxins in Africa: Current status and potential challenges in the face of climate change, World Mycotoxin Journal 9: 771–789.

Top: Training of trainers for the implementers. Bottom: IITA Scientist Ranajit Bandyophadyay explaining to a young farmer the importance of aflatoxin management in maize. Photos by Ezekiel Onasanya, IITA.

Realizing a hunger-free Nigeria

Kenton Dashiell, IITA, Ibadan, Nigeria

In 2016, IITA was instrumental in the development of the "Zero Hunger in Nigeria" Strategy – a document that outlines what the country needs to do to achieve hunger-free status by 2030, in line with one the United Nations Strategic Development Goals (SDGs). However, this gargantuan goal is easier said than done.

The 2016 edition of the Global Hunger Index (GHI), produced by the International Food Policy Research Institute (IFPRI), show that Nigeria has steadily been reducing its GHI scores since 2000 (GHI score of 40.9, or alarming) but the severity of hunger in the country is still categorized as serious (GHI score of 25.5). Additionally, IFAD statistics show that poverty and hunger remains widespread, and in recent years even increased in some areas, with an estimated 70% of the population—or a staggering 133 million Nigerians—who are mostly rural area dwellers living on less than $1.25 a day!

The beginnings of the Nigeria "Zero Hunger" Strategy

Nigeria is party to the historic Millennium Declaration, which was signed by leaders of 189 countries at the UN's Millennium Summit held in 2000. In this declaration, the signatories committed themselves to

Zero Hunger advocates in NIgeria led by former Pres. Olusegun Obasanjo during a meeting in Abuja. Photo by IITA.

achieving the Millennium Development Goals (MDGs)—eight goals with measurable targets and clear deadlines for improving the lives of the world's poorest people and eradicating poverty and hunger—within 15 years. As the MDGs ended in 2015, they were replaced by a set of 17 SDGs which began in 2016.

One of the SDGs—specifically SDG 2, also known as Zero Hunger—is of importance to Nigeria and relates deeply to IITA's work. This SDG focuses on food security and nutrition and calls on member-states to "…end hunger, achieve food security and improved nutrition, and promote sustainable agriculture by 2030".

In February 2016, the former President of Nigeria and presently the International Goodwill Ambassador for IITA, Chief Olusegun Obasanjo met with Ertharin Cousin, Executive Director of the World Food Program (WFP) to brainstorm on how Nigeria could best achieve Zero Hunger by 2030. This resulted in the agreement that Chief Obasanjo would head the Zero Hunger Strategic Review in Nigeria (ZHSRN). Chief Obasanjo then tasked IITA to be his technical advisor on this initiative and also serve as the Secretariat to the ZHSRN.

As an initial step, IITA organized an inaugural ZHSRN meeting on 29 April, which convened Nigerian partners and stakeholders concerned with food and nutrition security. During this convention, nine operational ZHSRN subcommittees were formed, each tasked with specific assignments to do data collection, research, and formulate recommendations related to food and nutrition security.

By September, the subcommittees completed their preliminary work and submitted their findings to IITA. In early October, IITA convened the second ZHSRN meeting in Abuja, during which the individual subcommittee reports were reviewed and refined. And by the third ZHSRN meeting also held in late-October in Abuja, the revised individual reports were deliberated and integrated into a synthesized report.

On 15 December, after incorporating further inputs from all participants in the review process, IITA finalized and produced

Top: IITA DG Nteranya Sanginga (left) and former Nigerian President Olasegun Obasanjo (wearing blue headdress) with some government officials and partners in IITA. Bottom: Zero Hunger meeting participants in a group discussion. Photos by IITA.

Top: Elizabeth Parkes, cassava expert, leads the team from Ebonyi, Nigeria, on a tour around IITA facilities. Bottom: Kenton Dashiell, IITA DDG, Partnerships for Delivery (left), presents the implementation document of the Forum to His Excellency, Engr. Dave Umahi, the Executive Governor of Ebonyi State. Photos by IITA.

the "Synthesis Report of the Zero Hunger Strategic Review in Nigeria", which was officially launched by the institute on 11 January 2017.

Full steam ahead

At the launch of the ZHSRN Synthesis Report in January 2017, Chief Obasanjo indicated that the initiative "is not an attempt at changing any government policy. The ZHSRN was undertaken to support and encourage the Nigerian Government to implement the policies, strategies, plans, and programs that itself and partners have formulated over the years, all with the focus of achieving SDG 2 by 2030, if not earlier."

According to the IITA Goodwill Ambassador, Nigeria has no shortage of good prescriptions and studies for reducing hunger but their implementation has been poor. This time around—especially with the establishment of the Nigeria Zero Hunger Forum based at IITA—this initiative will ensure that the recommendations in the ZHSRN Synthesis Report are fully implemented.

As outlined in the ZHSRN Synthesis Report, the IITA-based Nigeria Zero Hunger Forum will initially support, encourage, and monitor progress in Benue, Ebony, Ogun, and Sokoto states in 2017 and 2018, whose governors have agreed to prioritize the implementation of the report's recommendations. By January 2019, eight more states will follow suit. Finally, by January 2021 all 36 states plus Abuja are expected to be implementing the Zero Hunger in Nigeria Strategy.

The need for a collective will

Chief Obasanjo emphasized that the collective will of the Nigerian people is key to the successful implementation of a Zero Hunger Strategy in Nigeria. He reiterated that no single Nigerian sector or entity on its own—whether it is government, civil society, or the private sector—could make such a strategy work as intended. There must be strong support particularly for farmers, producers, and/or farmers' organizations

at all levels and from all sectors, with the government providing enabling policies, regulations, and incentives that will create an environment conducive to the strategy's implementation.

The Strategy is going to need the combined efforts of all Nigerians if it is to achieve its intended impact. To make this happen, however, will also require a major and collective shift in the mindset of the people to, first, be able to identify and, later on, maximize on the opportunities.

To put the Strategy in the right path at its onset, Chief Obasanjo emphasized the importance of providing farmers with sufficient and good quality farm inputs such as fertilizers and seeds in a timely manner, especially for the coming 2017 planting season which is the take-off period for the Zero Hunger Strategy. This is crucial if the country is to produce enough nutritious food for Nigeria's large and still booming population, while at the same time have enough raw materials to feed other agriculture-based industries.

A multilateral effort

The development of the ZHSN Synthesis Report, which forms the basis for the Zero Hunger in Nigeria Strategy, would not have been possible without the cooperation, dedication, and commitment of a diverse blend of development partners, Federal and State Governments, legislators, NGOs, farmers, farmer groups and other actors representing sectors relevant to food and nutrition security in Nigeria.

Special mention goes to His Excellency Muhammadu Buhari, President of the Federal Republic of Nigeria, for endorsing the Nigeria Zero Hunger Strategic Review, and Ms Ertharin Cousin, Executive Director of WFP for requesting that the review be conducted and, thereby, started the ball rolling.

Other donors and partners also pitched in to support the completion of the review process and the ZHSRN Synthesis Report. These included the African Development Bank (AfDB), WFP, the International Fund for Agricultural Development (IFAD), the United States Agency for International Development (USAID), the Food and Agriculture Organization of the United Nations (FAO), the Delegation of the European Union to Nigeria, and the United Nations Children's Fund (UNICEF).

Press briefing at the Zero Hunger meeting in Abuja, Nigeria.
Photo by IITA.

Chief Obasanjo credited IITA for its efforts in the development of the Synthesis Report and Zero Hunger Strategy.

"I must express my deepest thanks and appreciation to IITA for organizing the meetings, coordinating development of the review report, and for acting as the Secretariat, initially of the ZHSRN process, and later the Nigeria Zero Hunger Forum. As we move forward with this Strategy, I see IITA as playing a crucial role in its implementation and achievement of its intended goal, " he concluded.

References

Country Meters. 2017. Nigeria Population. http://countrymeters.info/en/Nigeria.

Global Hunger Index. 2016. Nigeria Hunger Index. International Food Policy Research Institute (IFPRI). http://ghi.ifpri.org/countries/NGA and http://www.ifpri.org/topic/global-hunger-index.

Open Data for Africa. 2017. Nigeria Data Portal. NIH, NBS, and the African Development Bank (AfDB). http://nigeria.opendataforafrica.org/.

Accuracy is the key: Lessons from the CMS project in Nigeria

Tesfamicheal Wossen, IITA, Abuja, Nigeria; Tahirou Abdoulaye and Ismail Rabbi, IITA, Ibadan, Nigeria; Arega Alene, IITA, Lilongwe, Malawi; Shiferaw Feleke, IITA, Dar es Salaam, Tanzania; Godwin Asumugha, National Root Crops Research Institute, Umudike, Nigeria; and Victor Manyong, IITA, Dar es Salaam, Tanzania

Many of the challenges we face today such as food insecurity and poverty require innovative and multidisciplinary approaches. The development, dissemination, and adoption of improved crop varieties provide a major pathway by which agricultural research can bring about gains in productivity, food security, and poverty reduction.

To attain these, understanding how and why smallholder farmers adopt improved varieties is vital for targeting and prioritizing technologies that are appropriate to their conditions.

To this end, IITA has implemented the project "Cassava Monitoring Survey (CMS) in Nigeria" which involves a multidisciplinary team of breeders, biotechnologists, bioinformaticians, economists, extension

The CMS team at the training session of field enumerators. Photo by IITA.

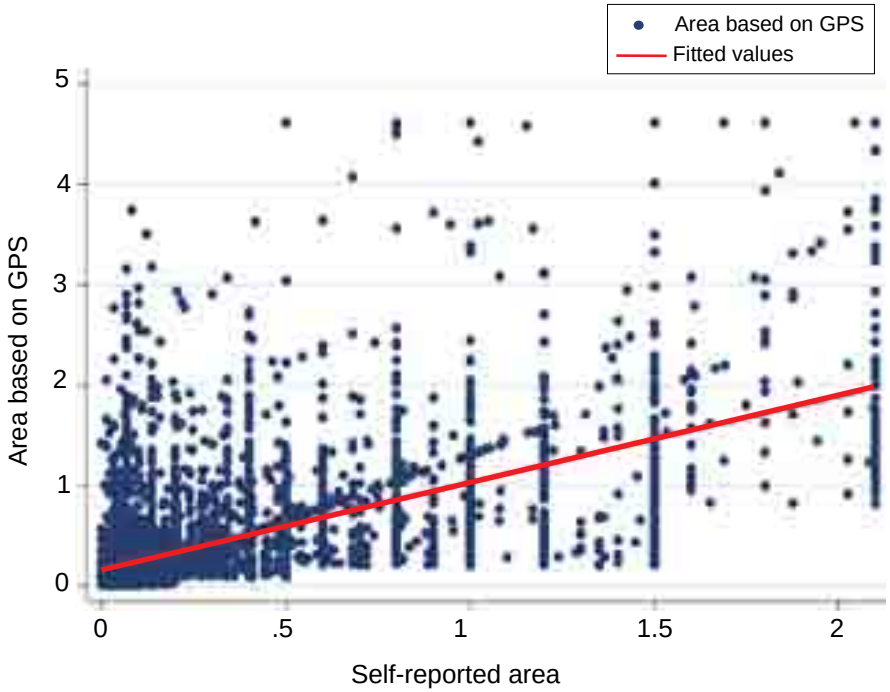


Figure 1. Correlation between GPS-based plot area and self-reported plot area.

officers, agronomists, gender experts, and postharvest specialists (Fig. 1). The project was jointly funded by the CGIAR Research Program (CRP) on Roots, Tubers and Bananas (RTB), the Bill & Melinda Gates Foundation, IITA, and the CGIAR Standing Panel on Impact Assessment (SPIA).

This project introduced area measurement based on the Global Positioning System (GPS) to accurately determine the land allocated to cassava among smallholders in Nigeria. Findings show a clear disparity between the GPS measurements and farmer-reported area measurements, with farmers overestimating the size of small plots and underestimating the size of large ones (Fig. 1).

Additionally, the CMS project—for the first time in CGIAR—introduced DNA fingerprinting to track the adoption of improved cassava varieties by smallholder farmers. The innovative method accurately identifies varieties grown by farmers and provides a benchmark against which the effectiveness of other potential methods for scaling up could be assessed. The project has enabled IITA to accurately document adoption rates of cassava varieties in Nigeria, and, consequently, undertake a credible assessment of the effect of adoption of improved varieties on productivity, food security, and poverty in the country.

Using farmer-reported data, the project showed that about 60% of the farmers grow improved cassava. However, when DNA fingerprinting was used to measure adoption, it was found that about 66% of the farmers actually grow improved varieties. A comparison

A female enumerator taking a cassava leaf sample for DNA-extraction. Photo by IITA.

between DNA fingerprinting and household survey adoption data further showed that 41% of the respondents misreported their cassava variety adoption status. About 28% of the farmers believed that they were growing local varieties when they were actually growing improved ones. Conversely, about 13% of the surveyed households believed that they were growing improved varieties when they were actually growing local ones.

Discussing with farmers. Photo by IITA.

Findings by the CMS project clearly underscore the perils of such misclassification of adoption status by farmers, which could lead to wrong conclusions and inappropriate policy recommendations. These underline the importance of designing a well-functioning seed system to reduce errors related to misreporting by farmers.

Using DNA fingerprinting, the project concretely showed that adoption of improved cassava varieties has led to a 58% increase in yields. If we had measured the productivity gains from the adoption of improved varieties using self-reported data from household surveys instead of DNA fingerprinting-based data, the result would have been 46%. This would have significantly undermined the role of crop genetic improvement in ensuring food security, a critical argument for funding such investments in Africa.

The project further showed that productivity gains resulting from the adoption of improved cassava varieties have reduced poverty by 4 percentage points, which translates to roughly 2 million individuals lifted out of poverty. Again, if only self-reported adoption data were used, the number of individuals escaping poverty would have been reported to be only 1.6 million, considerably undervaluing the role of improved varieties in enhancing rural livelihoods.

Despite the higher adoption rate, the intensification rate of improved cassava varieties was found to be only about 38%, which is quite modest. This would have been higher if the availability of planting material and access to extension and input and output markets were better.

In addition to its relevance in creating appropriate supporting policies, the CMS project also played a key role in building capacities. For example, IITA developed a toolkit for collecting samples from farmers' fields to be taken to laboratories for DNA extraction. IITA has also established a strong collaboration with Cornell University for undertaking genotyping-by-sequencing for the accurate identification of varieties grown by farmers. Learning from the CMS project, the Bill & Melinda Gates Foundation launched a similar new project called "The Nigerian Baseline Survey" that will use the methods developed in the CMS project in four priority states in the country. The Foundation is also funding similar research to track the adoption of other major crops in Nigeria.

A coming of age for African youth in agriculture

Adetola Adenmosun, IYA, IITA, Ibadan, Nigeria

The IITA Youth Agripreneurs (IYA) program has indeed come a long way since its inception four years ago, growing in number and activities and getting recognition along the way. The IYA was formally recognized as an IITA program in October 2016. An Office was established and personnel—a coordinator as well as one who underwent training and mentorship under IYA—were hired to oversee its operations. The Youth in Agribusiness Office coordinates all activities and projects of IYA.

Youth Agripreneurs: Surging ahead

In 2016 IYA partnered with Chevron Nigeria Ltd in a capacity building project in the Niger Delta region to train young men and women on agribusiness. In the first phase of this partnership, IYA established demonstration sites in different communities in Warri, Delta State.

IYA used its experience from its first private sector-funded project to leverage additional funding from other private sector players to implement projects that aided in reaching more African youth. Among these were the Hello-Tractor project sponsored by USAID through its Feed-the-Future Partnering for Innovation Initiative, and the Agrifood Youth Opportunity Lab (Ag Youth Lab) in partnership with Michigan State University (MSU) and sponsored by the Master Card Foundation.

The IITA Youth Agripreneurs and their supporters (in jackets and ties, from left): Chiji Ojukwu, AfDB; Nteranya Sanginga, IITA; and Akin Adesina, AfDB.
Photo by IITA.

Under the Hello-Tractor project, IYA trained young adults on the business of owning and managing a fleet of smart tractors—versatile farm machines that are networked to powerful software that increases their operational efficiency. In this business, farmers in need of a tractor can be connected to an owner of a smart tractor simply through text messaging. Those trained are expected to develop a business plan to enable them to apply for business loans from banks to start up their own smart tractor enterprise, with the longer term goal of promoting mechanization and improving farm efficiency in Nigeria.

The Ag Youth Lab is a multi-million dollar project that will run for five years and focus on the major food producing regions surrounding Lagos (Oyo, Osun, and Ogun states) in Nigeria and Dar es Salaam (Pwani and Morogoro regions) in Tanzania. It aims to train disadvantaged, out-of-school young people between the ages of 18 and 24. It will assist more than 14,550 of them in getting access to higher wage jobs and starting businesses in horticulture, aquaculture, or poultry keeping, and in the cassava or oilseeds sectors. The program will have a special focus on promoting gender equity across its activities.

In 2016, the IYA expanded its reach to Kano in northern Nigeria and Onne in Rivers State. Nine Agripreneurs were deployed to establish a replicate group and give the youth in the northern and south-south parts of the country an opportunity to go through the group's incubation program. The group at Onne has partnered with a major chain store in Port Harcourt, supplying them with catfish that they raise. They are also becoming known for producing disease-free plantain suckers for local farmers. The Kano IYA group has started a ram fattening business and sorghum production. They have also partnered with Honeywell Flour Mills for sale of the sorghum.

The IYA mother group based in Ibadan expanded its membership to compensate for the numbers who were relocated to Kano and Onne. During the year, a new batch of Agripreneurs, who call themselves the Green Magic Agripreneurs were recruited after going through a screening exercise.

Top: Agripreneurs harvesting vegetables to be sold to a wholesaler in town.
Bottom: Trainees being taught on the use of the Hello Tractor app. Photos by IITA.

The success of IYA paved the way for the African Development Bank (AfDB) to adopt it as a model for its Africa-wide ENABLE Youth Program which was launched in 2014. More than 30 countries indicated an interest in the Program. Towards the last quarter of 2016, the Bank approved the Program for Algeria, Nigeria, DR Congo, and Sudan as stand-alone projects; 12 other countries integrated the Program as a component of existing youth projects. IITA's own IYA members have been requested by the Bank to provide support.

During the year, IITA, in partnership with a private company, Ekimiks Nigeria Ltd, trained IYA members on developing business plans that would enable them to obtain loans from financial institutions to establish their own agribusiness enterprises. This is in line with IYA's tenet that Agripreneurs must put into practice what they have learned after an 18-month incubation program. Over 25 business plans were developed by the trainees, which are being reviewed by financial and business experts for funding in 2017.

In the DRC, the IYA opened a town center store that sells high-quality cassava flour that the group produces and that they also export to Rwanda, competing with a major brand there. This is a major market breakthrough for IYA in the country as it presents an expanded business opportunity. Similarly in Nigeria, IYA's business ventures continued to hold sway, seeing the group's earnings in 2016 jump by 40% over the previous year.

Influencing young minds, IYA in 2016 organized another debate during the visit of the IFAD President, Dr Kanayo Nwanze. The visit of Dr Nwanze heralded the jubilee celebration of IITA. Topics discussed included "There is more value in production than processing," "It is better to invest in loans than make grants," and "Men are better at production and women are better in business."

Increasing its visibility, IYA contributed youth-in-agribusiness articles in regional and international publications such as the World Farmers Organization, and ICT Update. Through stories, IYA is promoting its vision of African youth actively engaging in agriculture to influence a shift in the generational mindset. Technically, IYA is also sharing its experience in the use of drones (unmanned aerial vehicles – UAVs) as a tool in agricultural development. Members of IYA in Abuja also won a computer programming talent competition called AgriHack, which was organized by the Center for Technical Cooperation in Agriculture (CTA). The competition was based on how ICT can aid in fish farming. The IYA group won the top prize of $5000 and gained national recognition for their effort.

Still on the ICT front, the IYA group in Uganda has continued to successfully deploy their online marketing and sales platform, which

IYA's major distributor for Tidbits in Ile-Ife Osun State. Photo by IITA.

has helped eliminate the need for middlemen in the sale of the vegetables that they produce. This has helped to boost the group's profits, avoid being tied to prices usually dictated by middlemen, and get a better share of the market. Fewer vegetables are spoiled as they do not need to stock and display them.

In Kenya, the youth group is also making waves in the production and sale of farm-fresh tomato particularly in the Mombasa area. The Kenyan IYA group is also known for producing vitamin A potato crisps, the brainchild of one member. The potato crisps, known as Beta Crisp, are sold in shops and markets in the Kibwezi area.

Agripreneurs flanking the CEO of Master Card Foundation, Reeta Roy, at the Youth Summit in South Africa. Photo by IITA.

In 2015, business start-up grants were awarded to 40 young men and women in Borno State, Nigeria, who had been trained on agribusiness under the IITA-led N2Africa project, which is sponsored by the Bill & Melinda Gates Foundation. This year, many of the grantees now run their own successful agribusinesses and are employing other young people in their communities.

Also in 2016, an IYA member, Alabi Kelvin, won a scholarship to study in Japan under the African Business Education Initiative by the Japan International Cooperation Agency. Kelvin will be pursuing his MSc degree in Mechanical Engineering at the Ashikaga Institute of Technology in Tochigi, Japan.

The Abuja Agripreneurs during the year hosted a visit by the AfDB President, Dr Akinwumi Adesina, and staff members. During the visit, they gave an update on the group's recent successes and made a pitch for financial support from the Bank for some of their activities. This prompted an invitation from Dr Adesina for the group to make a reciprocal visit to AfDB's Headquarters in Abidjan, where they addressed the officials—the first Agripreneurs ever to do so. This visit resulted in the inclusion of IYA as one of the beneficiaries of AfDB's Youth-BOOST Africa initiative.

Since inception in 2012, the IITA Youth Agripreneurs has been influencing young minds through training and mentoring to become successful agribusiness entrepreneurs. These training sessions have also resulted in a perspective shift among the beneficiaries of the program, far beyond the financial gains and employment. Oyindamola Asaaju and Mercy Wakawaare are two young individuals among thousands who swear by the effectiveness of the IYA approach.

Oyindamola Asaaju: hope restored

Asaaju graduated with a Second Class Upper Division in Home Science and Management from the Federal University of Agriculture in Abeokuta, Nigeria, in 2012. Like every graduate, she had lots of hopes and the ambition to get a decent-paying job, but competition was stiff so she eventually ended up as a server in a local restaurant.

"I am a college graduate but I couldn't find a job after I finished school so I moved to Ibadan from Lagos with the hopes of getting one. However, the only job I could get was that of a server, cleaning tables and serving drinks and sometimes working in the pantry—a far cry from what I was hoping to get, given my education," Asaaju related. "Although there is nothing bad about being a waitress, I felt that I needed to be in a field where I could be mentally engaged."

Then she came across the IITA Youth Agripreneurs.

"Being an Agripreneur turned things around for me," she said. "I got trained in various aspects of the agricultural value chain. I experienced my first plane ride when I was part of the IYA group that travelled to South Africa for a Youth Summit by the Master Card Foundation. Another was on a trip to Los Angeles where I was also an IYA delegate to another Youth Summit that was held there. This has opened my eyes to the endless possibilities of agriculture as an enterprise. Today, I lead a team of Agripreneurs at the IITA station in Onne, Rivers State."

Mercy Wakawa: from depressed to impressive

Mercy studied Food Science and Technology at the University of Maiduguri, also in Nigeria. After graduation, she tried for a position at the Nigerian Immigration Service (NIS) but was disqualified because she was not tall enough. Then she got an opportunity to participate in a training conducted by IYA under the N2Africa project.

"I got depressed when I didn't get the job at the NIS but, as they say, when one door closes another opens. I was fortunate enough to be included in an agribusiness training conducted by IYA. Soon afterwards I applied for and received a grant from N2Africa, which I used to start my small groundnut oil processing business," Mercy narrated.

"Today, I am the CEO of my own company, Confianza Ltd, and I employ eight people from my community," she proudly stated. "I am encouraging others like me to build their careers in agriculture, and help other young people as well. IITA and the IYA helped me get to where I am now, and I am grateful."

Youth entrepeneur Mercy Wakawa is now the CEO of her own groundnut oil processing company, Confianza Ltd.
Photo by IITA.

Yohanna Yakubu: Kano's groundnut chinchin king

Yohanna is also a beneficiary of the N2Africa training. He is a graduate in Zoology and currently owns and operates a groundnut processing enterprise which he started with a grant from the project. "Before being trained by IYA, I had been employed in a bank but was retrenched because of the economic recession," he related. "With the training provided by IYA and the seed fund given by N2Africa, I now produce groundnut chinchin, which I supply to major stores, markets, and schools in Kano State," Yohanna happily reported.

His business venture has a healthy cost-benefit ratio of 1:1.8, which means that for every 1 Naira of investment he puts in, he gets back 1.8. Not too shabby for someone who would have been a simple bank employee if not for IYA.

Transforming Nigeria's agricultural landscape

Gbassey Tarawali, IITA, Ibadan, Nigeria

The Agricultural Transformation Agenda Support Program - Phase 1 (ATASP-1) contributes to the agricultural transformation objectives of the Federal Government of Nigeria by addressing the constraints in rice, sorghum, and cassava value chains in the country's four Staple Crop Processing Zones (SCPZs) of Adani–Omor, Bida–Badeggi, Kano–Jigawa, and Kebbi–Sokoto. Specifically, the program aims to enhance food and nutrition security, generate employment, and create wealth along the three priority commodity value chains to benefit more than 45,000 economically active smallholders, mostly women and youth.

Beneficiaries undertaking field activities related to the Rice and Cassava Value Chain components of ATASP-1. Photo by IITA.

Under the program, three CGIAR Centers each lead a commodity value chain: IITA for cassava, AfricaRice for rice, and ICRISAT for sorghum; with IITA as the Executing Agency. Each center works with a national partner: IITA with NRCRI-Umudike; AfricaRice with NCRI-Badeggi; and ICRISAT with IAR-Samaru. The program has three components: (1) technology verification and extension; (2) skills development activities on agribusiness; and (3) effective program management.

Technology adaptation and diffusion

The program conducted several training of trainers (TOTs) involving extension agents from the national agricultural and extension systems (NARES) in the SCPZs on how to establish and manage cassava, rice, and sorghum farms in a sustainable manner. Under the Cassava Value Chain, IITA and NRCRI-Umudike conducted TOTs in Bida–Badeggi and Adani–Omor. Similarly, the Rice and Sorghum Value Chains have conducted TOTs in over half of the target SPCZs. This has resulted in increased availability of high quality planting materials, and foundation, and certified seed to target beneficiaries.

As part of the contribution to purifying the national rice seed stock and strengthening the capacity of the primary actors in the seed

value chain, the Rice Value Chain produced and disseminated 10 and 15 tons of breeder and foundation seed, respectively, to 10 Nigerian seed companies for multiplication into the next classes of seeds. Feedback gathered from four of these 10 seed companies show that they harvested about 787.780 tons of certified rice seed that is available for uptake by rice farmers in 2017. Also, about 4.6 tons of breeder and foundation seeds have been handed over to community-based youth seed entrepreneurs, including members of the IITA Youth Agripreneurs (IYA), who had been trained on rice seed production technology. Of the 23 youth groups trained, 15 succeeded in cultivating about 71 ha of seed farms in 2016. These youth are being linked to seeds off-takers. To further expose farmers to improved technologies, the program organized farmer field days in 29 locations across the SPCZs, with a total of 2,217 producers participating (25.7% female and 74.3% male).

The Cassava Value Chain distributed 3,600 bundles of improved cassava stems to farmers and expects to produce an additional 12,512 bundles in 2017 and 2018. The Sorghum Value Chain, on the other hand, distributed 110 tons of improved sorghum seed to farmers, while 26 tons of foundation seed have also been given to seed companies and youth seed entrepreneurs.

Many program beneficiaries were also trained on good agricultural practices (GAP) to improve productivity, increase efficiency, and reduce drudgery. In 2016, the Rice Value Chain trained more than 5,000 farmers on rice GAP during the wet and dry seasons and closely monitored adoption of promoted practices in about 891 farmers' fields. Preliminary comparative findings show that GAP plots recorded average yields of 5.7 t/ha while non-GAP plots produced some 3.5 t/ha. The commonly adopted rice GAP included improved varieties, early transplanting, optimum plant density, early weeding, and optimum timing of nitrogen fertilizer application. Women were more prominent in the training in the Adani–Omor Zone than in other parts of the country, giving credence to the observation that women's participation in rice value chain activities decreases northwards.

On the other hand, the Sorghum Value Chain trained 2,236 farmers in 2016, with 1,727 males and 964 females. Training covered production, processing, and dissemination of technologies.

The program also organized a three-day Input Fair in Kano that brought seed companies and other agro-input dealers to display and sell their products directly to farmers. Seed companies sold 4,518 kg of seeds of different crops including sorghum, rice, maize, cowpea, and groundnut. In addition, 105 liters of herbicides were sold. A total of 1804 farmers, comprising 918 males and 208 females (678 youth) attended the fair.

Skills acquisition and enhancement

Intervention under this component has been carried out at both group and individual levels. The IITA-led Cassava Value Chain has done selection

Project implementers visiting a rice seed demonstration field in Bunkuru LGA, Kano State. Photo by IITA.

Youth in agribusiness with their processed seeds from sorghum farming. Photo by IYA.

and formation of youth/farmer groups. So far, 24 groups out of the target 32 have been reached. Women and youth were key foci. Consequently, training workshops were organized in the three SCPZs of cassava in crop utilization.

The target of eight units by 2015–2016 had been achieved (100% accomplishment rate). The target total number of training beneficiaries for the same period is 5000, out of which 3981 had been reached (78.62% accomplishment). These beneficiaries comprised 1,861 males and 1,510 females.

The Rice Value Chain outreach has also trained 181 youth seed entrepreneurs in 23 groups and signed a memorandum of understanding (MoU) for the construction of eight thresher-cleaners. These labor-saving, quality improving, and loss-reducing machines will be deployed to target communities once completed.

The Sorghum Value Chain outreach also made giant strides in market development and linkages through the Innovation Platform (IP) approach, in which it brought together aggregators, commercial banks, off-takers, and farmers. As a result, it signed MoUs with leading off-takers Honeywell Flour Mill Plc and Northern Nigeria Flour Mill Plc. Under this agreement, the off-takers will provide farmers with high-quality seeds of desired varieties, after which, they will buy the produce from the farmers at the prevailing market price.

Effective program management

The ATASP-1 Outreach Program is managed by the Project Coordination Office. In 2016, the Office oversaw the successful completion of the Youth Agribusiness Training Centers and auxiliary processing plants in Abuja while a second one in Kano is nearing completion as well. The upgrading of infrastructure at Onne under the program's Outreach Component has also reached advanced stages of completion. In the ENABLE Youth Program currently supported by the African Development Bank (AfDB) and led by IITA in partnership with FMARD, five incubation/training centers like the ones in Abuja and Kano will be established in each of the 36 states plus the FCT (making 37) to benefit 37,000 youth (1000 per state) in five years.

The Outreach Coordination Office also intensified its communication strategies for interaction between people, structures, technologies and social systems. It engaged many youth on social media platforms, providing them with the right information on how they can tap into the vast wealth potentials inherent across the agricultural value chains and the agribusiness sector of the Nigerian economy.

The recently completed ATASP-1 Youth Training Center in Abuja. Photo by IITA.

When exposure to the SUN is good

Therese Gondwe, IITA, Kabangwe, Zambia

SUN-trained mothers showing other members of their community the different nutritious dishes that they learned to prepare in training provided by the project.
Photo by IITA

Since 2014, IITA has been implementing the "Integrated approach to improve the nutrition status of women and children under two years through nutrition-sensitive agriculture in Eastern Luapula, and northern provinces of Zambia." It is a project supported by the Scaling-Up Nutrition (SUN) Fund, in collaboration with the Development Aid from People to People (DAPP). The SUN Fund is managed by CARE International and funded by UKAid, Irish Aid, and the Swedish International Development Agency (SIDA). It is under the overall administration by Zambia's National Food and Nutrition Commission.

Called the SUN project, it is basically a nutrition-through-agriculture initiative that aims to enhance the nutrition and health status of 12,000 children under two years and 3000 pregnant or lactating women in poor smallholder farming communities in the target provinces. It is done through more diversified crop production, dietary diversification, and consumption of nutrient-rich crops such as legumes, fruit, and vegetables. The project provided seeds of nutrient-rich crops and farm inputs, as well as conducted training on the production of nutrient-dense crops, best agronomic practices, postharvest and storage techniques, cooking methods, diet diversification, and basic nutrition.

As the SUN project was winding up in late-2016, IITA conducted an evaluation of its effectiveness through a survey of it beneficiaries. An important measure in this evaluation is the SUN's training component. Specifically, IITA assessed the role of training and awareness creation in building the capacities and transferring technologies to SUN's beneficiaries. The evaluation also explored the prospects for sustaining the project's efforts after it closes down.

About 95% of those surveyed perceived that the SUN's training activities assisted them, particularly the pregnant and lactating women, to grow

different types of nutritious crops and to improve the consumption of nutritious food among their children, contributing to the reduction of stunting (Table 1).

Respondents who indicated that they attended SUN-facilitated training in the past 24 months were further asked to state the type of training they attended (Table 2). The survey found that the SUN project was the main provider of training among farm households in the intervention areas while the government (Ministry of

Table 1. Distribution of surveyed farmers indicating attendance in SUN's training activities in 2015/2016.

	Non-intervention		Intervention	
	No.	%	No.	%
Yes	127	65.5	343	98.6
No	67	34.5	5	1.4
Total	194	100.0	348	100.0

SUN project participant in her maize field.
Photo by IITA.

Table 2. Distribution of respondents by type of training session attended.

Topic	Intervention		Non-intervention	
	No.	%	No.	%
Improved agronomic practices of nutrient dense crops	332	96.8	115	90.6
Improved varieties and nutrient-rich varieties	331	96.5	110	86.6
Postharvest handling of vegetables and improved food storage	332	96.8	104	81.9
Various methods of cooking food	330	96.2	99	78.0
Improved infant and young child feeding methods	332	96.8	99	78.0
Diet diversification	329	95.9	100	78.7

Table 3. Distribution of respondents by level of knowledge improvement and ability to practice what was learned in training sessions.

Training topic	Knowledge level after training						Able to practice the knowledge	
	Intervention			Non-intervention				
	Same	Improved	Can't tell	Same	Improved	Can't tell	Intervention	Non-intervention
Improved agronomic practices of nutrient dense crops	4.4	94.4	1.2	7.1	75.4	17.5	94.4	80
Improved varieties and nutrient-rich varieties	5.3	93.2	1.5	11.1	67.5	21.4	93.2	57.8
Postharvest handling of vegetables and improved food storage	5.3	93.5	1.2	7.9	66.7	25.4	95.3	66.4
Food preservation, processing, and utilization	4.7	94.1	1.2	12.7	63.5	23.8	95.9	60.7
Various methods of cooking food	5	93.8	1.2	12.7	61.9	0.8	95.9	55.6
Infant and young child feeding	5	93.8	1.2	15.1	61.9	23	95.9	56.3
Diet diversification	5.9	93.2	0.9	14.3	61.9	23.8	95.3	58.5

Agriculture) and other entities provided training for those in non-intervention areas.

IITA also measured the effectiveness of the training sessions in terms of the beneficiaries' actual use of the knowledge and skills that they learned. Table 3 shows the distribution of respondents by level of knowledge and ability to practice what was learned in training sessions. Over 93% of the respondents indicated that their knowledge level improved while about 95% said that they practice what they have learned.

The surveys revealed that the SUN's training activities positively contributed to the marked improvement in the diversity of food being produced by mothers of child-bearing age involved in the project. Furthermore, the evaluation recommended that the project's efforts be continued beyond its two-year lifespan or a similar one be implemented that will use the lessons learned in this project. It is recommended, though, that it should run for a minimum of three years for implementers and beneficiaries to realize more concrete results.

SUN aims to enhance the nutrition and health status of children under two years and pregnant or lactating women in poor farming communities through more diversified crop production, dietary diversification, and consumption of nutrient-rich crops such as legumes, fruit, and vegetables. Photo by IITA.

When success PICS up

Tahirou Abdoulaye, IITA, Ibadan, Nigeria; Onu Anyebe, IITA, Kano, Nigeria; Makuachukwu Ojide, IITA, Ibadan, Nigeria; and Tesfamicheal Wossen, IITA, Abuja, Nigeria

Women farmers participaing in the Open the bag *ceremonies.* Photo by IITA.

Grains in storage are destroyed within a few weeks by insect pests if they are left unprotected. Protecting harvested grains against insect pests has always been a priority but also a great challenge to farmers in Africa. The most common protection method used by farmers involves the application of chemicals. However, chemicals are often mishandled or the wrong chemicals are used, which endangers the health of both producers and consumers.

In Nigeria, several cases of food poisoning due to toxic grains resulting from the inappropriate use of chemicals for storage—or commonly called killer beans have been documented. Due to a lack of appropriate storage technologies, many smallholders are forced to sell their cowpea soon after harvest, only to buy it back at a higher price a few months later.

IITA and Purdue University thus undertook a research project called *Purdue Improved Crop Storage (PICS)* to disseminate a technology that will enable smallholder cowpea farmers to safely store the grains they produce. The airtight, non-chemical PICS bags with "triple bagging" technology consisted of an outer layer of woven polypropylene or nylon bag and two liners of 80-micron, high-density polyethylene bags. It keeps air out, thus, preventing the intrusion and survival of insect pests on the grains stored within. The simple idea behind the PICS technology is "no air, no life." Insect pests need air (oxygen) to survive; thus, if they are denied this, they will die.

In 2007 (first year of the project, PICS1), IITA, Purdue University, and local partners started a large-scale dissemination of the PICS technology in West Africa. It took off from the initial efforts of the project, which focused only on storing cowpea. Further research by PICS scientists has shown that the technology is also effective in storing other grains, thereby, giving birth to the PICS3 Project.

During the 2014/2015 season, IITA successfully demonstrated the use of PICS bags for storing maize, rice, cowpea, and sorghum in 21 states in Nigeria, covering 1500 villages and 79,817 farmer participants. Similarly, in Ghana, IITA, together with NGOs and extension services, also successfully demonstrated the effective use of PICS bags to store different types of grains to 65,646 farmers in 1000 villages.

The media played a crucial role in publicizing the PICS technology, especially in Nigeria. With the establishment of several vendors of PICS bags in different parts of the country, radio commercials (jingles) were found to be very effective in raising interest among target end-users. The jingles were broadcast in the local languages and in Pidgin English (a type of broken English spoken in the local vernacular). In addition to radio commercials, IITA also organized participatory radio phone-in programs with major radio stations to discuss PICS technology. The IITA PICS team of Nigeria also developed and disseminated videos in the local language about the bags using drama or as a feature in some popular film or comedy skit. The PICS jingles were interspersed with the videos which were shown in town halls, schools, marketplaces, or in the residence of the village head. To complement the video showing, local PICS bag vendors were invited to display and sell PICS bags. Some youth and unemployed graduates are also marketing PICS bags now.

Each time the PICS bags and technology are first introduced to farmers, they are usually met with some uncertainty. A commonly raised question is "Is it possible to store cowpeas without the use of chemicals?" To address this, the IITA PICS team stored grains with farmers in PICS bags and conduct "Open-the-Bag" Ceremony (OBC) in villages where the technology is initially being introduced. OBC is central to PICS' promotion strategies.

During village demonstrations, volunteer farmers offer to store their grains in PICS bags for six months without applying any chemical. At the end of the six-month period, the same farmer-volunteers publicly open the PICS bags during the OBC to attest to other farmers that the grains stored are safe and free from insect pests.

Farmers are drawing huge economic and health benefits from the use of the PICS bags. It is not uncommon in West Africa to have price increases of more than 50% between harvest and the next planting season for cowpea. Therefore, if farmers can store and keep grain quality, they can capture much of the price increase as profit. For instance, Hauwa Mohammed, a woman small-scale *kosai* (bean cake) processor in Kwalli, Gombe State, volunteered some of her cowpea for demonstration using PICS bags back in 2010.

Other women laughed at her saying that her cowpea would be chicken feed after the storage period because of the high weevil infestation in the village. They believed that it was impossible to safely store grains in a bag without chemicals. During the OBC six months later, she showed that the quality of the grain was retained using the PICS bag, much to the disbelief of her co-villagers. Hauwa made more money from her business during that year's planting season because she bought cowpea and stored them in PICS bags after harvest when there was a glut in production and prices were very low. She used the stored cowpea for her bean cake business throughout the year.

To date, about 5 million PICS bags have been produced and sold in Nigeria and Ghana alone. PICS bags are also being sold in Niger, Mali, Cameroon, Burkina Faso, and Togo. The PICS bag technology is also now moving to East and Southern Africa under the current PICS3 project.

The PICS bags help to keep grains pest free. Photo by IITA.

Mechanizing for progress

Peter Kolawole, Postharvest Specialist, SARD-SC (Mechanization Office), IITA, Ibadan, Nigeria

Mechanization reduces the drudgery usually associated with agricultural activities and increases efficiency on the farm. Since the early 1970s, IITA has been developing and promoting the use of agricultural machinery under various initiatives and projects with support from a myriad of donors, particularly for its cassava transformation agenda.

Group members working together in constructing raised drying platform.
Photo by IITA.

For example, between 2002 and 2010, IITA implemented the Integrated Cassava Project (ICP) to support Nigeria's Presidential Initiative on Cassava, under which hundreds of processing centers and fabricating enterprises were established. In 2012, under the USAID-funded project called Unleashing the Power of Cassava in Africa (UPoCA), IITA and partners met about 15% of the national needs for improved planting materials in the DR Congo, Sierra Leone, Tanzania, and Zambia.

Continuing the mechanization legacy through SARD-SC

The IITA-led *Support to Agricultural Research for Development of Strategic Crops in Africa* (SARD-SC) project, sponsored by the African Development Bank (AfDB), picked up where UPoCA left off, upscaling the promotion of the improved varieties chosen by farmers but also adding a focus on mechanization to develop the cassava commodity value chain.

Supporting farmers and youth in Tanzania

To boost postharvest processing in Tanzania, SARD-SC supported the upgrading of the facilities of smallholder processing communities in Zanzibar and Kigoma. In Zanzibar, the project supported the Tuambiwe nini group with construction materials that enabled the group to complete the community cassava processing center (CCPC) which they had started to build. In Kigoma, SARD-SC helped the KIEMA group (in Kibondo District) and Umoja group (in Kakonko District) build community processing centers to produce cassava flour. The project also helped rehabilitate several processing centers in Kigoma, Zanzibar, and Ruvuma (Table 1).

SARD-SC also financed the construction of a model processing center at Kwembe in Dar es Salaam. The processing center has several components including a processing building, an equipment fabrication workshop,

Table 1. Community cassava processing centers rehabilitated under the SARD-SC project in Tanzania.

Center name	Location
Kibondo Big Power Processing Center	Kibondo, Kigoma
KIEMA Processing Center	Kibondo, Kigoma
Bumbwini Processing Center	Zanzibar
Umoja Processing Center	Kakonko, Kigoma
Mshikamano Processing Center	Namtumbo, Ruvuma

offices, and washrooms. It is equipped with a peeler, grater, chipper, press, sifter, fryer, and hammer mill. The establishment of the Kwembe cassava processing facility created an avenue for youth, particularly the members of the IITA Youth Agripreneurs (IYA) in Tanzania, to shift from being just repackagers/brokers of high quality cassava flour (HQCF) to actual producers of the value-added product. Initially, the youth packaged and sold HQCF produced by other processors because they did not have access to a processing facility. Today, using the facility, they produce, package, and market their own HQCF under their own Mpishi Mkuu trademark.

Apart from the economic benefits, the processing centers also promoted better quality, safety, and efficiency in producing cassava-derived products.

The introduction of mechanized production and processing techniques by SARD-SC in Tanzania also paved the way for farmers and youth to produce more products derived from cassava roots and cassava flour such as cakes, buns, spicy porridge, titbits, chin chin (snack made of fried stringy cassava), and chicken-cassava pilau (a popular dish in which small-cut cassava is a substitute for rice). These have not only helped to improve nutrition in the communities but also generated additional income.

These technologies have also been scaled out to non-project areas such as in the Namtumbo District in Ruvuma Region where SARD-SC established a processing center equipped with a motorized grater, motorized chipper, manual chipper, and two presses. More than 140 community members have also been trained on mechanized cassava processing and product development.

Engr Diallo showing the automated garri fryer to the FARA Executive Director during a visit.
Photo by T. Diallo, IITA.

Helping youth and empowering partners in Zambia

In Zambia, SARD-SC supported the construction of two cassava processing centers: one located at IITA's Southern Africa Research and Administration Hub (SARAH) campus in Kabangwe, Lusaka Province, and another at the Zambian Agriculture Research Institute (ZARI) campus in Mansa, Luapula Province in the northern part of the country. The IITA-SARAH facility was completed in 2016, while the one at ZARI-Mansa is scheduled to be completed and commissioned by the first quarter of 2017.

Both centers are equipped with mechanized cassava graters, pressers, firewood-fuelled fryers, sieving machines, and high-capacity milling machines. They also have offices, workers' washrooms, loading and drying docks, and a cassava washing bay. Each center can process 5 tons of fresh roots daily into chips and HQCF, among other products.

Practical training session on how to operate cassava processing equipment.
Photo by IITA.

The cassava processing centers will be used to train youth, particularly members of the Zambia IYA, as well as build the capacity of our national partner, ZARI, on cassava value addition with the longer term goal of spurring the growth of the country's cassava industry.

Giving cassava communities a boost in Sierra Leone

Sierra Leone was one of the core countries of the previous UPoCA project implemented by IITA, which ended in 2013. Continuing the successes of UPoCA, SARD-SC facilitated the construction of four new community cassava processing centers in Kambui, Rogbaneh, and Sewa. While three of these processing centers are currently being supplied with equipment for installation, the Gaindema Community processing center—named the Manenkoh Cassava Farmers' Factory—has been fully equipped and made operational with the help of ACDI-VOCA/SNAP, a USAID-funded nutrition and food project operating in the northern Tonkolili District.

By the last quarter of 2016, SARD-SC had successfully carried out a 4-day training for 70 project beneficiaries in three key areas: processing machine operation and maintenance (12 men/3 women); cassava product development (5 men/35 women); and governance and business management skills (10 men/5 women).

Bridging the cassava gap in the DR Congo

In DR Congo, the absence of value addition has limited farmers' opportunities for increasing their income from cassava production. Some of the many challenges faced by cassava producers are limited markets for cassava roots, high postharvest losses, low level of and manual labor-based processing, and lack of diversity in derived products. Ugali and Chikwangue are the only known products from cassava in the country.

However, through its processing component, SARD-SC addressed these challenges by establishing CCPCs in the South-Kivu Province, which was patterned after a model processing center established at the IITA Station in Kalambo. To date, the project has established eight CCPCs in Katana, Kavumu, Mulamba, Kamanyola, Luvungi, Sange, Bunyakiri I, and Bunyakiri

II. Each is equipped with a mechanized miller, grater, chipper, and press. The centers are run by CCPC members who are also farmers coming from different farmer groups and who have been trained by SARD-SC on modern cassava production and processing techniques. Each center can process some 3,400 kg of fresh roots into HQCF. As a result of CCPC's activities, the demand for fresh roots has increased significantly in the areas where the centers are located, stimulating production.

HQCF production by the centers has also stimulated the production of other by-products apart from the traditional Ugali and Chikwangue. In Mulamba, Bunyakiri, Bitale, and Bukavu people have been introduced to other products and are consuming different cassava-based products such as chin-chin, doughnuts, biscuits, cookies, samosa, sausage, cakes, bread, cassava-oatmeal cookies, cassava-butter cookies, and pies. The centers have also been linked to marketing outlets established by members of the IITA-Kalambo Youth Agripreneurs.

The CCPCs have also offered respite to rural unemployment. The eight CCPCs have employed 33 regular employees who receive an average of $50 per month, with some getting as much as $120 per month. At least 200 women are employed every month as casual workers and paid about $1.20 dollars for a 4-hour workday.

The enterprising activities of CCPCs have encouraged private sector actors to join the cassava processing business. Presently, there are three companies (Groupe KABEGO, Ets. JANDA, and APAFED asbl) in South-Kivu that are engaged in cassava processing. The promising agroprocessing business environment has also provided income opportunities for local machine fabricators trained by SARD-SC.

At the IITA-Kalambo Station, SARD-SC established a cassava processing center to produce flour and garri. Through the center, which was built in phases in 2014 and 2015, SARD-SC facilitated the training of five local equipment fabricators, who have also been certified by SARD-SC engineers to fabricate cassava processing machines. Additionally, the project designed, constructed, equipped, and handed over two cassava centers to community members of Sangue and Kavumu in Kalambo.

Young women adding value to cassava processing. Photo by IITA.

Making better soybean seeds more accessible to farmers in Malawi: The MISST experience

Gbenga Akinwale and Daniel Nyirongo, IITA, Lilongwe, Malawi

Limited access to good quality seed of improved varieties by smallholder farmers is one of the constraints to the productivity of soybean in Malawi. The IITA-led Malawi Improved Seed Systems and Technologies (MISST) project, funded through USAID's Feed-the-Future initiative, attempts to address this by promoting public–private sector partnership to develop pathways for soybean farmers to have better access to seed of improved varieties.

A community seed multiplier from Masuku EPA in Mangochi district. Photo by IITA.

One of the approaches MISST uses is supporting the establishment and scaling out of market-oriented, community-based seed production and delivery systems in seven districts within the identified USAID Zones of Influence in Malawi.

During the year, MISST facilitated the production of 587.36 tons of seed of various classes from 541 ha of land, consequently improving the access of over 40 small- and medium-scale seed enterprises to quality basic seed and thousands of smallholder farmers to certified seed. With a seeding rate of 70 kg/ha, this quantity of seed will be planted on 8390 ha of farmland to produce 12,586 tons of grains, thus providing benefits to both seed and grain producers. MISST also trained over 30 community-based seed producer groups, comprising 320 farmers (235 men and 85 women) on seed production, internal quality control, and postharvest handling. The project also provided basic seed to these trained seed producer groups, who, in turn, produced 506 tons of certified seed during the 2015/2016 season. The groups sold over 271 tons of certified seed, valued at some MWK184 million (about $245,768), through market linkages created by the project.

The project also provided 1419 smallholder farmers (530 men and 889 women) with 3 kg of seed each of the early maturing drought-tolerant Tikolore variety, particularly those in the drought-prone districts of Balaka, Mangochi, and Machinga. Additionally, MISST worked closely with partners to multiply certified seed of the variety on 245 ha of land in the 2016 season.

Through the 642 variety demonstration plots established by the project, a total of 10,734 soybean farmers (5219 men and 5515 women) acquired knowledge and skills on good agronomic practices. With the successful introduction of double row technology, farmers can now save money on weed control. Preliminary information shows that the combination of these interventions resulted in an average increase in farmers' productivity of 1.3 t/ha compared to the baseline figure of 0.8 t/ha.

As the project's interventions are gaining momentum through enhanced seed production, many cooperative groups and individual farmers are now emerging as seed entrepreneurs in the covered districts of Malawi. Such are the cases of Gafali Saweta and Chionetsero Thomas, two successful beneficiaries of the MISST project.

Gafali Saweta, seed multiplier extraordinaire

Gafali Saweta, a member of the Fumaki Farmers' Cooperative within the Lobi Extension Planning Area (EPA) of Dedza, is one of MISST's successful community-based seed multipliers. Saweta's path to success began when he was selected in the 2016 season as one of the beneficiaries of the MISST soybean seed production training. The 52-year-old received training on soybean seed production and quality control, and 240 kg of basic seed of the early maturing Tikolore variety. He planted the seed on 4 ha to produce certified seed following the cultural practices recommended by MISST. At harvest, he obtained a remarkable yield of 141 50-kg bags of Tikolore certified seed. "It was unbelievable! I was skeptical at first to try soybean seed production, but now I have seen that this venture is a real money-maker," says Saweta.

"Despite the unusually dry spell that Malawi experienced during the 2015/2016 season, the 4 ha of Tikolore that I planted from the seed given by the MISST project still produced 141 50-kg bags of soybean seed, which has been certified by the government's Seed Services Unit."

"I sold some of the certified seed at MWK 600 (about $0.827) per kg to other farmers in my community, as well as to some agrodealers around Lobi EPA. In total, I earned some MWK 4.2 million (about $6000) from the sale of the seed," Saweta happily related. "Since I ventured into farming, I never imagined that soybean seed production can be as profitable as this."

"Hopefully, I will realize my dream of buying a car one day," added Saweta, who attests that the income he gained from the sale of soybean seed last year was the biggest he had ever had since he started farming.

His successful seed production inspired and encouraged him to increase the size of land allocated to soybean seed production from 4 to 7 ha this year.

Saweta's success turned him into a model soybean seed farmer. Here, he explains to a group of farmers from Lilongwe (100 km away) who visited his farm in Dedza to hear of his experience under the MISST project. Photo by IITA.

"I am thankful to IITA and the MISST project for this opportunity," he said, referring to the project's community-based seed multiplication approach. Saweta's success has been recognized by other members of his farming cooperative, inspiring them to also start growing soybean for seed.

Chionetsero Thomas: Seeding the good news

Chionetsero Thomas is a lead farmer and MISST beneficiary from Napulu II Village in Traditional Authority (TA) Kaphuka in Dedza. During the 2016 season, he planted 1 ha of Tikolore using seed he got from the project and harvested 49 50-kg bags of certified seed.

"Following the recommendations from IITA/MISST and extension workers, I sold some of the certified seed that I harvested to other farmers in and around my village as a way of promoting soybean farming. I sold 20 bags at MWK 750 per kg, and another 14 bags at MWK 650 per kg. I realized a total of MWK 1.2 million (about $1655) from the sale of my seed last year," Thomas related.

"I am also elated to know that several other farmers within my area are growing soybean this year from the seed that I produced in the previous season," he narrated.

He added that he used the money he realized from the sale to buy molded bricks for a house that he intends to build later this year. He also bought pigs, which he is rearing to complement his soybean seed production business. In the current farming season, Thomas has also doubled the size of his farm to 2 ha.

"I am a very happy man. I feel like I am now realizing my dream and my full potential as a farmer. I am thankful to IITA for bringing the MISST project to Dedza, and I am calling on other farmers to adopt soybean as their number one cash crop," Thomas joyfully concluded.

Saweta in his farm. Due to the success he had in the 2015/2016 season, he was able to expand his farm from 4 to 7 hectares. Photo by IITA.

Improving gender equity and nutrition in the DRC

Renee Bullock, IITA, South-Kivu, DRC and Patchimaporn Udomkun, IITA, Bukavu, DRC

In the Democratic Republic of Congo (DRC), rates of food insecurity and malnutrition are severe and growth in the agricultural and rural sectors is undermined by gender disparity and gender-related constraints, particularly in access to productive resources, inputs, knowledge, and markets. High levels of gender inequality have been associated with high levels of food insecurity.

Training women farmers in DRC. Photo by IITA.

In South-Kivu Province, food insecurity and malnutrition are leading causes of mortality among the population. Previous studies have shown that malnutrition rates in the Province are linked to poverty and low purchasing power of the population, poor dietary habits, intra-household food allocation, and traditional customs that result in poor food preparation practices. Furthermore, approximately 83% of the people in the province spend less than $1.90 per day on food items, which reflects income constraints to supplementing diets with essential items to improve nutrition.

Additionally, pervasive gender inequalities pose considerable challenges to improving livelihoods in this area. Men's and women's roles and responsibilities in the household often differ, with the women often being responsible for food collection and preparation. In some areas, gender disparities also exist in what men and women consume. For example, in Uvira, women are forbidden to drink milk, even when they contribute substantial labor to on-farm livestock management. Gender inequalities also exacerbate and place a heavy burden on women's health. Women are particularly affected by high rates of drudgery associated with casual labor, on-farm household labor, and childcare. Furthermore, women have almost no access to resources and have less decision-making powers concerning production.

Women's empowerment is key to attaining positive development outcomes in agricultural households and, if supported, will help accelerate economic growth and contribute to the well-being of rural households (Doss 2013; Ochieng et al. 2014). Empowering women through programs that both engage men and women and seek to increase their knowledge and challenge gender inequity will be essential to improving health and nutrition outcomes.

To this end, IITA, through the Support to Agricultural Research for Development of Strategic Crops in Africa (SARD-SC) project funded by the African Development Bank has created opportunities for women and men to work together through the cassava community processing centers (CCPCs) established in project countries, including the DRC. The CCPCs serve as entry points to address gender and nutrition challenges in the region.

Currently, five CCPCs have been established in Kavumu, Katana, Kabare, Kamanyola, Luvungi, and Sange in the Ruzizi Plains. Three of these CCPCs are chaired or managed by women, which places them in important leadership positions where they serve as role models for other women and girls in these communities. However, in general, the male members of these CCPCs are better educated than the women, owing to better access to information sources that they often control such as mobile phones and radio. Additionally, women's responsibilities in the household and in childcare limit their opportunities to attend social and educational events.

Recognizing the importance of gender, nutrition, and hygiene, SARD-SC conducted a 2-day, awareness training for members and their spouses of the five CCPCs. More than 165 individuals, 100 of whom were women, participated. The first day of the training specifically focused on sensitizing CCPC members—through participatory approaches—on gender, community gender norms related to division of tasks and labor, and developing community-led strategies to attain gender equity at the household and community levels. Some of the salient strategies proposed by the participants to reduce women's workloads and to provide equal opportunities for women and men included: (1) sensitizing local leaders, including chiefs and clergy; (2) providing joint training for husbands and wives to facilitate and enhance dialogue and joint decision-making in the household; (3) sensitizng children, and parents leading by example; and (4) creating activities to encourage young men and women to work together such as baking bread.

The second day focused on nutrition, particularly improving knowledge on basic nutrition, household food security, and hygiene. Pre- and post-test questionnaires were used to assess participants' basic knowledge on nutrition and hygiene. The surveys showed that the men had generally better knowledge of basic nutrition and hygiene than the women, likely stemming from men's access to better education and information when compared to women. Following the training, however, the men and women's knowledge levels on nutrition and hygiene evened out.

This training demonstrated the need to intensify and address gender within agricultural projects to achieve better outcomes for production and wider development outcomes. This will lead to a better understanding about how IITA and its partners can incorporate gender transformative approaches that will significantly change gender relations and improve the plight of women.

Carrier women of Bukavu and Renee Bullock, IITA Gender Specialist.
Photo by IITA.

Training and seminars

Agripreneurs using ICT facilities to develop apps for agriculture. Photo by IITA.

In 2016, IITA Training focused on providing training for both internal (staff development) and external participants (partners in the national programs and projects). Training programs include Professional Capacity Advancement and Short-Term Courses.

Table 1 shows the breakdown for degree-related training. This includes postgraduate students recruited during the year (113) and those who completed the research portion of their degrees at IITA (124). Of the new students, there were 68 MSc and 45 PhD students, with 69 males and 44 females. Those who completed their research include 70 MSc and 54 PhD candidates, with 63 males and 61 females.

Table 2 lists the number of training workshops organized and participants per country, broken down into male and female participants. All in all, IITA conducted 244 training with more than 17,700 participants—with 64% male and 36% female participants from 21 different countries.

For staff, professional skills development training courses were initially offered only in Ibadan with 71 male and 50 female participants. Staff training covered topics such as effective communication, customer relations, business development, project management, management and leadership, financial planning/management/reporting, and monitoring and evaluation.

A total of 18 awards were given to staff under the Talent Grant program in 2016 (Table 4).

Table 1. Summary for graduate students, 2016.

	MSc		PhD		Total		Grand total
	Male	Female	Male	Female	Male	Female	
Students commenced in 2106	39	29	30	15	69	44	113
Students completed in 2016	35	35	28	26	63	61	124
Total	74	64	58	41			237

Table 2. Summary for training workshops.

	Country	Training organized (no.)	Male (no.)	Female (no.)	Total (no.)
1	Burkina Faso	5	1,340	1,081	2,421
2	Burundi	1	19	9	28
3	Cameroon	7	139	51	190
4	Cote d'Ivoire	1	10	3	13
5	DR Congo	6	170	143	316
6	Ethiopia	1	13	5	18
7	Gabon	1	15	10	25
8	Ghana	19	279	76	355
9	Kenya	5	67	36	103
10	Liberia	2	30	13	43
11	Malawi	2	22	5	27
12	Mali	1	18	1	19
13	Mozambique	1	42	89	131
14	Netherlands	1	7	8	15
15	Nigeria	141	7,492	4,073	11,565
16	Rwanda	3	35	20	55
17	Sierra Leone	13	288	183	471
18	Tanzania	10	228	159	387
19	Thailand	1	15	4	19
20	Uganda	11	807	237	1,044
21	Zambia	12	322	137	459
	Total	244	11,358	6,343	17,701

Table 3. Summary of Staff Development

S/N	Title	Location	Male	Female	Date	Resource person
1	Effective Communication and Presentation Skill	Ibadan	15	11	1–3 June 2016	Industrial Training Fund (ITF)
2	Excellent Customer Service Relations	Ibadan	9	4	7–8 June 2016	Industrial Training Fund (ITF)
3	Business Development and Customer Service Management	Ibadan	4	3	14–16 June 2016	Industrial Training Fund (ITF)
4	Project Management	Ibadan	11	5	20–24 June 2016	Kayode Awobajo, Richardson Oil and Gas Limited, Nigeria
5	Managerial and Leadership Skills	Ibadan	13	6	11–12 July 2016	Richardson Oil and Gas Limited, Nigeria
6	Financial Planning, Management and Reporting	Ibadan	13	17	29–31 August 2016	Omoshalewa Sholol**a**
7	Monitoring and Evaluation	Ibadan	6	4	18–20 October 2016	Thomas Wobill
	Total		71	50		

Table 4. Summary of Talent Grant recipients, IITA, 2016.

Units	No.	Hubs	No.	Type	No.
FMS/Engineering	2	Western Africa	14	Individual	16
Hotel and Catering	1	Central Africa	2	Group	2
HR/Administration	2	Eastern Africa	1		
IT/ICT	1	Southern Africa	1		
Project Management	1				
Science/Research (R4D)	9				
Supply Chain/Procurement	1				
CDO/International School	1				

Hands-on training for women researchers. Photo by IITA.

Publications

Students using the IITA Knowledge Center. Photo by IITA.

In 2016, IITA scientists published 146 publications in peer-reviewed, Thomson-indexed journals. Selected articles from the different hubs are listed here by research theme.

Natural resource management

Adamtey, N., Musyoka, M.W., Zundel, C., Cobo, J.G., Karanja, E., Fiaboe, K. K., Muriuki, A., Mucheru-Muna, M., Vanlauwe, B., Berset, E., Messmer, M.M., Gattinger, A., Bhullar, G., Cadisch, G., Fliessbach, A., Mader, P., Niggli, U., and Foster, D. 2016. Productivity, profitability and partial nutrient balance in maize-based conventional and organic farming systems in Kenya. Agriculture, Ecosystems and Environment 235, 61–69. Impact Factor: 3.564

Beuel, S., Alvarez, M., Amler, E., Behn, K., Kotze, D., Kreye, C., Leemhuis, C., Wagner, K., Willy, D. K., Ziegler, S., and Becker, M. 2016. A rapid assessment of anthropogenic disturbances in east African wetlands. Ecological Indicators 67, 684–692. (ISSN: 1470-160X) Impact Factor: 3.190

De Bauw, P., Van Asten, P., Jassogne, L., and Merckx, R. 2016. Soil fertility gradients and production constraints for coffee and banana on volcanic mountain slopes in the East African rift: a case study of Mt. Elgon. Agriculture, Ecosystems and Environment 231, 166–175. Impact Factor: 3.564

Kihara, J., Nziguheba, G., Zingore, S., Coulibaly, A., Esilaba, A.O., Kabambe, V.H., Njoroge, S., Palm, C., and Huising, J. 2016. Understanding variability in crop response to fertilizer and amendments in sub-Saharan Africa. Agriculture, Ecosystems and Environment 229, 1–12. Impact Factor: 3.564

Liebig, T., Jassogne, L., Rahn, E., Laderach, P., Poehling, H., Kucel, P., et al. 2016. Towards a collaborative research: a case study on linking science to farmers' perceptions and knowledge on arabica coffee pests and diseases and its management. PLoS ONE 11(8[e0159392]), 1–23. Impact Factor: 3.057

Masunga, R.H., Uzokwe, V.N., Mlay, P.D., Odeh, I., Singh, A., Buchan, D., and De Neve, S. 2016. Nitrogen mineralization dynamics of different valuable organic amendments commonly used in agriculture. Applied Soil Ecology 101, 185–193. Impact Factor: 2.670

Momo, M.N., Yemefack, M., Tematio, P., Beauvais, A., and Ambrosi, J. 2016. Distribution of duricrusted bauxites and laterites on the Bamileke plateau (West Cameroon): Constraints from GIS mapping and geochemistry. Catena 140, 15–23. Impact Factor: 2.612

Norgrove, L. and Hauser, S. 2016. Biophysical criteria used by farmers for fallow selection in west and central Africa. Ecological Indicators 61(1), 141–147. (ISSN: 1470-160X). Impact Factor: 3.190

Paul, B.K., Pulleman, M.M., Ayuke, F., Six, J. and Vanlauwe, B. 2016. Response to G.W. Sileshi's letter to the Editor on AGEE13857 (2015): Exclusion of soil macrofauna did not affect soil quality—statistical artefact or true lack of effect? Agriculture Ecosystems and Environment 221, 282–284. Impact Factor: 3.564

Reis, S., Bekunda, M., Howard, C., Karanja, N., Winiwarter, W., Yan, X., Bleeker, A., and Sutton, M. 2016. Synthesis and review: Tackling the nitrogen management challenge: from global to local scales. Environmental Research Letters 11(12), 1–13. Impact Factor: 4.134

Ronner, E., Franke, A.C., Vanlauwe, B., Dianda, M., Edeh, E., Ukem, B., Bala, A., van Heerwaarden, J., and Giller, K. 2016. Understanding variability in soybean yield and response to P-fertilizer and rhizobium inoculants on farmers' fields in northern Nigeria. Field Crops Research 186, 133–145. Impact Factor: 2.927

Salack, S., Klein, C., Giannini, A., Sarr, B., Worou, O.N., Belko, N., Bliefernicht, J., and Kunstman, H. 2016. Global warming induced hybrid rainy seasons in the Sahel. Environmental Research Letters 11(10), 1–11. (ISSN: 1748-9326). Impact Factor: 4.134

Schroth, G., Laderach, P., Martinez-Valle, A.I., Bunn, C., and Jassogne, L. 2016. Vulnerability to climate change of cocoa in West Africa: Patterns, opportunities and limits to adaptation. Science of the Total Environment 556, 231–241. Impact Factor: 3.976

Smith, A., Snapp, S., Chikowo, R., Thorne, P., Bekunda, M., and Glover, J. 2016. Measuring sustainable intensification in smallholder agroecosystems: a review. Global Food Security 1–12. Impact Factor: 3.745

Ulzen, J., Abaidoo, R.C., Mensah, N.E., Masso, C., and Abdelgadir, A.H. 2016. Bradyrhizobium inoculants enhance grain yields of soybean and cowpea in northern Ghana. Frontiers in Plant Science 7, 1–9. Impact Factor: 4.495

Plant production and plant health

Adhikari, B.N., Bandyopadhyay, R.,and Cotty, P. 2016. Degeneration of aflatoxin gene clusters in Aspergillus flavus from Africa and north America. AMB Express 6(62), 1–16. (ISSN: 2191-0855). Impact Factor: 2.167

Bandyopadhyay, R., Ortega-Beltran, A., Akande, A., Mutegi, C., Atehnkeng, J., Kaptoge, L., Senghor, A.L., Adhikari, B.N., and Cotty, P. 2016. Biological control of aflatoxins in Africa: Current status and potential challenges in the face of climate change. World Mycotoxin Journal 9(5), 771–789. Impact Factor: 2.091

Bayissa, W., Ekesi, S., Mohamed, S., Kaaya, G.P., Wagacha, M., Hanna, R., and Maniania, N.K. 2016. Selection of fungal isolates for virulence against three aphid pest species of crucifers and okra. Journal of Pest Science 1– 14. Online first. Impact Factor: 3.103

Bennett, K.L., Shija, F., Linton, Y., Misinzo, G., Kaddumukasa, M., Djouaka, R.F., Anyaele, O., Harris, A., Irish, S., Hlaing, T., Prakash, A., Lutwama, J., and Walton, C. 2016. Historical environmental change in Africa drives divergence and admixture of Aedes aegypti mosquitoes: A precursor to successful worldwide colonization? Molecular Ecology 1–18. Online first (ISSN: 0962-1083). Impact Factor: 5.947

Bomer, M., Turaki, A., Silva, G., Kumar, P.L., and Seal, S. 2016. A sequence-independent strategy for amplification and characterisation of episomal badnavirus sequences reveals three previously uncharacterised yam badnaviruses. Viruses 8(7), 1–22. (ISSN: 1999-4915). Impact Factor: 3.042

Chiumenti, M., Morelli, M., De Stradis, A., Elbeaino, T., Stavolone, L., and Minafra, A. 2016. Unusual genomic features of a badnavirus infecting mulberry. Journal of General Virology 97(11), 3073–3087. (ISSN: 0022-1317). Impact Factor: 3.192

Coyne, D., Kolombia, Y.A., Kariuki, G., Luambano, N., and Bert, W. 2016. First report of dry rot disease of yam caused by scutellonema bradys in East Africa. Plant Disease 100(8), 1– 6. Online first (ISSN: 0191-2917). Impact Factor: 3.192

Djouaka, R.F., Riveron, J., Yessoufou, A., Tchigossou, G., Akoton, R., Irving, H., Djegbe, I., Moutairou, K., Adeoti, R., Tamo, M., Manyong. V., and Wondji, C.S. 2016. Multiple insecticide resistance in an infected population of the malaria vector Anopheles funestus in Benin. Parasites & Vectors 9, 1–12. (ISSN: 1756-3305). Impact Factor: 3.234

Goergen, G., Kumar, P.L., Sankung, S.B., Togola, A., and Tamo, M. 2016. First report of outbreaks of the fall armyworm Spodoptera frugiperda (JE Smith) (Lepidoptera, noctuidae), a new alien invasive pest in west and central Africa. PLoS ONE 11(10), 1–9. (ISSN: 1932-6203). Impact Factor: 3.057

Janssen, T., Karssen, G., Verhaeven, M., Coyne, D., and Bert, W. 2016. Mitochondrial coding genome analysis of tropical root-knot nematodes (Meloidogyne) supports haplotype based diagnostics and reveals evidence of recent reticulate evolution. Scientific Reports 6(22591), 1–13. Impact Factor: 5.228

Jorge Junior, A., Cares, J.E., Mattos, V.S., Coyne, D., Dos Santos, M.F.A., and Carneiro, R. 2016. First report of Meloidogyne izalcoensis (nematoda: meloidogynidae) on coffee, cabbage, and other crops in Africa. Plant Disease 100(10), 2173–2173. Impact Factor: 3.192

Kolombia, Y.A., Kumar, P.L., Claudius-Cole, A.O., Karssen, G., Viaene, N., Coyne, D., and Bert, W. 2016. First report of Meloidogyne enterolobii causing tuber galling damage on white yam (Dioscorea rotundata) in Nigeria. Plant Disease 100(10), 2173–2173. Impact Factor: 3.192

Lamboni, Y., Frisvad, J.C., Hell, K., Linnemann, A., Nout, R. M., Tamo, M., Nielsen, K.F., van Boekel, M.A., and Smid, E.J. 2016. Occurrence of Aspergillus section Flavi and section Nigri and aflatoxins in raw cashew kernels (Anacardium occidentale L.) from Benin. LWT - Food Science and Technology 70, 71–77. (ISSN: 0023-6438). Impact Factor: 2.711

Lamboni, Y., Nielsen, K.F., Linnemann, A., Gezgin, Y., Hell, K., Nout, R.M., Smid, E.J., Tamo, M., van Boekel, M.A., Hoof, J.B., and Frisvad, J.C. 2016. Diversity in secondary metabolites including mycotoxins from strains of Aspergillus section Nigri isolated from raw cashew nuts from Benin, West Africa. PloS ONE 11(10), 1–14. (ISSN: 1932-6203). Impact Factor: 3.057

Leke, W.N. , Khatabi, B., Mignouna, D.B., Brown, J., and Fondong, V.N. 2016. Complete genome sequence of a new bipartite begomovirus infecting cotton in the Republic of Benin in West Africa. Archives of Virology 1–5. Online first (ISSN: 0304-8608). Impact Factor: 2.255

Mulenga, R., Legg, J., Ndunguru, J., Miano, D., Mutitu, E. W., Chikoti, P., and Alabi, O. 2016. Survey, molecular detection and characterization of geminiviruses associated with cassava mosaic disease in Zambia. Plant Disease 100(7), 1379–1387. Impact Factor: 3.192

Ndunguru, J., De Leon, L., Doyle, C.D., Sseruwagi, P., Plata, G., Legg, J., Thompson, G., Tohme, J., Aveling, T., Ascencio-Ibanez, J.T., and Hanley-Bowdoin, L. 2016. Two novel DNAs that enhance symptoms and overcome cmd2 resistance to cassava mosaic disease. Journal of Virology 90(8), 4160–4173. Impact Factor: 4.606

Ndyetabula, I., Merumba, S., Jeremiah, S.C., Kasele, S., Mkamilo, G., Kagimbo, F.M., and Legg, J. 2016. Analysis of interactions between cassava brown streak disease symptom types facilitates the determination of varietal responses and yield losses. Plant Disease 100(7), 1388–1396. Impact Factor: 3.192

Nwadili, C., Augusto, J., Bhattacharjee, R., Atehnkeng, J., Lopez-Montes, A., Onyeka, T. J., Kumar, P.L., Asiedu, R., and Bandyopadhyay, R. 2016. Comparative reliability of screening parameters for anthracnose resistance in water yam (Dioscorea alata). Plant Disease 1–8. Online first (ISSN: 0191-2917). Impact Factor: 3.192

Otti, G., Bouvaine, S., Kimata, B., Mkamilo, G., Kumar, P.L., Tomlins, K., and Maruthi, M.N. 2016. High-throughput multiplex real-time PCR assay for the simultaneous quantification of DNA and RNA viruses infecting cassava plants. Journal of Applied Microbiology 120(5), 1346–1356. (ISSN: 1364-5072). Impact Factor: 2.156

Tatineni, S., Wosula, E.N., Bartels, M., Hein, G.L., and Graybosch, R.A. 2016. Temperature-dependent wsm1 and wsm2 gen-specific blockage of viral long-distance transport provides resistance to wheat streak mosaic virus and triticum mosaic virus in wheat. Molecular Plant-Microbe Interactions 29(9), 724–738. Impact Factor: 4.145

Wosula, E.N., Tatineni, S., Wegulo, S N., and Hein, G.L. 2016. Effect of temperature on wheat streak mosaic disease development in winter wheat. Plant Disease 1–35. Impact Factor: 3.192

Yahaya, A., Dangora, D.B., Alegbejo, M., Kumar, P.L., and Alabi, O. 2016. Identification and molecular characterization of a novel sugarcane streak mastrevirus and an isolate of the A-strain of maize streak virus from sugarcane in Nigeria. Archives of Virology 1–6. Online first (ISSN: 0304-8608). Impact Factor: 2.255

Genetic improvement and biotechnology

Amit I., Baker D., Barker R., Berger B., Bertozzi C., Bhatia S., Biffi A., Demichelis F., Doudna J., Dowdy S.F., Endy D., Helmstaedter M., Junca H., June C., Kamb S., Khvorova A., Kim D.H., Kim J.S., Krishnan Y., Lakadamyali M., Lappalainen T., Lewin S., Liao J., Loman N., Lundberg E., Lynd L., Martin C., Mellman I., Miyawaki A., Mummery C., Nelson K., Paz J., Peralta-Yahya P., Picotti P., Polyak K., Prather K., Qin J., Quake S., Regev A., Rogers J.A., Shetty R., Sommer M., Stevens M., Stolovitzky G., Takahashi M., Tang F., Teichmann S., Torres-Padilla M.E., Tripathi L., Vemula P., Verdine G., Vollmer F., Wang J., Ying J.Y., Zhang F., and Zhang T. 2016. Voice of biotech: Nature biotechnology asks a selection of researchers about the most exciting frontier in their field and the most needed technologies for advancing knowledge and applications. Nature Biotechnology 34(3), 270–275. Impact Factor: 43.113

Anderson, J.A., Gipmans, M., Hurst, S., Layton, R., Nehra, N., Pickett, J., Shah, D.M., Souza, T.L.P.O., Tripathi, L. 2016. Emerging agricultural biotechnologies for sustainable agriculture and food security. Journal of Agricultural and Food Chemistry 1–11. Impact Factor: 4.052 DOI: 10.1021/acs.jafc.5b04543.

Anjanappa, R.B., Mehta, D., Maruthi, M.N., Kanju, E., Gruissem, W., and Vanderschuren, H. 2016. Characterization of brown streak virus-resistant cassava. Molecular Plant-Microbe Interactions 29(7), 527–537. Impact Factor: 4.145

Boukar, O., Fatokun, C., Huynh, B., Roberts, P.A., and Close, T.J. 2016. Genomic tools in cowpea breeding programs: Status and perspectives. Genomic tools in cowpea breeding programs: status and perspectives. Frontiers in Plant Science 7(757), 1–13. (ISSN: 1664-462X). Impact Factor: 4.495

Bredeson, J.V., Lyons, J.B., Prochnik, S., Wu, G.A., Ha, C.M., Edsinger-Gonzales, E., Grimwood, J., Schmutz, J., Rabbi, I.Y., Egesi, C., Nauluvula, P., Lebot, V., Ndunguru, J., Mkamilo, G., Bart, R., Setter, T.L., Gleadow, R.M., Kulakow, P., Ferguson, M., Rounsley, S., and Rokhsar, D.S. 2016. Sequencing wild and cultivated cassava and related species reveals extensive interspecific hybridization and genetic diversity. Nature Biotechnology 34, 562–570. Impact Factor: 43.113

Chen, J., Shrestha, R., Ding, J., Zheng, H., Mu, C., Wu, J., and Mahuku, G. 2016. Genome-wide association study and qtl mapping reveal genomic loci associated with fusarium ear rot resistance in tropical maize germplasm. G3-Genes Genomes Genetics 1–48. Impact Factor: 2.910

Christelova, P., De Langhe, E., Hribova, E., Cizkova, J., Sardos, J., Husakova, M., Van den Houwe, I., Sutanto, A., Kepler, A.K., Swennen, R., Roux, N., and Dolezel, J. 2016. Molecular and cytological characterization of the global musa germplasm collection provides insights into the treasure of banana diversity. Biodiversity and Conservation 1–24. Impact Factor: 2.258

Janssens, S.B., Vandelook, F., De Langhe, E., Verstraete, B., Smets, E., Van den Houwe, I., and Swennen, R. 2016. Evolutionary dynamics and biogeography of musaceae reveal a correlation between the diversification of the banana family and the geological and climatic history of southeast Asia. New Phytologist 1–13. Impact Factor: 7.210

Kitavi, M., Downing, T., Lorenzen, J., Karamura, D., Onyango, M., & Nyine, M., Ferguson, M., and Spillance, C. 2016. The triploid east African highland banana (eahb) genepool is genetically uniform arising from a single ancestral clone that underwent population expansion by vegetative propagation. Theoretical and Applied Genetics 1–15. Impact Factor: 3.900

Mahuku, G., Chen, J., Shrestha, R., Narro, L. A., Guerrero, K. V., Arcos, A. L., and Xu, Y. 2016. Combined linkage and association mapping identifies a major qtl (qrtsc8-1), conferring tar spot complex resistance in maize. Theoretical and Applied Genetics 1–13. Impact Factor: 3.900

Manoharan R., Tripathi J.N., and Tripathi L. 2016. Plant regeneration from axillary bud derived callus in white yam (Dioscorea rotundata). Plant Cell Tissue Organ Culture 126, 481–497. DOI 10.1007/s11240-016-1017-2. Impact Factor: 2.39

Mburu K., Oduor R., Mgutu A., and Tripathi L. 2016. Silicon application enhances resistance to Xanthomonas wilt disease in banana. Plant Pathology 65, 807–818. Doi: 10.1111/ppa.12468. Impact Factor: 2.12

Munoz-Amatriain, M., Mirebrahim, H., Xu, P., Wanamaker, S., Luo, M., Alhakami, H., Alpert, M., Atokple, I., Batieno, B.J., Boukar, O., Bozdag, S., Cisse, N., Drabo, I., Ehlers, J.D., Farmer, A., Fatokun, C., Gu, Y.Q., Guo, Y., Huynh, B., Jackson, S.A., Kusi, F., Lawley, C.T., Lucas, M.R., Ma, Y., Timko, M.P., Wu, J., You, F., Roberts, P.A., Lonardi, S., and Close, T.J. 2016. Genome resources for climate-resilient cowpea, an essential crop for food security. Plant Journal 1–40. Online first (ISSN: 0960-7412). Impact Factor: 5.468

Ndunguru, J., De Leon, L., Doyle, C.D., Sseruwagi, P., Plata, G., Legg, J., et al. 2016. Two novel DNAs that enhance symptoms and overcome cmd2 resistance to cassava mosaic disease. Journal of Virology 90(8), 4160–4173. Impact Factor: 4.606

Nie, X., Sutherland, D., Dickison, V., Singh, M., Murphy, A., and De Koeyer, D. 2016. Development and validation of high-resolution melting markers derived from Ry sto STS markers for high-throughput marker-assisted selection of potato carrying Ry sto. Phytopathology 106(11), 1366–1375. (ISSN: 0031-949X). Impact Factor: 3.011

Tatineni, S., Wosula, E.N., Bartels, M., Hein, G.L., and Graybosch, R.A. 2016. Temperature-dependent wsm1 and wsm2 gen-specific blockage of viral long-distance transport provides resistance to wheat streak mosaic virus and triticum mosaic virus in wheat. Molecular Plant-Microbe Interactions 29(9), 724–738. Impact Factor: 4.145

Ulzen, J., Abaidoo, R. C., Mensah, N.E., Masso, C., and Abdelgadir, A.H. 2016. Bradyrhizobium inoculants enhance grain yields of soybean and cowpea in northern Ghana. Frontiers in Plant Science 7, 1–9. (ISSN: 1664-462X). Impact Factor: 4.495

Wolfe, M., Kulakow, P., Rabbi, I.Y., and Jannink, J. 2016. Marker-based estimates reveal significant non-additive effects in clonally propagated cassava (Manihot esculenta): Implications for the prediction of total genetic value and the selection of varieties. G3-Genes Genomes Genetics 1–41. Online first (ISSN: 2160-1836). Impact Factor: 2.910

Wolfe, M., Rabbi, I.Y., Egesi, C., Hamblin, M., Kawuki, R., Kulakow, P., Lozano, R., Carpio, D.P., Ramu, P., and Jannink, J. 2016. Genome-wide association and prediction reveals genetic architecture of cassava mosaic disease resistance and prospects for rapid genetic improvement. Plant Genome 9(2), 1–13. (ISSN: 1940-3372). Impact Factor: 3.509

Zorrilla-Fontanesi, Y., Rouard, M., Cenci, A., Kissel, E., Do, H., Zorrilla, J., Rouard, M., Cenci, A., Kissel, E., Do, H., Dubois, E., Nidelet, S., Roux, N., Swennen, R., and Carpentier, S. 2016. Differential root transcriptomics in a polyploid non-model crop: the importance of respiration during osmotic stress. Scientific Reports 6(22583), 1–14. 5.228

Social science and Agribusiness

Awotide, B.A., A.D. Alene, T. Abdoulaye, and V.M. Manyong. 2016. Impact of agricultural technology adoption on asset ownership: the case of improved cassava varieties in Nigeria. Food Security 7, 1239–1258. Impact Factor: 2.271

Frelat, R., Lopez-Ridaura, S., Giller, K., Herrero, M., Douxchamps, S., Djurfeldt, A., Erenstein, O., Henderson, B., Kassie, M., Paul, B.K., Rigolot, C., Ritzema, R., Rodriguez, D., Van Asten, P., and van Wijk, M.T. 2016. Drivers of household food availability in sub-Saharan Africa based on big data from small farms. Proceedings of the National Academy of Sciences of the United States of America 113(2), 458–463. Impact Factor: 9.423

Gichohi-Wainaina, W.N., Tanaka T., Towers G.W., Verhoef H., Veenemans J., Talsma E.F., Harryvan J., Boekschoten M.V., Feskens E.J., and Melse-Boonstra A. 2016. Associations between common variants in iron-related genes with haematological traits in populations of African ancestry. PLoS One, 11(6). Impact Factor: 3.234

Kuivanen, K.S., Michalscheck, M., Descheemaeker, K., Adjei-Nsiah, S., Mellon-Bedi, S., Groot, J.C.J., and Alvarez, S. 2016. A comparison of statistical and participatory clustering of smallholder farming systems – a case study in Northern Ghana. Journal of Rural Studies 45, 184–198. (ISSN: 0743-0167). Impact Factor: 2.206

Manda, J., Gardebroek, C., Khonje, M.G., Alene, A.D., Mutenje, M., Kassie, M. 2016. Determinants of child nutritional status in the eastern province of Zambia: The role of improved maize varieties. Food Security 8, 239–253. Impact Factor: 2.271

Mwongera, C., Shikuku, K.M., Twyman, J., Laderach, P., Ampaire, E., Van Asten, P., Twomlow, S., and Winowiecki, L. 2016. Climate smart agriculture rapid appraisal (csa-ra): a tool for prioritizing context-specific climate smart agriculture technologies. Agricultural Systems 1–12. Impact Factor: 2.867

Njenga, M., Iiyama, M., Jamnadass, R., Helander, H., Larsson, L., de Leeuw, J., Neufeldt, H., Roing de Nowina, K., and Sundberg, C. 2016. Gasifier as a cleaner cooking system in rural Kenya. Journal of Cleaner Production 121, 208–217. Impact Factor: 4.959

Schut, M., Van Asten, P., Okafor, C., Hicintuka, C., Mapatano, S., Nabahungu, N.L., Kagabo, D., Muchunguzi, P., Njukwe, E., Dontsop-Nguezet, P., Sartas, M., and Vanlauwe, B. 2016. Sustainable intensification of agricultural systems in the central African highlands: The need for institutional innovation. Agricultural Systems 145, 165–176. Impact Factor: 2.867

van Ittersum, M.K., van Bussel, L.G., Wolf, J., Grassini, P., van Wart, J., Guilpart, N., Claessens, L., de Groot, H., Wiebe, K., Mason-D'Croz, D., Yang, H., Boogaard, H., van Oort, P.A., van Loon, M.P., Saito, K., Adimo, O., Adjei-Nsiah, S., Agali, A., Bala, A., Chikowo, R., Kaizzi, K., Kouressy, M., Makoi, J.H., Ouattara, K., Tesfaye, K., and Cassman, K.G. 2016. Can sub-Saharan Africa feed itself? Proceedings of the National Academy of Sciences of the United States of America (PNAS) 113(52), 14964– 14969. ISSN: 0027-8424. Impact Factor: 9.423

Wigboldus, S., Klerkx, L., Leeuwis, C., Schut, M., Muilerman, S., and Jochemsen, H. 2016. Systemic perspectives on scaling agricultural innovations: A review. Agronomy for Sustainable Development. 36(46), 1–20. Impact Factor: 4.141

Food technology

Maziya-Dixon, B., Alamu, O.E., and Dixon, A. 2016. Variation in the evaluation of cis- and trans-<beta>-carotene in yellow-fleshed cassava (Manihot esculenta Cranz) varieties as a function of the storage root portion and sampling method. LWT - Food Science and Technology 70C, 296–301. DOI information: 10.1016/j.lwt.2016.03.002. Impact Factor: 2.711

Oladeji, Dixon, G.A. 2016. Variation in the evaluation of cis- and trans-carotene in yellow-fleshed cassava (Manihot esculenta Cranz) varieties as a function of the storage root portion and sampling method. LWT - Food Science and Technology 70C, 296-301. DOI information: 10.1016/j.lwt.2016.03.002. Impact Factor: 2.711

Udomkun, P., Nagle, M., Argyropoulos, D., Mahayothee, B., and Muller, J. 2016. Multi-sensor approach to improve optical monitoring of papaya shrinkage during drying. Journal of Food Engineering.189, 82–89. Impact Factor: 3.199

Udomkun, P., Nagle, M., Argyropoulos, D., Mahayothee, B., Latif, S., and Muller, J. 2016. Compositional and functional dynamics of dried papaya as affected by storage time and packaging material. Food Chemistry 196, 712–719. Impact Factor: 4.052

Our finances and supporters

Women selling their yam in the market. Photo by Clement Ono-Raphael, IITA.

Funding overview

Omoshalewa Sholola

Funding for 2016 was US$112.478 million, of which 99.7% came from CGIAR investors and 0.3% from other sources. Expenditures were $113.877 million (net of indirect costs recovery of $10.525 million), of which 91.2% was used for program expenses and 8.8% for management and general expenses.

The governments and agencies that provided the largest share of our funding in 2015 and 2016 are shown in Figure 1 (top 10 donors).

IITA`s 2016 total budget-cum-total expenditure are respectively depicted in Figures 2 and 3. Table 1 shows the 2016 Investment by CGIAR Research Programs. Table 2 gives an indication of the financial health of IITA, while Table 3 lists the various investors.

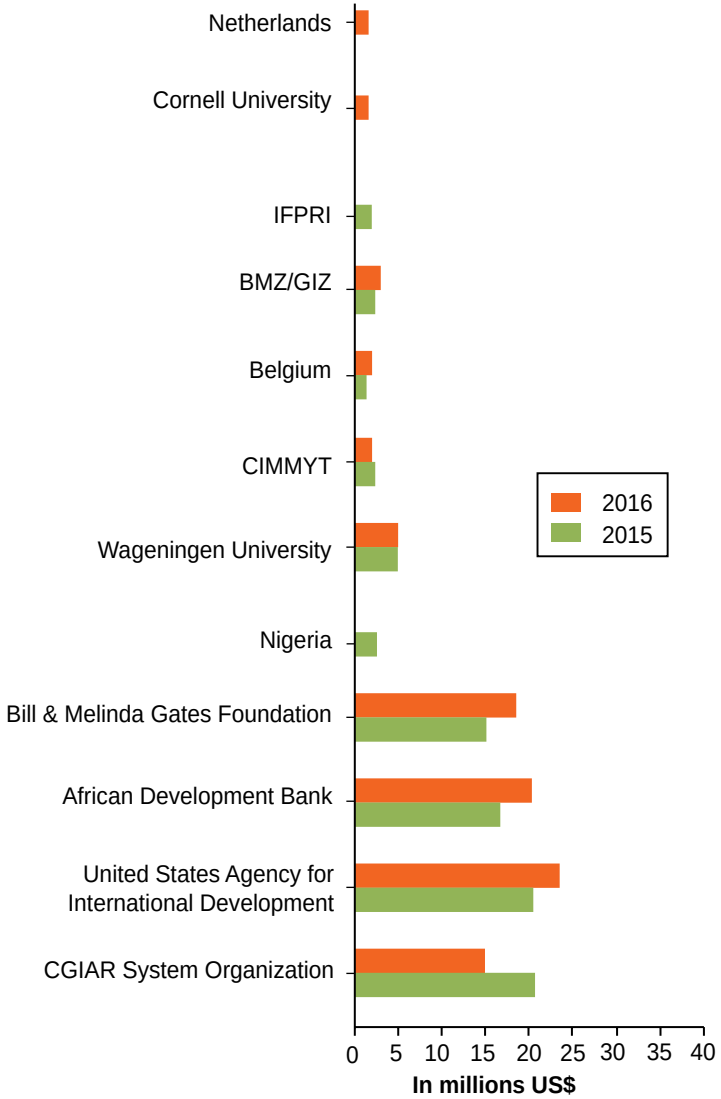


Figure 1. Funding: Top 10 donors, 2015 and 2016.

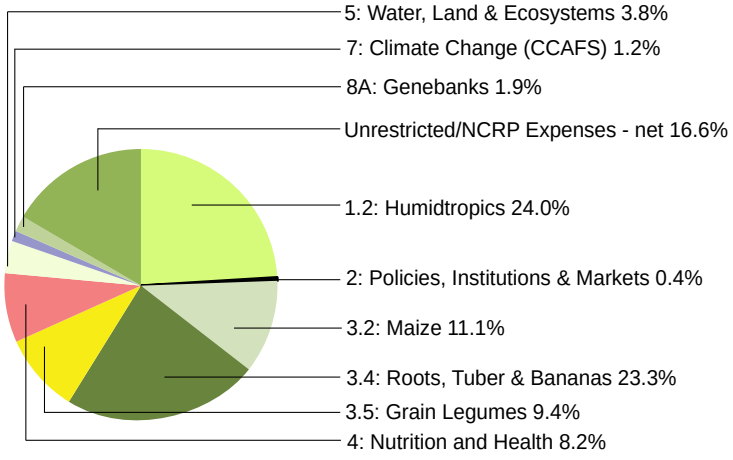


Figure 2. 2016 Investment by CGIAR Research Programs Budget.

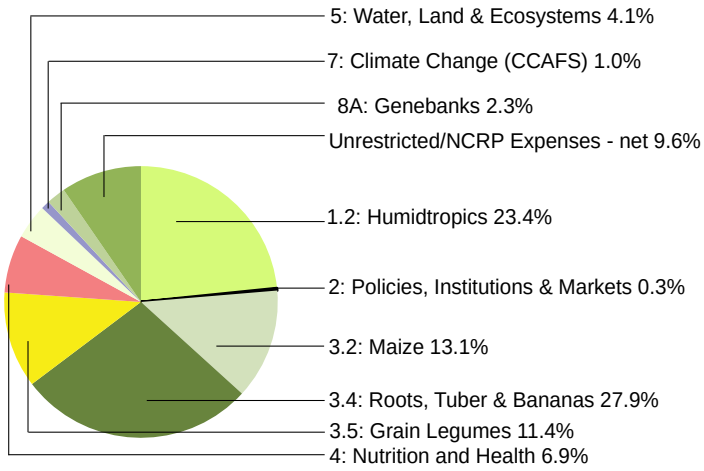


Figure 3. 2016 Investment by CGIAR Research Programs Expenditure.

Table 1. 2016 investment by CGIAR Research Programs.

CRP title	Budget ($`000) W1/2	Budget ($`000) W3 /Bilateral Project	Budget ($`000) Total	Actual Expenes ($`000) W1/2	Actual Expenes ($`000) W3 / Bilateral Project	Actual Expenes ($`000) Total
1.2: Humid Tropics	7,200	25,017	32,217	6,296	20,312	26,608
2: Policies, Institutions & Markets	335	202	537	335	–	335
3.2: Maize	1,674	13,161	14,835	1,690	13,252	14,942
3.4: Roots, Tuber & Bananas	1,645	29,657	31,302	2,851	28,912	31,763
3.5: Grain Legumes	645	11,999	12,644	560	12,476	13,036
4: Nutrition and Health	419	10,548	10,967	780	7,087	7,867
5: Water, Land & Ecosystems	83	5,069	5,152	83	4,614	4,697
7: Climate Change (CCAFS)	–	1,666	1,666	171	1,000	1,171
8A: Genebanks	1,046	1,462	2,508	2,135	440	2,575
CRP	13,047	98,781	111,828	14,901	88,093	102,994
NCRP	–	9,926	9,926	–	8,639	8,639
Core Unrestricted	600	–	600	2,244	–	2,244
	13,647	108,707	122,354	17,145	96,732	113,877

1/ Includes CRP1.2 Windows 1&2 Partners' expenditures (2016: $3.454 M and 2015: $5.026 M) per CGIAR Advisory Note.

Table 2. Performance indicators: Financial health.

	2015	2016
Short-term Solvency (or Liquidity)	39 days	30 days
Long-term Financial Stability (adequacy of reserves)	39 days	30 days
Indirect Cost Rates	14.96%	11.90%
Cash Management on Restricted Operations	0.33	0.95
Audit Opinion	Unqualified / Clean Bill of Financial Health	

Table 3. List of IITA investors.

Investors	2015 (expressed in US$ thousands)	2016 (expressed in US$ thousands)
ACD/VOCA	–	–
African Agricultural Technology Foundation (AATF)	16	–
African Development Bank	16,660	20,204
AGRA	819	587
Austria	92	205
Belgium	1,409	1,877
Bill & Melinda Gates Foundation	15,157	18,466
BMZ/GIZ	2,690	2,856
Califonia University	183	124
Canada	–	–
Catholic Relief Service	12	4
Chemonics International	–	–
Chevron	–	99
CIAT	–	28
CIMMYT	2,361	1,985
CIP	–	835
CORAF/WECARD	77	499
Commission of the European Communities	727	31
Common Fund for Commodities	91	–
Cornell University	999	1,571
CGIAR System Organization	20,680	14,901
Delloite Consulting LLP	1,090	1,082
Denmark	6	–
DDPSC	177	276
DRC	–	1,269
FARA	60	–-
Food and Agriculture Organization	72	435
France	–	–
Global Crop Diversity Trust (GCDT)	235	365
ICIPE	–	–
ICRISAT	670	1,486
Illinois University	328	–
International Fund for Agricultural Development	–	1,483
IFPRI	2,001	210
ILRI	267	641
Ireland	–	–
Japan	936	505
Leventis Foundation	–	40
Liberia GOV.	–	445
L`Union Economique et Monetaire Quest Africaine	–	–
Meridian Institute	657	–
Michigan State University	368	–
Nestle	–	–
Netherlands	900	1,572
Niger	269	–
Nigeria	2,453	789
Norway	–	–
Purdue University	411	273
Rockefeller Foundation	–	–
Sierra Leone	207	–
Sweden	65	45
Swiss Agency for Dev. & Coop. (SDC)	–	720
Switzerland	604	23
United States Agency for International Development	20,436	23,496
Wageningen University	4,884	4,988
WASCO	–	–
World Bank	–	–
Miscellaneous Projects	5,501	5,552
Challenge Programs	1,989	2,212
Grand Total	**106,559**	**112,179**

Board of Trustees

Headquarters and hubs

The new IITA-Mozambique Research Station in Nampula. Photo by IITA.

Headquarters, Hubs, and Stations

Headquarters and Western Africa Hub

PMB 5320, Oyo Road, Ibadan 200001
Oyo State, Nigeria
Tel: +234 2 751 7472 | USA Tel: +1 201 633 6094 |
Fax: +44 208 711 3786

Central Africa Hub

IITA Central Africa Hub Coordination Office
icipe, c/o IITA Projects
Duduville Complex, Kasarani off Thika Road
PO Box 30772-00100
Nairobi, Kenya
Tel: +254 020 863 2900

IITA-DR Congo (Kinshasa)
4163, avenue Haut-Congo
Quartier Revolution, Commune de la Gombe
Kinshasa, Republique Democratique du Congo
Tel: +243 99 021 2603
Email: admins@iitadrc.org

Eastern Africa Hub

IITA-Tanzania (Dar es Salaam)
Plot 25, Mikocheni Light Industrial Area
Mwenge Coca-Cola Road, Mikocheni B
PO Box 34441
Dar es Salaam, Tanzania
Tel: +255 22 270 0092 | Fax: +255 22 277 5021
E-mail: iita-tanzania@cgiar.org

Southern Africa Hub

IITA-Zambia
Southern Africa Research and Administration Hub (SARAH) Campus
Plot 1458B, Ngwerere Road (5 km off Great North Road and adjacent to ZamSeed Farms)
Chongwe District, Lusaka Province, Zambia
Tel: +260 211 840 365 | Fax: +260 211 285 417
PO Box 310142, Chelston
Lusaka, Zambia

International Mailing Address

IITA Ltd 7th Floor, Grosvenor House
125 High Street
Croydon Surrey CR0 9XP, UK

Stations

IITA-Benin

08 BP 0932 Tri Postal
Cotonou, Republic of Benin
+229 6418 1313, +229 6418 1414, +229 6418 1515, +229 9596 1159
E-mail: iita-benin@cgiar.org

IITA-Burundi

PMB 1893 Bujumbura-Burundi
Quartier Kabondo
Avenue du 18 Septembre, 10
+257 (0) 79 33 1024 / +257 (0) 76 19 4193
E-mail : IITA-Burundi@cgiar.org

IITA-Cameroon

Ecoregional Center, BP 2008 (Messa)
Yaounde, Cameroon
Tel: 237 2 223 7434, 2 223 7522
E-mail: iita-cameroon@cgiar.org

IITA-Côte d'Ivoire

2pltx, 7eme Tranche, Rue L54-27
BP 696 Abidjan 27, Cote d'Ivoire
Tel: 225 22 52 37 32

IITA-DR Congo (Kinshasa)

4163, avenue Haut-Congo
Quartier Revolution, Commune de la Gombe
Kinshasa, Republique Democratique du Congo
Tel: +243 99021 2603
Email: admins@iitadrc.org

IITA-DR Congo (Kalambo)

Route Kavumu, Km 18, bifurcation Birava
Site UCB (Université Catholique de Bukavu)
Phone +243 999 78 82 78 | +243 979 30 22 03

IITA-Ghana (Accra)

Council for Scientific and Industrial Research (CSIR)
INSTI Building
Off Augustinho Neto Road
Airport Residential Area
PO Box M32, Accra, Ghana
Tel: + 233 303931 023
E-mail: iita_ghana@cgiar.org

IITA-Ghana (Tamale)

Near Tamale Sport Stadium
1st Road, Off Sagnarigu Main Rd.
PO Box TL 6, Tamale-Ghana
Tel: +233 37 202 8913

IITA-Nigeria (Ibadan)

PMB 5320, Oyo Road, Ibadan 200001
Oyo State, Nigeria
Tel: +234 2 700800IITA | USA Tel: +1 201 6336094 |
Fax: +44 208 7113786

Abuja R4D Station

Beside Old Water Works, Kubwa
PMB 82, 901101, Abuja
Federal Capital Territory, Nigeria

IITA Research and Training Center

Ago-owu Farm Settlement Road
Ikoyi, Osun State, Nigeria

Kano Station

Sabo Bakin Zuwo Road
PMB 3112, Kano, Nigeria
Tel: +2348060522205, +2347034847459

Ikenne Station

Ikenne-Ayepe Road
IAR&T Farms
Ikenne, Ogun State, Nigeria

Mokwa Station

Km 8 Mokwa-Kainji Road
Abu Farms
Mokwa, Niger State, Nigeria

Onne Station

IITA Road, Onne
Eleme LGA, Rivers State

IITA-Kenya (Nairobi)

c/o International Livestock Research Institute (ILRI)
PO Box 30709 – 00100, Nairobi, Kenya
Tel: +254 20 422 3350/422 3000
E-mail: iita-kenya@cgiar.org

IITA-Malawi

Chitedze Research Station
Off-Mchinji Road
PO Box 30258
Lilongwe 3, Malawi
Tel: +265 (0)1 707 014/022, Fax: +265 (0)1 707 026
Email: iita-malawi@cgiar.org

IITA-Mozambique

Av. FPLM, Via Corrane, Km 8
PO Box 709, Nampula, Mozambique
Tel: +258 20031477
E-mail: iita-mozambique@cgiar.org

IITA-Rwanda

KG 563 street, no 3,
Behind Telecom house
Kacyiru, Kigali, Rwanda

IITA-Senegal

CORAF/IITA,7 Avenue Bourguiba B.P. 48. cp 18523
Dakar RP, Senegal
Tel: Standard +221 33 869 9618

IITA-Sierra Leone

SLARI Building, Tower Hill
PMB 134
Freetown, Sierra Leone

IITA-Tanzania (Arusha)

c/o AVRDC- The World Vegetable Centre
PO Box 10, Duluti, Arusha, Tanzania
Tel: +255 27 255 3051

IITA

c/o The Nelson Mandela African Institution for Science and Technology (NM-AIST)
PO Box 447, Arusha, Tanzania

IITA-Tanzania (Dar es Salaam)

Plot 25, Mikocheni Light Industrial Area
Mwenge Coca-Cola Road, Mikocheni B,
PO Box 34441

IITA is a member of the CGIAR System Office