ROOTS TUBERS & BANANAS

RTB PERFORMANCE MONITORING REPORT FOR 2014

APRIL 2015

RESEARCH PROGRAM ON Roots, Tubers and Bananas

CGIAR

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ABBREVIATIONS

BBTD	Banana bunchy top disease
Bioversity	Bioversity International
BTI	Boyce Thompson Institute for Plant Research
BXW	Banana Xanthomonas wilt
CGIAR	Organization dedicated to international agricultural research
CIAT	International Center for Tropical Agriculture
CIP	International Potato Center
Cirad	Centre de Coopération Internationale en Recherche Agronomique pour le Développement
CMD	Cassava mosaic disease
CRP	CGIAR Research Program
CWR	Crop wild relative
DNA	Deoxyribonucleic acid
DRC	Democratic Republic of the Congo
HH	Household
Humidtropics	CGIAR Research Program on Integrated Systems for the Humid Tropics
IDO	Intermediate Development Outcome
IFAD	International Fund for Agricultural Development
IITA	International Institute of Tropical Agriculture
INIA	Instituto Nacional de Investigación Agrícola (Peru)
INRA	Institut National de la Recherche Agronomique
IRD	Institut de Recherche pour le Développement
M&E	Monitoring and evaluation
NARS	National agricultural research system
NGO	Nongovernmental organization
OFSP	Orange-fleshed sweetpotato
PMU	Program Management Unit
RBM	Results-based management
RTB	CGIAR Research Program on Roots, Tubers and Bananas
SDSR	Single Diseased Stem Removal
SNNPR	Southern Nations, Nationalities and People's Region
SNP	Single Nucleotide Polymorphism
t	Tonne
USAID	United States Agency for International Development
VAD	Vitamin A deficiency
W 1/2/3	Window 1/2/3 – CGIAR Funding system

PART I: TECHNICAL REPORT

A. KEY MESSAGES

A.1 Synthesis of progress and challenges

In 2014 the CGIAR Research Program on Roots, Tubers and Bananas (RTB) brought together four CGIAR centers— led by the International Potato Center (CIP) with Bioversity International, International Center for Tropical Agriculture (CIAT), and International Institute of Tropical Agriculture (IITA). Joining these centers were Cirad, representing Institut de Recherche pour le Développement (IRD), Institut National de la Recherche Agronomique (INRA), and Vitropic; and more than 200 partners comprising 66 national agricultural research systems, 63 universities and advanced research institutes, 14 nongovernmental organizations (NGOs), and 18 private sector companies (http://bit.ly/1zVujrj). RTB research covers six crops—bananas (and plantains), cassava, potato, sweetpotato, yams, and other roots and tubers—and is organized around seven disciplinary Themes[1] (http://bit.ly/1hzeWAN). Under the guidance of RTB's Theme leaders, multi-year complementary funding projects on cross-crop and multicenter research were initiated in 2012 and 2013. In 2014, four complementary funding projects ended and were preparing for a two-year extension; four ex-post impact assessment studies got underway.

The disciplinary Themes offer a strong basis for planning and monitoring of research products, but do not provide a coherent basis for tracking research and development outcomes. Achieving outcomes requires several Themes to come together, building on the entire stock of available technology. At the 2014 Annual Meeting, RTB scientists developed a new program structure (following CGIAR guidelines) to facilitate results-based management (RBM) based upon a linked set of discovery, delivery, and impact at scale flagship projects (http://bit.ly/1NXUbLz). RTB will move to the new program structure beginning in January 2016. In 2014, writing teams began to scope out business cases for the flagships and their respective clusters of activities. For clusters in delivery flagships, research products were identified, impact pathways were tentatively mapped out, and indicators for Intermediate Development Outcomes (IDO) were estimated. Central to putting RBM in place is securing the collaboration of stakeholders — especially of the downstream development partners who share accountability for achieving outcomes.

A.2 Synthesis of two most significant achievements

Impact pathways co-constructed with stakeholders. The CGIAR Consortium awarded RTB a grant in 2014 to implement a pilot project of RBM (http://bit.ly/1kBI62P). Stakeholder planning workshops were held for two clusters linked with delivery flagships: Seed potato systems in sub-Saharan Africa (SSA) and Banana *Xanthomonas Wilt* (BXW) management in Eastern and Central Africa (http://bit.ly/1C6tb51). Clusters integrate multiple initiatives from different sources of RTB funding. A broad range of stakeholders participated in the workshops: farmers and farmer organizations; national, regional, and international research organizations; relevant ministries and national agencies; private companies; national and international NGOs; and international development agencies. During the workshop, stakeholders and RTB scientists co-constructed more realistic, nonlinear impact pathways (http://bit.ly/1FkBU8Z). They illustrate the interactions between outcome levels and among products and outcomes. Additionally, the intervention was better contextualized, with priorities and specific strategies identified by region or by country. Scientists and stakeholders collaborated to identify enabling and disenabling factors for the causal sequences to work through. Co-constructing the results framework facilitated the definition of an agreed indicators' framework for monitoring expected changes. Participants agreed that the

[1] **Theme 1**: Unlocking the value and use potential of genetic resources; **Theme 2**: Accelerating the development and selection of cultivars with higher, more stable yield and added value; **Theme 3**: Managing priority pests and diseases; **Theme 4**: Making available low-cost, high-quality planting material for farmers; **Theme 5**: Developing tools for more productive, ecologically robust cropping systems; **Theme 6**: Promoting postharvest technologies, value chains, and market opportunities; and **Theme 7**: Enhancing impact through partnerships.

quantitative indicators-based monitoring approach was feasible, and that future workshops for qualitative follow-up and reflection are needed.

As part of the RBM pilot, RTB scientists and partners took part in a workshop to develop a monitoring and evaluation system (M&E) for genetic gains in RTB crops. The conclusions of this workshop established a solid basis for setting up metrics by which results from laboratories, experiment stations, and farms will be evaluated for their contribution to improve, monitor, and evaluate the rates of genetic gain (http://bit.ly/1bpr8SJ).

Applying state-of-the-art biological tools. The second achievement relates to the project "Enhancing global RTB productivity through more targeted use of global RTB genetic diversity," which has concluded its first phase. This integrated all RTB centers and brought together conservation biologists, breeders, molecular geneticists, molecular biologists, biochemists, and bioinformatics experts to build a research platform that brings state-of-the-art biological tools to advance breeding for bananas, cassava, potatoes, sweetpotatoes, and yams. The aim was to unravel the genetic potential of the underutilized RTB crop diversity held in trust by CGIAR centers. Three main work packages were: (i) genotyping, (ii) phenotyping and (iii) breeding applications. Nearly 6,500 RTB accessions from the genebanks and elite breeding pools have been characterized using next-generation sequencing. This effort helped to identify hundreds of thousands of single nucleotide variants that together will help RTB scientists in the near future to unravel the genetic mechanisms behind key sustainability traits, including drought and pest/diseases tolerance, or those related to high productivity (e.g., heterosis), high quality (e.g., postharvest losses and consumer preferences), and high nutritional potential (e.g., high vitamin and micronutrient content).

The game changer for phenotyping has been the investment in metabolomics capacity to help measure genotypic and phenotypic responses at the molecular level. Accessing this technology required improved experimental design for all crops, since small variations in metabolite concentrations need to be detected. This technology depends on extensive technical and biological replicates to accurately hone in on important gene effects. This investment has produced the first diversity metabolic compound libraries of approximately 7,000 metabolic features per crop, which will help unlock the genetic potential of current traits.

For breeding applications, this project accelerated the use of genome-wide association to quickly and accurately link areas of the genome with important traits. For banana, this includes the ability to produce pulpy seedless fruit. For cassava, genes controlling cyanogenic potential have been placed in two chromosomes. For tetraploid potato, genome-wide association studies showed that regions of chromosome 4 and chromosome 5 have significant effects on traits associated with tuber initiation and bulking. In addition, feasibility of genomic selection in potato breeding was demonstrated. Prediction accuracies for traits associated with early bulking and tuberization in tetraploid breeding populations and for accumulation of minerals, vitamin C, and yield in diploid landrace germplasm were sufficiently high to merit implementation of genomic selection of superior progenitors in these two gene pools.

A.3 Financial Summary

The total budget for RTB approved in October 2014, after the indication of retroactive budget reduction of 7% (US$2.5M) by CGIAR, was US$92.7M, comprising US$33.9M (37%) from W1 and W2 funding and US$58.8M (63%) from bilateral and W3 funding. Total expenditures during the project reporting period were US$75.4M, or 81% of the budget, of which US$31.1M (41%) is from W1 and W2, and US$44.3M (59%) from W3, bilateral and centers other funds. W1 and W2 expenses reached 92% execution in comparison with the revised budget and W3, bilateral and centers other funds expenditure, 75% of the budget. Of total expenditure, 6% was on gender research and 17% was reported as collaborations with non-CGIAR partners.

B. IMPACT PATHWAY AND IDOs

RTB scientists are estimating IDOs for the clusters in delivery flagships, drawing on results of the RTB strategic assessment of research priorities, likelihood of adoption, and total area of adoption domain. Figures were obtained by aggregating country-specific estimates that are available for cluster business cases (e.g., adoption area, number of beneficiaries, changes in yield and income).

Table 1. RTB selected IDOs and example indicators

IDO	Indicator (2026)
Increased incomes and employment	Potato income of 600,000 farmer households (HH) increased by at least 10% through the use of adapted gender-sensitive techniques for on-farm seed management in SSA (Eastern & Central Africa 400,000, Southern Africa 150,000, and West Africa 50,000)
Productivity	Total crop output increased by 7% through the introduction of agile potato varieties in cereal-based cropping systems (aggregation of individual crop outputs) for 590,000 poor HH in China and 735,000 poor HH in nine other targeted Asian countries
Improved diets for poor and vulnerable people	50% of women of reproductive age increase their intake of vitamin A-rich foods by 40% in 2.5 million HH in all targeted countries in Africa, Asia, and the Caribbean
More sustainably managed agro-ecosystems	Annual banana yield (t/ha) restored to 85% of the pre-infection conditions in fields recovered from BXW for 2.5 million HH in 6 Eastern and Central African countries
Enhanced benefits from ecosystem goods and services	20,000 small- and medium-scale cassava processing centers eliminate discharge of processing waste into surface water in SSA and Asia
Equity and inclusion achieved	Empowerment of at least 3,000 village-based seed multipliers, to generate more equitable access to better potato seed for at least 150,000 marginalized farmers (at least 50% women) in 10 SSA countries
Enabling environment improved	Cost-effective pest and disease surveillance systems that take into account the heterogeneity of cassava cropping systems, adopted in at least 5 different South-East Asian countries
National partners and beneficiaries enabled	Under development—this new crosscutting IDO could use periodic questionnaires to key partners to assess their appreciation of partnerships

Note: see http://bit.ly/1bBECLX for full list of countries for each indicator.

C. PROGRESS ALONG THE IMPACT PATHWAY

C.1 Progress toward outputs

Principal achievements are listed by RTB disciplinary Theme below (further background and detail are available in the source materials presented in the crop reports (http://bit.ly/1Pcrtbg) and Theme leaders' reports (http://bit.ly/1yap8bI).

Genetic resource conservation, use, and improvement (Themes 1 and 2)

RTB funded comprehensive gap analyses, completed in 2014, of the crop wild relatives (CWR) of potato and sweetpotato. Scientists compared herbaria occurrence data with seeds and germplasm held in genebanks to identify CWR species that are either under-represented or absent. The gap analysis for potato was the most extensive analysis of its kind for any CWR, comprising 49,164 herbaria records for 73 species. Thirty-two of the potato CWR species and 11 of the sweetpotato CWR species analyzed received a high-priority status for gap-filling. Both studies identified priority regions for CWR field collection. The gap analyses were supported by the Global Crop Diversity Trust and involved CIP, CIAT,

and several universities. A paper on the potato gap analysis has been accepted for publication in *PLOS ONE* this year (http://bit.ly/1zlu4LI).

A mass field screening for heat tolerance of 1,973 sweetpotato accessions from the CIP genebank resulted in the identification of 146 accessions that performed well under heat-stress conditions, of which at least 21 produced high yields and early bulking. Heat-tolerant clones identified in the trials are potential candidates for breeding efforts in marginal areas of Africa and Asia, where intense heat and drought are major constraints for the crop.

Accurate identification of crop cultivars is crucial in assessing the impact for clonally propagated species that rely on informal seed for variety dissemination. IITA, in partnership with Michigan State University, and the Crops Research Institute of Ghana, implemented a pilot study on the utility of DNA markers to track improved cassava varieties in Ghana. A total of 917 accessions collected from 495 farming households (HH) were genotyped-by-sequencing at 56,849 single nucleotide polymorphism (SNP) loci along with a "reference library" of 64 accessions of released varieties and known landraces. CIAT identified 96 SNP, fitting on one typical type of micro-array (*chip*) that can *fingerprint* varieties, reliably and cheaply, and used this for a cassava variety adoption survey in Cauca, Colombia, with over 400 samples collected.

Pest and disease management and farmer access to clean seeds (Themes 3 and 4)

Research into improving the management of seed degeneration (i.e., the accumulation and transmission of pathogens via planting material from one crop cycle to the next) produced improvements in theoretical modeling that argue for a more integrated approach to the problem in developing nations. Data from field studies in China and several African and South American countries were used to strengthen a theoretical model for predicting yield under different management strategies. Researchers began enhancing the model with management performance maps, which could be used to predict the effectiveness of strategies in specific regions and agro-ecologies.

The aroid root crops taro (*Colocasia esculenta*) and cocoyam (*Xanthosoma sagittifolium*) are important for the food security, nutrition, and livelihoods of poor farmers in West and Central Africa, since they can be grown on marginal land and have high levels of protein, vitamins, and minerals. However, they are increasingly threatened by cocoyam root rot disease and taro leaf blight; the latter causes an estimated crop loss of US$1.4 billion annually. RTB commissioned a scoping study of the crops' status in West and Central Africa. The study calls for a more comprehensive assessment of the diseases' status, the initiation of breeding for resistance, and creation of a regional network of specialists in the crop (http://bit.ly/1aaKuup).

Researchers from the four CGIAR centers, the University of Wageningen, and Kansas State University completed and analyzed 12 case studies of banana, cassava, potato, sweetpotato, and yam seed systems in Africa and Latin America as part of a cross-center effort to construct an RTB seed systems framework. Questions arose about the efficiency and value for money of rapid seed multiplication and seed quality regulation interventions. And researchers cited a need to better assess farmer demand before initiating seed system work. As the team moves forward on the framework, closer links will be established with RTB seed degeneration research (http://bit.ly/1C6wt8h).

Cropping systems and postharvest technologies (Themes 5 and 6)

Latest research shows that well-sequenced simple and affordable steps toward sustainable intensification can effect large productivity increases in cassava and close the yield gap by up to 50% (assuming 100 t/ha fresh root yield potential). A multifactorial trial in Nigeria showed the differences in yield margins caused by different factors. The factor providing the largest yield increase was the correct

choice of variety. An improved variety that was erect, resistant to Cassava Mosaic Disease (CMD), and non-branching out-yielded a similarly CMD-resistant branching variety by 23%. Many smallholders intercrop cassava, chiefly with maize. And although this practice lowers yields, such losses are more than compensated for by the income from maize (with a 30% increase of total system gross income). Sustainable intensification requires close collaboration between disciplines and the full consideration of the biophysical and economic consequences of changes to the production system (http://bit.ly/1SA5wBL).

RTB launched a three-year project, funded by International Fund for Agricultural Development (IFAD)/ European Union, in Uganda in 2014, to improve postharvest management practices for banana, cassava, potato, and sweetpotato through collaborative research. The project began with a scoping phase, in which the participating CGIAR centers (CIP, IITA, Bioversity) and their partners submitted seven business cases for review. Four were subsequently funded: (i) increase of farmer access to specialized ware potato markets through improvements in storage technologies, (ii) testing of techniques for extending the shelf life of cassava such as high relative humidity storage and coating the roots with paraffin wax, (iii) improvement of the utilization of sweetpotato and other root-and-tuber-crop byproducts as pig feed; and (iv) identification of cooking banana varieties and farming practices that will facilitate a steadier market supply and to diversify the way cooking banana is presented and sold. Each business case is being executed by a specialized team with more than 20 national organizations participating in the project. These include universities, Uganda's National Agricultural Research Organization, NGOs, private companies, and farmer associations (http://bit.ly/1NNDKiS).

Impact through partnership (Theme 7)

Research under Theme 7 is reported under sections C.3 (impact), D (gender), and F (capacity building).

C.2 Progress towards the achievement of research outcomes and IDOs

Progress was made towards the achievement of RTB IDOs (see Table 1) as detailed below.

IDO: **Productivity — potato yields tripled in Ethiopia**. Over the past five years, the project "Better Potato for a Better Life" in Ethiopia has established close partnerships with a range of research and development partners, including five government research and extension institutions, four NGOs, three universities, and six commercial seed companies. In collaboration with these partners, decentralized seed production systems were successfully established in Tigray and the Southern Nations, Nationalities and People's Region (SNNPR). Tissue culture laboratories and rapid minituber multiplication facilities with the Ethiopian Institute of Agricultural Research, Tigray Agricultural Research Institute, the Southern Agricultural Research Institute, and two private sector companies produce disease-free planting material. This material is then further multiplied by the private sector and farmer groups and cooperatives located in major production areas. As a result, the demand for quality seed in SNNPR and Tigray can now be met through local production, thereby achieving seed self-sufficiency and reducing the risk of introducing seed-borne diseases through seed imports from neighboring regions. Farmer groups supported by the project have produced, sold, and distributed more than 16,000 t of quality seed tubers. Potato seed storage—an important bottleneck—has been alleviated through the construction of more than 860 diffused light seed stores with a total capacity of around 5,800 t. Approximately 1,200 extension agents and more than 24,000 farmers have been trained on improved potato production and postharvest technology. Participating farmers experienced average yields that increased to 22.2 t/ha (based on 133 yield measurements), from average yields of around 8 t/ha (close to national average) prior to the project. This yield increase was due to the use of (i) CIP-bred varieties that were high yielding and resistant to late blight, (ii) high-quality seed, and (iii) improved agronomic practices.

IDO: **More sustainably managed agro-ecosystems — dramatic reduction in banana *Xanthomonas* wilt**. As a result of collaboration between Bioversity, IITA, and national partners in Eastern and Central Africa, banana farmers are changing their approach to managing the devastating banana *Xanthomonas wilt* (BXW). When BXW first struck in the early 2000s, farmers were advised to remove the male bud (attracts vectors), disinfect cutting tools, uproot infected mats, and replant with clean planting material—preferably tissue culture plantlets. The new, single diseased stem removal (SDSR) technique builds on research by Bioversity and IITA which showed that, as long as fresh infections are prevented, infected mats will recover under the combined effects of slow bacterial spread from one stem to another and latent infections. SDSR is now being evaluated on 540 smallholdings across 10 pilot sites in eastern Democratic Republic of the Congo (DRC). Initial results showed that SDSR has reduced disease incidence to very low levels within three months. Continued control is expected to keep incidence at levels that do not imply any significant losses for farmers. The effect of SDSR on farm income is illustrated by the Katana Center trial results from DRC. Healthy stems increased from less than 20% at the onset of the trial to over 99% at eight months after trial initiation. By the end of 2014, close to 300 bunches were harvested and another 400 will be harvested before June 2015. Representing the only source of significant income, earnings from these bunches will be around US$2,300 from the 600 mats. During the early stages of the trial, the farmers also planted income-earning alternative annual crops (mainly bush beans), exploiting the low density of banana stems. The Katana pilot site (600 mats distributed over 10 plots) is now acting as a demonstration and training center.

Meanwhile, a project aiming to increase scaling options, led by Bioversity and Institutional Learning and Change Initiative (ILAC), is shedding light on the interactions between livelihood strategies and BXW control in the highlands of South Kivu, with important implications for the design of intervention strategies (http://bit.ly/1PcdphW). Three important insights emerged, which will be used to redefine the goals, design, and evaluation of control campaigns. First, SDSR effectively controls BXW at low cost in individual plots in South Kivu, with the potential to convert BXW from a devastating disease that requires collective control into a disease that individuals can manage effectively and efficiently. Second, the diverse livelihood strategies of farmers, with varying roles of bananas, require a differentiated approach to BXW management. And third, household efforts to control BXW vary accordingly.

Both the SDSR work and the RBM pilot for BXW management have strengthened the engagement with a broad range of stakeholders. In North Kivu, the provincial branch of the DRC Ministry of Agriculture commissioned an SDSR out-scaling project between March and September 2014, based on the ongoing SDSR pilot-site work in North Kivu (led by Université Catholique du Graben, Butembo). The project worked with five big farmer associations (in 10 villages, 2 villages per association, 21,000 members with near gender balance) and trained around 250 agronomists and lead farmers across the villages, reaching 1,500–2,000 farmers by September 2014. Further scaling is underway with other DRC stakeholders involved in the BXW–RBM pilot. Diverse communication channels have been used to spread the word.[2]

IDO: **Improved diets for poor and vulnerable people — doubling of dietary Vitamin A intake in Kenya**. Vitamin A deficiency (VAD) causes significant rates of blindness, disease, and premature death in SSA. Orange-fleshed sweetpotato (OFSP) is an important source of beta-carotene, which is converted into vitamin A in the body. Pregnancy is an opportune time to reach women with nutritional and health interventions that can lower their risk of VAD and enhance growth of infants under 2 years. Intervention at the community level in selected health facilities across Busia and Bungoma districts of Western Province, Kenya, showed successful introduction of beta-carotene-rich sweetpotato and increases in the

[2] SDSR is documented on a Musapedia page in the section on BXW. The field trials have featured in InfoMus@ news. These pages received more than 1,500 visits from May to December 2014.

consumption of vitamin A-rich foods and use of antenatal care services. (These facilities were implemented within the existing USAID/Kenya AIDS, Population and Health Integrated Assistance Program Plus, 2010–2014.) During each antenatal care visit, nurses provided improved nutrition counseling along with vouchers that women used to obtain OFSP vines to plant. Over 5,900 pregnant or lactating women redeemed 4,464 pairs of vouchers for vines. Community health workers established 215 pregnant women clubs made up of 2,764 members and, together with agricultural extension agents, disseminated information on the production and consumption benefits of OFSP through community field days and food preparation demonstration activities. A longitudinal Cohort for Vitamin A study was carried out among 505 women from mid-pregnancy through 9 months postpartum to assess how uptake of the OFSP interventions impacts nutrition and health status, including uptake of health services by mothers and their children. Preliminary analysis indicates that intake of dietary vitamin A from OFSP doubled for both mothers and infants in intervention areas compared with those in control areas.

IDO: **National partners and beneficiaries enabled — with knowledge-sharing platform for banana**. After two years of funding, ProMusa, a knowledge-sharing platform on bananas managed by Bioversity, RTB commissioned an impact assessment of the platform to evaluate its role in facilitating research for development around the world. The assessment found that users have a very positive view of ProMusa, seeing it both as a hub for dissemination of information and a platform that facilitates collaboration and networking within the banana community. ProMusa has 689 members, most of whom work in banana research or academia. It also serves a much wider audience, with some 70,000 user visits in 2014.

C.3 Progress towards impact

CIP and INIA (the National Agricultural Research Institute of Peru) finalized a study that used a nationally representative survey to estimate adoption of potato varieties in Peru. This improved the estimates of adoption of potato varieties based on more than 1,000 surveys nationwide. Results showed that more than 26% of planting area is covered by varieties released under the CIP-INIA long-term collaboration ('Canchan', 'Amarilis', 'Unica', and 'Serranita'). Propensity score-matching techniques applied to a sub-sample of commercially oriented farmers suggest that higher adoption of improved varieties increased yields by 1.0 t/ha on average and total volume of potato sales by 2.7 t. Data produced will continue to be analyzed under the partnership with Virginia Tech to look at measures of impact on the farmers' fields.

IITA finalized a study of the impact of a cassava research for development program (emergency response to the outbreak of cassava mosaic disease, 2001–2009) on farm-level outcomes in DRC. Propensity score-matching analyses show that the program has statistically significant positive effects on household participation in cassava markets, adoption of improved varieties, crop management practices, and household food adequacy. There was, however, no statistically significant effect on yields and gross margins. The program merits further promotion since these positive outcomes tend to be preconditions for realizing long-term yield and profit benefits (http://bit.ly/1OlLdex).

D. GENDER RESEARCH ACHIEVEMENTS

The RTB-funded "Gender Integration" and "Gender Strategic Research" projects completed their first phase in 2014. The first project identified gender concerns and integrated gender analysis into RTB thematic research to enhance development outcomes, whereas the second focused on raising awareness, sensitizing, and building capacity on gender research. Highlights for gender integration research are presented below.

Sex-differentiated trait preferences. In Nigeria, the IITA-RTB gender team worked closely with Cornell University and the National Roots Crops Research Institute in the NEXTGEN Cassava project, funded by

the Bill and Melinda Gates Foundation. This helped social and biophysical scientists to understand gender concepts in cassava-producing communities and identify sex-differentiated trait preferences of cassava varieties. Scientists are currently engaging in research to transform these local descriptions of trait preferences into standardized measurable units. Linking farmers' preferences and trait descriptions can help identify genomic markers for these traits for use in genomic selection. Researchers conducted surveys of cassava trait preferences at six field sites in Southeast and Southwest Nigeria. This process will be expanded to more regions in 2015, collecting trait preferences for processing and sampling cassava products for lab analysis. Preference evaluation revealed that women's and men's trait preferences differed: women often give a higher weighting to processing quality. Better understanding of differences in trait preferences by men and women will help researchers to breed and select varieties that are more likely to match women's needs. When these varieties are released and tested, their adoption will enhance food security and income for producers and processors by increasing productivity or food quality by 15%. (http://bit.ly/1t4RZto).

Gender strategy for seed potato interventions. Building on lessons learned from the 2013 gender integration research, the CIP-RTB gender team and breeders in Malawi developed a gender strategy for seed potato interventions. A key finding was that women's increased access to new potato seed technologies, information, training, and greater involvement (proportion of women in group members) in seed multiplication and improved market access contributed to outcomes tied to gender equity.

Gender-sensitive value chain research. The Bioversity-RTB gender team was involved in a collaborative research project to strengthen the capacity of partners in four East African countries to conduct gender-sensitive value chain research and to design gender-responsive value chain programs for banana beverages.

Value chain tools with a gender lens. RTB initiated collaboration with the CGIAR Research Program on Policies, Institutions and Markets to develop training guides for gender equitable value chain development (http://bit.ly/1HHwzHh). This initiative garnered appreciation from biophysical scientists, breeders, and nutritionists as it provided a framework for their collaboration and cooperation. The workshop resulted in the development of minimum standards for mainstreaming gender into value chain development in RTB. Through leveraging networks built during the workshop, funding has been secured for a new project to scale value chain tools with a gender lens, involving Bioversity, CIAT, CIP, and the World Agroforestry Center (ICRAF).

Gender-sensitive intrahousehold income allocation tool. The CIAT-RTB gender team, in collaboration with the University of San Francisco, Cornell University, and the University of Cordoba, prioritized the development and assessment of gender-sensitive tools and guidelines to support and build capacity of biophysical researchers. A tool to measure intrahousehold income allocation was tested in the field in Colombia. The tool will help researchers understand how income derived from the sale of improved varieties or better market access is distributed among male and female family members.

RTB-universities gender partnership. Under the gender strategic research, a collaborative partnership among RTB and faculties for social and gender studies at nine US universities and the University of Guelph, in Canada, has been initiated. The objective is to facilitate interdisciplinary exchanges among RTB biophysical scientists, researchers, and the US university students with aim of enhancing capacity on gender research work. This arrangement matches a student with interest in gender research with an opportunity in RTB activities in Africa, Asia, and Latin America (http://bit.ly/1PcdH8B).

Gender, norms, and agency study. RTB has been supporting and contributing to a CGIAR-wide strategic research initiative on "Gender, Norms, and Agency in Agricultural/NRM Innovation." So far, RTB has

contributed 13 cases that have been documented: 4 in Colombia (CIAT), 4 in Uganda (Bioversity and CIP), 2 in Malawi (CIP), and 3 in Bangladesh (CIP). Data analysis and report writing will begin in 2015.

E. PARTNERSHIPS BUILDING ACHIEVEMENTS

Scaling up with Humidtropics. RTB scientists engaged with the CGIAR Research Program on Integrated Systems for the Humid Tropics (Humidtropics) continue to grow and provide opportunities for going to scale. Linkages with Humidtropics innovation platforms and stakeholders in Uganda and DRC offer an opportunity for building capacities and monitoring the scaling of the BXW management approach on SDSR (see section C.2) with a systems perspective. Emerging results of BXW management are being incorporated into Humidtropics packages and promoted across all the BXW-affected Humidtropics action sites.

Surveillance network for Africa. RTB supported an initiative of the Global Cassava Partnership for the 21st Century to organize a meeting on La Réunion of more than 40 cassava specialists from African national and regional organizations, Cirad, and IRD. The workshop was the first step in implementing a roadmap to improve management of cassava viruses and bacteria in Africa, and led to the creation of the Pan-African Cassava Surveillance Network (PACSUN). PACSUN comprises members of existing networks and organizations, extension services, NGOs, and policymakers in Africa. It will add value to the work of existing organizations and networks by providing diagnostic expertise and information on viruses, bacteria, and the whitefly vectors affecting cassava. The Network's goals include promoting the use of mobile phone technology for diagnostics, mapping the incidence of cassava diseases in Africa, and coordinating responses to halt or slow disease spread. The workshop also laid the foundation for the establishment of an International Cassava Transit site on La Réunion (http://bit.ly/1F5UQcm).

Development partnerships for scaling. The FoodSTART project, launched in 2014 as a CIP-IFAD regional collaboration, looked at how root and tuber crops contribute to food security in Asia. This became a platform to explore how to partner with development organizations that scale-out innovations. This work has been undertaken with IFAD "investment projects" (i.e., large-scale infrastructure and development initiatives with low-interest loans and government co-financing) that operate in the same geographic areas as the FoodSTART research focus sites. Over four years of the project, mutually beneficial relationships have slowly but surely prospered. Activities included (i) participation in each other's planning and review meetings; (ii) capacity building in value chain development capacity and use of the farmer business school methodology; and (iii) preparation of enterprise development plans for small-scale enterprises based on root and tuber crops, plus support to implementation (i.e., business plan monitoring in the field). IFAD recognized the success of this research–development collaboration by inviting FoodSTART to present the approach to a large, Asia-wide regional meeting of all the investment projects in 2014. A second phase for 2015 was approved.

Learning alliance for BBTD. An RTB learning alliance to contain and help farmers recover from banana bunchy top disease (BBTD) in eight African countries advanced with the establishment of field sites and capacity building for researchers from each participating country (http://bit.ly/1DEyf6Q). Amongst others, Cirad trained 20 researchers (of whom 5 were women) from the target countries in "Banana virus diagnostics for clean seed production, safe germplasm exchange and surveillance of invasive bunchy top disease" at a workshop in Montpellier, France. The initiative has been strengthened by the integration of three PhD students and five MSc students.

Harmonizing bio-informatics. RTB established a strategic partnership with the Boyce Thompson Institute for Plant Research (BTI), at Cornell University, to create shared databases and bioinformatics platforms to support next-generation breeding of RTB crops (http://bit.ly/1CKLbV4). Such platforms are

essential for making advances in genomic research accessible and user-friendly for crop breeders around the world. Data from RTB-funded cassava gene sequencing have already been entered into the open access database, "CassavaBase," which BTI created with support from the Bill and Melinda Gates Foundation. RTB has facilitated collaboration among scientists at BTI, Bioversity, and Cirad on the harmonization of bioinformatics for banana and the consolidation of genomic data on a new BTI platform called "MusaBase." CIP scientists are collaborating with BTI on the improvement of the potato bioinformatics platform of the BTI-managed "SOL Genomics Network" through the organization and integration of phenotypic and ongoing gene-sequencing data into that platform. BTI and RTB will also collaborate to develop bioinformatics platforms for sweetpotato and yam (http://bit.ly/1FvLFiO).

F. CAPACITY BUILDING

RTB provided short-term training to 9,342 men and 22,999 women, and longer-term training to 62 men and 59 women on different topics (for more details see http://bit.ly/1bjoFcq Capacity Enhancement section). Some of the highlights are presented below.

A total of 20,900 women were trained in crop management practices for sweetpotato: 15,000 in Asia (mainly Bangladesh) and around 5,900 in Africa.

A course on "Production of Quality Seed Yam Tubers to Enhance Yam Productivity in Nigeria" trained 78 men and 139 women, including farmers, farmer groups, extension agents, and other actors in the value chain.

The global *Musa* Genetic Resources Network (MusaNet) held a workshop to address the urgent need of *Musa* collection curators for an unequivocal standardized characterization of germplasm and the associated management of information. The 13 partners of the Taxonomic Reference Collection Project were joined by national and regional curators as well as scientific staff from the National Research Centre for Banana, where the workshop was held; 22 trainees benefited. The workshop unveiled the new *Musa* Germplasm Information System website and tested a new mobile device application for capturing data in the field (http://bit.ly/1Cc1hU9).

More than 200 farmers and over 20 technicians were trained in preventing and managing Moko disease in plantain in order to help mitigate the disease's impact in Latin American and the Caribbean and benefit smallholder households dependent on this crop.

There were 30 short trainings in 2014 on cassava, mostly in Zambia, DRC, and Nigeria. Topics included quality attributes of high-quality cassava flour, fortification of gari-based products, disease and pest identification and management viruses, virus indexing, virus elimination, tissue culture techniques, and virus diagnostics methods. Training on the topic "Best-bet cassava planting techniques," organized in Sierra Leone, attracted 360 participants (42% women).

A three-year effort to develop and test learning-by-doing training materials for a 10-day training of trainers course was held in Nigeria (in English), Tanzania (in Kiswahili), and Mozambique (in Portuguese). It culminated in the publication of the manual "Everything you ever wanted to know about sweetpotato" (see http://bit.ly/1JmnbNe). The course is aimed at senior extension personnel and leaders of farmer organizations who will become "change agents" and train others. The main intended learning outcomes are being able to (i) identify sweetpotato varieties; (ii) understand how OFSP can contribute to reducing VAD; (iii) identify, select, and conserve clean planting materials; and (iv) deliver a 5-day training on "Everything you ever wanted to know about sweetpotato."

G. RISK MANAGEMENT

The highest set of risks has to do with the obligation, receipt, and disbursement of funds from CGIAR by CIP, as lead center for RTB, and as managed by the RTB Program Management Unit (PMU). The Program Advisory Committee (PAC) assumed a proactive role in assessing and managing these and other risks, working together with the Board of Trustees of CIP. The PAC has drawn attention to a persistent mis-match between indicated and actually committed funding levels by CGIAR, with the concomitant risk that entails for the management of RTB. In October 2014, a retro-active budget reduction for the year, linked to funds commitment and disbursement, was announced. This unanticipated risk damaged RTB credibility with CGIAR participants and, most dramatically, with non-CGIAR partners not used to this system.

RTB set up an internal, projectized funding mechanism out of W1&2 funds to support cross-crop and cross-center activities in accordance with the RTB program portfolio. Projects are designed for two to three years' duration with respective work plans. As such, these time-bound, concrete projects require a reliable commitment of funds as well as cash flow for implementation. Because it is not possible to commit additional funds for complementary funding projects until there is a level of funding certainty about the actual financial plan for the year (usually after June), the award, implementation, and expenditure by RTB-participant Centers and their outside partners are compromised. Signing of collaboration agreements with participating centers, and especially with non-CGIAR participants, and assembling complex teams for these projects often further delay start-up and slow expenditure.

H. LESSONS LEARNED

Investment in RBM. Through the RBM pilot we learned that the co-construction of impact pathways and development of M&E jointly with stakeholders can transform thinking around RTB clusters and put the IDOs and their indicators center stage. This requires a considerable investment (time and budget) in capacity development for the RBM change process, including facilitators, organizing stakeholder workshops, and designing and implementing M&E across multiple initiatives. RTB will search for buy-in from senior managers in the centers and additional resources for the RBM change process and the co-construction of impact pathways with partners/stakeholders. There is a need for longevity of the CRP programs to allow RTB to reap the benefits of this investment. We hope that any portfolio reorganization would not jeopardize this effort.

Incentives for reporting. The PMU has developed a "traffic light" system for evaluating planning/update of milestones in the RTB product portfolio at the start of the year and for assessing completion at the end. However, so far, no incentives or rewards exist for timely performance. In 2015 the PMU plans to introduce some financial incentives to reward compliance with reporting requirements. This will require an adjustment in budget allocation and also heavier time investment from PMU.

Effective planning software. Linked to RBM, there is an urgent need for a new planning and M&E software platform. The original platform on GoogleDrive has been overwhelmed by ad hoc additions. RTB analyzed several software options—giving preference to platforms that are already in use by other CRPs—and plans to migrate to a new platform as part of the shift to the new program structure.

Common approaches for gender analysis. Integrated gender research has prioritized particular topics, such as varietal selection and value chains. But research activities so far have been based on case studies and are rather fragmented. The RTB gender team needs to consolidate results and to develop and apply common tools and approaches to build a more compelling evidence base of what works (e.g., for disaggregating gender trait preferences).

Complementary funding projects generated specific lessons learned:

- **Investment in data analysis**. Allocate enough time and budget for centers to develop the expertise necessary to perform in-depth analysis of the huge quantity of data generated with the high-throughput technologies (laboratory infrastructure and bioinformatics skills).
- **Phenotyping accuracy**. Little can be expected toward improving genomic predictions in future generations, despite the use of high-throughput genotyping or larger training populations, if a high level of phenotyping accuracy cannot be attained for these traits. This is worth investing in because it is a one-shot effort whose results will be used extensively.
- **Equipment and inputs for metabolomics**. For the careful preparation of samples for highly sensitive metabolomics analyses, logistics were extremely challenging. The lack of appropriate supply chains and lab equipment (e.g., in the sweetpotato growing area) required the experiment to be repeated at headquarters with consequent delays.
- **Combining social and scientific research**. Action research approach through community action plans in the BBTD project involves new skills and stages of work not called for in surveys or replicated experiments. This included the integration of gender understanding, community dynamics of land tenure, attention to resource levels, and different household typologies. These are not easily addressed in replicated trials, but are essential factors in the recovery of banana production in BBTD-affected areas.
- **Importance of sharing expertise**. The participatory approach to the design of the Pest Risk Assessment project and the multidisciplinary skills of centers and partners—spanning pest and disease management, risk assessment and modeling, surveillance, diagnostics, and geospatial and economic modeling—provided many opportunities for cross-crop and cross-disciplinary sharing of expertise. This strongly benefited project start-up, planning, and implementation. Wide geographical spread of the main partners makes regular face-to-face meetings difficult. Team members have therefore planned joint field visits at both action sites and a mid-project planning meeting.

Annex 1: RTB indicators of progress in 2014[3]

Indicator	**Deviation narrative** (if actual is more than 10% away from target)	2014		2015[4]	2016
		Target (if available for 2014)	Actual	Target	Target
KNOWLEDGE, TOOLS, DATA					
1. Number of flagship "products" produced by CRP	Plus: 3 Impact@scale Plus: Genebank Plus Breeding platform CA1/CA2 merged CA4/CA5 merged	23	25	23	23
2. % of flagship products produced that have explicit target of women farmers/NRM managers		17%	16%	22%	25%
3. % of flagship products produced that have been assessed for likely gender-disaggregated impact		35%	32%	44%	50%
4. Number of "tools" produced by CRP	Higher than projected	63	71	65	67
5. % of tools that have an explicit target of women farmers	Slight underachievement here was compensated by higher than projected completion of tools assessed for gender-disaggregated impact	30%	24%	32%	34%
6. % of tools assessed for likely gender-disaggregated impact	Higher than projected	14%	20%	16%	18%
7. Number of open access databases maintained by CRP		14	16	18	22
8. Total number of users of these open access databases	Additional promotion is required to improve uptake	70,000	29,321	90,000	105,000
9. Number of publications in ISI journals produced by CRP		100	92[5]	108	120

[3] Indicators not relevant for RTB are left out. See explanations for indicators of progress still in construction: http://bit.ly/1KiWes7
[4] Targets for 2015 and 2016 as given in the Performance Matrix for the RTB Extension Phase 2015/16.
[5] For full list of publications (including non ISI) see: http://bit.ly/1fjxg0R

Indicator	Deviation narrative (if actual is more than 10% away from target)	2014		2015[4]	2016
		Target (if available for 2014)	Actual	Target	Target
10. Number of strategic value chains analyzed by CRP	Higher than anticipated as value chain increases in importance	8	15	9	11
CAPACITY ENHANCEMENT AND INNOVATION PLATFORMS					
13. Number of trainees in short-term programs facilitated by CRP (male)	Systematically targeting women in our programs to enhance gender equity	21,000	9,342	22,000	23,000
14. Number of trainees in short-term programs facilitated by CRP (female)	Much higher	9,500	22,999	10,000	10,500
15. Number of trainees in long-term programs facilitated by CRP (male)	Slightly higher than anticipated	52	62	55	60
16.Number of trainees in long-term programs facilitated by CRP (female)	Slightly higher than anticipated	50	59	55	60
TECHNOLOGIES/PRACTICES IN VARIOUS STAGES OF DEVELOPMENT					
18. Number of technologies/NRM practices under research in the CRP (Phase I)	Higher than projected	56	78	58	60
19. % of technologies under research that have an explicit target of women farmers	Lower than projected but more than compensated for by higher than projected gender-disaggregated	12%	9%	14%	16%
20. % of technologies under research that have been assessed for likely gender-disaggregated impact	Higher than projected	12%	25%	14%	16%
23. Number of technologies /NRM practices field tested (phase II)	Lower than projected – although opted to list multiple varieties moving to field as a single technology	88	48	92	96
27.Number of technologies/NRM practices released by public and private sector partners globally (phase III)	Lower than projected – although opted to list multiple varieties moving to release as a single technology	31	22	32	33

Indicator	Deviation narrative (if actual is more than 10% away from target)	2014		2015[4]	2016
		Target (if available for 2014)	Actual	Target	Target
POLICIES IN VARIOUS STAGES OF DEVELOPMENT					
28. Numbers of Policies/ Regulations/ Administrative Procedures Analyzed (Stage 1)		3	4	4	5
29. Number of policies/regulations/administrative procedures drafted and presented for public/stakeholder consultation (Stage 2)		2	1	2	3
30. Number of policies/regulations/administrative procedures presented for legislation(Stage 3)		1	1	1	1
31. Number of policies/regulations/administrative procedures prepared passed/approved (Stage 4)		1	0	1	1
32. Number of policies/regulations/administrative procedures passed for which implementation has begun (Stage 5)		2	2	2	1
OUTCOMES ON THE GROUND					
33. Number of hectares under improved technologies or management practices as a result of CRP research	Includes adoption of technology released prior to start-up of RTB	414,000 (new)	414,000 (new)	430,000 (new)	447,000 (new)
34. Number of farmers and others who have applied new technologies or management practices as a result of CRP research	Total	1,656,000 (new)	1,656,000 (new)	1,720,000 (new)	1,780,000 (new)
	34 (a) number of women farmers concerned	476,000 (new)	476,000 (new)	490,000 (new)	510,000 (new)
	34 (b) number of male farmers concerned	1,180,000 (new)	1,180,000 (new)	1,220,000 (new)	1,270,000 (new)

Annex 2: Performance indicators for gender mainstreaming with targets defined

Performance Indicator	CRP performance approaches requirements	CRP performance meets requirements	CRP performance exceeds requirements
1. Gender inequality targets defined	*Sex-disaggregated social data collected and used to diagnose important gender-related constraints in at least one of the CRP's main target populations*	*Sex-disaggregated social data collected and used to diagnose important gender-related constraints in at least one of the CRP's main target populations* *AND* *The CRP has defined and collected baseline data on the main dimensions of gender inequality in the CRP's main target populations relevant to its expected outcomes (IDOs)*	*Sex-disaggregated social data collected and used to diagnose important gender-related constraints in at least one of the CRP's main target populations* *AND* *The CRP has defined and collected baseline data on the main dimensions of gender inequality in the CRP's main target populations relevant to its expected outcomes (IDOs)* *AND* *CRP targets changes in levels of gender inequality to which the CRP is or plans to contribute, with related numbers of men and women beneficiaries in main target populations*

In terms of defining **gender inequality targets, RTB performance meets requirements**.

RTB gender team is increasingly working with scientists to:

- Ensure gender mainstreaming into new project proposals
- Provide technical backstopping in the development and implementation of survey instruments, tools, and checklists to facilitate collection and analysis of sex-disaggregated data (e.g., experimental tool to measure intrahousehold income distribution; gender-responsive training material/gender-integrated user guide on evaluation, data collection and analysis for participatory Mother & Baby trials; protocol for HH social/gender relations and cropping systems; guideline for value chain analysis with gender mainstreamed
- Collect sex-disaggregated baseline data (both qualitative and quantitative) related to access to resources, decision making, gender division of labor, participation in different aspects of production and marketing, and gender-related constraints and benefits in technology adoption. Data were collected for:
  - Value chains (Burundi, Colombia, DRC, Nigeria, Rwanda, Tanzania, and Uganda)
  - Nutrition (Peru, Ecuador, and Bolivia)
  - Seed systems (Malawi and Bangladesh)
  - Management of priority pests and diseases (Burundi, Malawi, DRC).

RTB gender researchers and more than 30 RTB-linked staff are working on strategic gender research in the CGIAR-wide global Norms and Agency Study (in 13 cases data collected in Uganda, Malawi, DRC, Burundi, Colombia, and Bangladesh); pending additional cases in Vietnam, Peru, Bolivia; and data analysis in 2015.

Performance Indicator	CRP performance approaches requirements	CRP performance meets requirements	CRP performance exceeds requirements
2. Institutional architecture for integration of gender in place.	• *CRP scientists and managers with responsibility for gender in the CRP's outputs are appointed, have written TORs* • *Procedures defined to report use of available diagnostic or baseline knowledge on gender routinely for assessment of the gender equality implications of the CRP's flagship research products as per the Gender Strategy* • *CRP M&E system has protocol for tracking progress on integration of gender research*	• *CRP scientists and managers with responsibility for gender in the CRP's outputs are appointed, have written TORs <u>and funds allocated to support their interaction.</u>* • *Procedures defined to report use of available diagnostic or baseline knowledge on gender routinely for assessment of the gender equality implications of the CRP's flagship research products as per the Gender Strategy* • *CRP M&E system has protocol for tracking progress on integration of gender research* *<u>AND</u>* • *A CRP plan approved for capacity development in gender analysis*	• *CRP scientists and managers with responsibility for gender in the CRP's outputs are appointed, have written TORs <u>and funds allocated to support their interaction.</u>* • *Procedures defined to report use of available diagnostic or baseline knowledge on gender routinely for assessment of the gender equality implications of the CRP's flagship research products as per the Gender Strategy* • *CRP M&E system has protocol for tracking progress on integration of gender research* • *A CRP plan approved for capacity development in gender analysis* *<u>AND</u>* • *The CRP uses feedback provided by its M&E system to improve its integration of gender into research*

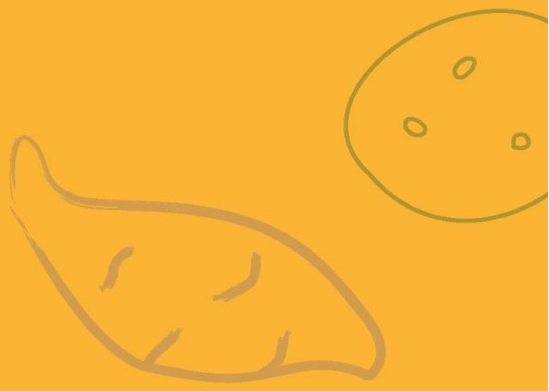
In terms of defining **institutional architecture for integration of gender in place, RTB performance meets requirements**.

The gender team kept on growing in 2014, adding regional gender specialists in Latin America and the Caribbean, SSA, and Asia, and senior social scientists with expertise in gender and responsibility for research supervision.

In RTB programmatic aspects:

- Gender was adequately mainstreamed in the RTB extension proposal
- RTB product portfolio has been revised to harmonize with the gender strategy and gender is integrated into research activities, based on a simplified classification system for tracking gender relevance
- Gender team is involved in the redesign of RTB research program structure into flagship and clusters of activities by contributing to the respective business cases
- Ensuring gender responsiveness in the new RTB planning and M&E system, especially concerning indicators
- Building a formal network/partnership/fellowship program to bring US universities (up-to-date gender science) to RTB research work in the field was launched.

Ongoing capacity building and training of Gender team and interested biological scientists on conducting gender research as, for example, part of Global Gender Norms study and stronger cross CRP collaboration and participation in relevant workshop of other CRP gender workshops (e.g., A4NH gender and nutrition).



A broad alliance of research-for-development stakeholders & partners