ABOUT

The CGIAR Research Program on Roots, Tubers and Bananas (RTB) is a partnership collaboration of research-for-development stakeholders and partners. Our shared purpose is to exploit the underutilized potential of root, tuber, and banana crops for improving nutrition and food security, increasing incomes and fostering greater gender equity – especially amongst the world's poorest and most vulnerable populations.

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www.rtb.cgiar.org/2017-annual-report

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IITA Transforming African Agriculture

ANNUAL REPORT 2017

FROM SCIENCE TO SCALING

CGIAR

RESEARCH PROGRAM ON
Roots, Tubers and Bananas

From science to scaling
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DASHBOARD

The CGIAR Research Program on Roots, Tubers and Bananas in 2017

3.1 Million

Households in Nigeria using improved cassava with positive effects on yield*

403,590

Households in Peru using improved potato varieties. 28% are using CIP-related material*

558,634

Farmers in 14 sub-Saharan African countries who accessed clean sweetpotato planting material through 1,100 small seed enterprises

106,477

Participants in short-term trainings and scaling activities

222

Trainees involved in academic programs (Bsc, MSc, PhD)

132

Peer reviewed journal articles published of which 103 are open access

*cumulated results of past and ongoing initiatives

FOREWORD

BARBARA H. WELLS
CIP Director General

GRAHAM THIELE
RTB Program Director

2017 was a notable year for the CGIAR Research Program on Roots, Tubers and Bananas (RTB). It marked the start-up of Phase II, where we significantly accelerated the scaling of the diverse set of innovations developed since the program's inception in 2012. This is supported by a flagship project (Flagship Project 5), which is facilitating the design and implementation of strategies for scaling innovations to achieve the greatest possible impact. One of the mechanisms created for this is the RTB Scaling Fund, which in 2017 awarded its first grants to three teams of scientists engaged in bringing to scale: 1) an approach, known as single diseased-stem removal, for controlling the disease banana Xanthomonas wilt; 2) a method for conserving sweetpotato roots to produce planting material known as Triple S; and 3) a technology for turning cassava peels into an ingredient of animal feed.

Likewise, we have seen the impact that the breeding of improved root, tuber and banana varieties – a core part of our program since its onset – has had through RTB-supported adoption studies. This report explores, amongst others, the adoption of improved potato varieties with provenance from the International Potato Center (CIP) in Peru.

In 2017, RTB launched the CGIAR Gender and Breeding Initiative with a generous grant from the CGIAR System Management Office and CGIAR Trust Fund contributors. The Initiative brought together plant and animal breeders and social scientists to develop a strategy for gender-responsive breeding with supporting methods, tools and practices. An important result generated was the 'decision checklist', a tool that provides a practical guide for plant and animal breeding programs to become more gender-responsive.

Digital innovations contributed in reaching significant achievements for more effective virus surveillance. The use of artificial intelligence and mobile devices to develop image-based cassava disease detection tools has shown to be effective for cassava mosaic disease, cassava brown streak disease, and other emergent and persistent important diseases of root, tuber and banana crops. An RTB team led by the International Institute of Tropical Agriculture (IITA) teamed up with Penn State University to win the INSPIRE award from the CGIAR Platform on Big Data in Agriculture and expand this work to other crops.

We thank all our partners and donors for their contributions to get Phase II off to a great start with enhanced trust and collaboration, which bodes well for future impact.

Barbara H. Wells and Graham Thiele

RTB AT A GLANCE

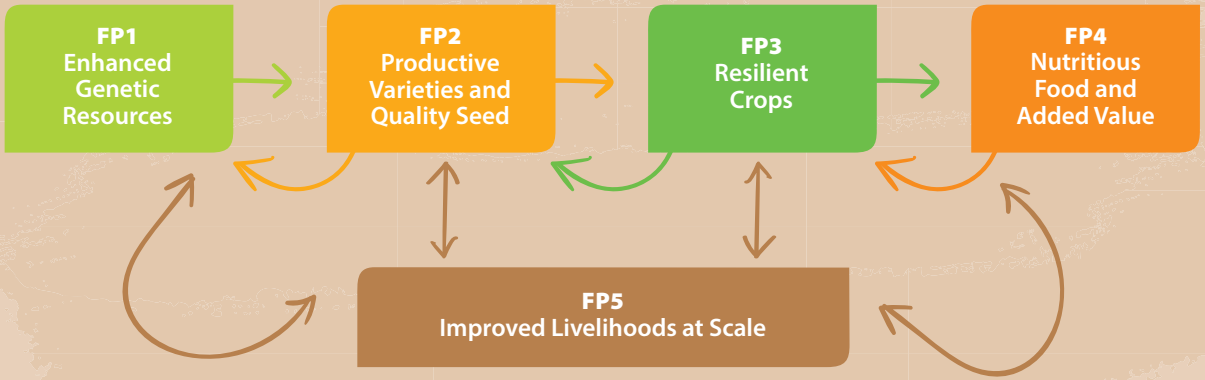
More than 300 million people living below the poverty line in developing countries depend on root, tuber and banana crops for food and income, particularly in Africa, Asia and the Americas. RTB was launched in 2012 to harness the untapped potential of these crops – including banana, cassava, potato, sweetpotato and yam – to improve food security, nutrition, income and climate change resilience of smallholders, especially women and youth. During its second phase, which began in 2017, RTB better integrated food systems thinking with commodity-based research to build a comprehensive Agri-Food System CGIAR Research Program and identified program targets to be achieved by 2022.

Root, tuber and banana crops are some of the most important staple crops in the world's poorest regions. They provide around 15% or more of the daily per capita calorie intake for 763 million people living in the least developed countries. Often rich in key nutrients such as pro-vitamin A, RTB crops can significantly improve nutrition and food security. Many can also be grown with few inputs and often under harsh conditions. They respond very well to intensification and are high yielders in terms of calories produced per hectare. As important cash crops they can help boost family incomes and are frequently grown or marketed by women.

However, RTB crops present several common challenges. They are propagated clonally rather than with seeds, which allows yield-reducing pathogens to build up over time. This calls for a strong design of private-public seed systems. The crops' bulk and perishability put pressure on postharvest innovation. High genetic complexity also means breeding for improved varieties is especially difficult.

SUSTAINABLE DEVELOPMENT GOALS	SELECTED RTB PROGRAM TARGETS (2022)		
	**20 million** people (50% women) increased their income	**30,000** small and medium enterprises operating profitably in the seed and processing sectors	**8 million** farm households increased yield through the adoption of improved varieties and sustainable management practices
	**10 million** people (50% women) have improved their diet quality		
	**1.9 million** ha of current RTB crops production area converted to sustainable cropping systems		
	**At least 2 million** households with increased capacity to deal with climate risks and extremes	**9,500 individuals** (50% women) with improved capacities in partner organizations	**At least 5 partnership** and scaling models tested in a minimum of 5 target countries

THE PROGRAM IS STRUCTURED AROUND FIVE FLAGSHIP PROJECTS



RTB is a partnership collaboration which brings together the expertise and resources of five centers: the International Potato Center (CIP), which leads the program; Bioversity International; the International Center for Tropical Agriculture (CIAT); the International Institute of Tropical Agriculture (IITA); and the Centre de Coopération Internationale en Recherche Agronomique pour le Développement (CIRAD), which represents several other French partners in the research program. The centers work together on common issues affecting RTB crops by mobilizing complementary expertise and resources and creating synergies among different research teams.

RTB is also a broad partnership platform including a diverse set of upstream research partners and downstream scaling partners. In 2017, RTB maintained formal collaboration with 134 partners, primarily national agricultural research organizations, academic and advanced research institutions, private companies and nongovernmental organizations. Together, RTB and its broad network of partners will work to achieve the program's intermediate development outcomes – which are fully aligned with the Sustainable Development Goals – by 2022.

CROP TRUST

FLAGSHIP PROJECT 1

ENHANCED GENETIC RESOURCES

Flagship Project 1 (FP1) is developing and applying leading-edge science to build advanced tools, methods and models that improve the accuracy and speed of root, tuber and banana breeding. It also adds value to genebanks through enhanced conservation research and the linking of genes or traits to genebank accessions.

A RTB breeding community of practice (BCoP) has been established to share tools and methods that are applicable to the different crops. The BCoP, by identifying and resolving in a cross-cutting manner the major challenges to RTB breeding, is contributing to accelerating genetic gains in the RTB breeding programs. "RTB molecular geneticists, physiologists and bioinformaticians are helping to co-develop new molecular and analytical tools, such as metabolite studies, which are contributing to the implementation of genomics-assisted breeding as well as high throughput phenotyping," says Luis Augusto Becerra, FP1 Leader and a Principle Research Scientist at CIAT.

FP1 is using the latest genetic and genomic technologies to tackle major constraints in RTB crops, as well as enhancing quality traits. Moreover, stewardship and advocacy activities are being promoted to address the relevant risks associated with these innovations. In addition, research is being carried out to improve and refine existing ex situ conservation methods and tools as well as to improve understanding of how root, tuber and banana diversity is maintained on-farm and in wild habitats and the threats to this diversity.

Breeding improved cassava varieties that women and men want

Understanding gender differences in trait preferences for cassava can accelerate adoption as this knowledge is incorporated into breeding programs.

Cassava is the daily bread of Nigeria, but it is hardly ever simply boiled and eaten. Nigerian cassava is processed into products like gari (toasted cassava starch granules), which are made in villages and trucked to cities across the country. Processing usually involves several different steps and quite a lot of work. While women do grow cassava, they also provide most of the labor for cassava processing, both for food products to eat at home and in many cases, to make a living from small-scale enterprises. Men grow larger cassava farms than women and prefer to sell cassava as fresh roots instead of processing it. Because of these varying roles, women's and men's perception of the most critical traits needed in cassava may differ.

The Next Generation Cassava Breeding (NextGen) project aims to take these traits into account to improve targeting of cassava varieties for end users. NextGen uses a new approach to accelerate breeding called genomic selection that relies on statistical modeling to predict cassava performance before field-testing.

Hale Ann Tufan of Cornell University leads the survey component of NextGen. She explains, "We need to think like a company. Companies have to build consumer profiles of their users and then develop typologies around these to inform the breeding program." Likewise, plant breeders need to understand how important a trait is for farmers, as not all the traits that farmers list are equally important.

A joint study by the International Institute of Tropical Agriculture (IITA) and the National Root Crops Research Institute (NRCRI) in eight communities in Southwest and Southeast Nigeria was supported by NextGen. It used focus group discussions and individual interviews to assess differences in trait and varietal preferences of men and women. The researchers found that women mentioned weeding more often as a constraint, as it's a task mainly done by women, whereas men referred to the lack of machinery for production. While both men and women seek out new varieties, it was found that men have more access to these varieties.

On the other hand, the overall frequency of which most traits were mentioned is similar for men and women, who want cassava varieties with high

Toasting cassava flour is the final step in creating gari, and is a task mainly done by women. H.Holmes/RTB

yield and big roots and that mature early. "There's a lot of cohesion between what men and women are telling us are the most important traits," Tufan noted.

Men and women may prefer the same varieties, but for different reasons. For example, one variety, which farmers call "IITA", is ranked highly by both genders. Men like it for its high yield and because it stores well in the ground, while women like its "good product quality" which means its pleasant taste and high dry matter content. A high dry matter content leads to good 'swelling' during processing, which is an important characteristic for women.

Understanding these differences helps breeders to select not just for high yield, but for other traits that are important for growers, processors and consumers. However, farmers' concepts are often too complex to be captured in a simple trait list. For example, Nigerian farmers like gari that swells nicely. But there are three types of swelling – when one adds hot water to make a paste called eba, when one eats the eba and it swells in the stomach and the swelling of the cassava mash when toasted into gari.

There is also a lot of variability in how gari is processed, which also influences how much it swells. Breeders still don't know enough about the underlying genetic determinants to breed for good swelling cassava. Currently IITA and NRCRI are conducting participatory trials with farmers and processors in Imo and Osun states, Nigeria to disentangle these different effects.

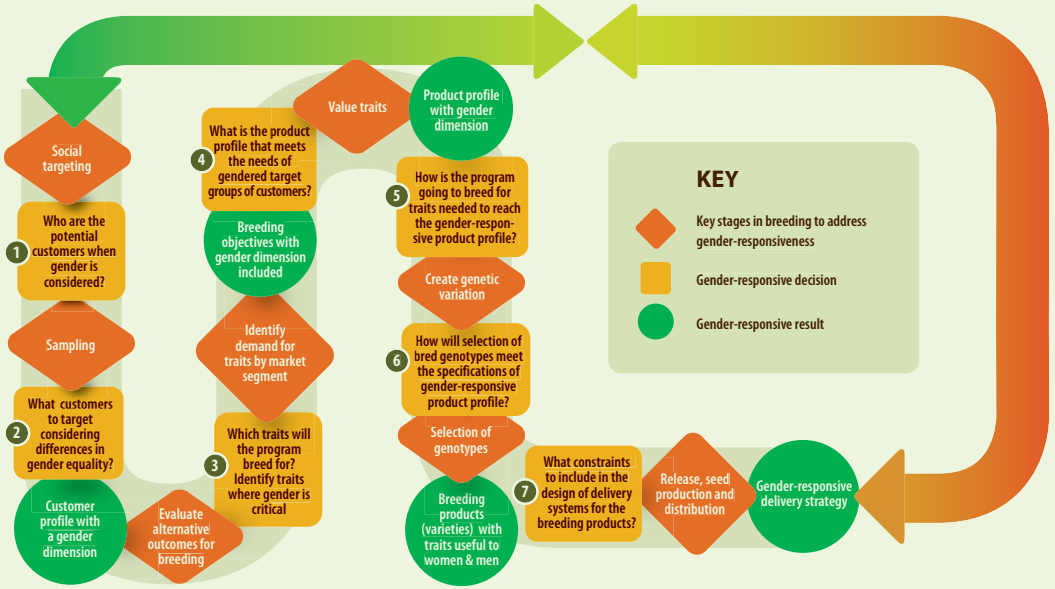
So, identifying farmer "preferences" is complex. Cassava farmers have a tacit feel for the traits they prefer but unpacking those into the underlying genetic determinants is challenging. Nor is there a simple binary list of traits preferred by women and by men. But thanks to this effort, cassava breeders can now improve combined traits for product qualities, high yield and harvesting time.

The researchers found that women often mentioned weeding as a constraint. It's a laborious task mainly done using machetes. H.Holmes/RTB

Checklist guides breeding programs to develop varieties that benefit women and men

Widespread adoption of improved crop varieties depends on the benefits they provide for the resource-poor users who grow, eat, process and sell them. Farmers' needs vary by gender, geography and market involvement. Social scientists and breeders especially have to understand the different priorities that women and men assign to traits like size, shape and taste, and reflect those priorities in breeding decisions.

The CGIAR Gender and Breeding Initiative, led by RTB and the International Potato Center, produced a practical 'decision checklist' to help plant and animal breeding programs become more gender-responsive. Developed by an interdisciplinary group from 11 CGIAR centers and partner organizations who met in Nairobi, Kenya, in October 2017, the checklist lays out an approach for systemically including information about gender differences in critical decisions made at key points in the breeding cycle, including the definition of gender-responsive product profiles which describe a future variety to be developed.



Flowchart of critical decision points for gender-responsive breeding. GBI/RTB

Genetic markers identify the sex of yams and accelerate breeding

Researchers have identified the genetic markers that distinguish the sex of yam plants, saving time and resources for future breeding efforts.

A yam farmer in Nigeria, where the crop is a source of rural employment. IITA

White Guinea yam (*Dioscorea rotundata*) is native to West Africa, where it has been a food security crop for centuries. As Africa is rapidly urbanizing, yams are now being grown commercially. This labor-intensive crop provides a source of rural employment. The large tubers are traded in open air, city markets and are increasingly sold as prepared food, such as 'pounded yam' in popular, moderately-priced restaurants.

However, productive yam cultivation is constrained by various pests and diseases and by the lack of improved varieties. Yam has been an orphan crop with progress in breeding limited by a lack of genetic and genomic tools. This may be about to change. For the first time, researchers have sequenced the genome of the white Guinea yam, the most important food yam in West Africa. Using the sequence information, and characterizing lines segregating for different traits, the team identified genetic markers, including those for the sex of the yam, which has male and female flowers on separate plants. The markers will allow plant breeders to separate male from female plants at the seedling stage, greatly improving the efficiency of planning and carrying out crosses in breeding programs.

Farmers usually grow yams from tubers or pieces of tuber. Although the crop is conventionally reproduced vegetatively, crossing two individual plants to obtain new genetic combinations is the basis for breeding programs. The plant is highly heterozygous, so when it is crossed, the resulting genetic combinations are quite diverse.

The team of researchers from the International Institute of Tropical Agriculture (IITA) Yam Improvement Program and partner institutions in Japan, Nigeria and the UK assembled a genome of 579 million base pairs and identified 26,198 putative genes and over 22,000 candidate genetic markers, including one for sex in yam. Sex in yams is determined not by X and Y chromosomes, as in humans, but by genes, ZZ for male and ZW for female. As an added complication, some ZW individuals are non-flowering, and some change their sex over generations.

"In yams it is important to establish male and female crossing blocks in separate and isolated plots to avoid pollen contamination during hand pollination. In addition to avoiding unwanted pollination by insects or any other means, it is important to know the flower sex of the parents to design a crossing plan as male and female flowers in most of our parental lines are in separate plants," explained Robert Asiedu, Director, Research for Development, for IITA-West Africa, who conceived and supervised the study.

Other genetic markers identified by this research will help in the future to locate genes to breed for resistance to pests and diseases, and to improve other desired traits, such as yield. Much work remains to be done, but future plant breeding will be enhanced by the new genome map, genetic markers and the ability to separate male and female plants. This should make possible the release of improved varieties leading to greater yam harvests, with improved rural employment, greater food security and providing a nourishing, culturally appropriate food for the growing cities of Africa.

Disease-resistant potato and banana give hope to farmers

Late blight remains one of the most devastating diseases for potato worldwide, costing farmers an estimated USD3 – 10 billion per year globally.

Traditional breeding for resistant varieties takes years, and resistance can break down as the pathogen mutates when it encounters resistance genes, leaving farmers no options than using fungicides up to 15 times per season. Similarly, banana Xanthomonas wilt (BXW) is a growing threat to the livelihoods of small-scale farmers. Since its appearance in Uganda in the early 2000s, BXW has spread rapidly in the region, causing food insecurity and income loss. No resistant cultivars have been identified, and it can only be controlled through on-farm management practices.

In the face of these serious and persistent challenges to food security and livelihoods, RTB centers and national research partners have developed a biotech late blight-resistant potato with multi-gene resistance, and a BXW-resistant cooking banana variety for East Africa. Confined field trials have shown the crops to be very disease resistant, and otherwise identical to the original varieties.

In 2017, an RTB cross-crop initiative began to ensure the responsible management and regulation of biotech crops. Stewardship in plant biotechnology is the responsible management of a product from its inception through its ultimate use (learn more: http://www.excellencethroughstewardship.org). In addition, biotech crops need to be assessed for their safety to humans and animal health prior to release to the public for commercialization. Environmental risk assessments are also an essential part of regulatory decision-making for biotech crops. Consequently, stewardship plans along with risk assessments and experimental evidence are required to gain regulatory approval and for the responsible cultivation of these crops.

RTB scientists and Ugandan and Kenyan national partners came together with regulatory and stewardship experts to receive training on developing stewardship plans for the disease-resistant potato and banana varieties, as well as to develop plans for risk assessment for food, feed, and environmental safety. Participants were introduced to the data and methodology used to conduct risk assessments. In addition, they were informed about the regulatory policy and framework in Kenya and Uganda. A well-organized regulatory dossier helps regulators to review the application and speeds the review process. Stewardship plans for both products were developed, and a plan was laid out identifying the gaps in information needed for a regulatory dossier, and the field trials required. Following approval, these disease-resistant varieties will be made available to farmers, helping to safeguard their livelihoods against persistent pests and diseases.

Researchers harvest late blight-resistant potatoes in a trial at Kachwekano Zonal Agricultural Research and Development Institute in Uganda. CIP

CIP

FLAGSHIP PROJECT 2

ADAPTED PRODUCTIVE VARIETIES AND QUALITY SEED

Flagship Project 2 (FP2) makes available high-yielding varieties of roots, tubers and bananas that respond to the needs and preferences of different stakeholders in the value chain, while also ensuring the availability of good quality planting material.

The flagship uses participatory, gender-responsive tools to understand the traits and criteria that stakeholders consider when adopting or rejecting varieties and uses this intelligence to guide breeding processes. Predictive modeling and foresight work help identify what features RTB varieties need under future climate change scenarios.

To ensure that improved varieties are accessible to stakeholders, the flagship is strengthening seed systems through an integrated approach to promote inclusive seed value chains.

"Our scientists are making exciting progress in working with the private sector, national partners and farmers to reduce seed multiplication and distribution bottlenecks, improve seed quality and on-farm seed management, and creating enabling regulations and certification schemes," explains Elmar Schulte-Geldermann, FP2 Leader and Program Leader: Seed Potato for Africa at CIP.

DNA fingerprinting shows high adoption of improved cassava varieties in Nigeria

DNA fingerprinting has improved the accuracy of adoption studies and revealed that 66% of surveyed cassava farmers in Nigeria are cultivating improved varieties.

Improved cassava varieties can boost yields, helping rural African farm families to become food secure and overcome poverty. A study published in 2017 by the International Institute of Tropical Agriculture (IITA) and partners, with support from RTB, suggests that the adoption of improved cassava varieties is higher than was previously thought. DNA fingerprinting of cassava leaves revealed that about 66% of surveyed Nigerian cassava growers have adopted improved varieties. Extrapolating these results suggests that around 3.1 million households nation wide grow the new cassava varieties.

Since the early 1970s, the IITA has been breeding cassava varieties with resistance to major diseases such as cassava mosaic virus disease and cassava bacterial blight. IITA and partners have developed and released more than 46 high-yielding, disease-resistant cassava varieties, working with the National Root Crops Research Institute of Nigeria (NRCRI), state governments and multiple agencies and projects to promote uptake.

The 2017 study used a large survey to determine the rate of adoption of improved cassava varieties on small farms in Nigeria. The survey covered 2,500 farming households in 16 states that contribute at least 80% of the total production of cassava in Nigeria. Each surveyed household self-reported the improved cassava varieties they had adopted. Besides collecting socio-economic data, the team also sampled cassava leaves for DNA fingerprinting from each cassava variety in each farm plot of surveyed farmers. DNA fingerprinting is an accurate way to identify varieties grown by farmers, allowing credible measurement of adoption of improved varieties.

About 60% of the cassava farmers reported planting improved varieties. However, DNA fingerprinting showed that about 66% of the farmers had adopted improved cassava varieties. This may seem like a slight difference, but the misclassification rate is large. Misclassification happens when farmers who think they are growing improved varieties are actually growing local ones or vice versa.

"Farmers do not always know if they are growing improved cassava varieties or not. By comparing farmers' responses with the DNA fingerprinting we were able to see that some farmers were growing improved cassava without realizing it and others were growing local varieties that they thought were improved," said Dr. Abdoulaye Tahirou, impact economist at IITA.

The surveyed farmers plant about 38% of their cassava area with improved varieties. Informal seed systems are important for sharing improved varieties, with over 70% of the farmers obtaining new varieties mainly from friends, relatives and neighbors. As cassava planting material is shared through local networks, farmers are often

IITA and partners have developed more than 46 improved cassava varieties. IITA

unsure if such varieties are improved or not. For example, in the village of Oke Dayo, in Kogi State in 2016, women farmers told researchers Tessy Madu of NRCRI and Olamide Olaosebikan of IITA, "Most of us plant Oko Iyawo which we believe is an improved variety. Last year some women who went for immunization at the health center were given some cassava cuttings and we believe those are improved variety." This uncertainty over varietal identity in seed provision is a strong justification for a more structured and integrated approach where trueness to type of seed can be guaranteed, such as is being promoted under the 'Building a Sustainable, Integrated Seed System for Cassava in Nigeria' (BASICS) project.

About 4.7 million households in Nigeria grow cassava on about 5.2 million ha. An adoption rate of 66% means that about 3.1 million households

Close to 4.7 million households in Nigeria grow cassava which is a major staple food. H.Holmes/RTB

adopted improved cassava varieties on 2 million ha. Improved varieties are associated with productivity gain of 82% in farmers' fields, so adoption has led to a 4.6% poverty reduction (using a poverty line of USD1.90 per person, per day), implying that 7.5% of the rural poor cassava producers escaped poverty by adopting improved cassava varieties.

LEARN MORE
http://hdl.handle.net/10568/80706

Climate-resilient potatoes for India

A climate-resilient potato variety developed by the International Potato Center (CIP) with resistance to early heat and drought has been tested in India and approved for release. The variety, called 'Kufri Lima', is ideal for early planting and resistant to the viruses PVX and PVY and is moderately resistant to late blight. 'Kufri Lima' has 30% more marketable tuber yield than the popular heat-tolerant variety, 'Kufri Surya'. It stores well, is attractive and tasty. Farmers who harvest early earn higher prices and can plant an additional winter crop, such as wheat. 'Kufri Lima' also has a low degeneration rate so farmers can plant it for two to three generations, saving seed costs.

Another drought-tolerant clone, CIP 397006.18, was tested under the All India Coordinated Research Project and was found to be flavorful, blight-resistant and to have higher yields than locally grown varieties. These promising new varieties are good news for India's small-scale potato farmers.

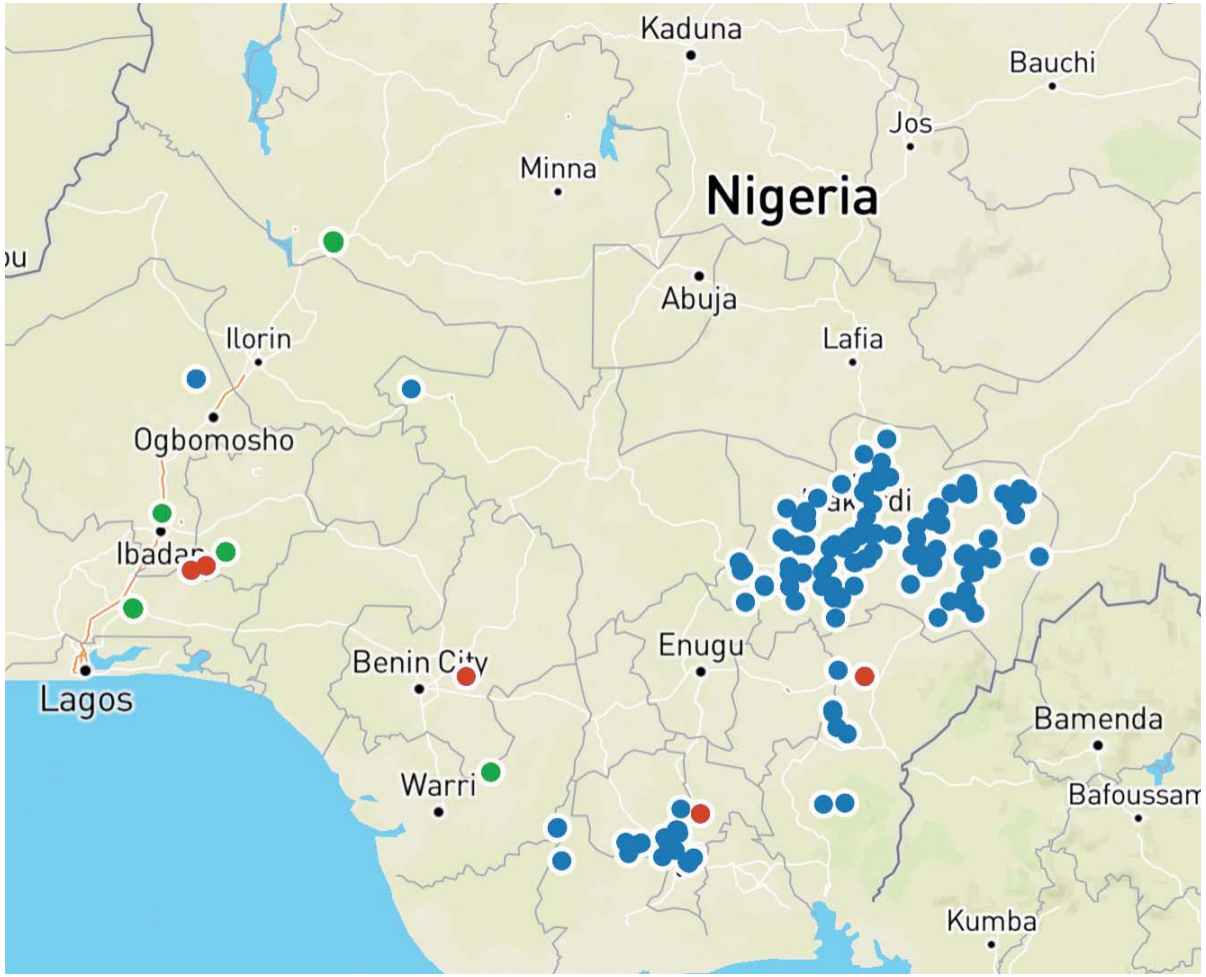
Toolbox to understand and enhance root, tuber and banana seed systems

A suite of tools for understanding root, tuber and banana seed systems is helping document and guide the implementation of ongoing seed interventions.

Root, tuber and banana crops are clonally propagated, meaning they are grown by planting tubers, suckers, stalks, or vine cuttings, referred to as 'seed'. This presents several challenges for farmers, including low seed multiplication rates, bulky and perishable planting material and rapid seed degeneration leading to low crop yields.

RTB centers have collaborated to develop tools that allow practitioners to understand and systemically diagnose seed systems and determine how to effectively intervene in them. In 2017, experts from Wageningen University and the RTB centers met to incorporate and describe these tools in a single toolbox using a standard format.

"This toolbox is a much-needed guide, a collection of 14 tools that enables researchers to come to grips with the seed systems of vegetatively propagated crops, and to overcome social, economic and market constraints," said Jorge Andrade-Piedra, seed expert and plant pathologist at the International Potato Center (CIP). The toolbox is being validated in 14 projects in Asia, Africa, and South America across all major RTB crops.



Cassava seed producers registered in the Cassava Seed Tracker. Blue dots represent commercial seed producers, green dots represent breeder seed and red dots are foundation seed. CST/IITA

One of the tools, a 'multi-stakeholder framework for intervening in root, tuber and banana seed systems' will be used in all locations to allow the designers of new seed projects to identify the major stakeholders, their roles, and critical bottlenecks of vegetatively propagated seed systems. So far, the framework is being used in ongoing interventions in Nigeria for cassava, in India for potato, in Ethiopia for sweetpotato, and in Uganda for banana. It has

Potato farmers in Ecuador were surveyed to understand the networks of farmer seed and ware potato transactions to simulate how pathogens may spread. J.L.Gonterre

allowed researchers to organize multi-stakeholder workshops to analyze the seed system, identify appropriate interventions and to guide the design of household questionnaires to probe deeper into key constraints to seed use.

Another tool, the 'impact network analysis' is being used widely to improve researchers' understanding of farmers' seed exchange networks and how seed degeneration occurs. For example, as reported in the journal *Phytopathology* in 2017, farmers in Ecuador were surveyed to estimate the structure of the networks of farmer seed and ware potato transactions. This was used to simulate pathogen spread through seed networks and to identify priority nodes for disease monitoring and management training, including a market, certain farms and a farmers' cooperative called CONPAPA. Karen Garrett, of the University of Florida, explained that "mapping out seed system networks like this can enable us to evaluate different scenarios and options for system improvements, so it's a really core tool in the RTB seed system toolbox."

The 'seed tracing' tool is being piloted for cassava seed value chain management in Nigeria through

a software application called the 'Cassava Seed Tracker' (CST). The tracker is tailored to suit seed certification procedures of Nigeria, and the needs of the 'Building a Sustainable, Integrated Seed System for Cassava in Nigeria' (BASICS) project which is working to strengthen all components of the cassava seed value chain. CST can be used to access project seed inventory and for real-time tracking of the seed field status. It also provides users with defined data for estimating trends, planning and monitoring and evaluation of project partners' performance. The CST database includes records of nearly 300 seed fields of BASICS, including 68 seed fields in 2016 and 214 in 2017, with many more to be added in 2018.

The tracker also incorporates features for e-certification by the National Agricultural Seed Council (NASC) and facilitates direct communication between the producer and seed inspector. CST has user accounts for designated seed inspectors to carry out e-seed certification. NASC seed certification officers have been trained to apply CST and will perform e-seed certification in three states (Oyo, Benue and Abia) in 2018. A server facility at NASC headquarters in Abuja was established in 2017 and three of their IT staff were trained to manage the e-certification database.

The toolkit will continue to evolve and improve in the coming years as it is enriched with the results of these and other ongoing seed interventions.

Registering sweetpotato vine multipliers to expand sales and monitor outreach

Decentralized vine multipliers benefit communities in multiple ways, including reducing the distances farmers must travel for planting materials and providing casual employment. H.Rutherford/CIP

Decentralized sweetpotato vine multipliers provide smallholders with access to the vines needed to plant nutritious orange-fleshed sweetpotato. As demand for the vines grows in different countries, the Sweetpotato for Profit and Health Initiative (SPHI) registers vine multipliers and has established a database of multipliers on the Sweetpotato Knowledge Portal so extension personnel and growers can locate them to make purchases. The database is updated annually, and studies are conducted to understand why some multipliers have stopped and others expanded.

By 2017, more than 1,100 vine multipliers, of whom 34% are women, had been registered in 11 African countries – Burkina Faso, Nigeria, Ghana, Ethiopia, Rwanda, Uganda, Kenya, Tanzania, Zambia, Malawi, and Mozambique. Since the launch of the multi-partner, multi-donor SPHI platform in 2010, over 4.5 million households have benefitted, directly or indirectly, from improved varieties of sweetpotato.

CIP

FLAGSHIP PROJECT 3

RESILIENT ROOTS, TUBERS AND BANANAS

Roots, tubers and bananas are vulnerable to several biotic and abiotic stresses that reduce yields for farmers, and which are predicted to intensify under climate change. Flagship Project 3 seeks to close these yield gaps. Monitoring pest and pathogen movement is critical to assess risks and design responses for emerging threats. The flagship also works to improve the agronomic practices and production systems of farmers, and so enhances the productivity and sustainability of RTB agri-food systems.

The flagship has developed pest and disease risk models related to climate change, conducted pest risks analyses, and advanced integrated pest management strategies. It is strengthening the capacity of plant health stakeholders to prevent and manage the risk of invasive and emerging pests and diseases which can undermine farmers' livelihoods. Many of these pests and diseases are transboundary, so RTB provides a broad platform for cross country collaboration. Because patterns of disease build-up and spread are similar for all root, tuber and banana crops, solutions developed for one crop can, in many cases, be applied to others.

Mobile app uses artificial intelligence to diagnose crop diseases

Researchers have developed a mobile app that diagnoses cassava diseases in the field using images captured on a smartphone, helping farmers to identify and manage diseases and reduce losses.

Nuru's database contains more than 15,000 images of cassava leaflets. E.Massam/IITA

Pests and diseases reduce cassava yields in Africa by more than half. Plant health problems include cassava brown streak disease, cassava mosaic disease, brown leaf spot, cassava green mites (*Mononychellus tanajoa*) and cassava red spider mites (*Oligonychus biharensis*). In fact, mites are so small that they are readily confused with plant diseases. Early identification of these plant health problems would help farmers to manage them and reduce significant losses.

Babuali Ahmed, a researcher at the International Institute of Tropical Agriculture (IITA) in Tanzania, explains that to diagnose these pests and diseases, "we can use our eyes, but that means we have to be well trained and experienced. We can go to the lab, but this is expensive and there are not many labs out there. Of course, we can take pictures with our smartphones and send them to experts, or even better, what if we could train our smartphones to diagnose the diseases for us, from the images they capture?"

That is what researchers at IITA and Penn State University have done; they have created an app that identifies cassava diseases and pests. The app is called 'Nuru', which means 'light' in Swahili. It was designed in collaboration with Google, using TensorFlow, an open source software for object recognition. Nuru was crafted by taking 11,670 photos, to create 2,756 images of leaves which were cropped to form 15,000 images of leaflets. After experts diagnosed the diseases, the photos were organized into a database which was used to train the software using machine learning to recognize the symptoms of cassava pests and diseases.

The app is user-friendly, and farmers or extension agents simply point their smartphone camera at several cassava leaves and Nuru responds with a diagnosis. The app was purposefully designed to be cautious, so if it doesn't recognize the disease, it gives no diagnosis. It can also be used offline, which is important in remote farm communities.

The IITA-Tanzania team working to validate the app in real farming conditions in sub-Saharan Africa has tested its ability to correctly diagnose disease symptoms. It is correct 70-80% of the time, which while not quite as good as experienced cassava researchers, is already better than trained extension workers or farmers. Furthermore, as its development continues, it will keep getting better.

"Smartphones are becoming more and more common in rural Africa. Smallholders or extension officers with a basic smartphone with a camera can already download the app for free via Google's Play Store, fire it up, point it at a leaf with disease symptoms and get an instant diagnosis. That is truly revolutionary!" said James Legg, a plant virologist at IITA and RTB's Flagship Project 3 leader. Furthermore,

reports across the globe are picked up in real-time by the team of cassava disease experts involved in Nuru's development, which allows direct interaction between users and research specialists. Although Nuru provides advice on how to manage each of the major cassava diseases identified, this direct link with researchers means that users can also get personalized advice appropriate to their situation. Data generated through the app can also be used to identify new areas of disease occurrence and to generate maps to plot disease spread, which helps to target control interventions.

The team that designed the app was awarded a USD100,000 prize for their creation by the CGIAR Platform for Big Data in Agriculture during their annual conference in in 2017. This is helping to fund the development and validation of the app.

Efforts in 2018 will focus on extending the AI technology used to the other RTB crops (including banana, potato and sweet potato), and on providing training on app usage to farming communities in Kenya and Tanzania, including 28,000 farmers working with Self-Help Africa. Data generated by the app will also be used to plot disease incidence and spread.

The user-friendly app allows farmers and extension agents to diagnose diseases in the field. IITA

Decision support tools remove the guesswork from agronomic innovation

Decision support tools being piloted in Nigeria and Tanzania can help cassava growers decide if agronomic recommendations will be profitable under their local conditions.

Crop yields in Africa are often limited because farmers and extension agents lack reliable agronomic recommendations that are tailored for their local conditions. For example, judging the most effective quantity of fertilizer depends on knowing fertilizer and labor costs, expected weather, soil type, cropping history and past soil management. Crops in different locations may respond to fertilizer in different ways. Or, the market may reward farmers with high crop prices in one area, but not in another. As a result, farmers may not be able to judge if an investment is worthwhile before trying it.

Since 2016, the African Cassava Agronomy Initiative (ACAI), a project managed by the International Institute of Tropical Agriculture (IITA) in partnership with national and international research institutes, universities, development organizations and the private sector, has developed tools to support cassava growers and extension agents in Nigeria and Tanzania to make decisions by tailoring

Researchers have developed decision-making tools that help farmers and extension agents decide whether agronomic recommendations will be profitable under their local conditions. R.Enese/ACAI

investments in agronomic practices to farmers' local conditions, maximizing profits.

The project worked on cases involving:

- recommendations for cassava planting density and tillage,
- intercropping cassava with maize or sweetpotato,
- agronomic interventions to increase the starch content of cassava roots,
- scheduled planting and harvesting to sustain supply to the cassava processing industry,
- recommendations on best blends of NPK fertilizers for the fertilizer industry,
- site-specific fertilizer recommendations for commercial cassava growers.

For each case, researchers began by reviewing literature on promising recommendations. Next, they conducted surveys of thousands of fields and households to learn about the current practices, major limitations in cassava cultivation, and the role of cassava within the households' food and cash generation strategies.

This was followed by hundreds of on-farm agronomic trials of the proposed agronomic recommendations, including 600 fertilizer response trials in 2017. The large sample sizes for the surveys and trials created robust datasets. The analysis of these trials showed that the profitability of many innovations, such as changing the crop's planting date or density, adding fertilizer or ridging of the soil, depends on the field's location and environment, as well as past crop and soil management. Researchers then developed new decision-making tools, like mobile apps, to help farmers and extension agents decide whether an innovation is profitable under their local conditions.

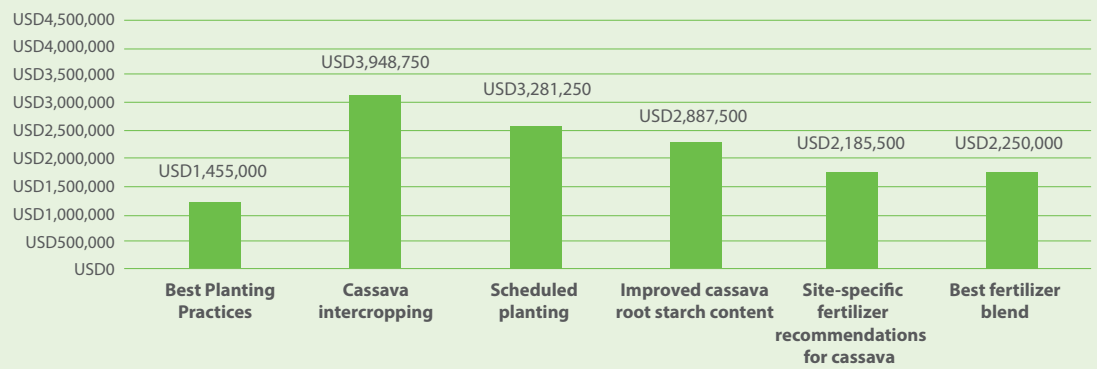
The farmer or extension agent enters data such as the area of the field, cassava variety, the date of planting, fertilizer and labor costs, expected harvest price and date of harvest. The app infers soil and weather information from the GPS location and uses the input data to calculate the expected profit from using a new practice, such as a higher rate of fertilizer, or an alternative date of planting or harvesting. It provides information on the increase in net revenue, and the risk associated with the innovation to help the user decide if the innovation will be profitable.

During 2019-2020, the tools will be scaled through a partnership with development actors involved in the cassava value chain in Nigeria and Tanzania. The expected yield and income gains of the improved agronomic recommendations should benefit about 100,000 farming families, with a total benefit of over USD16 million.

Currently, the tools are in their first version, and being validated in a pilot program involving over 1,000 cassava growers in both countries. "One of the biggest challenges has been getting the key players to trust the technology, participate in the exercises and apply ACAI methods. As the project moves forward, we are working to change mindsets by encouraging active participation, practical demonstration, versatile feedback mechanisms and real-time knowledge and information sharing," noted Stefan Hauser, systems agronomist at IITA.

In the future, farmers and extension agents will have user-friendly apps on smartphones, tablets or laptops that can help to decide if a given innovation is right for each farmer. These decision-support tools will also help farmers to make management decisions efficiently over large geographical areas. When these decision-support tools are mature, they should improve the profits earned by millions of African farmers, make extension work easier and more rewarding, while doubling the yields of cassava on the continent.

EXPECTED VALUE OF BENEFITS FOR FARMERS



Pest Distribution and Risk Atlas for Africa includes potato and sweetpotato pests

Insect pests cause major yield losses in agricultural crops. Climate change is expected to exacerbate this impact, with warming temperatures affecting insect populations, range expansion and outbreaks. To inform the development of integrated pest management strategies, the International Potato Center (CIP) launched an online Pest Distribution and Risk Atlas for Africa in early 2017.

This open-access, mobile-accessible resource combines up-to-date information on major insect threats to potato, sweetpotato, vegetable and maize production with current risk maps for each pest and predictions for future climate scenarios. Researchers, agricultural ministry officials and extensionists can use that information to plan efforts that help farmers better manage crop pests now and prepare for future threats. The maps were generated using insect life cycle modelling software (https://research.cip.cgiar.org/confluence/display/ilcym/Home).

"Any increase in temperature caused by climate change will have drastic effects on pest invasions and outbreaks that will affect pest management, crop production and food security," said Jürgen Kroschel, CIP Agroecology and Integrated Pest Management science leader, who started the Pest Risk Atlas project.

To predict the risks of insect pests linked to range expansion and more intense outbreaks at global, regional and local levels, CIP scientists used advanced pest phenology modeling and geographic information system risk mapping, among other tools. This included risk assessments from a collaborative project with the International Institute for Tropical Agriculture (IITA) and the International Centre of Insect Physiology and Ecology (ICIPE). The Atlas also includes information on pest identification, ecology and impacts, as well as pest management recommendations.

CIP researcher Joshua Okonya inspects the health of a potato field. CIP

Funded by RTB, the Atlas promotes sustainable pest control methods that reduce the use of pesticides, such as biocontrol strategies for invasive pests. The goal is to improve pest management on the ground, increase crop yields, and contribute to the food security and the incomes of Africa's smallholder farmers.

LEARN MORE
https://cipotato.org/riskatlasforafrica/


CIP

FLAGSHIP PROJECT 4

IMPROVING NUTRITION AND LIVELIHOODS

There is great scope in diversifying and improving the utilization of root, tuber and banana crops for nutrition and economic goals, resulting in healthier diets and better livelihoods for women, men, and youth.

Flagship Project 4 (FP4) is harnessing the nutritional potential of roots, tubers and bananas, sustainably expanding their utilization and adding value through post-harvest innovation. Post-harvest researchers and nutrition specialists collaborate with breeders to design and develop more nutrient-dense crops, such as biofortified orange-fleshed sweetpotato and cassava, which also have other market-preferred traits such as high dry matter or starch content. Market development research strengthens demand for biofortified crops and accelerates the uptake of varieties that are both nutritious and profitable.

Among the common challenges shared by RTB crops are their bulky and perishable nature, which have typically restricted them from entering urban markets. "By improving storage, transportability and processing, while reducing postharvest losses, FP4 is working to increase consumption among growing urban populations," adds Simon Heck, FP4 Leader, and a program leader with CIP.

Making storable orange-fleshed sweetpotato purée a commercial reality

Orange-fleshed sweetpotato purée is a profitable and nutritious commercial product to meet urban consumers' needs in Kenya.

Vitamin A deficiency is a serious problem in East Africa. Through the efforts of the International Potato Center (CIP) and its partners, many vitamin A-rich, orange-fleshed sweetpotato (OFSP) varieties have been made available to rural households. As Africa is rapidly urbanizing, more people want to buy food that is ready to eat or easy to prepare.

Earlier research in Rwanda demonstrated that OFSP purée (steamed, mashed roots) was an economically viable ingredient in baked products when the purée was produced and used in the same bakery. Between 2010 and 2014, CIP and the Rwanda Agricultural Board worked with a bakery, Urwibutso Enterprises, to make biscuits and donuts from sweetpotato purée. The bakery made its own purée and used the waste for animal feed at their piggery. However, most bakeries do not want to make purée or deal with the waste.

"The challenge for us as researchers was to develop a more complex market chain that could take orange-fleshed sweetpotatoes all the way from the field, through processing and baking, to reach consumers with bread that was rich in vitamin A," noted Tawanda Muzhingi a food scientist at CIP. In 2014, the Center began to work with a wider range of value chain actors in Kenya to develop baked goods made with OFSP. During product development, the food technology specialist at Euro Ingredients Ltd. created improved OFSP bread, buns and cake recipes.

Based on a CIP consumer assessment, Tuskys supermarket in Kenya agreed to sell products in some of its 56 stores, and Organi Ltd., a Kenyan bakery, agreed to produce the purée. Adding this actor made the value chain longer but was necessary to encourage the supermarket to bake with sweetpotato purée. In 2015, equipment was installed at the Organi factory and CIP recruited 334 sweetpotato growers, of whom two-thirds were women, to produce the roots. These were peeled by hand and shipped as frozen purée to Tuskys' bakery in Nairobi.

The first OFSP bread was marketed in six branches of Tuskys in 2015 at a premium price (USD 10 cents above its regular bread), reaching 20 stores in 2016. The bread was well-received by consumers as a healthier alternative, good source of antioxidants and vitamin A – with two slices providing about 10% of the vitamin A requirements for adults.

Commercial development in 2016 focused on intensifying and improving the purée processing, by increasing output and reducing costs. The processing was improved with better washing and by introducing high fiber purée from unpeeled sweetpotato. This allowed Tuskys to sell 3,000 loaves of sweetpotato bread per day with a profit margin of 18%.

In 2017, CIP started working on a shelf-stable purée. Researchers tested different doses of safe, locally available food preservatives, such as citric acid, to develop a vacuum-packed purée with a 3-to-6-month shelf life that does not need refrigeration. This is important because keeping a cold chain is expensive in sub-Saharan Africa, and sweetpotato is often a seasonal crop, so the purée must be storable.

Jan Low, leader of the Sweetpotato for Profit and Health Initiative at CIP, explained that the greatest challenge is "getting all parts of the chain

Intensifying and improving purée processing allowed Tuskys to sell 3,000 loaves of OFSP bread per day with a profit margin of 18%. CIP

consistently flowing. If the purée processor does not have capital to risk up front, if the supermarket purchasing the purée delays significantly in paying for the product, the payments to farmers for their roots are delayed, which clearly is demotivating. Yet the owner is hesitant to take out loans to pay farmers up front until all is working. It is a classic chicken and egg problem."

A key lesson from this is the importance of having a partnership with a private sector company, such as Organi, which is willing to adopt recommendations. Periodic feedback at all levels with the farmers and processors was crucial. Commercial OFSP purée production has been improved and is poised for profitable, larger scale output. Baked goods rich in vitamin A will provide farmers with a guaranteed market for their produce while making healthy food available to consumers.

OFSP bakery goods are both profitable for producers and healther alternatives for consumers. CIP

Vitamin A-rich bananas offer new hope to address vitamin A deficiency

Researchers in East Africa are introducing banana varieties from across the world to address severe vitamin A deficiency. Taste tests help to identify and fast track new varieties that consumers prefer.

Vitamin A deficiency is high in the East African countries of Uganda, Tanzania, Burundi, Rwanda, DRC and Kenya, ranging from 39% to 64%. Vitamin A deficiency increases the risk of disease and death from severe infections in children and it contributes to poor pregnancy outcomes among women, besides being the leading cause of preventable blindness in children.

In East Africa and the Great Lakes Region, bananas are an important part of the diet for over 100 million people who eat an average of 250 to 400 kg of bananas a year. Banana varieties grown in this region are generally low in vitamin A with 7 to 27 nmol g-1 dry weight, but some varieties from South Asia, West Africa and the Pacific have levels (as much as 220 nmol g-1). Vitamin A deficiency could be avoided by introducing these banana varieties that are naturally rich in the vitamin. This is particularly useful for banana, which is difficult to breed.

Farmers tested the varieties for qualities like ease of peeling, pulp appearance and taste. Bioversity International

Bioversity International and partners screened over 400 varieties of bananas and found a number that were rich in vitamin A. But healthy food is of little value if people will not eat it. So, researchers from Bioversity International and partners did taste tests (organoleptic, or sensory tests) at eight locations in Burundi and in North Kivu and South Kivu in the eastern Democratic Republic of the Congo. The study compared eight introduced varieties (five for cooking and three dessert varieties) with 10 varieties grown locally (six cooking and four dessert types). Researchers prepared samples of the bananas in various popular styles: roasted with and without the peel, fried, and raw (for the dessert bananas).

At each site, panels of farmers (50% women) evaluated the varieties for peel appearance, ease of peeling, pulp appearance, aroma, texture in hand, texture in mouth, taste and overall acceptability. While there was some variation by gender and by region, in general farmers gave some local varieties a score of 4 (out of 5), but the introduced Apantu

plantain variety (from Ghana) also scored a 4. All three regions and both men and women accepted some cooking bananas, and the communities in Burundi and North Kivu accepted new dessert bananas. It is not really surprising that the locally grown varieties scored a bit higher than introduced ones; after all, people like the foods that they are used to eating. But in some regions the farmers ranked introduced plantains Apantu, Bira, Pelipita and Lahi, and dessert bananas Lai and To'o nearly as high as the local ones. People may learn to like the new varieties more as they become familiar with them, especially if the nutritional benefits are also explained. Children who eat just one of these introduced bananas per day will get enough vitamin A to avoid blindness from vitamin deficiency.

The introduced varieties are already being grown locally by participating farmers. Over 1,400 farmers have received more than 11,000 cuttings or suckers to plant their own banana gardens.

Telesphore Ngayure, a Burundian farmer, has grown these varieties since 2014. "After eating some of the bananas at my home, my neighbors liked them so much that they asked for the suckers so they too could plant them in their fields," he said.

To scale up these findings, Bioversity International and partners have reached 9,797 households in Burundi and DRC with crucial information on general banana management, nutrition and dietary diversity. This initiative has now been extended to Tanzania and Uganda and will soon reach Kenya. An efficacy study is being planned to measure the improvement in people's vitamin A levels by eating the improved bananas. This rapid identification of vitamin A-rich banana varieties that are acceptable to East African farmers will ensure that a major food crop is more nutritious, offering new hope to address the crippling effects of vitamin-A deficiency for 100 million people.

Over 1,400 farmers have received more than 11,000 cuttings or suckers of the vitamin A-rich varieties. Bioversity International

New energy-efficient dryers for small-scale cassava processors

Cassava is processed into food products like gari. H.Holmes/RTB

Cassava deteriorates rapidly after harvest. In villages across Africa, roots are usually processed into semolina-type products (especially gari) and other foods using basic, locally made equipment. The lack of appropriate small-scale drying equipment is a barrier to expanding these enterprises. As part of collaborative research by CIAT, IITA and CIRAD, experiments were conducted with flash dryers at two cassava processing centers in Tanzania and Nigeria. Sensors were installed on the dryers and the mass and energy balance of the equipment was analyzed. The air mass flow rates of both dryers were then reduced by 24% in Tanzania and 14% in Nigeria. The modifications decreased the dryers' heat input without jeopardizing evaporation rates, or the final moisture content of the dry products. The modification improved energy efficiency by 25% in Tanzania and by 14% in Nigeria. This research will allow practical flash dryers to be developed for small-scale, on-farm processors elsewhere in Africa, Asia and Latin America.

FLAGSHIP PROJECT 5

IMPROVED LIVELIHOODS AT SCALE

Achieving ambitious improvements in the lives of millions of beneficiaries is a central focus of RTB. Flagship Project 5 (FP5) works together with RTB's four other flagships to enhance and scale innovations, while paying special attention to gender equity.

FP5 is developing pioneering tools, methods and approaches that enable researchers to analyze trends for RTB crops and identify new opportunities in a context of climate change. It conducts ex-post assessment to understand adoption processes and measure impacts of innovation. It provides tools to support decision-making on investments among competing enterprises for actors at household, landscape, value chain and policy levels. FP5 also supports strategic gender and youth research and capacity development.

Co-learning, capacity development and participatory testing of RTB innovations are used to guide innovation and scaling in Flagships 1 to 4 using the novel scaling readiness approach.

Gender mainstreaming in value chain development triggers women's empowerment in Uganda

A gender focus introduced in value chain development in Uganda has allowed women and men to start new seed businesses, to train other farmers, and to share planting material of varieties that consumers want.

Banana is a major staple in Uganda. However, traders and other value chain actors face post-harvest loses that limit their incomes. The 'Expanding utilization of roots, tubers and bananas and reducing their post-harvest losses' (RTB-ENDURE) project implemented the Participatory Market Chain Approach (PMCA) with a gender lens to address this concern.

Jointly facilitated by Bioversity International and the International Potato Center (CIP), the PMCA began with a gendered value chain study to identify the needs of banana value chain actors and new market opportunities specifically considering post-harvest losses. This identified the short shelf-life of most cooking banana cultivars and the mismatch between the varieties grown by farmers and those demanded by consumers. Other challenges included low production of the market-preferred varieties due to a lack of access to clean and affordable planting materials, and limited linkages between farmers and major market outlets. Male and female value chain actors also highlighted these challenges in the first stakeholders' meeting held as part of the PMCA.

During the PMCA, thematic groups were created in order to stimulate innovation in banana value chains, and seed was identified as a business opportunity for women. In several meetings of the seed group, banana market chain actors created a joint plan to focus on these business opportunities. Consequently, a low-cost seed multiplication technology using macropropagation techniques, developed by the International Institute of Tropical Agriculture (IITA), was introduced with five women's groups and five men's groups in Rakai and Isingiro districts in Uganda. Male and female farmers were trained to build the macropropagation and hardening chambers with locally available materials. They also learned to prepare corms and other seed production techniques. Farmer groups working with the RTB-ENDURE project developed gendered business plans so that men and women would reap equitable benefits.

The seed thematic group in PMCA was aligned to an existing Banana Multi-Stakeholder Platform to build trust and avoid the expense of costly thematic meetings. Male and female farmer representatives were elected to sub-county, district and regional level platforms, further increasing farmers' networks with traders, input suppliers, fellow-farmers and other stakeholders. The chairperson of Bakyala Kwekulanya ('Women in Development') seed production group in Rakai was introduced to several potential seed buyers from these interactions.

When the first plantlets were nearly ready, farmers sold them using seed distribution models which ensured that both men and women members accessed clean seed of the market-preferred cultivars in exchange for labor, such as fetching irrigation water, preparing corms and weeding. When neighboring farmers saw the performance of the improved seed, they also ordered planting material. Women found it easier to access seed from women's groups and men from men's groups. In Rakai, one farmers' group could not meet the high demand for seed and turned to the thematic group for advice.

The first strategy was to organize collective marketing with other groups. However, the seed was bulky and the groups were far apart. So the Bakyala Kwekulanya women's group devised a strategy to build a new commercial chamber using their own funds. At a final event attended by district officials, technical experts and the private sector, the group showcased the large, new chamber. The district councilor was impressed and offered the group a grant of USD2,000.

The group realized the need to work harder to address challenges such as the lack of water during the long dry season in Rakai, and to try other seed production methods they had learned. This required financial and technical support, yet the initial project had ended. This is when they banked on the linkages created during the project, especially with the Banana Multi-Stakeholder Platform. The group was able to acquire a water tank which eased the water shortage. The group also produced and sold plantlets worth USD3,000 in 2017, and now offer training services to NGOs to train other farmers in clean seed production.

Using a gender lens with PMCA enabled women to identify, access and benefit directly from a series of innovations. The reflexive process of identifying and addressing market chain bottlenecks and opportunities enhanced their negotiation and

A gender focus introduced in value chain development allowed farmers to start seed businesses, producing planting material of varieties that consumers want. S.Quinn/CIP

planning skills as well as their overall self-esteem. Income generated by the new initiatives is controlled by women, enhancing their economic empowerment. Their journey towards sustainability and growth is challenging, but for Bakyala Kwekulanya women's group, it is one they are willing to pursue and invest in.

LEARN MORE
https://cgspace.cgiar.org/handle/10568/88096

Peruvian potato farmers benefit from productive varieties

The International Potato Center has worked with the potato breeding program of the National Institute of Agricultural Innovation of Peru to develop and release more than 34 improved potato varieties over the past 40 years. These varieties have higher yields and lower production costs, increasing farmers' income and reducing pesticide use.

A national survey of 1,098 potato producing households, published in 2017, showed that 62% of the potato area is under improved varieties – benefitting 202,676 farmers. Improved varieties have a net yield gain of 1.0 ton per ha, and an additional 2.7 tons of potato sold per farmer, resulting in an additional revenue of USD493 per farmer.

The new varieties reached women farmers as well as men with the survey revealing that 60% of female headed households adopted the improved potatoes, while 74% of male headed households adopted improved varieties.

Applying the science of scaling

A new RTB initiative is applying the science of scaling to accelerate promising agricultural technologies, showing researchers how to reach more farmers, much sooner.

Scaling up agricultural innovations is one of the biggest challenges facing research and development organizations. Projects have often tried to scale technologies at the end of the intervention, in an ad hoc way such as by giving flyers to farmers or briefs to policymakers. However, the successful scaling of a new technology depends largely on the enabling environment and needs to be considered from the outset.

The Scaling Readiness Approach treats innovation as a flexible package of technological, organizational, and institutional components that may include crop varieties, equipment, management practices, legislation, and marketing. An innovation may be ready in a technical sense, –for example, a new crop variety may thrive in the local environment,– but if farmers lack funds to buy seed or if the policy environment discourages the uptake of new varieties, it may not be adopted. This approach assesses the potential of technologies and other innovations supported by RTB to be used at scale, and guides researchers and other stakeholders in implementing these innovations in practical contexts.

"Agricultural researchers often think their innovation is ready to go to scale, and sometimes it is in a way. However, an idea can be technically sound and fail because it is not affordable, or too different from what farmers are used to," said Marc Schut, senior social scientist from the International Institute of Tropical Agriculture (IITA) and Wageningen University, who is RTB's Flagship Project 5 Leader.

"Innovations often consist of technological, social, capacity development and market components, that together form the innovation package. Scaling of innovation is like filling a barrel with water. The water will only rise as high as the shortest slat of the barrel; in other words, the limiting innovation dimension in the package. To enable scaling, we need to invest in raising the height of those shorter slats," he explained.

The Scaling Readiness Approach was developed and tested in four case studies in 2016 and 2017: 1) scaling best cassava agronomy practices in Tanzania and Nigeria 2) scaling a method to control banana Xanthomonas wilt (BXW) in the Democratic Republic of the Congo and Uganda; 3) developing a national policy for a sustainable and resilient cassava sector in Cambodia; 4) decision support tools for potato late blight management in Ecuador.

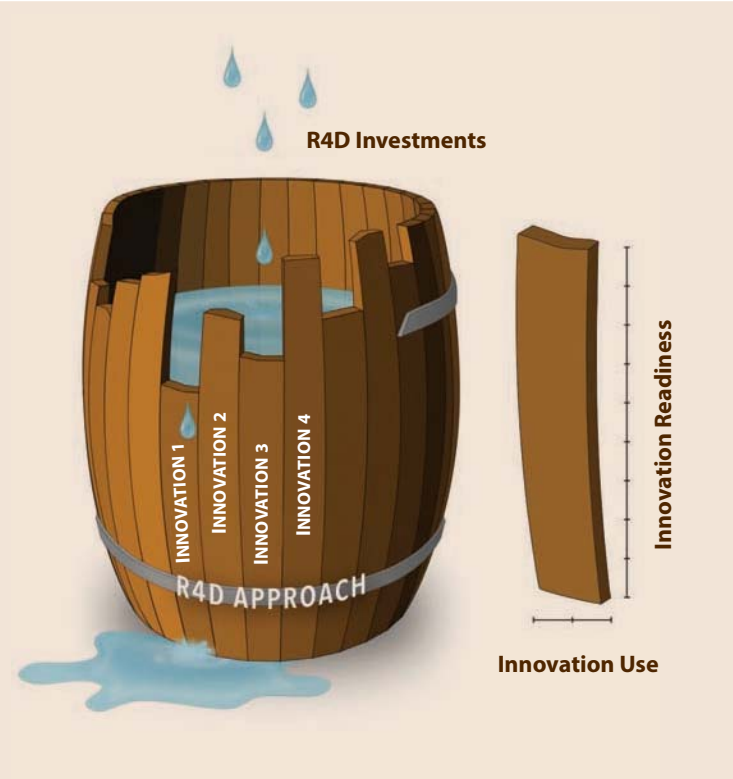
In 2017, the program established the RTB Scaling Fund, which awarded its first grants to three teams of scientist who will share USD2 million to scale three promising technologies.

One innovation, led by Bioversity International, is 'single diseased stem removal' (SDSR), a method for managing BXW. Earlier innovations required destroying large numbers of banana plants; but with SDSR, by removing a single diseased stem, sterilizing tools, and removing male flowers from healthy plants, smallholder farmers can manage BXW while still producing fruit and earning money.

Another innovation funded, Triple S (Storage in Sand and Sprouting), is a way of storing sweetpotato roots in sand during the dry season and planting them in seedbeds six to eight weeks before the rains start. This allows farmers to produce enough vines to plant during the rainy season. Triple S, under the leadership of the International Potato Center (CIP), is proposed for scaling in nine African countries.

The third innovation is a technology to turn cassava peels – waste from food production in Nigeria – into a high-quality ingredient that can be substituted for part of the maize in livestock or fish feed. Led by IITA, the technology can simultaneously

READINESS OF THE ENABLING ENVIRONMENT



The successful scaling of a technology depends on the enabling environment and context. H.Rutherford/CIP

create a new source of employment for half a million Nigerians each year, while eliminating harmful waste from the environment.

"We have put scaling of innovations center stage in this second phase of our program. The Scaling Readiness Approach provided us a lens so we could take stock of what are our most promising innovations," said Graham Thiele, RTB Director.

"The approach has allowed RTB to interrogate our innovation portfolio and see what's truly ready to go to scale, considering the weakest or limiting element in the innovation package. We've invested in three really promising technologies that have the potential to benefit millions," he added.

New guidelines refine the use of innovation platforms to support scaling

New guidelines are helping the agricultural research for development sector to rethink how and when to use 'innovation platforms' to most effectively develop and scale technologies.

Innovation platforms are increasingly used in agricultural research for development initiatives to help researchers, farmers, food processors, government officials and other actors design effective innovations. An innovation platform is a group of individuals and organizations with different backgrounds, expertise and interests who come together to diagnose problems, identify opportunities, and find ways to achieve their goals. They may design and implement activities together or as individual members.

Based on early successes, innovation platforms are now being used widely in agricultural research for development to test local innovations and take them to scale at the national level by increasing the collaboration, exchange of knowledge and influence mediation among stakeholders. However, these cases often involved highly motivated people in well-supported initiatives.

"Innovation platforms are fast becoming part of the mantra of agricultural research for development projects and programs. However, innovation platforms run the risk of being promoted as a panacea for all problems in the agricultural sector. Recent studies have shown that there are some practical limitations that must be considered, which led us to develop a set of guidelines on how to best use innovation platforms," said Marc Schut, social scientist at the International Institute of Tropical Agriculture and Wageningen University, and the leader of RTB's Flagship Project 5.

A 2017 study on the innovative capacity and scaling potential of innovation platforms in Burundi, Rwanda and the Democratic Republic of Congo (DRC) found that effective innovation and scaling were hampered by mismatches between collaboration, knowledge exchange and influence networks. In particular, it was found that NGOs were over-represented and the private sector was under-represented, linkages between local and higher levels were weak, and influential organizations such as high-level government actors were often not part of the platform or were weakly linked to other organizations. The platform could support the scaling of innovations between the same types of organizations, for example between NGOs, however it had limited potential to support scaling across different kinds of organizations.

A second study published in 2017 gathered data on 39 innovation platform events in Burundi, 66 in Rwanda and 20 in DRC. Events included launch meetings, platform meetings, field trials and data collection events. The innovation platforms were not always as inclusive as they were intended to be. Researchers usually made decisions and many national members were poorly aware of community level activities of the platform. The Ministries of Agriculture were often poorly integrated into the platforms.

Guidelines published in 2017 by Schut and colleagues, supported by RTB, are intended to address these shortcomings. They help funders and project developers to reflect on when to use innovation platforms, how to design them, set goals, allocate resources, and create enabling conditions for effective implementation of innovation platforms. The guidelines explain design and implementation principles, the financial and human resources, and suggest ideas for more effective monitoring, evaluation and learning to better assess the impact that the platform has.

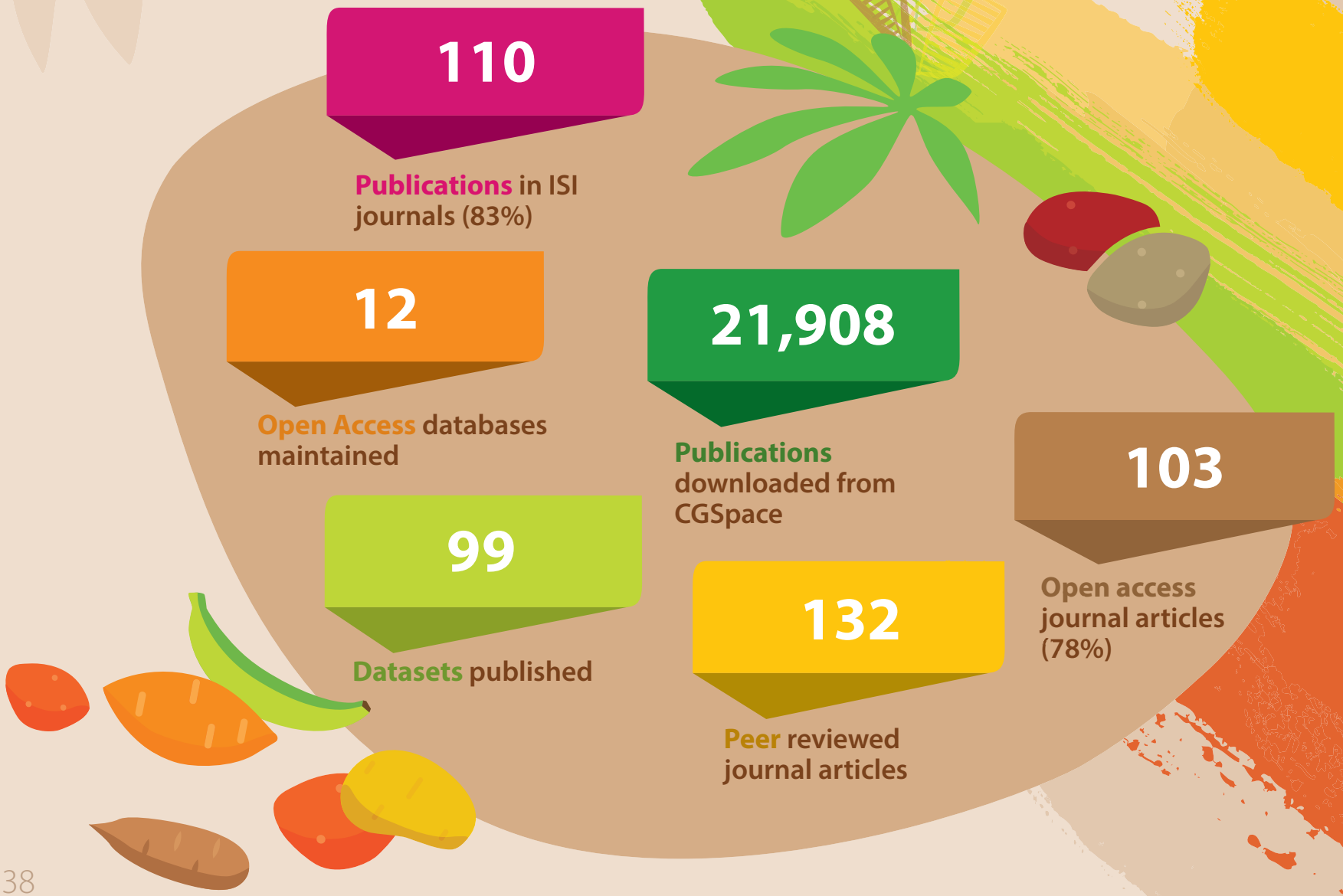
Innovation platforms are made up of individuals with different backgrounds and interests, such as farmers, food processors, researchers and government officials. B.Seyoum and T.Girma/ILRI

"The guidelines provide a decision support tool for research, development and funding agencies that can enhance more critical thinking about the purposes and conditions under which innovation platforms can contribute to achieving agricultural development outcomes. The fact that 12 of the 15 CGIAR centers participated in writing the guidelines is a good sign that researchers see the need for, and have the will to use the guidelines," Schut added.

Published in June 2017, the guidelines were accessed nearly 1,200 times in the same year.

LEARN MORE
http://hdl.handle.net/10568/82550

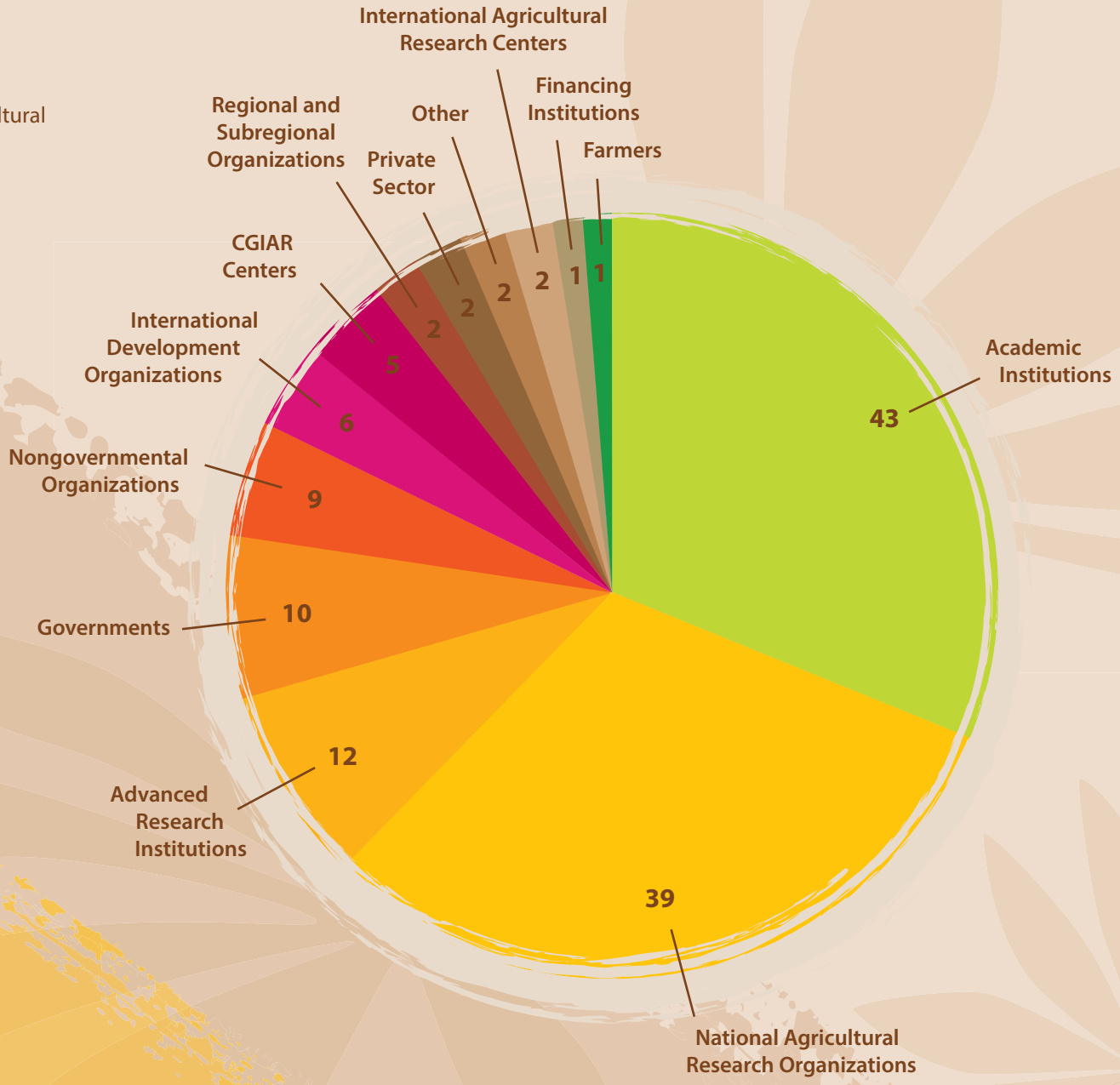
KNOWLEDGE PRODUCTS



PARTNERS

Partnership is central to international agricultural research for development. Collaboration mobilizes research results through bringing together diverse actors at international, regional, national and local levels. Partnerships are crucial for RTB's success and form an intrinsic part of the theories of change which make outcomes possible, with the scale and scope of partnerships changing along the continuum from research to development.

In 2017, RTB worked with 134 formally established partners, including private sector, national agricultural research organizations, advanced research institutions, academic institutions, governmental and non-governmental organizations. Innumerable community-based organizations and farm households not individually listed here were also central to the program's success.



DONORS

RTB is grateful for the funding support provided by our donors, including through contributions to the CGIAR Trust Fund (www.cgiar.org/funders).

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- Australian Centre for International Agriculture Research
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- Friedrich-Alexander-Universität Erlangen-Nürnberg
- Food and Agriculture Organization of the United Nations
- Government of Belgium
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- Government of Liberia
- Government of Netherlands
- Government of Tanzania (Ministry of Agriculture, Food Security and Cooperatives)
- Government of Uganda
- International Bank for Reconstruction and Development
- Irish Aid
- International Fund for Agricultural Development
- MEDA Economic Development Associates, Tanzania
- National Agricultural Research Organisation
- Natural Resources Institute, University of Greenwich
- North Carolina State University
- Programa Nacional de Innovación Agraria - Government of Peru
- Queensland University of Technology
- Syngenta Foundation
- Université de Lausanne
- United States Agency for International Development
- Wageningen University

FINANCIAL REPORT

RTB started 2017 with a conservative budget scenario of Window 1&2 (W1&2) of USD18.7M. During the year the budget was adjusted upward with a final allocation of USD20.6M (including carry-over from 2016 of USD0.1M).

The total 2017 budget for the program was USD107.4M: USD20.6M (19%) from W1&2, and USD86.8M (81%) from W3, bilateral funds and RTB participant centers' own funds.

CGIAR FUNDING WINDOWS

- **Windows 1&2** funds are provided by the CGIAR to RTB for allocation across the agreed product portfolio. Window 1 funds are allocated by the CGIAR System Organization to different CRPs including RTB, while Window 2 funds are designated by donors specifically to RTB.
- **Window 3** funds are allocated directly to CGIAR Centers by donors and are mapped into RTB when they are consistent with the RTB product portfolio. Window 3 includes a deduction of 2% of the total budget as contribution to the CGIAR System Organization.
- **Bilateral** funds are contracts directly signed between a center and a donor and mapped into RTB.

2017 EXPENDITURE

Total expenditure for 2017 was USD93.5M, or 87% of the budget, of which USD18.3M (20%) was from W1&2, and USD75.2M (80%) from W3, bilateral and centers' own funds. W1&2 expenses reached 89% execution of the final budget and W3, bilateral and centers' own expenditure, reached 87% execution.

RTB had an average execution of 86% of each flagship budget, with the exception of Flagship Project 1 which was overspent by 6% due to the execution of W3 and bilateral projects.

Expenditure for gender research was USD10.4M, representing 11% of RTB total expenditure in 2017.

The chart below shows the W1&2 budget and expenditure by flagship and the management expenditure of USD1.59M.

FLAGSHIP 2017 W1&2 BUDGET VS EXPENSES (USD MILLIONS)

Flagship W1&2	Budget								
	Bioversity	CIAT	CIP	IITA	CIRAD	WUR	Partners	PMU	Total
FP1 : Enhanced Genetic Resources	0.72	0.86	1.23	0.65	0.11	-	0.12	-	3.68
FP2 : Productive Varieties and Quality Seed	0.63	0.56	2.56	1.12	0.03	0.07	-	-	4.97
FP3 : Resilent Crops	1.34	0.41	0.81	1.32	0.07	-	0.10	-	4.04
FP4 : Nutritious Food and Added Value	0.18	0.33	0.30	0.66	0.22	-	0.09	-	1.80
FP5 : Improved Livelihoods at Scale	0.73	0.59	1.14	1.36	0.02	0.24	-	-	4.08
CRP Management & Support Cost	0.04	0.06	0.08	0.08	-	-	-	1.77	2.03
Total	3.64	2.81	6.12	5.19	0.46	0.30	0.31	1.77	20.60

Flagship W1&2	Expenses								
	Bioversity	CIAT	CIP	IITA	CIRAD	WUR	Partners	PMU	Total
FP1 : Enhanced Genetic Resources	0.71	0.87	1.16	0.61	0.13	-	0.03	-	3.51
FP2 : Productive Varieties and Quality Seed	0.61	0.59	2.02	1.12	0.02	0.07	-	-	4.43
FP3 : Resilent Crops	0.91	0.41	0.78	1.26	0.07	-	-	-	3.42
FP4 : Nutritious Food and Added Value	0.19	0.30	0.29	0.48	0.17	-	0.09	-	1.53
FP5 : Improved Livelihoods at Scale	0.72	0.46	1.10	1.36	0.02	0.16	-	-	3.81
CRP Management & Support Cost	0.04	0.06	0.08	0.08	-	-	-	1.33	1.59
Total	3.17	2.69	5.43	4.92	0.40	0.23	0.12	1.33	18.30

RTB 2012 -2017

The distribution of budget by funding sources shows an increased contribution of W1&2 between the last year of Phase I and first year of Phase II, rising from 15% in 2016 to 19% in 2017 – with an additional USD6.4M funds compared with 2016.

Total expenditure in 2017 increased by 10% compared with 2016 and 71% compared with 2012, showing an overall positive trend for the program (USD93.5M in 2017 vs. USD54.6M in 2012). The cumulative expenditure reached USD448.9M over the six years of the program (USD135.6M from W1&2, and USD313.3M from W3, bilateral and center funds).

RTB EXPENDITURE: 2012 - 2017