Three years of

CBSD Control Project

in Rwanda and Burundi

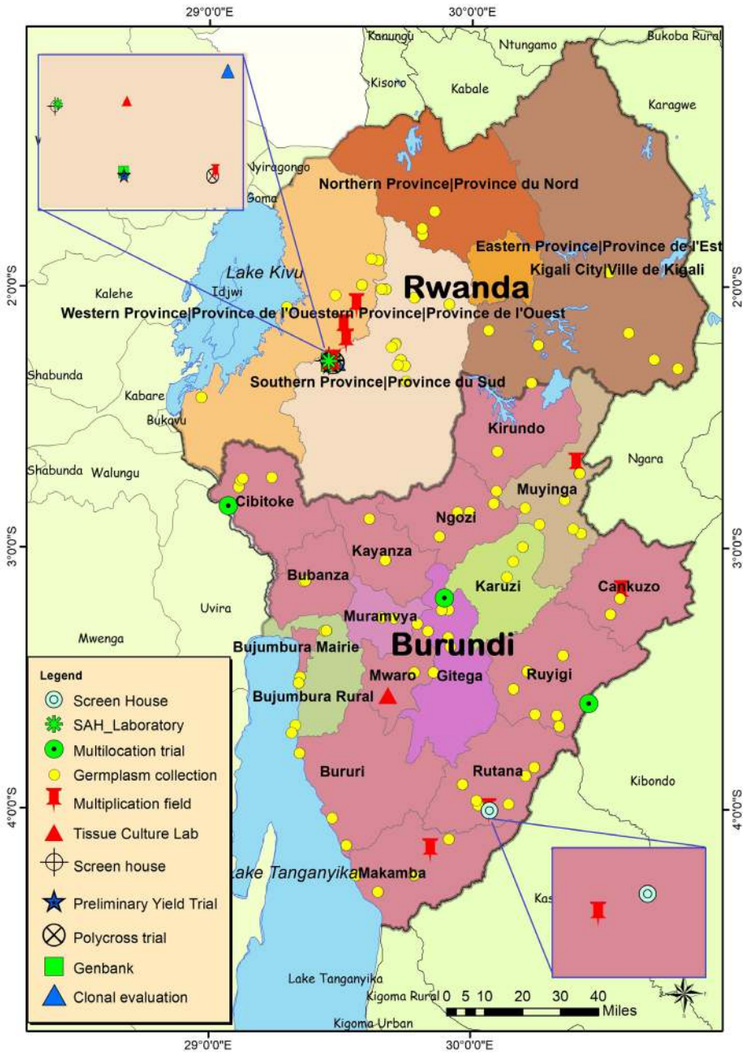
Fighting Cassava Brown Streak Disease and Cassava Mosaic disease through deployment of new resistant germplasm and clean seed in Rwanda and Burundi

IITA Transforming African Agriculture

RAB Rwanda Agriculture and Animal Resources Development Board

ISABU Institut des Sciences Agronomiques du Burundi

IFAD Investing in rural people



Map showing locations of project activities in Rwanda and Burundi.

FACTS ABOUT THE PROJECT

Main partners

- **IITA** is the leading partner with technical backstopping and financial management roles.
- **RAB** is the lead implementing partner of all project activities in Rwanda.
- **ISABU** is the lead implementing partner of all project activities in Burundi.

Other partners

- Seed quality regulation agencies i.e. Office National de Control et de Certification des Semences (ONCCS) for Burundi and RAB Seed Systems Division.
- NGOs/CBOs promoting cassava in both Rwanda and Burundi
- Seed multiplying groups

Donors

International Fund for Agricultural Development (IFAD) provided 2 million US dollars. Additional 0.5 US million dollars was committed as in-kind contribution by the main project partners.

Key timelines

The project started on April 1, 2017, will be completed will be completed on March 31, 2021.

Introduction

Early April 2017, the International Institute of Tropical Agriculture (IITA) received a grant from the International Fund for Agricultural Development (IFAD) to implement, in partnership with Rwanda Agriculture and Animal Resources Development Board (RAB) and Institut des Sciences Agronomiques du Burundi (ISABU), a project to fight two deadly cassava viral diseases that were seriously affecting cassava productivity in both Rwanda and Burundi.

Cassava Brown Streak Disease (CBSD) and Cassava Mosaic Disease (CMD) have singly or both affected cassava productivity in the two countries threatening the income and food security of farmers and other actors that depend on the crop. For example, in Rwanda, the KINAZI Cassava Plant temporarily stalled due to lack of sufficient fresh roots, the raw materials needed for processing high quality cassava flour. In Burundi, the government was forced to enforce a provincial quarantine to control further spread of the CBSD in the country.

The project has been implementing a dual strategy of: a) developing and deploying improved CBSD/CMD resistant varieties, and b) establishing cassava clean seed systems to mitigate the effects of both CBSD and CMD. To ensure sustainability, the project is also strengthening both human and infrastructural capacities of key stakeholders in variety development and seed delivery in Rwanda and Burundi. Overall, the project has been implemented to lay foundations for both cassava breeding and clean seed delivery systems in the two target countries.

This brochure presents the progress made by the project in the three years of implementation (i.e. April 2017 to March 2020). It shares the challenges met and the mitigation efforts used to keep the project progressing.

The brochure also shares early insights on the follow up steps to the current project.

Project progress up to date - March 2020

The progress is reported below by the three main components of the project.

1 Variety development and deployment

The objective of this component is to improve the genetic diversity for CBSD/CMD dual resistance selection in the two target countries i.e. to support the current and future breeding efforts for CBSD/CMD resistance among other traits. To achieve this objective, progress has been accomplished towards the following outputs:

Introducing and testing elite clones

Under this output, the project aimed at adapting elite clones with high dual tolerance to CMD and CBSD that are already advanced or officially released in other African countries where CBSD is endemic. The target was to identify at least 5 elite clones for official release in each of the target countries. Up to 17 elite clones, each with about 200 tissue culture (TC) plantlets, were introduced in both Rwanda and Burundi. The introduced germplasm was managed through post-flask management. Macro-propagation and field multiplication before trials, to evaluate them in the field for adaptability, were conducted. The trials have been completed in Burundi and they are currently ongoing in Rwanda. In Burundi, the trials were conducted in collaboration with ONCCS to fast-track the homologation process and the reports will soon be made to support application of the official homologation of the best identified clones.

Identifying new elite resistant clones from introduced cassava true seeds

While the introduced elite clones above were aimed at quickly identifying adapted CBSD/CMD resistant varieties for Rwanda and Burundi, the project found it important to identify another set of elite clones with high CBSD/CMD resistance among other traits of importance for future variety options to farmers and other end users. To achieve this target, the project has introduced up to 72,621 true seeds in three batches from IITA cassava breeding platforms in Eastern and Western Africa (Table 1) where breeding for resistance to viral problems is advanced. The seeds were obtained from parents with strong genetic background for CBSD/CMD dual resistance. The seeds have been germinated mostly by field method and advanced through different early stages of selection depending on the batch. From first batch seeds, up to 15 and 13 clones have been identified and established for advanced yield performance evaluation during February/March in Burundi and Rwanda, respectively. The second and third batch seeds have been managed together in Rwanda but differently in Burundi. Up to 66 clones (11 yellow fleshed) and 294 clones (249 yellow fleshed) have been identified and established for preliminary and clonal yield performance evaluations, respectively, in Burundi. In Rwanda, 37 clones (13 yellow/orange-fleshed) have been selected and established in a preliminary yield trial at two sites.

It is important to note that the project has over achieved

1. TC plantlets at Rubona station, Rwanda.

2. Screen house macro-propagation at Moso station, Burundi.

3. Field multiplication at Murongwe station, Burundi.

4. Field trial at Moso station, Burundi.

Seed batch	Source	Rwanda		Burundi		Total seeds	Date of introduction
		# families	# seeds	# families	#seeds		
1st	UG/TZ	19	8,765	16	8,608	17,373	Jan 2017
2nd	UG/TZ	23	15,746	25	15,872	31,618	Jan 2018
3rd	IITAHQ	33	16,330	30	7,300	23,630	Dec 2018
Total families & seeds		75	40,841	71	31,870	72,621	

Table 1. Cassava true seeds introduced in Rwanda and Burundi for CBSD/CMD resistant clonal selection.

this output. The target was to introduce at least 5000 true cassava seeds per country from which about 500 new clones were to be identified for preliminary yield evaluation. However, the project has gone beyond the target as follows:

- Up to 72,621 true cassava seeds were introduced compared to 10,000 seeds previously targeted;
- Whereas the project targeted only to go as far as clonal evaluations, it has advanced clones to preliminary yield trials (Burundi = 66, Rwanda = 37) and advance yield trials (Burundi = 15, Rwanda = 13) within the three years of project progress.
- Yellow clones with high β- carotene content have been identified which represent bio-fortification of vitamin-A rich cassava in the two countries.

Local germplasm collected, cleaned and conserved

Through germplasm collection missions, a total of 155 cassava accessions were collected in both Rwanda (55) and Burundi (100). These have been morphologically characterized under field gene bank conditions at Moso in Burundi and Rubona in Rwanda. All the local varieties collected in Moso were severely infected by both CMD and CBSD, suggesting that they are susceptible. Moso lies in a high CMD/CBSD pressure zone in Burundi. Contrastingly, some local cultivars collected at Rubona expressed mild or no foliar CBSD and CMD symptoms. Unlike Moso, Rubona lies in a low CMD/CBSD pressure zone in Rwanda. Also, molecular characterization has been conducted to assess the genetic diversity of the germplasm within and across the two countries. While in Burundi, the characterization studies are part of the MSc studies and a manuscript is being drafted; in Rwanda, the data will be used by the country coordinator to draft another manuscript. The molecular data will also be part of global genetic diversity analysis. Up to 61 most local popular advanced or released varieties (Burundi 29; Rwanda 32) were sent in June 2018 to Kenya Plants Health Inspectorate Services (KEPHIS) for virus cleaning and indexing. Only 22 (Rwanda 19; Burundi 3) have so far been successfully cleaned and returned. The virus cleaning process has proven challenging and requires more time than earlier anticipated, especially for Burundi materials which as reported above were heavily infected with viruses. Efforts to clean and return all the cultivars by the end of the project are ongoing.

Generate new breeding populations involving local germplasm

The objective was to cross the local varieties with the exotic elite clones to generate new breeding populations, that combine CBSD/CMD dual resistance with local adaptability and preferred quality traits. About 10 local varieties (selected from the 61 local popular advanced or released varieties) were selected, along with 10 exotic elite clones as parents and established in a polycross nursery in each of the countries.

The parents were planted in a randomly in 10 replications to allow equal mating chances between the local and exotic elite clones. Both hand and open pollination have been used to generate the seeds. In Burundi, up to 4488 true seeds, all open pollinated (half-sib) have been collected from the polycross nursery. An additional 7667 half-sib seeds were collected from the multi-location trial at Moso station resulting into a total of 12149 seeds for Burundi. In Rwanda, 11 261 true seeds (4723 full-sib, and 6538 half-sib) have been generated. In both countries, some of the seeds have been germinated to identify clones that combine exotic and local traits.

It is important to note that the project is performing very well under this output to build and demonstrate local capacities to generate their own seeds, and not any more depend on external supplies. The project has already achieved above the target of 5000 seeds per country. Moreover, there is opportunity to generate more seeds by the end of the project.

2 Establish clean seed systems

The objective of this component is to develop production and delivery systems for clean pre-basic and basic cassava seeds in the two countries. To achieve this objective, progress has been made along the following outputs:

Stakeholder engagement

The project considered stakeholder engagement as the first step to establish sustainable clean seed production and delivery systems in the two countries. Workshops were organized to bring all the key actors along the seed value chain, to analyze the pertaining situation in terms of working systems and challenges, and to build a consensus on the way forward. It was through the stakeholder engagement that consensus to review cassava seed standards and the seed systems structure was reached. Proposed seed system structures for Rwanda and Burundi are presented in the figures 1 and 2, respectively.

Review policy frameworks for cassava seed quality regulation

The seed standards are one key cornerstone of the sustainable clean seed systems the project is aiming to

Photo 1. Dr. Athanase Nduwumuremyi receives a copy of the standards from RSB Director General on behalf of RAB and MINAGRI.

establish in the two countries. The launch (photo 1) of cassava clean seed standards for Rwanda, on February 7, 2019 in Kigali by Rwanda Standards Board (RSB), stands out as a key achievement of the CBSD Control Project. This came after a yearlong concerted engagement of key stakeholders in the cassava seed value chain in Rwanda, to develop the standards for cassava seed quality regulation. Also, in Burundi, the reviewed cassava clean seed standards have been approved by the National Seed Advisory Council (NSAC) and incorporated into the main national seed law document for reproduction. This is after the Ministry of Environment, Agriculture and Livestock through NSAC, tasked a technical committee to review the cassava seed standards. Like in Rwanda, the project supported and participated in the review process by technical committees. The approved standards are anticipated to pave way for the removal of a more than five-year-old provincial quarantine on cassava seed dissemination in Burundi. Under the quarantine, cassava seeds can not be disseminated beyond a province to stop further spread of the CBSD that was threatening cassava production in Burundi.

Building Pre-basic and basic seed multiplication systems

Pre-basic and basic clean seed production and dissemination systems are a critical step to delivery of quality seed of any crop. Both pre-basic and basic seed centers based on TC derived clean plants have been established in both Rwanda and Burundi. In both countries, screen house pre-basic units have been established and improved techniques for high macro-propagation rates have been adopted. In Rwanda, this has been strengthened by introducing and installing Semi-Autotrophic Hydroponics (SAH) capacities to increase the multiplicative rates while overcoming low survival rates during plantlet acclimatization.

Currently, two screen houses have been installed at two of the five selected basic seed centers (per country) to test the feasibility of using macro-propagation technique to support field basic seed multiplication. This is closely similar to the net tunnel technique that has been widely promoted for centralized sweetpotato clean vine multipliers by the International Potato Center in many countries.

Four basic centers have been established in each of the target countries and will be supported and strengthened during the remaining period of the project. Together with the pre-basic seed units, the project has aimed at creating a formal structure of clean seed multiplication and dissemination of early generation seed in the two countries.

Seed inspection implementation

This has just started but a lot needs to be done especially to build more capacities on cassava seed inspection in terms of disease and pest identification as well as diagnostics by the regulation agencies. The different seed categories need to be considered at seed crop registration and inspection

3 Building capacities of key stakeholders

Under this component, the project aims to build both the physical infrastructure and human capacities of the key stakeholders to sustainably implement the first two main components. To achieve this objective, progress has been made along the following outputs:

Photo 2. Macro-propagated plantlets in the SH at Rubona station, Rwanda.

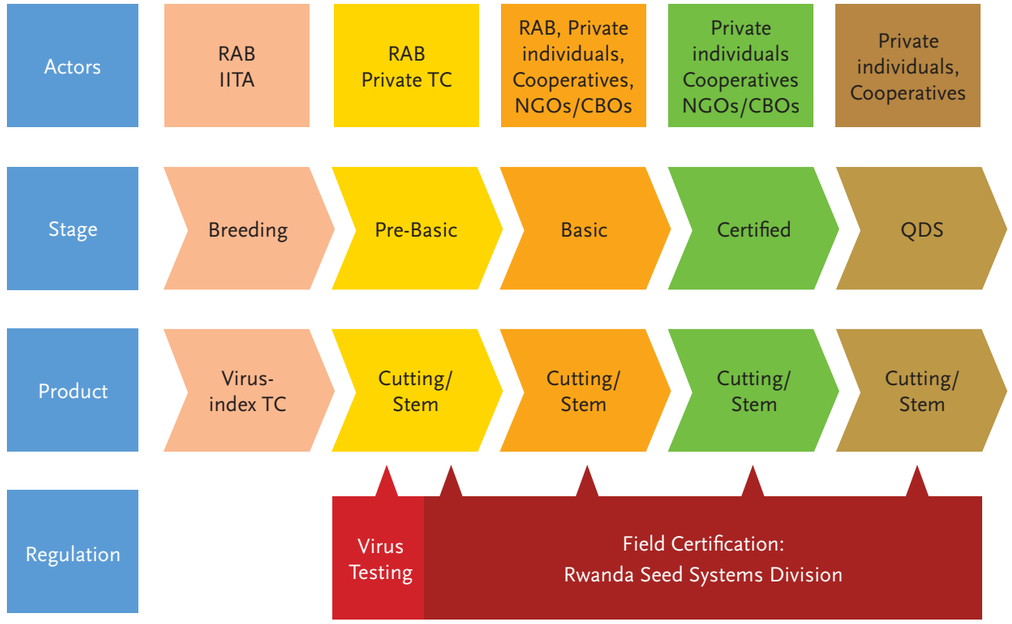


Figure 1: Proposed seed system structure in Rwanda

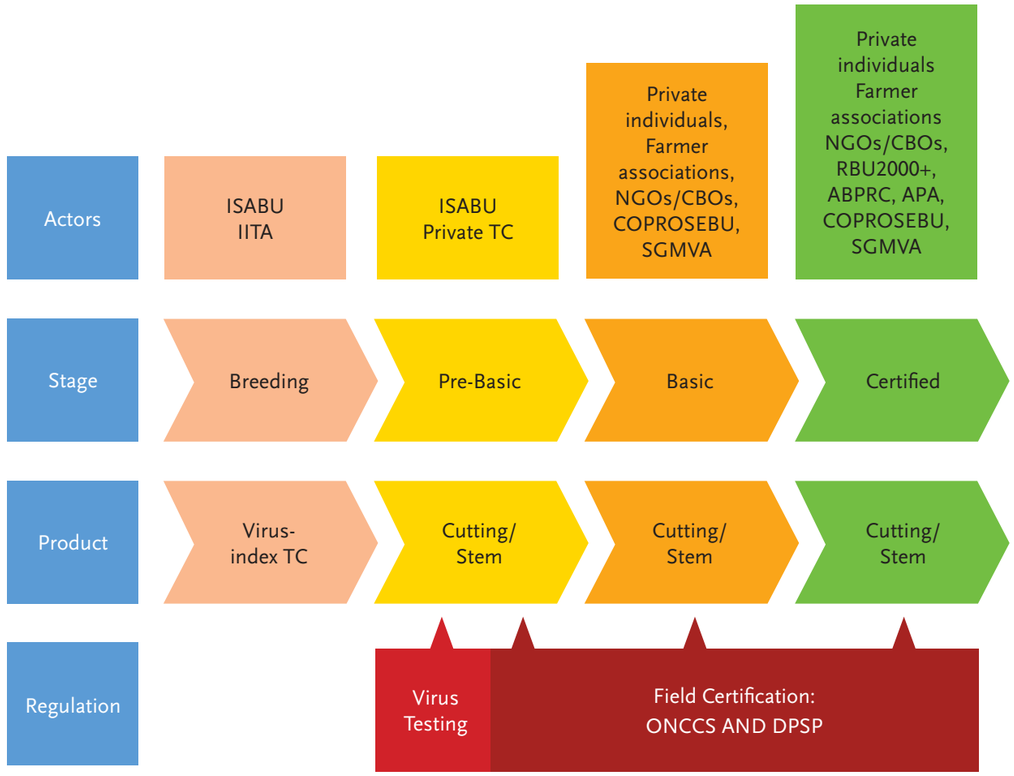


Figure 2: Proposed seed system structure in Burundi

Physical Infrastructure

The following physical infrastructure has been provided to different stakeholders involved in the project.

- A double-cabin pickup vehicle was provided to each of the target country's national cassava research program to improve mobility for project implementation and other activities.
- One screen house per country was installed per country to ensuree TC plantlet hardening capacities as well as pre-basic seed macro-propagation and management.
- One Real-Time PCR was provided per country to enhance virus diagnostics and quantification capabilities. This is important in variety resistance assessment and clean seed systems quality control.
- A set, combining a growth chamber, a bio-safety cabin and a water purification system for virus cleaning has been provided per country. The equipment will help countries to clean their local popular varieties, re-introduce them through a clean seed system established and promoted by the project.
- The TC laboratory in Gisozi-Burundi has been modified to improve growth room temperature conditions to micro-propagate or conserve cassava plantlets in. This was in response to slow growth and low survival rates of micro-propagated TC plantlets at Gisozi due to cold night temperatures.

Human capacity building

Capacities of different stakeholders to implement current project and future research activities have been strengthened through several training courses conducted by the project.

- Eight (8) lab and field technicians (Burundi = 4 and Rwanda = 4) were trained on TC techniques and post-flask management. Through a one-week short training course, technicians were equipped with practical knowledge and skills on TC techniques, hardening of TC plantlets as well as field propagation of the hardened plantlets. The training was conducted as part of the preparations to introduce the TC plantlets of the elite clones.
- Eleven (11) staff of NARS including breeders and research field assistants (Burundi = 4, Rwanda = 7) benefited from a three-days training on ***G x E*** ***experimental design and data management*** conducted at Rubona station. The training was part of preparations to establish and manage multi-location trials involving the introduced elite clones and other breeding experiments.
- A delegation of eight (Rwanda 4 and Burundi 4) comprising of researchers, chief seed inspectors, policy makers and seed multipliers visited Tanzania, to learn ***commercialized seed and certification systems***. They drew learning lessons from Tanzania Official Seed Certification Institute (TOSCI) and commercial cassava seed multipliers.
- Thirty three (33) cassava seed value chain actors participated in a training of trainers (ToT) on ***Commercial Cassava Seed Multiplication*** in Rwanda and Burundi. Among them, 24 trainees [16 men, 8 women; 17 Rwanda, 7 Burundi] and 6 facilitators) attended the training. The participants included research technicians as well as government and non-government extension personnel.
- Thirty five (35) national seed inspectors and selected officers from seed production departments were trained on ***Cassava Seed Inspection***. In Rwanda, a total of 16 participants (12 trainees [6 men & 6 female] and 4 resource persons) attended the training. In Burundi, a total of 19 participants (16 trainees [15men and 1 woman] and 3 resource persons) attended the training. The trainees carried out cassava seed inspection and certification of cassava seeds produced to control their quality.
- Thirty nine (39) cassava seed value chain actors attended a training on ***Seed Multiplication***. The skills have strengthened their seed business, seed quality control, and seed agronomy. In Rwanda, a total of 20 participants (15 trainees [13 men & 2 women] and 5 resource persons) attended the training. In Burundi, a total of 19 participants (14 trainees [12 men & 2 women and 5 resource persons) attended the training.
- A two-step training on ***Semi-Autotrophic Hydroponics*** (SAH) was conducted for RAB technicians working in tissue culture. Step one involved two technicians (1 male, 1 female) attending a two-week practical training at IITA HQ SAH facility. Step two involved two SAH experts from IITA HQ conducting a follow-up training with the same and three more technicians (total five; two male and three female). With this capacity, it is now possible to run SAH for cassava multiplication in Rwanda

Screen house in Moso.

Vehicle handover to ISABU.

Screen house in Rubona.

Dr. Malu Ndavi visits the field genebank at Rubona station.

Graduate training

The project has sponsored two MSc students i.e. Ms Josette Uwimana from Rwanda registered at Kenyatta University and Mr Pierre Niyonzima from Burundi registered at University of Nairobi. Both commenced their studies in September 2018, and have since successfully completed course works and defended thesis research proposals. The students have completed their research and are currently analyzing data for thesis and manuscript development.

4 Challenges encountered

Generally, the project has experienced a few major challenges. They include:

1. The project has not been able to conduct trials to assess the degeneration rates of the local popular or released varieties in any of the countries. This was due to lack of clean planting materials for the target clones that are critical for the correct assessment of degeneration rates. Any efforts to first clean them would have taken more time than what was planned in the project to achieve the output. However, the project later decided to study the degeneration rates of some of the introduced elite clones for this purpose on the understanding that the generated information will be relevant since those elites stand chances of being officially released in the target countries.
2. The multi-location trials in Rwanda have delayed because of setbacks suffered during hardening stages of introduced TC plantlets and later during field multiplication. Rubona station where the plant hardening took place is characterized by cold nights, which slowed growth rates and resulted in low survival rates of hardening plants. Moreover, a few surviving plantlets grew poorly with majority of plants stunting when established in a multiplication field at Rubona research station. Acidic soil and drought conditions at Rubona station jointly affected the first field multiplication of the hardened TC plantlets in preparation for the multi-location trials in Rwanda.
3. The virus cleaning process at KEPHIS has been glossily slow than earlier anticipated. Only 22 out of the 61 accessions submitted to KEPHIS in June 2018 have been cleaned and returned to countries of origin. Burundi is most affected than Rwanda, possibly due to severe infections of the accessions observed during germplasm characterization at Moso station. However, there are continued efforts to clean all of them by the end of the project.

Conclusion and the next logical steps

The project has laid foundation for both cassava breeding and clean seed systems in the two countries during its first three years of implementation.

In conclusion, the project has over the three years made significant progress towards realizing a holistic approach to mitigating the devastating effects of two major cassava viral diseases In Rwanda and Burundi. The first key achievement is the increased genetic diversity for CBSD/CMD dual resistance breeding in both countries. This has been achieved through; a) introducing and testing 17 elite clones for local adaptability, b) introducing lots of biological seeds and select new elite clones with dual resistance; and c) generating locally more biological seeds from poly cross nurseries that comprise local and exotic parental germplasm. Indeed, the introduced seeds have resulted into different promising clones, at PYT and AYT stages of evaluation. Some of the clones are yellow/orange-fleshed hence representing an opportunity for vitamin A rich cassava bio-fortification in both countries. The project has also strongly progressed towards establishment of a sustainable clean seed system for cassava in both countries. This has been done through: a) key stakeholder engagement (and advocacy) to analyze the status quo and build consensus on the way forward; b) developing or reviewing cassava seed standards for quality control; c) develop capacities and systems for functional multiplication and management of early generation seed (pre-basic and basic seed). Indeed the cassava seed standards in both countries are key to the sustainability of the clean seed delivery systems being initiated. To sustain the above gains, the project has built both physical and human capacities for research and seed regulation as well as seed multiplication.

However, even when the project has made strong progress towards realizing her goals, there is a need for follow up actions that will help to achieve sustainability and realize long-term outcomes and impacts. The key next steps should include: a) Breeding varieties for improved nutrition and end-use qualities --- this is important to respond to the needs of the increasing investment by the private sector in cassava agro-businesses; b) Supporting commercial quality seed delivery systems --- this is necessary for sustainability and to break the traditional informal seed systems that have contributed to the spread of the pests and diseases; and c) Improve seed quality certification systems for sustainability and disease control purposes. To achieve this, a follow-up project will be necessary and all opportunities for proposal development will be made by IITA and partners.

Ms Josette Uwimana, Msc student at Kenyetta University attending to her trials at Rubona station.

KEY ACHIEVEMENTS

1	17 elite clones with CBSD/CMD dual resistance were introduced and have been tested for local adaptability i per country. At least three to five varieties will be identified for homologation, a process that has already started for Burundi..
2	New promising clones with CBSD/CMD dual resistance parental genetic background have been identified in the two countries and are being evaluated at different stages. For example 37 clones have been selected and established in PYT in Rwanda and 66 in Burundi. Among these are yellow/orange-fleshed clones which represent bio-fortification of vitamin-A rich cassava in the two countries. Another 13 clones for Rwanda and 15 clones for Burundi have been identified and established for advanced yield performance evaluation.
3	Up to 22 local popular clones (Rwanda 19 and Burundi 3) have been cleaned of the cassava viruses at KEPHIS and returned for conservation and breeding in their countries of origin. More are awaited.
4	Countries have generated their own trues seeds (Burundi = 12149 and Rwanda = 11261) by crossing local and introduced germplasm. This shows improved national capacities to generate their own seeds and not rely on introductions.
5	Cassava Seed Standards have been developed and reviewed for Rwanda and Burundi. The one for Rwanda has been officially launched. While for Burundi, the reviews have been integrated into the entire seed law document to produce a new copy.
6	One pre-basic seed multiplication unit based on TC virus indexed plantlets has been established and it is functional per country. In Rwanda, the unit has been strengthened by installation of an SAH facility to increase multiplicative rates and overcome the low survival rates during the hardening.
7	Four basic seed multiplication centers have been established in each country.
8	Equipped national research and seed regulation agencies' laboratories with key equipment e.g. Real Time PCR for virus diagnostics, Growth Chamber for virus cleaning, Elisa plate, Water purification system and Biosafety Cabin.
9	Conducted a series of short courses targeting different stakeholders e.g. post-flask management; GxE experimentation methods, commercial seed multiplication & management, cassava seed inspection and certification; virus cleaning and indexing; SH based macro-propagation.

WHO TO CONTACT

Dr. Silver Tumwegamire is a Cassava Breeder and Seed Systems Expert and the Project Leader.
Email: s.tumwegamire@cgiar.org

Dr. Athanase Nduwumuremyi is a Cassava Breeder, head of cassava research program, and the Project Coordinator for Rwanda.
Email: athanase.nduwumuremyi@rab.gov.rw

Mr. Simon Bigirimana is a plant pathologist, head of cassava research program, and the Country Project Coordinator for Burundi.
Email: sbigim@gmail.com

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