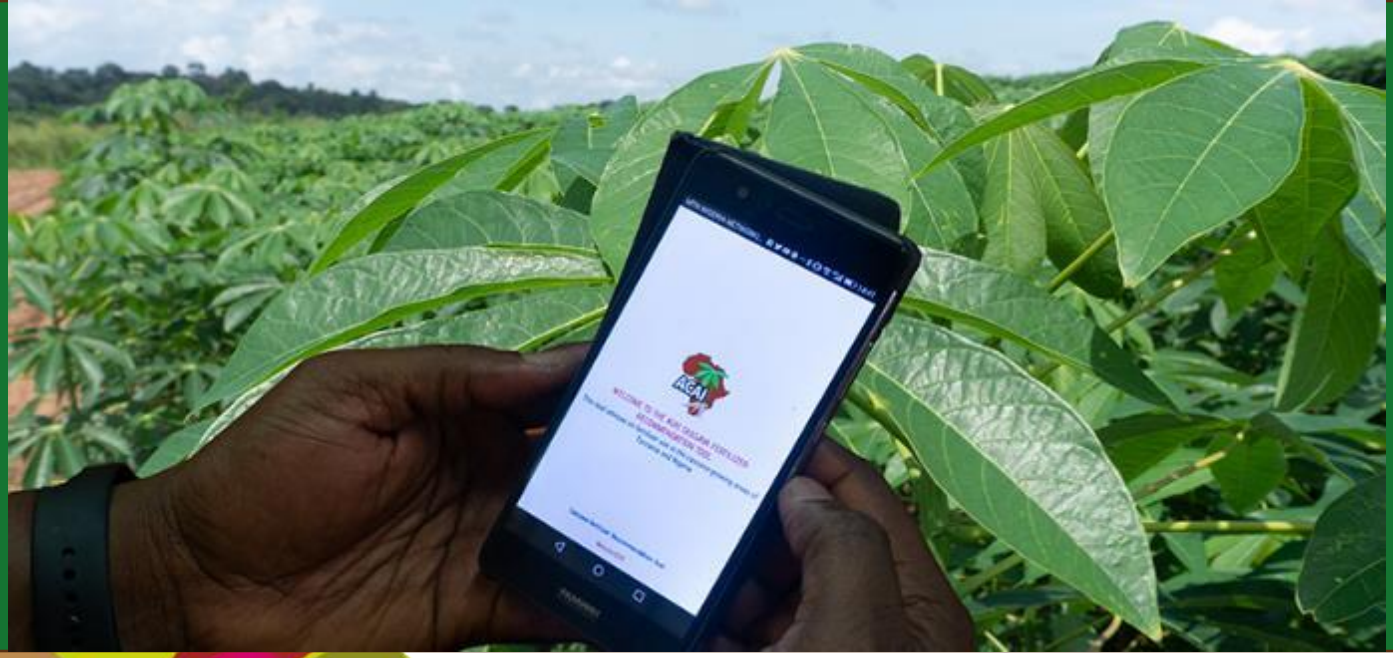


J U L Y 2 0 2 1

Flagship Project 3: Resilient Cropping Systems

JAMES LEGG• RTB ISC ANNUAL MEETING

CGIAR RESEARCH PROGRAM ON Roots, Tubers and Bananas

Alliance

OUTLINE

KEY SCIENTIFIC ACHIEVEMENTS 2020 & 2021

GENDER OVERVIEW

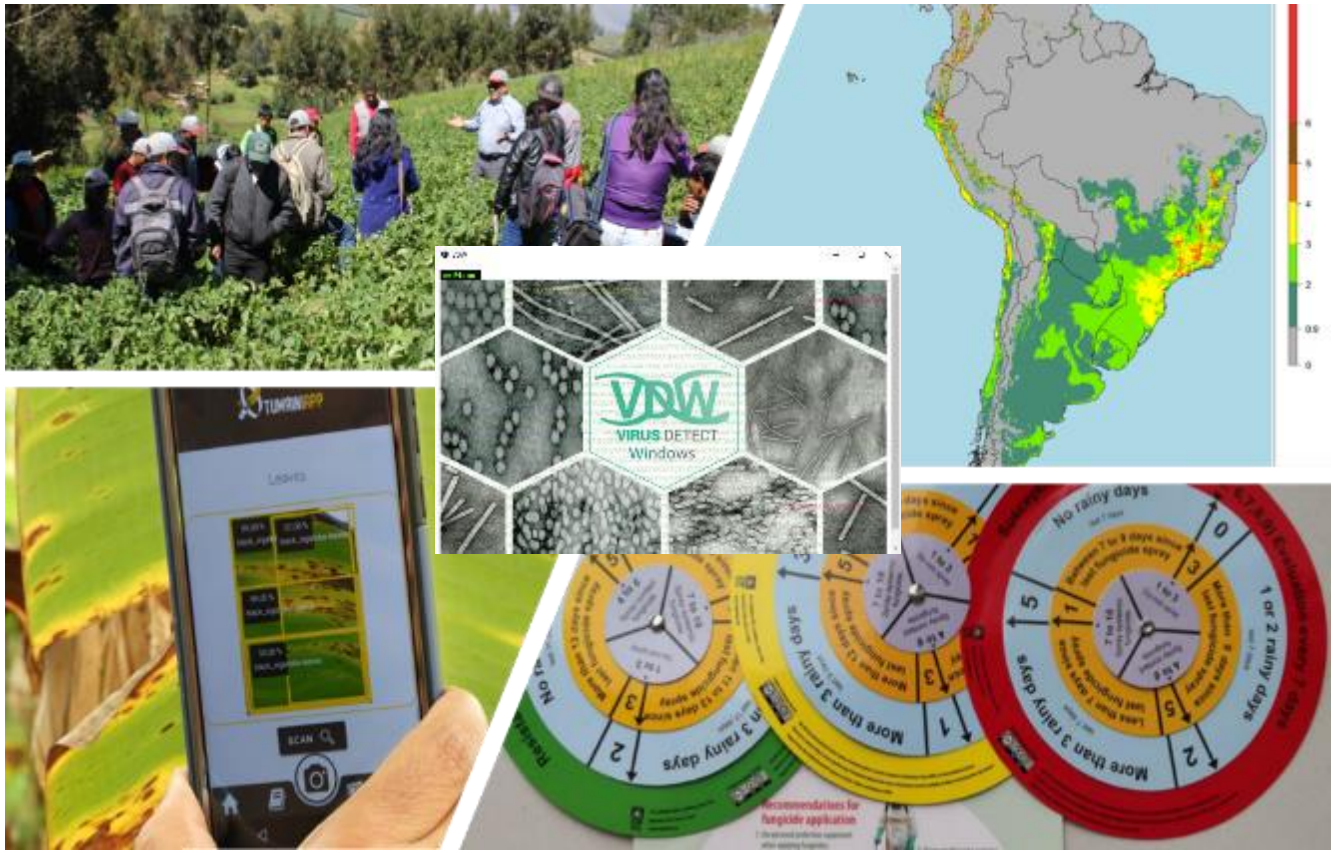
PROGRESS TOWARDS OUTCOMES & IMPACT

OPPORTUNITIES, PLAND AND TRANSITIONAL RECCOMENDATIONS

Key scientific achievements 2020-2021

Cluster CC3.1 Pest Risk and IPM

1. Smartphone image-based disease diagnosis: Tumaini, Nuru
2. Temperature based insect pest and vectored disease risk prediction
3. Simple hand-held decision support tool for late blight management
4. User friendly software for virus identification from sequencing data



Xanthomonas wilt of banana pathogen diversity

→**Taxonomy updated**: The BXW agent is actually a member of the species *Xanthomonas vasicola*, thus related to the sorghum and sugarcane pathogens.

→**Xvm molecular epidemiology** (see section on the right)

- Xvm most likely originated from a unique center of diversity, Ethiopia, both on Enset and banana (6 genomic clades).
- Xvm diversity is structured in 12 MLVA genetic clusters, of contrasted distribution in Eastern Africa (*paper in preparation*).

→Two Xvm core-collections available, for banana and Enset breeders.

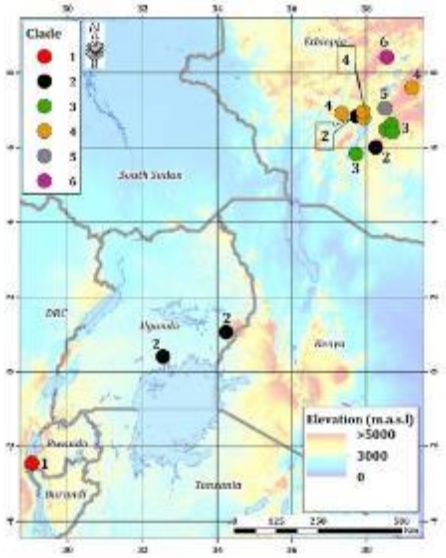
Received: 5 May 2020 | Accepted: 19 October 2020
DOI: 10.1111/ppa.13308

ORIGINAL ARTICLE

Plant Pathology WILEY

SNP-based genotyping and whole-genome sequencing reveal previously unknown genetic diversity in *Xanthomonas vasicola* pv. *musacearum*, causal agent of banana xanthomonas wilt, in its presumed Ethiopian origin

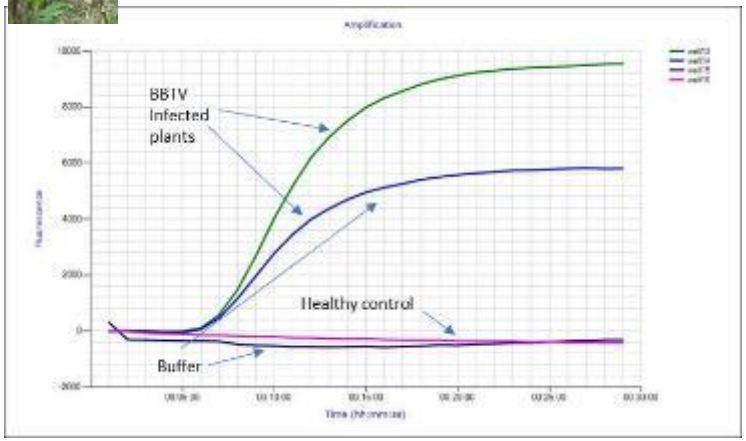
Gloria V. Nakato[1,2] | David J. Studholme[3] | Guy Blomme[4] | Murray Grant[5] | Teresa A. Coutinho[2] | Evans M. Were[1] | Emmanuel Wicker[6,7] | George Mahuku[1,8]



Phylogenetic reconstruction from whole-genome SNP data revealed six well-defined genetic clades.

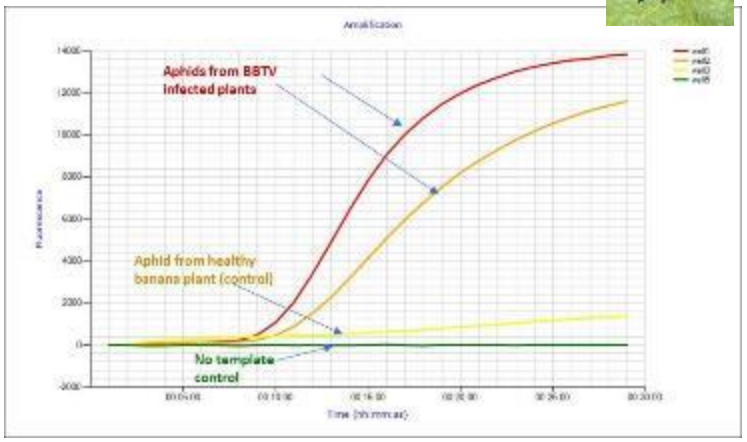
- **Freeing from expensive readers: RPA-LFD based on-field BBTV detection**

BBTV detection in plants



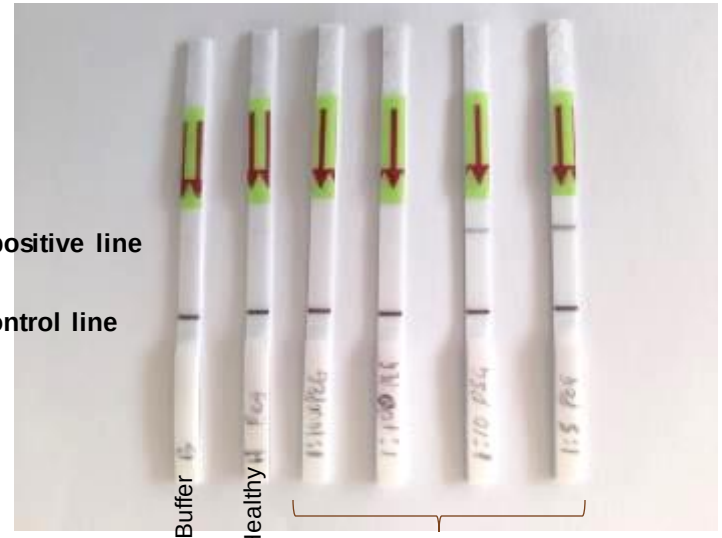
Machine-dependent RPA detection

BBTV detection Aphids

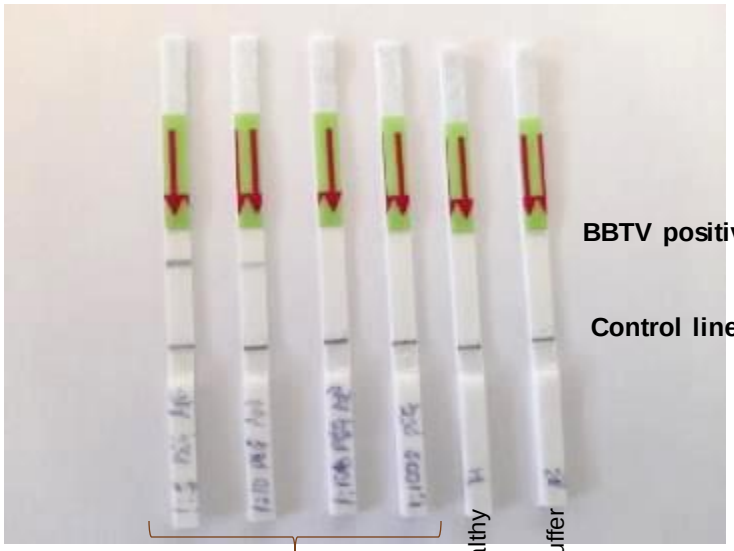


BBTV positive line

Control line



Machine-free detection of RPA amplified BBTV DNA using LFD strips



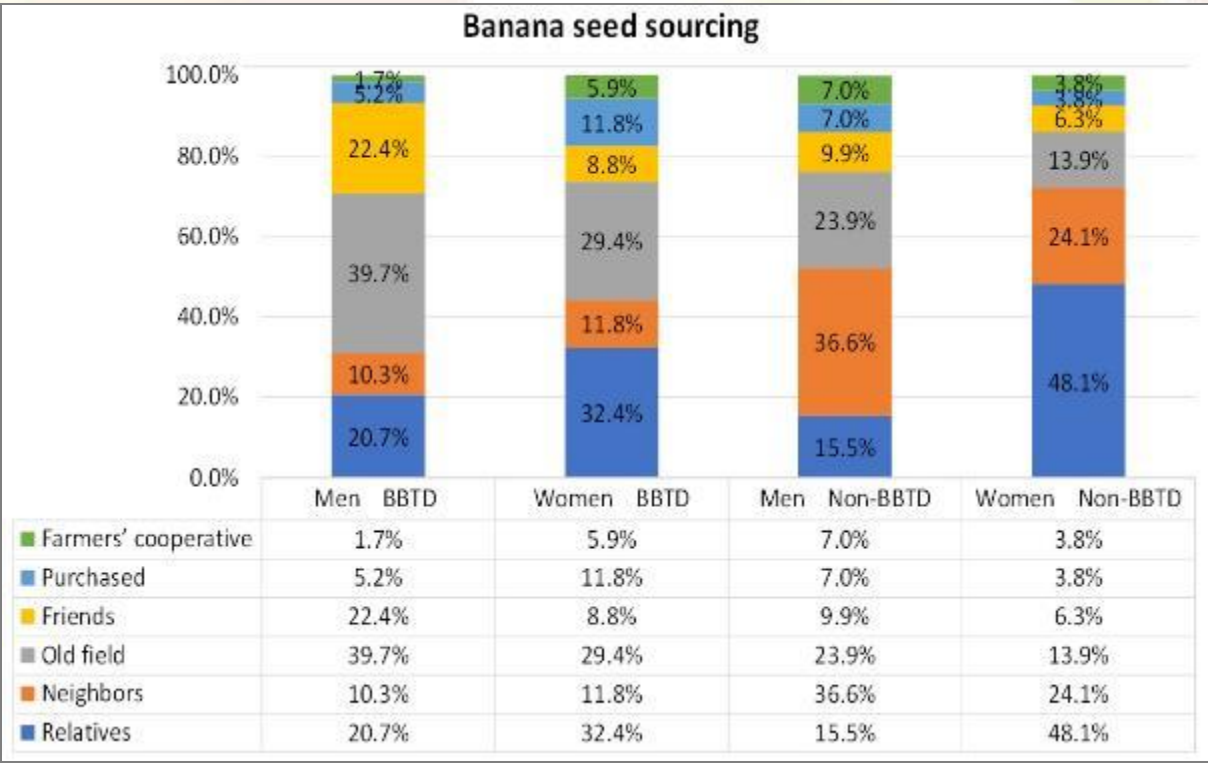
BBTV positive line

Control line

Kumar et al., (2021), unpublished

Gender Overview

Gender Norms and their effect on BBTD Management



- Seed sourcing and sharing behavior in BBTV affected and unaffected communities in Nigeria reveled key factors influence the virus spread
- More than 95% of planting material is sourced within communities
- Men are mainly responsible for long-distance sourcing
- Gender roles need to be considered in designing control programmes

Nkengla et al., 2021, Sustainability *Sustainability* **2021**, *13*(6), 3310; https://doi.org/10.3390/su13063310

Enriching Gender Research Literature

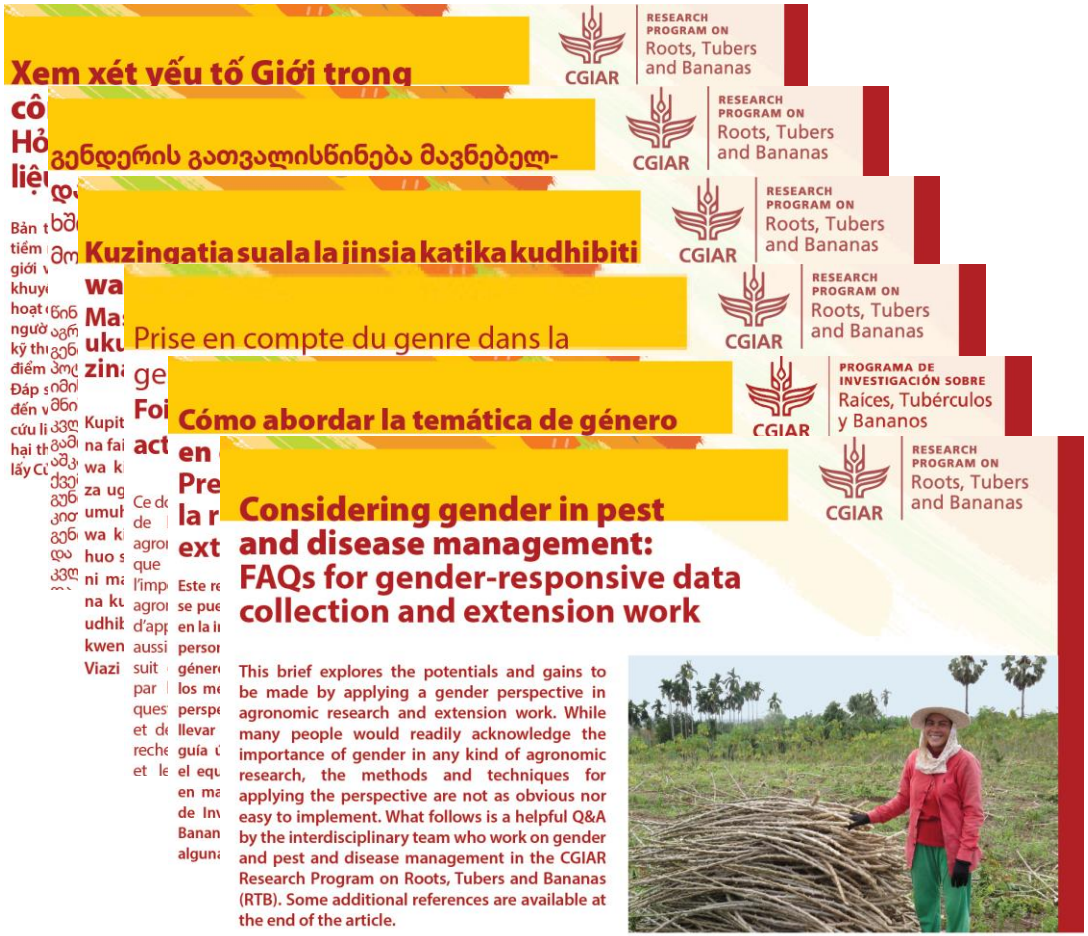
Article: gender perspective on pest and disease management in RTB crops

frontiers in Agronomy

PERSPECTIVE
published: 03 July 2020
doi: 10.3389/fagro.2020.00007

A Gender Perspective on Pest and Disease Management From the Cases of Roots, Tubers and Bananas in Asia and Sub-Saharan Africa

Nozomi Kawarazuka[1], Elias Damtew[2], Sarah Mayanja[3], Joshua Sikhu Okonya[4], Anne Rietveld[5], Vanya Slavchevska[6] and Béla Teeken[7]*



gender brief to help extension workers to apply a gender perspective to their research in 6 languages

Progress towards outcomes & Impact

Innovations & Progress in FP3

Type	Stage 1: Discovery/ proof of	Stage 2: Successful piloting	Stage 3: Available/ ready for uptake	Stage 4: Uptake by next user
Biophysical Research				
Genetic (variety and breeds)				
Production systems and Management practices	2	3	2	
Research and Communication Methodologies and Tools	3	2	5	2
Social Science				
Total	**5**	**5**	**7**	**2**

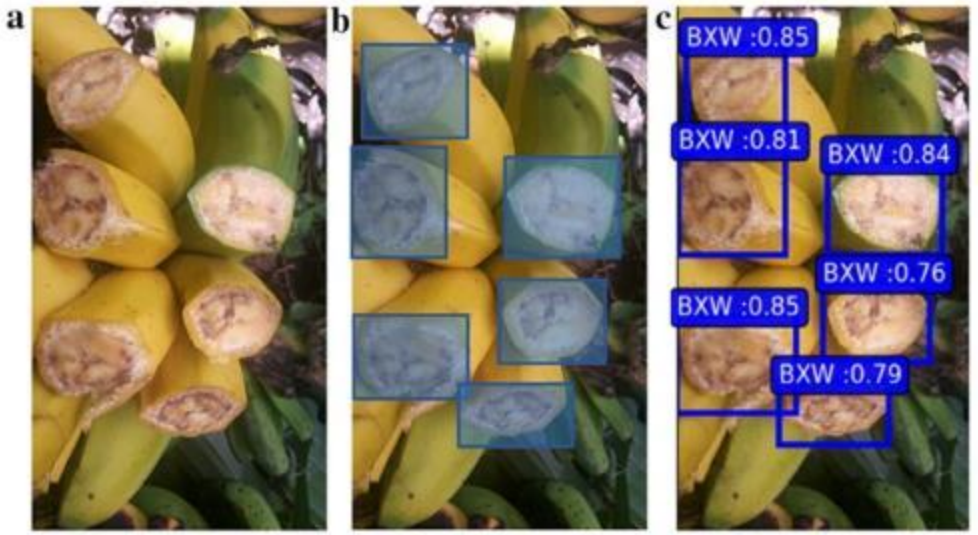
Tumaini: an Artificial Intelligence (AI)-powered banana diseases and pest detection App

2019: Stage 2 ; 2020: Stage 4

app can be used to diagnose 5 banana diseases (Banana Xanthomonas Wilt (BXW), Banana Bunchy Top Disease (BBTD), Fusarium wilt, Black Leaf Streak and Yellow Sigatoka) and one pest (weevil)

Tumaini smartphone app [meaning hope in Swahili] to detect banana diseases

- Mobile application - uses artificial intelligence to quickly identify common banana diseases
- 90% success rate in detecting pests and diseases
- Free from Google Play Store
- Over 3000 downloads of the app have been made worldwide
- NARS, universities, and extension bodies helping to scale out
- Most users are from Asia
- Demonstrated on famous radio & TV channels in India



Demonstration of the disease detection process during training. **a** Original raw images, **b** labeled process (desired output), **c** disease detection

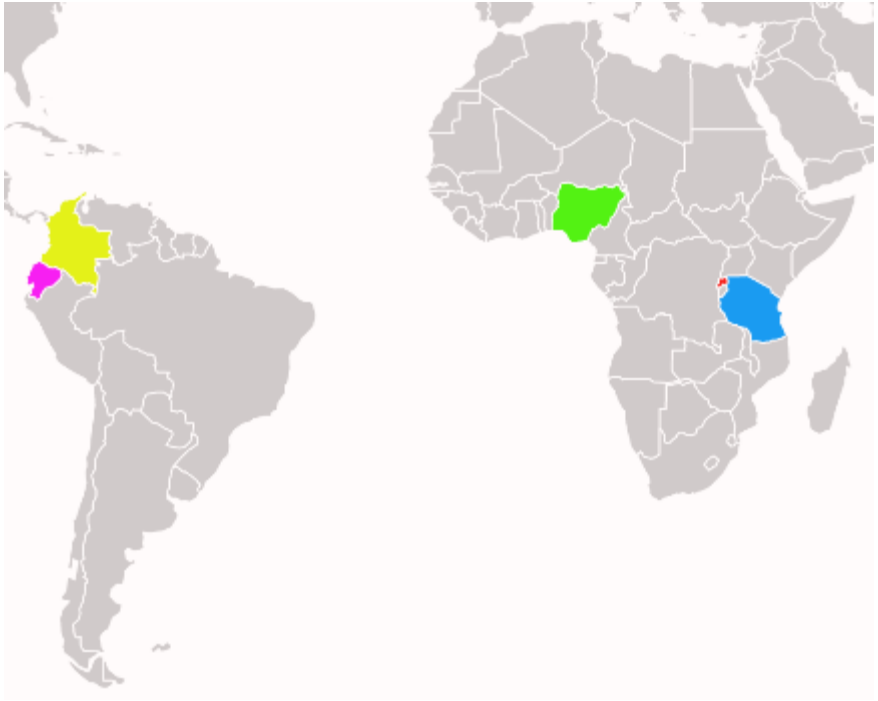
Selvaraj et al., 2019

More than 180,000 farmers are supported with practices to control the Banana Xanthomonas Wilt (BXW) in Burundi, DRC and Uganda

- 'Single Diseased Stem Removal' (SDSR) reduces plant disease incidence levels to less than 2% within 6 months
- Capacities of extension services on BXW control were strengthened
- Enables farmers to control the disease which causes severe banana productivity declines in the whole region and to maintain or recover banana production
- In DRC, close to 80% of all farmers sampled (N=440) in 41 villages in 3 territories post-intervention, currently apply SDSR (70%)

Policies

- Control of potato purple top in Ecuador: Evaluation of CGIAR contributions to a policy outcome trajectory
- National Plant Protection Organizations (NPPOs) define a common research strategy to manage impact of the Frogskin Disease in Colombia
- Contribution to deregistration of Paraquat pesticide by the National Agency for Food and Drug Administration and Control (NAFDAC) of Nigeria



- Rwanda Agricultural and Animal Resources Board initiate national action to control Banana Xanthomonas Wilt informed by RTB/IITA scientists
- Cassava seed standards launched by Rwanda Standards Board to enhance competitiveness of cassava products
- Tanzania passed into law seed certification standards for all classes of seed, from pre-basic to quality declared seed (QDS) for cassava, potato and sweetpotato
- CIAT developed diagnostic and surveillance protocols implemented by National Plant Protection Organizations to understand the impact of the Cassava Mosaic Disease in Southeast Asia

Looking ahead: opportunities, plans and transitional issues for One CGIAR

RTB FPx transitioning to One CGIAR

FOOD, LAND & WATER SYSTEMS LEVEL

ST: Transforming food systems from **net carbon sources to sinks**

ST: Realizing gains across the **water-energy-food-forest-biodiversity** nexus

ST: **Agroecology** across food, land & water systems

ST: Building systemic resilience to **climate extremes**

Pest Climate Models

ST: Food systems transformation for **healthy, safe & affordable diets**

ST: **Informing sustainable development pathways** with foresight & metrics

ST: **National strategies & policies** for driving transformation

ST: **Rethinking markets and value chains** for inclusion & sustainability

ST: Levering **gender & social equality** in agrifood systems

FARMING SYSTEMS LEVEL

RAFS: **Climate-resilient dryland** crop-tree-livestock systems – dealing with climate variability & risks

RAFS: **Urban and peri-urban** agri-food systems – delivering safe healthy food sustainably

RAFS: **Sustainable intensification** of mixed crop-tree-livestock systems – reducing environmental footprint & improving livelihoods

AgDx

RAFS/ST/GI: Harnessing **digital technologies** for timely decision-making across food, land, & water systems

THEMATIC LEVEL (COMPONENTS OF SYSTEMS)

RAFS: Protecting human health through a **One Health** approach

RAFS: **Resilient aquatic foods** in food, land & water systems

RAFS: **Climate smart livestock** – policy & practice

RAFS: **Nature-positive agriculture** for agrobiodiversity, water & environment

RAFS: Sustainably improving **livest productivity** for improved livelihood

RAFS: Excellence in **agronomy**

Akilimo

Surveillance Protocols

Gender-responsive P&D guide

AgDx

BXW/Foc Management

Clean Seed Protocols

GI: Farmer-preferred **crop varieties**

GI: Market intelligence & **product profiling**

GI: Breeding innovation, **modernization** & services

GI: Delivering genetic **gains in farmers' fields**

GI: **Gene banks**

RAFS: **Plant health** & rapid response protecting income & food supply

GI: Strategic innovation – **gene editing** & novel technologies

RTB FP3 transitioning to One CGIAR

Contributions to Plant Health Initiative Innovations

S.No.	Innovation	Work Package	Crops	Target Pests & Diseases	Geographic Mapping					
					ESA	WCA	CWANA	South Asia	SE Asia	LAC
1	Global crop pests and diseases diagnostic and surveillance network	WP1	Across the target crops	Across the target crop pests and diseases	Global					
2	A toolbox for diagnostics and characterization of crop pests and diseases	WP1	Cassava, Banana, Maize, Wheat, Potato, Sweetpotato, Soybean, Yam, Cocoa, Rice, Beans, Vegetables	Across the target crop pests and diseases	Global					
3	A toolbox for surveillance of crop pests and diseases	WP1	Maize, Wheat, Rice, Vegetables (Cabbage, Tomato, Cowpea), Cassava, with potential to expand to other crops	Fall armyworm, legume pod borer, pod sucking bugs, Cassava diseases, whiteflies, Rice pests and diseases	Global					
4	Field-based digital detection and surveillance toolbox for established crop pests and diseases using satellites and smartphone apps	WP1	Rice, Banana, Cassava, Maize, Potato, Sweet potato	Rice brown planthopper, blast, bacterial leaf blight, etc.; Major banana pests and diseases; Cassava virus diseases, Cassava green mite; MLN; Fall armyworm; being expanded to potato and sweet potato diseases	Global					
5	Interoperable open-source crop disease and pest databases	WP2	Across the target crops	Across the target crop pests and diseases	Global					
6	Modelling tools for pest and disease spread predictions	WP2	Across the target crops	Across the target crop pests and diseases	Global					
7	Pest/disease risk assessment and control	WP2	Across the target crops	Across the target crop pests and diseases	Global					
8	IPM toolbox for delivering sustainable pest solutions for rice	WP3	Rice	Rice yellow mottle virus, Rice Blast, Bacterial leaf blight, Brown spot, Sheath blight						
9	Agroecological crop protection for rice-based systems	WP3	Rice plus other crops in rice-based systems	Insects, diseases, rats, weeds, snails in rice-based cropping systems						
10	Integrated disease management of necrotrophic and hemi-biotrophic wheat pathogens	WP3	Wheat	Wheat blast, Fusarium head blight, and other diseases	Global					

- **Innovations**: 11 out of 27 PH innovations derived from RTB-FP3 work
- **Regional Integrated Initiatives (RII)**: Innovations incorporated into RIIs
- **FP & Cluster Leader Involvement**: Lava Kumar (PH-IDT), James, Jan (PH-Reference Group), Lava & James (Seedqual RTB taskforce)
- **Golden Eggs**: All included in PH and Excellence in Agronomy

RESEARCH PROGRAM ON Roots, Tubers and Bananas

CGIAR

Thank you

CIP INTERNATIONAL POTATO CENTER

Bioversity Internacional

CIAT

cirad

IITA

Complementary material

CC3.1

Milestones – CC3.1

ICT tools for disease/pest surveillance and crop management promoted in 12 countries: Nuru has been promoted in Tanzania, Kenya, Ivory Coast, Nigeria, Cameroon, DR Congo and installed over 5000 times by users in more than 40 countries on all continents and generated more than 18.000 disease status reports, it's now also being used by national programs for cassava disease surveillance in the west African WAVE project and has been integrated with an SMS system in Kenya, reaching >350.000 farmers

Downscaled climate change models linked to insect disease modelling for at least 5 major pest/regional combinations: Models have progressively been developed and improved for various insect pests and recently insect vectored diseases using the ILCYM software, which has also undergone important improvements during the years. With these detailed risk maps have been generated.

Many RTB CC3.1 products considered for plant health initiative (even if details not clear yet):

- Interoperable pest and disease databases (AgDxAPI)
- Image based disease detection (Nuru, Tumaini, drone, satellite)
- Pest & Disease risk assessment (ILCYM)
- Diagnostic toolbox (LAMP, sequencing)
- IPM toolbox (nematode/whitefly/weevil management, late blight DSS)

CC3.2

Innovations - CC3.2

- AKILIMO Mobile Application Decision Support System For Cassava Farmers for Nigeria and Tanzania
- Herbicides Calculator App to Help Farmers Control Weeds in Cassava production in Nigeria
- Accelerated multiplication and deployment of clean planting materials in Laos, Vietnam and Cambodia
- Open-source thermal image processing software for improving irrigation management in potato crops
- ICT-based decision support tools to scale agronomic technologies and practices for cassava production

Scientific achievements:

Year	Title	DOI
2021	Modeling growth, development and yield of cassava: A review	https://doi.org/10.1016/j.fcr.2021.108140
2021	Yield Response of an Ensemble of Potato Crop Models to Elevated CO2 in Continental Europe	https://doi.org/10.1016/j.eja.2021.126265
2021	A Multi-Objective Model Exploration of Banana-Canopy Management and Nutrient Input Scenarios for Optimal Banana-Legume Intercrop Performance	https://doi.org/10.3390/agronomy11020311
2021	Altitude and management affect soil fertility, leaf nutrient status and Xanthomonas wilt prevalence in enset gardens	https://doi.org/10.5194/soil-7-1-2021
2021	On-farm assessment of cassava root yield response to tillage, plant density, weed control and fertilizer application in southwestern Nigeria	https://doi.org/10.1016/j.fcr.2020.108038

Scientific achievements:

Year	Title	DOI
2020	Cassava breeding and agronomy in Asia: 50 years of history and future directions	https://doi.org/10.1270/jsbbs.18180
2020	Can a Combination of UAV-Derived Vegetation Indices with Biophysical Variables Improve Yield Variability Assessment in Smallholder Farms?	https://doi.org/10.3390/agronomy10121934
2020	Plant tissue analysis as a tool for predicting fertiliser needs for low cyanogenic glucoside levels in cassava roots: An assessment of its possible use	https://doi.org/10.1371/journal.pone.0228641
2020	Potassium fertilisation is required to sustain cassava yield and soil Fertility	https://doi.org/10.3390/agronomy10081103
2020	On-farm assessment of cassava root yield response to tillage, plant density, weed control and fertilizer application in southwestern Nigeria	https://doi.org/10.1016/j.fcr.2020.108038
2020	Leaf and roots yields responses of three improved cassava (*Manihot esculenta* Crantz) varieties to organo-mineral fertilizers and leaf harvest in the South-West Nigeria	http://www.ifgdg.org Int. J. Biol. Chem. Sci. 14(4): 1432-1447, May 2020

Milestone (*reporting year 2020*)

Site-specific decision support tools for crop and soil fertility management have been validated under diverse agro-ecologies with extension agents and farmers

Progress towards outcomes

RTB is developing and promoting soil fertility management practices, water-efficient irrigation practices, weed management strategies together with digital decision support tools that may enhance the access of small-holder farmers to technical advices and valuable crop management knowledge. Examples of the ongoing interventions are: African cassava agronomy initiative in Nigeria and Tanzania; Sustainable weed management technologies for cassava systems in Nigeria; Improved soil fertility management for sustainable intensification in potato-based systems in Ethiopia and Kenya; Taking integrated crop management to scale in highland banana systems in East Africa.

Milestone (*reporting year 2020*)

Information and Communication Technology (ICT) tools for disease/pest surveillance and crop management promoted in 12 countries (Nuru - Tanzania, Kenya, Ivory Coast, Nigeria, Cameroon, DR Congo); Tumaini (Burundi, Rwanda, DR Congo, Uganda, Colombia, India, China); Akilimo (Nigeria, Tanzania, Rwanda)

Progress towards outcomes

Decision support tools, AKILIMO mobile app and paper-based tool to improve management practices, water use, nutrient use (see below), resource capture and partitioning to harvest products have been reported. A software has been updated for collecting large-scale multilocation data. The model allows to combine analogue (barcode) identifiers with virtual identifiers and thus enhances data integrity, and it can be used for RTB and non-RTB crops.

Milestone (*reporting year 2021*)

Gender-sensitive, context -specific agronomic practices adopted in 1,200,000 HH, of which at least 25% are female headed households

Progress towards outcomes

Due to the nature of the products, scientific publications and tools, it is difficult to explicitly quantify gender relevance. However, for example, at the start of a project in Southeast Asia, a household survey was carried out. The survey included an assessment of gender roles in cassava production in Cambodia, Laos, Vietnam and Indonesia. Furthermore, women's and men's land rights in Sub-Saharan Africa has been documented in a publication.

Milestone (*reporting year 2021*)

Results provided by prediction models used for developing or updating national and regional strategies

Summary narrative on progress towards outcomes

Starch and dry matter dynamics of cassava roots have been summarized from previous 18 models and a new module has been developed that enables simulation of cassava quality; furthermore, most sensitive genotype-specific parameters (GSPs) and their contribution to the uncertainty of the MANIHOT simulation model have been identified. A list of cassava breeding outputs and their agronomic performance over the last 50 years in Southeast Asia have been documented.

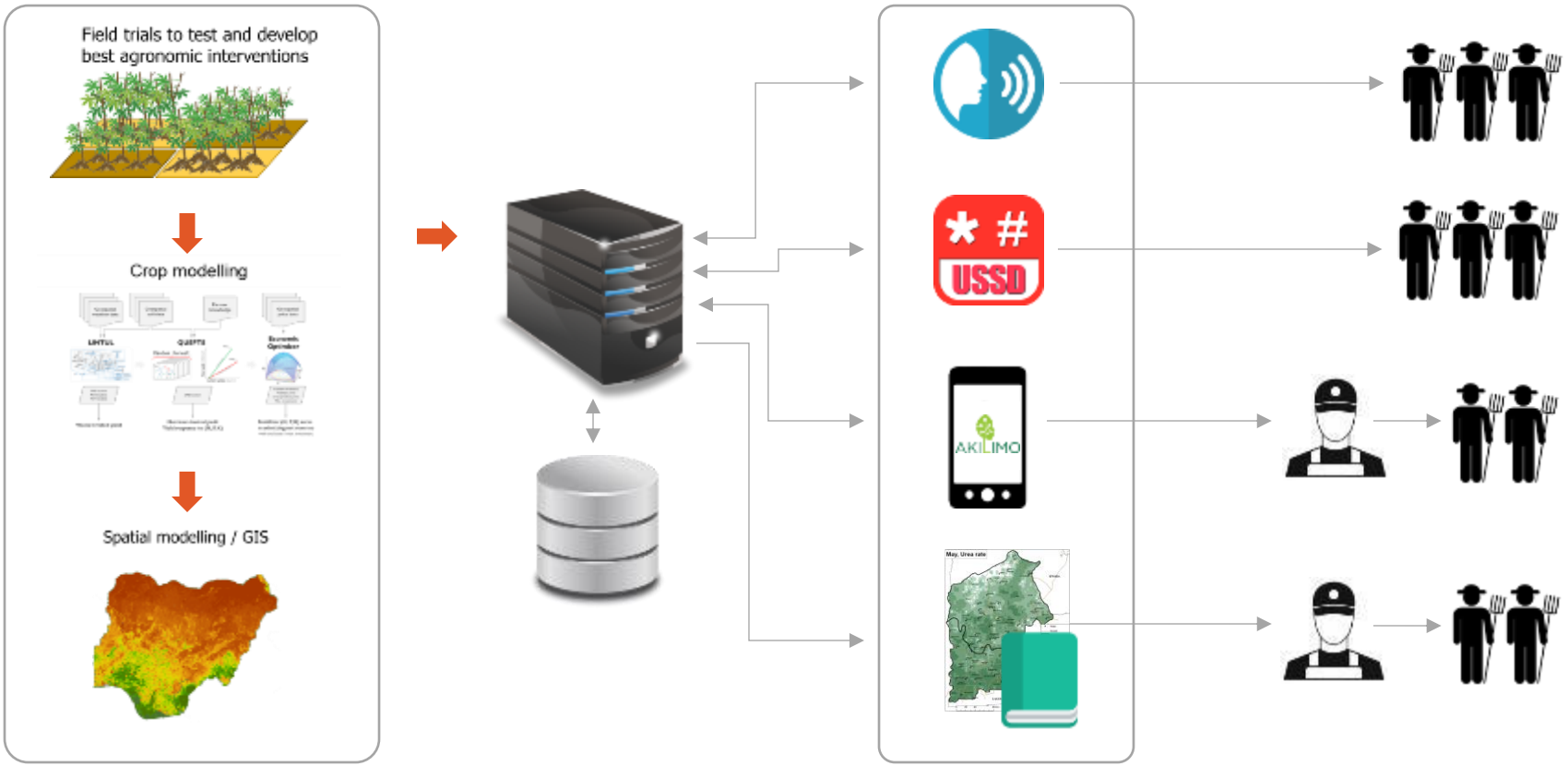
Transition activities into One CGIAR and moving forward golden eggs beyond RTBTitle (examples)

[1]**AKILIMO:** Different partners agreed to continue the collection of data beyond the lifespan of the ACAI project.
It is likely to be included as Use Cases in EiA2030 initiative.

[2]**Future stems**: Partnerships with NAR systems have been developed in Southeast Asia. A private company in Laos has taken up the technology.
It is likely to be included in bilateral project and in EiA2030 initiative.

[1]AKILIMO Mobile Application Decision Support System For Cassava Farmers for Nigeria and Tanzania
[2]Accelerated multiplication and deployment of clean cassava planting materials in Laos, Vietnam and Cambodia.

AKILIMO a digital service to provide tailored agronomic advice



Validated by 3,362 farmers, 714 extension agents & 11 partner organizations

Future stems: Accelerated multiplication and deployment of clean cassava planting materials

Investment in “Future Stems” at NAFRI, Laos research station

Facilitate Industry & Donor visits and training at Future Stems

Leverage Public- Private Partnerships in supply zones

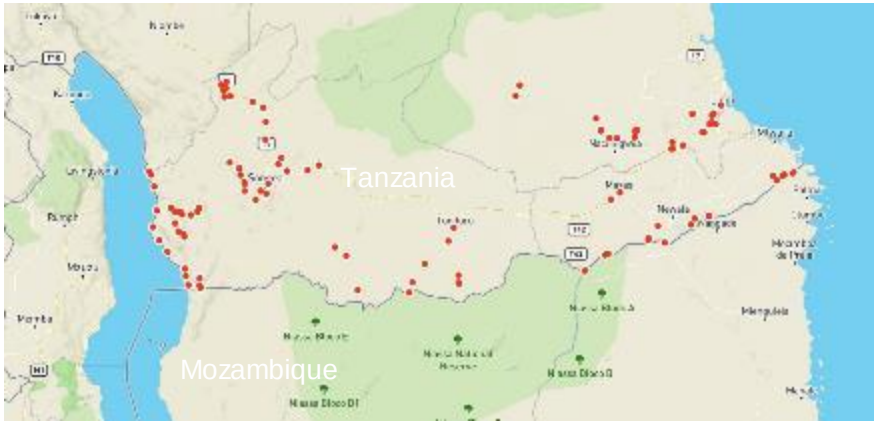
Establish local source of disease-free stems and new varieties

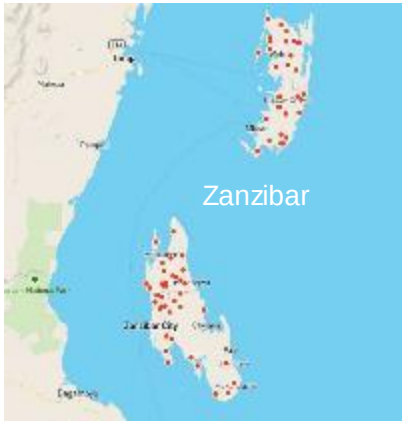
Awareness raising and capacity building in surveillance, diagnostics and extension for rapid response

Sale of stems to smallholder farmers

BA3.3

ODK tool for Banana Fusarium wilt surveillance in Tanzania



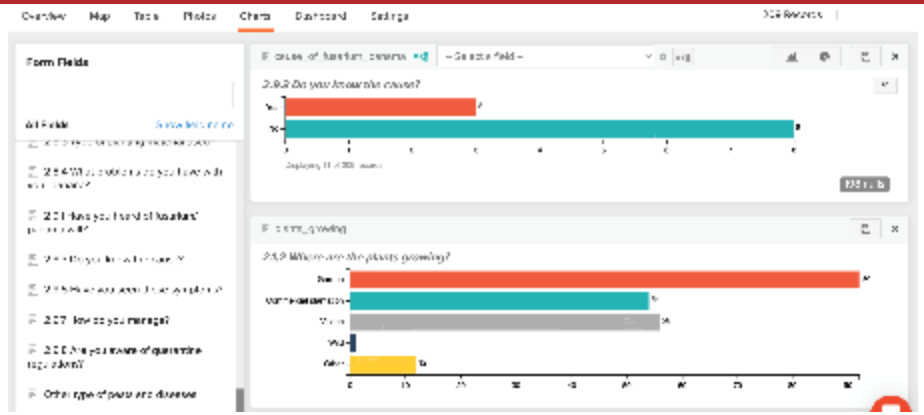


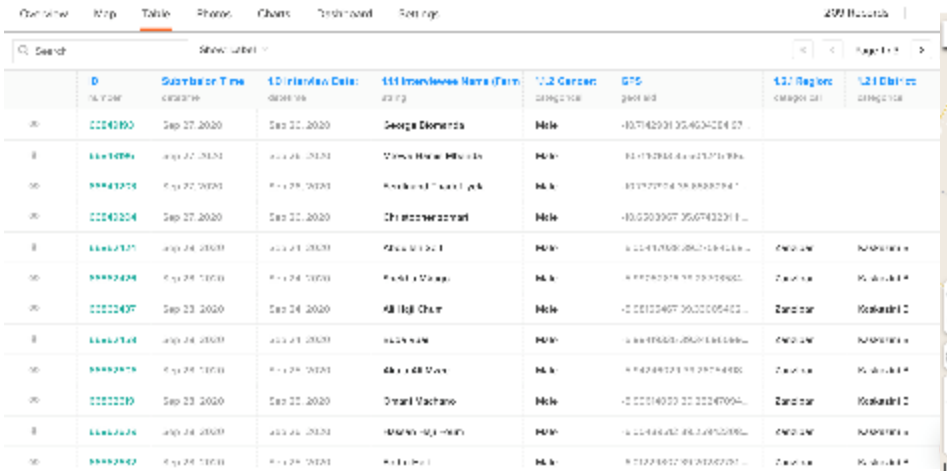
Country	District	Samples from plants with Fusarium Wilt symptoms
Tanzania Mainland	Lindi	21
	Mtwara	35
	Ruvuma	66
Zanzibar	Pemba	35
	Unguja	40
	Total	**197**

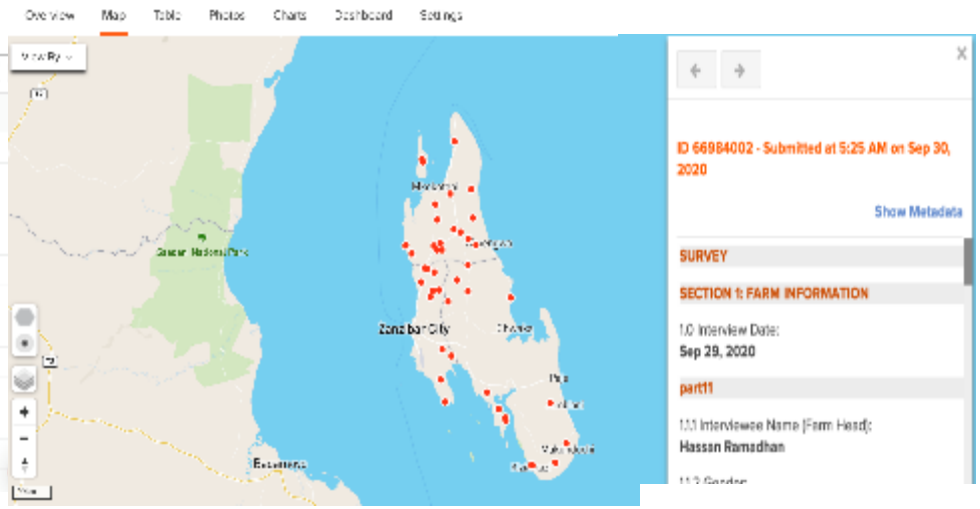
Benefits

- Data collection made easy, accurate (inbuilt validations) and quick
- Integrated GPS for accurate location details, geo-referenced data points across country
- Preventing data loss through data backup and automated data transfer
- Timely and comprehensive summary reports
- Uniform surveillance protocols, making it easy to integrate data
- One tool for pictures, videos, GPS, bar codes, etc

Instant Report generating / reviewing / feedback



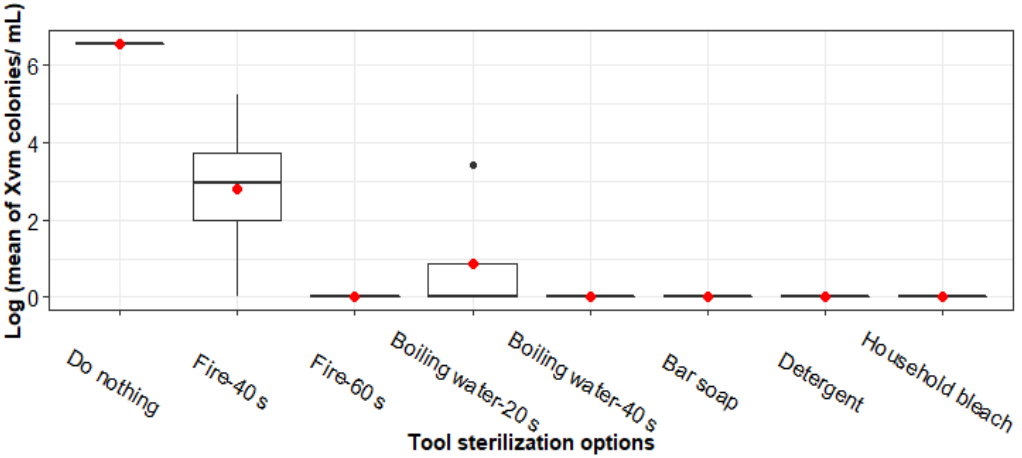




Breaking Xanthomonas wilt disease (XW) of banana and enset

- BXW badly compromising livelihoods in ECA.
- Currently managed using cultural practices
- Tool sterilization using household bleach or fire, a core practice is not widely used.
- Household bleach is costly & less accessible while fire weakens metal blades of tools.
- We found washing with bar soap or detergents or tool insertion into boiling water is as effective as household bleach or fire.
- Laundry soaps readily accessible and cheaper.
- Their inclusion into the control package will increase farmers flexibility and improve XW management.

Manuscript:
https://www.frontiersin.org/articles/10.3389/fagro.2021.655824/full



Log10 mean *Xanthomonas vasicola* pv. *musacearum* (Xvm) colonies per mL recovered from contaminated tools treated with various methods. “Black lines”= medians; “red points”= mean

A farmer washing with soap a machete previously used on a Xanthomonas wilt infected banana plant

Gender perspective enhances research and extension

RTB researchers illustrated a series of cases from their experiences to show how a gender perspective can enhance research and extension for pest and disease management.

For more information see our 'golden egg' portal
https://https://gender-portal.rtb.cgiar.org/pests-and-diseases/gender-portal.rtb.cgiar.org/pests-and-diseases/

Publications: Kawarazuka N., Assefa E., Mayanja S., Okonya J.S., Rietveld A., Slavchevska V., Teeken B. (2020) A gender perspective on pest and disease management from the cases of roots, tubers and bananas in Asia and sub-Saharan Africa, Frontiers in Agronomy, section Pest Management, doi: 10.3389/fagro.2020.00007

Kawarazuka, N.; Damtew, E.; Mayanja, S.; Okonya, J.S.; Rietveld, A.M.; Slavchevska, V.; Teeken; B. (2020). Considering gender in pest and disease management: FAQs for gender-responsive data collection and extension work. (Georgian). Lima, Peru: International Potato Center. 4p.

Outcome story BXW

Based on research by RTB/Alliance and partners, farmers in East and Central Africa are supported with practices to control Banana Xanthomonas Wilt (BXW). An improved control package, 'Single Diseased Stem Removal' (SDSR), has been promoted to more than 180,000 farmers. Further, capacities of extension services and their staff in Burundi, Uganda and Democratic Republic of the Congo on BXW control were strengthened.

https://mel.cgiar.org/projects/rtbscalingbxw/356/more-than-180000-farmers-are-supported-with-practices-to-control-the-banana-xanthomonas-wilt-bxw-disease-in-burundi-uganda-and-democratic-republic-of-congo

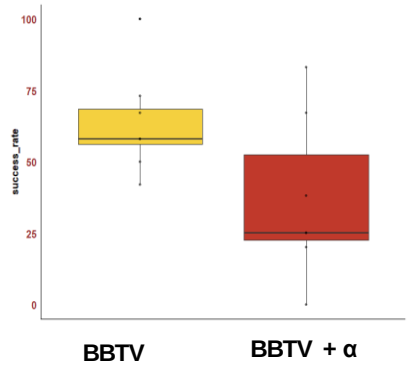
Publications: Rietveld, A.M., Dusingizimana, P., Blomme, G., Gaidashova, S.V., Ocimati, W., Ntamwira, J. (2020). A superior technology to control Banana Xanthomonas Wilt (BXW) in Rwanda. RTB Research Brief 03. Lima, Peru: CGIAR Research Program on Roots, Tubers and Bananas. 6 p.

BA3.4

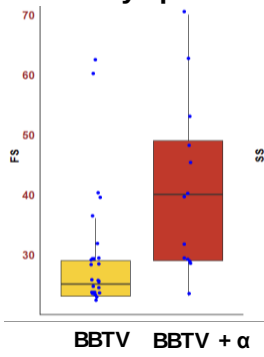
A new alphasatellite of BBTV in Sub-Saharan Africa negatively impacts BBTV replication and disease transmission by aphids

DRC-alphasatellite reduces virus transmission rate and delays symptoms appearance

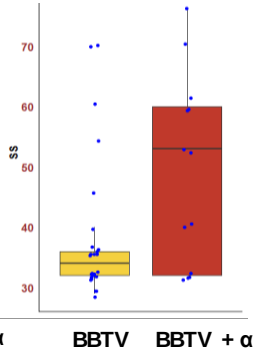
Transmission rate

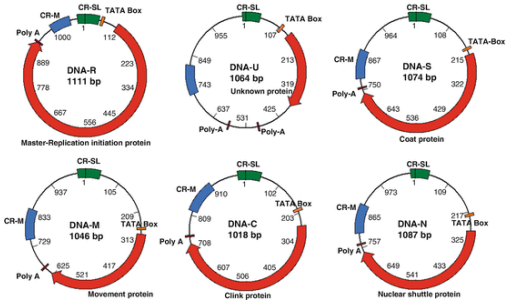


First symptoms



Severe symptoms

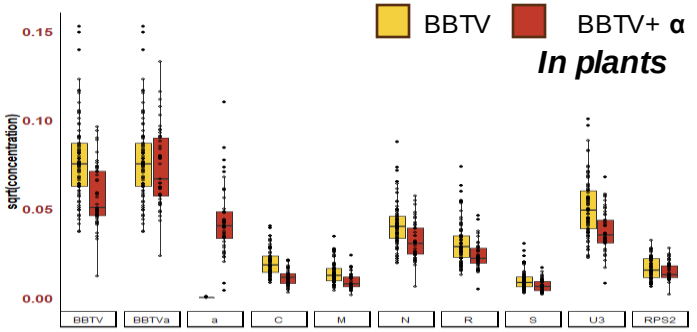




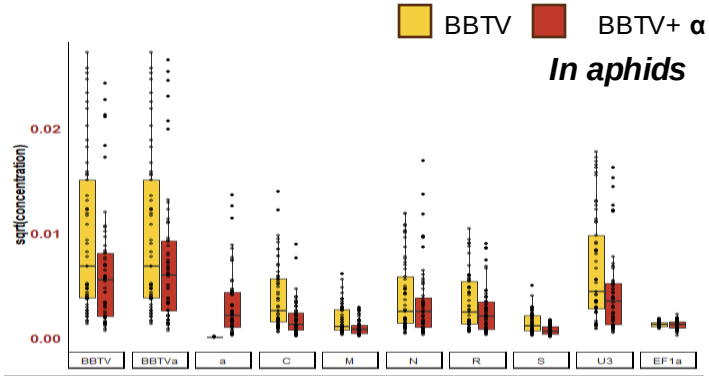
Six BBTV Genomic Components
(Source: Islam et al. 2010)

Alpha-satellite structure
(Source: Snehi et al. 2017)

DRC-alphasatellite reduces helper virus loads and genome formula



BBTV Genomic components and α Sat

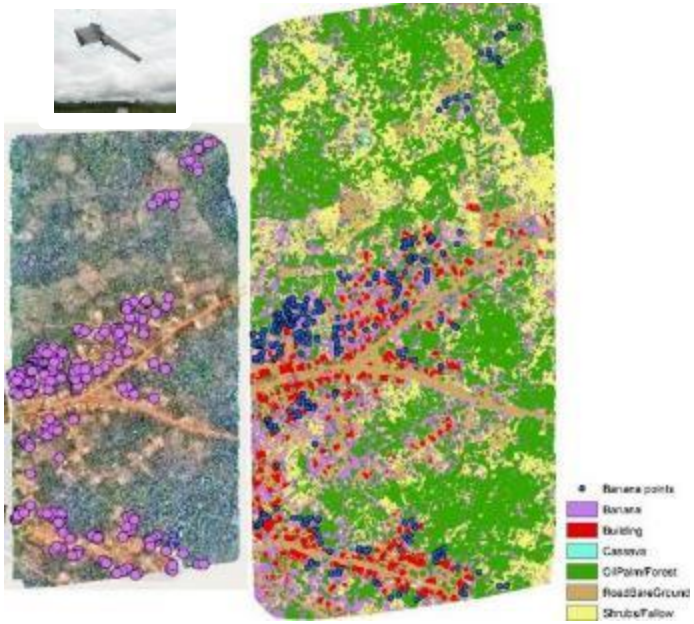


BBTV Genomic components and α Sat

Digital BBTV surveillance and reporting system

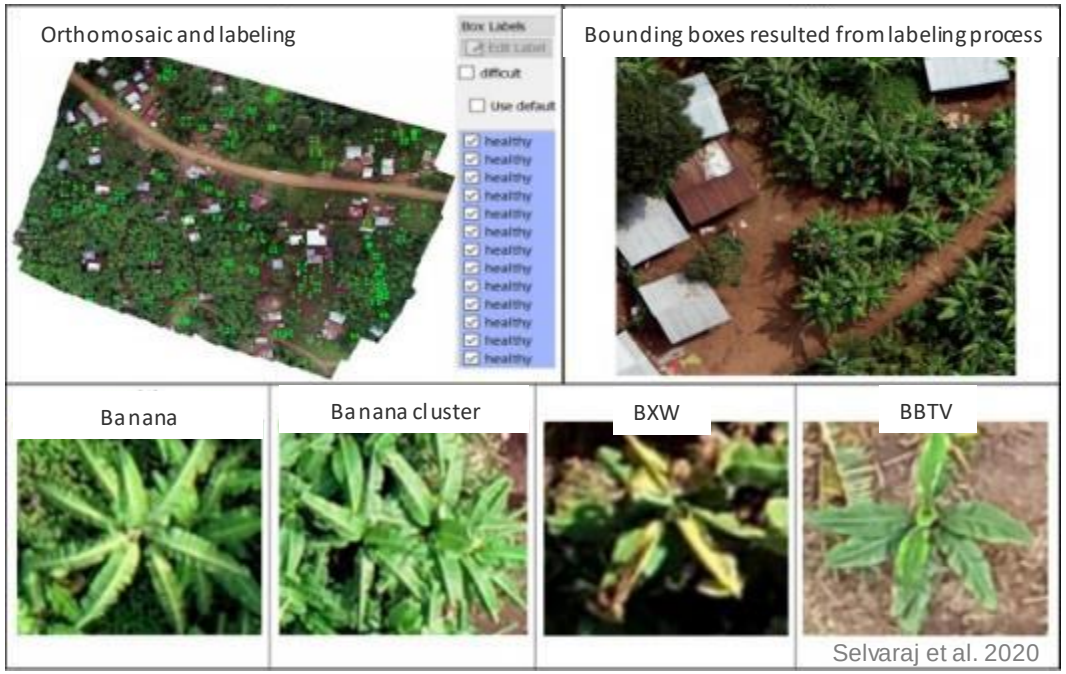
Remote sensing tools, drones, coupled with machine learning (ML) methods for BBTV surveillance.

- ML for crop type classification (area measurement)
- Image-based disease diagnosis based on RGB and spectral imaging
- Rapid field-based BBTV diagnostic tests based on RPA
- Real-time reporting and mapping using ICT apps (CDC, Tumaini)
- Easy to use disease surveys and early warning system for BBTV



Drone-based surveillance for banana and BBTV

Alabi & Kumar, 2021, unpublished



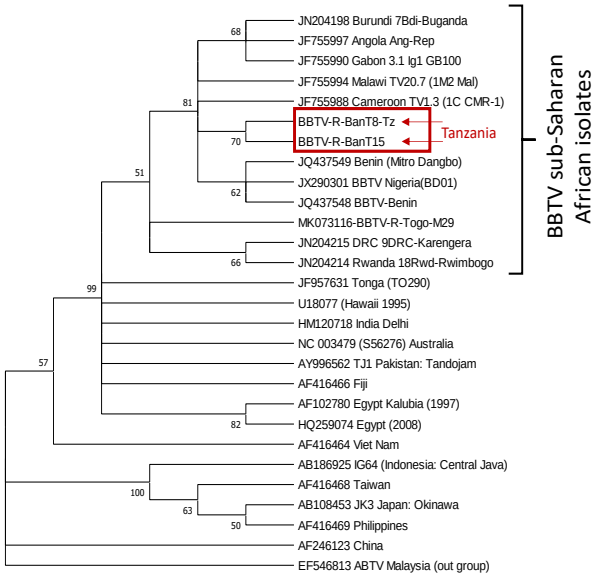
Selvaraj et al. 2020

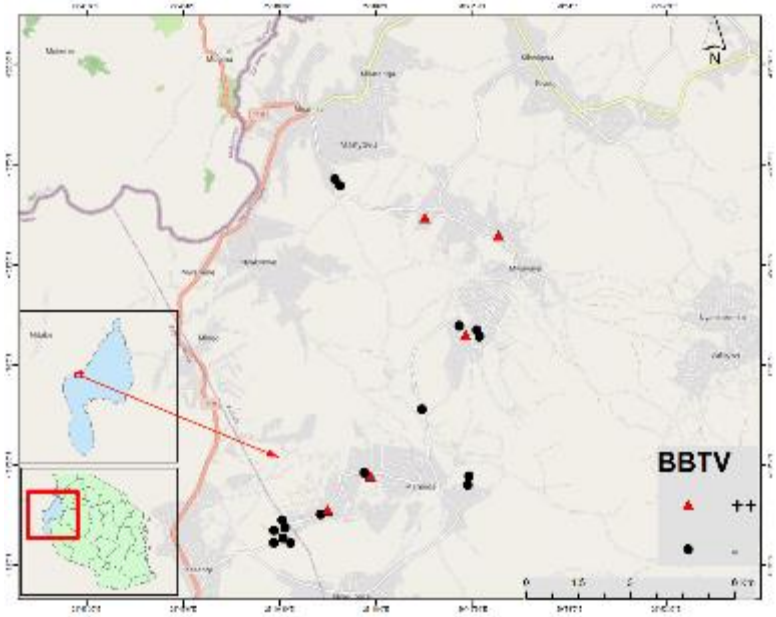
Cluster BA3.4: BBTV Control in Africa

In collaboration with BA3.3

First report of BBTV in Tanzania and East Africa

- Banana disease surveys conducted in Tanzania identified occurrence of BBTV in Buhigwe District in Kigoma Region
- Virus presence confirmed by molecular diagnosis and sequencing of BBTV genome
- The information communicated to the official Tanzania authorities (Plant Health Services of Ministry of Agriculture and TARI) and obtained permission for public notification
- The BA3.4 and BA3.3 joined to conduct delimitation surveys to identify diseased areas and implement eradication



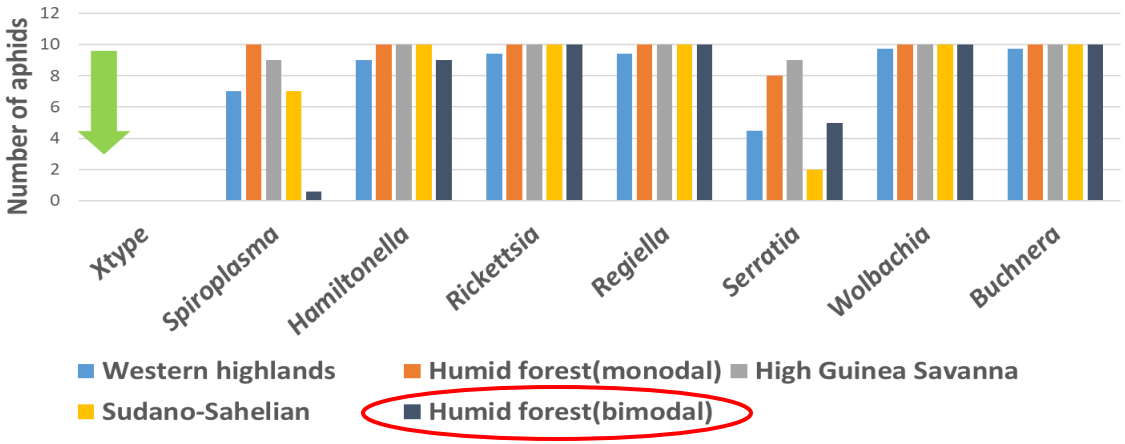


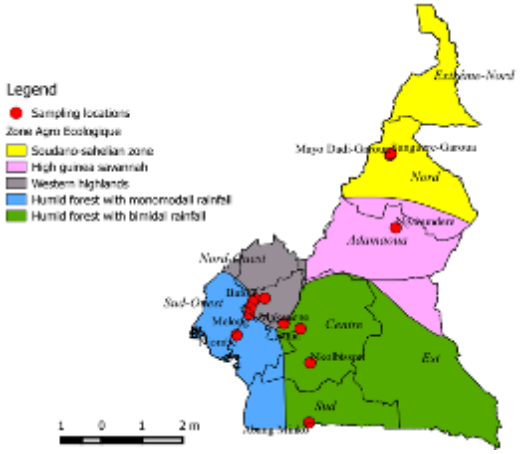
TARI and PHS teams, G Mahuku & L. Kumar, 2021 unpublished

Studies on banana aphid–symbiont relationship and the role of symbionts in banana aphid ecology and BBTV transmission

- Characterize endosymbionts in banana aphid from 5 agro-ecologies in Cameroon and Nigeria
- Assessing the effect of facultative endosymbionts in banana aphid defense against entomopathogenic fungal infection (*Metarhizium* sp. and *Beauveria* sp.)
- No clear evidence of endosymbionts offering defense against entomopathogenic fungi
- *Metarhizium* sp., and *Beauveria* sp., resulted in banana aphid mortality under controlled conditions

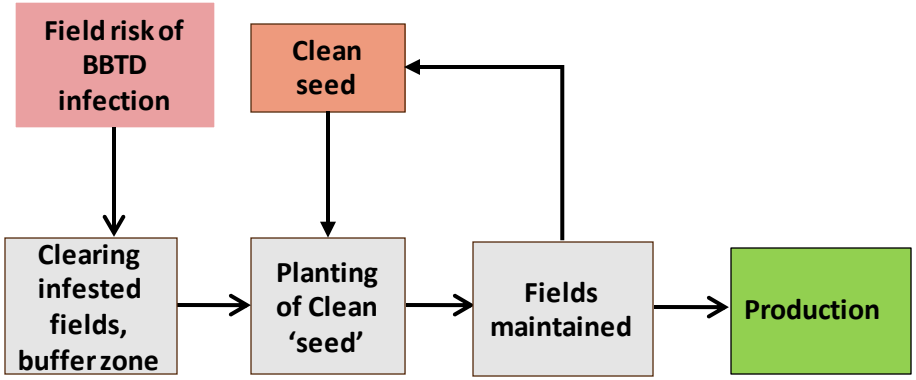
- **Seven genera detected:** *Buchnera, Wolbachia, Regiella insecticola, Hamiltonella defense, Serratia symbiotica, Rickettsia and Spiroplasma. All but spiroplasma and Serratia distribution were uniform.*





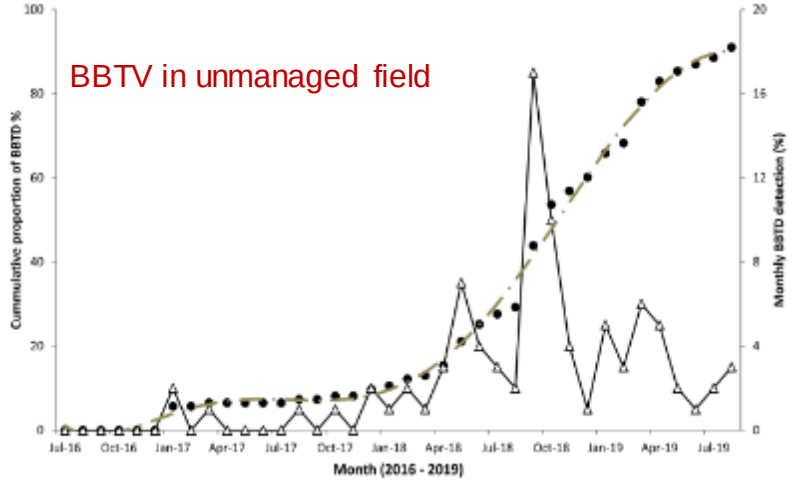
Fiobe et al., (2021), unpublished

Community management helped banana production recovery in the BBTV affected areas

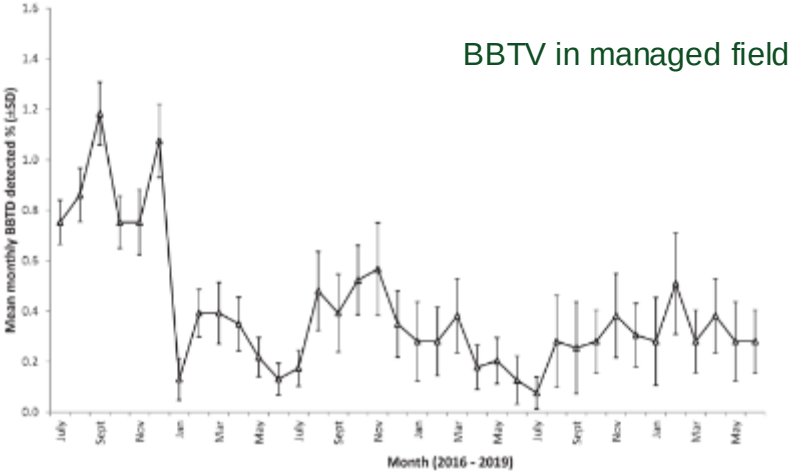


Community banana recovery plan

- Regular inspection and early removal of infected plants sustains banana production in the fields planted with virus-free material (2 to 10% incidence in 3 years).
- BBTV incidence >90% in unmanaged fields (no inspection or rouging) during the same time and production collapsed to "zero"



Without management BBTD approaches 99% in 3 years



Managed fields remain in below 2% disease rate

Omondi et al., (2020), Plant Pathology

Inspection and rogueing: timing and consistency

<u>Nkota-kota, Malawi</u>

intermittent rogueing 2/mo

Initial: 6% BBTD incidence

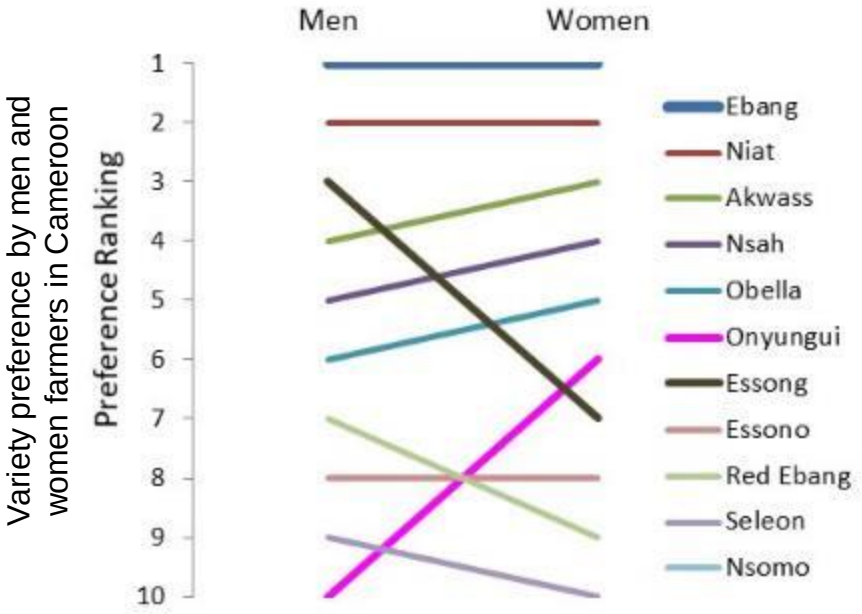
increased to 45% in two years

Mzuzu, Malawi

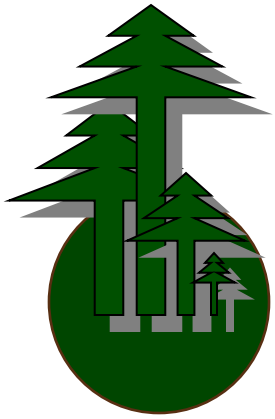
Regular monthly rogueing

Reduced BBTD infection from 6% at early stage to present 1 to 3 % in old farms

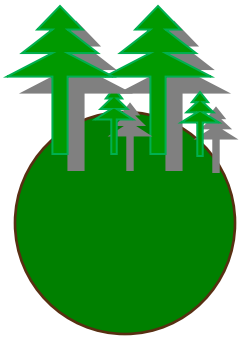
Gender norms and BBTD management



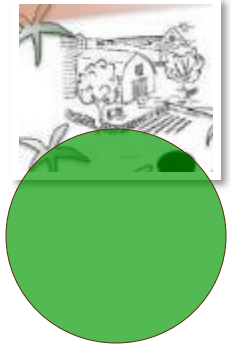
- Commercial varieties preferred most by both men and women
- Minimal difference in variety preference by men and women



Virgin Forest
Highland plantations



Secondary Forest
Proximal gardens



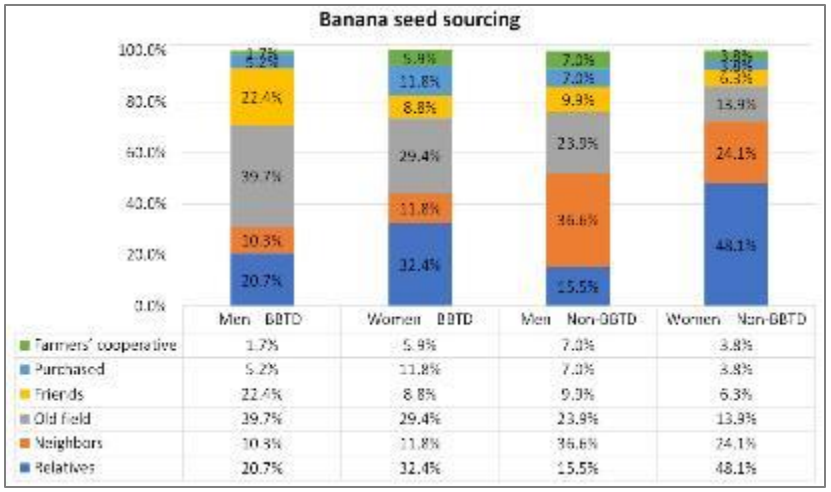
Backyards/ Homesteads

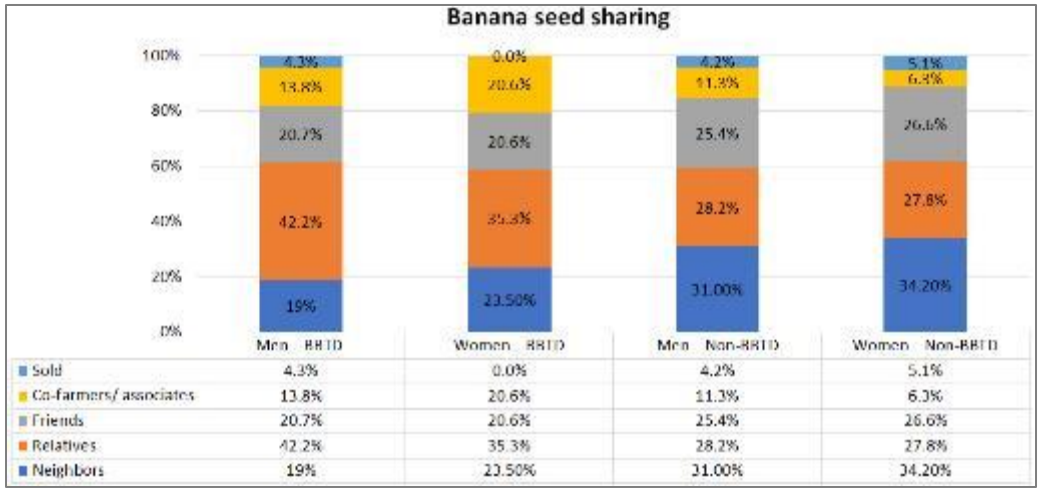
- Access to land is gender linked
- Two dimensions: Size and potential
- Decision making contrasts

Ajambo et al., 2018
Nkengla et al., 2020, Outlook in Agriculture
Nkengla et al., 2021, Sustainability

Gender norms and BBTD management

- Seed sourcing and sharing behavior in BBTV affected and unaffected communities in Nigeria revealed key factors that influenced the virus spread





- Farmers seed sourcing and sharing in BBTV-affected and unaffected areas are similar
- Almost 95% of the planting material used by farmers are sourced within communities
- Men are involved in long-distance movement and likely to introduce BBTV infected sources into communities
- Once introduced into communities, further spread take place at a faster pace due to the high rate of local sharing of planting materials, which explains the clustered pattern of BBTV spread in SSA
- Educating communities on best seed sourcing practices and risk of BBTV is crucial to BBTD management

Nkengla et al., 2021, Sustainability

Miscellaneous

- PhD students in BA3.4

Enoh (Cameroon)
Aphid endosymbionts

Oresanya (Nigeria)
BBTV-aphid-host interactions

Hervé Degbey (Benin)
Response of local cultivars to BBTV in Nigeria and Benin

Ibanda (DRC)
On-farm management of BBTV using phytosanitation methods

G Vangu (DRC)
BBTV epidemiology in DRC

- Students are expected to complete by the end of 2021. Any residual work will be supported through complementary projects
- Covid19 impacted field work in the pilot sites in 2020. The team effectively used online tools to overcome some bottlenecks.
- Organized annual meeting online in October 2020 jointly with BBTV BMGF project

CA3.5

Cluster CA3.5 Scientific Publications 2020-2021

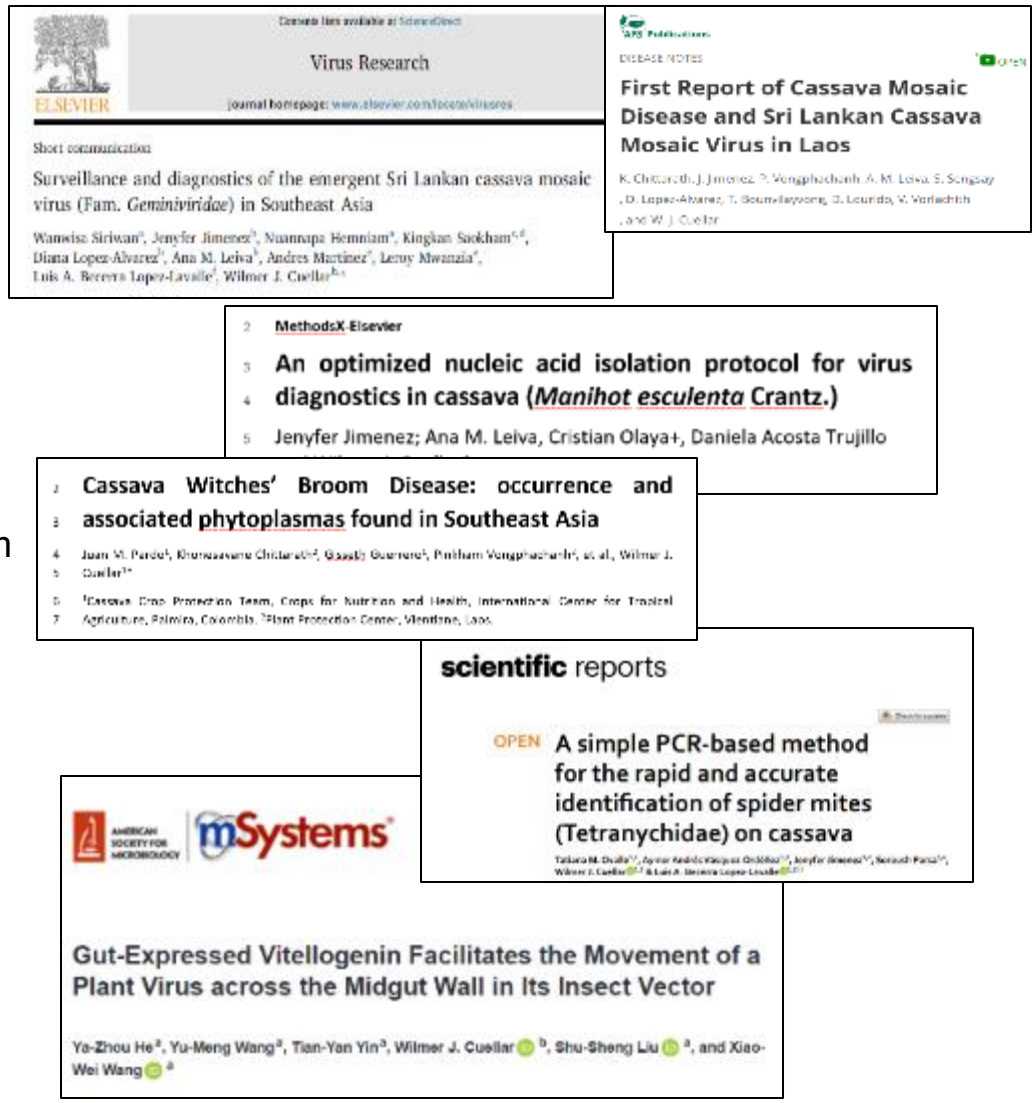
Validated standard protocols for characterization and detection of pests and pathogens:

SLCMV (SEA) and CsCMV (LAC)
In collaboration with: Kasetsart University (KU), Thailand and Agricultural Research and Development Institute (CARDI), Cambodia

Characterization of Cassava Witches' Broom Disease and Cassava whiteflies using nanopore In collaboration with: Plant Protection Center (PPC), Laos

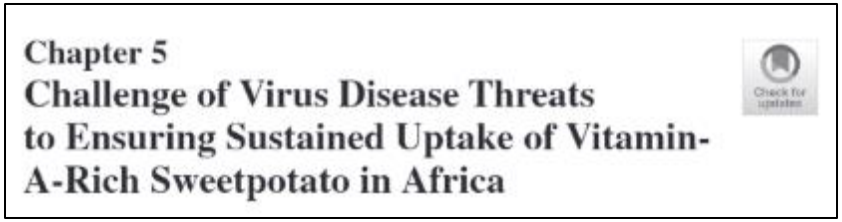
Indetification of cassava mites
In collaboration with: Universidad del Valle, Colombia

Virus transmission by whiteflies.
In collaboration with: Zhejiang University, China



Cluster CA3.5 Cross Cluster and Bilateral Collaboration 2020-2021

Review on the disease challenge for OFSP. In colab with CC3.1



Chapter 5
Challenge of Virus Disease Threats to Ensuring Sustained Uptake of Vitamin-A-Rich Sweetpotato in Africa

Evaluation of SLCMV-infection in Asian cultivars and in disease-free cassava seed produced at large scale. In colab. CC3.2

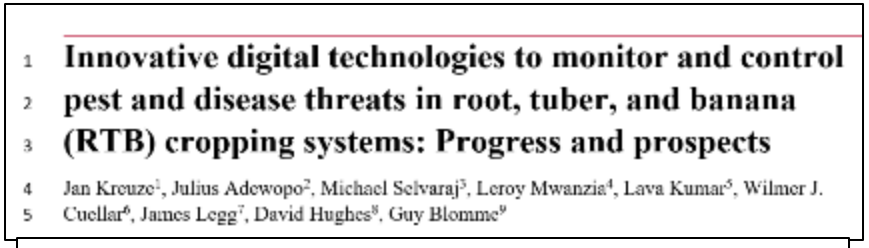
Alliance Bioversity International CIAT

Annual Report for the Research Project

"Increase Cassava production and profitability through clean seed technology"

May 2021

Digital technologies to monitor pests and diseases In colab. with CC3.1, BA3.3, CA3.6 and Pennstate



Innovative digital technologies to monitor and control pest and disease threats in root, tuber, and banana (RTB) cropping systems: Progress and prospects

Jan Kreuze[1], Julius Adewopo[2], Michael Selvaraj[3], Leroy Mwanzia[4], Lava Kumar[5], Wilmer J. Cuellar[6], James Legg[7], David Hughes[8], Guy Blomme[9]

Analysis for an Innovations Hub for early warning of transboundary pests. In colab. With FAO.

POLL: Challenge and Opportunity Analysis for an Innovations Hub for coordinative surveillance and early warning for sustainable management of Transboundary Plant Pests (TPPs) in Asia and the Pacific

Goal

Asia has been hit by major TPPs events. Fusarium TR4, Cassava Mosaic Disease, Rice Stripe Virus, amongst those that have recently entered and spread causing yield loss and food insecurity. However, the capacity to effectively forecast and mitigate these threats need to rely on evidence (including a substantive knowledge of the pest, the host, the environment/ farming system and the technology and innovations available). Getting this knowledge is specially challenging in developing countries, where data is often lacking or inaccurate, the capacity to acquire data is low and/or likely to be slow to obtain, and where the economic impact of TPPs is often not readily measured.

Use of nanopore technology to identify and detect quarantine pathogens in cassava.
In colab, with SENAS and INIA, Peru

Milestones and progress towards 2022 outcomes Cluster CA3.5

Innovation: Diagnostic and surveillance protocols, developed by CIAT and implemented by National Plant Protection Organizations (NPPOs), to understand the impact and current status of the Cassava Mosaic Disease in Southeast Asia (Cluster CA3.5)
https://mel.cgiar.org/innovation/getinnovationview/id/700

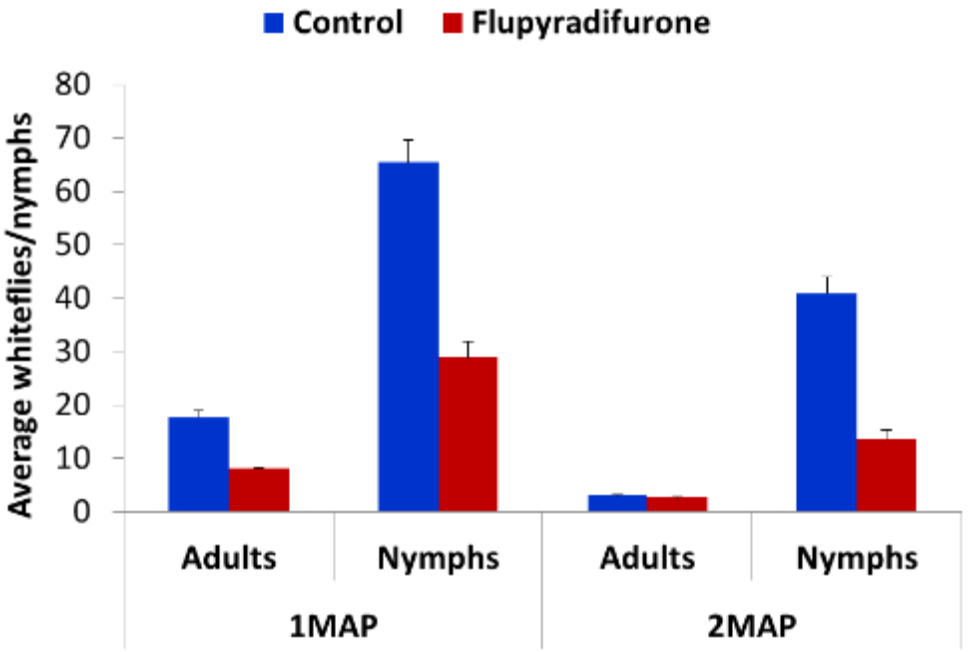
Innovation: A tunnel system for rapid propagation of disease-free planting material piloted in the Lao People's Democratic Republic
https://mel.cgiar.org/innovation/addinnovation/id/582

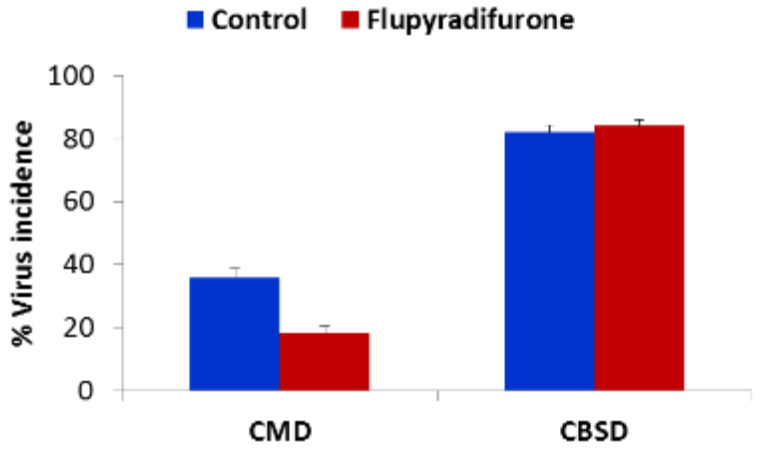
Policy contribution: National Plant Protection Organizations (NPPOs) define a common research strategy to manage impact of the Frogskin Disease in Colombia (Cluster CA3.5)
https://mel.cgiar.org/projects/-15/358/national-plant-protection-organizations-nppos-define-a-common-research-strategy-to-manage-impact-of-the-frogskin-disease-in-colombia

CA3.6

CA 3.6. Controlling Cassava Pests

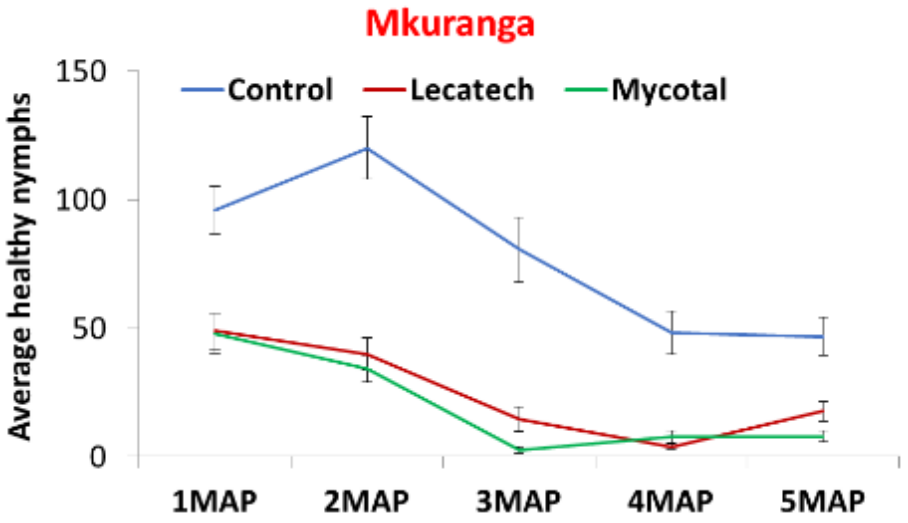
Cutting soaking - Flupyradifurone

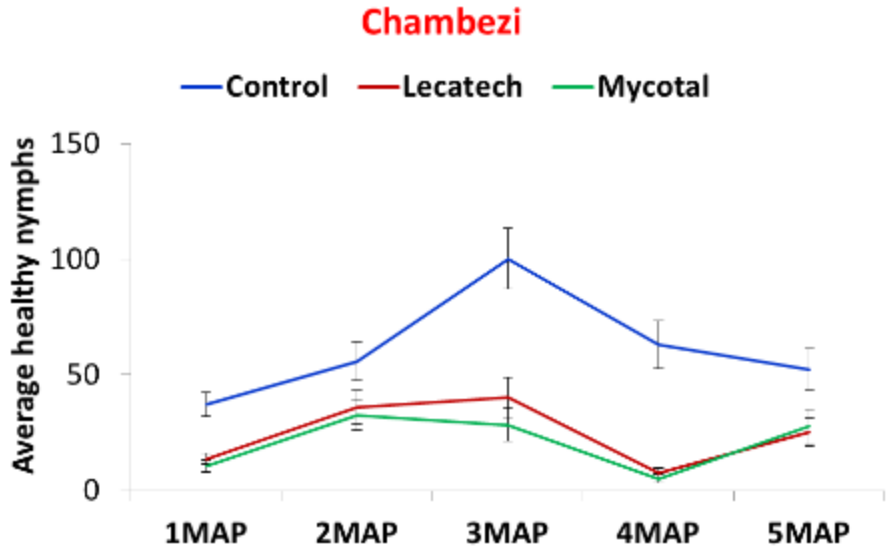




CA 3.6. Controlling Cassava Pests

Entomopathogens

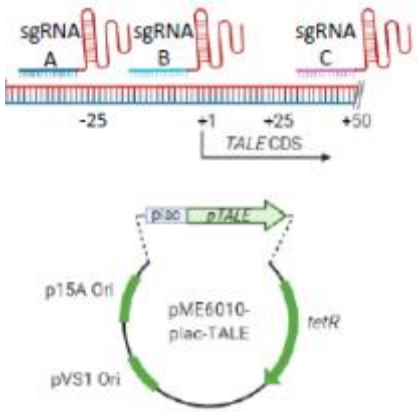


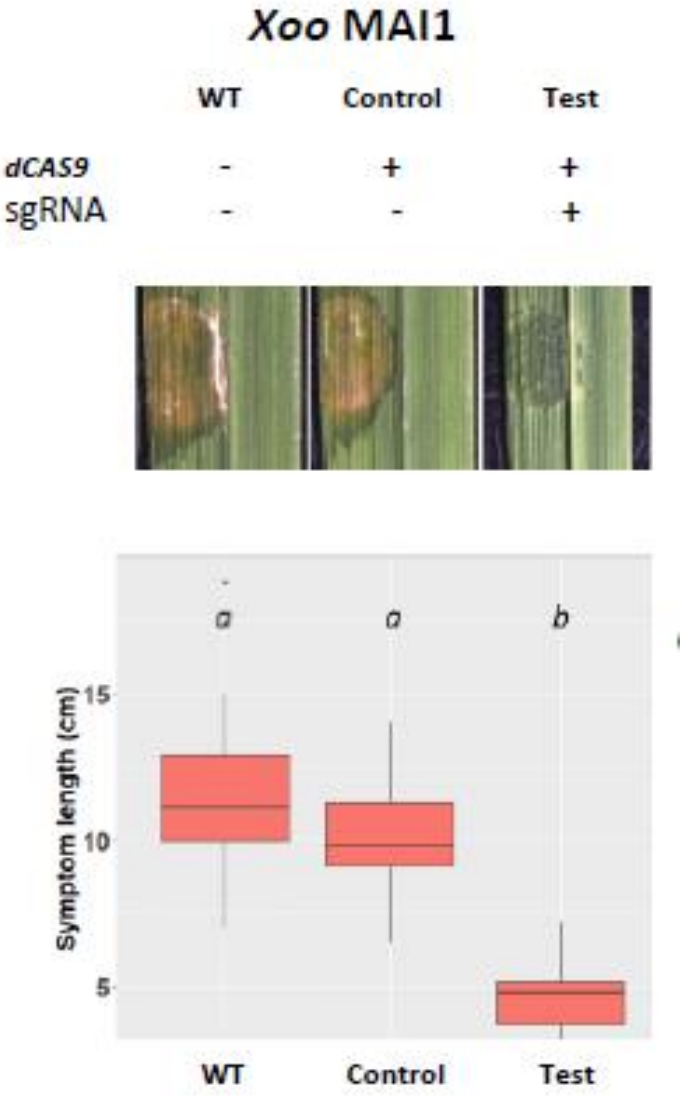


CA 3.6. Controlling Cassava Pests

CRISPRi platform to study gene function of Xanthomonas species

- A CRISPRRi tool employing sgRNA to knock down mutiple genes was developed
- TALE family of genes in encoding virulence in Xa spp were silenced
- Symptom severity reduced in TALE silenced Xa bacteria





CA 3.6. Publications

Open Access Article

TAL Effector Repertoires of Strains of *Xanthomonas phaseoli* pv. *manihotis* in Commercial Cassava Crops Reveal High Diversity at the Country Scale

by Carlos A. Zárate-Chaves [1,2], Daniela Osorio-Rodríguez [2], Rubén E. Mora [3], Álvaro L. Pérez-Quintero [1], Alexis Dereeper [1], Silvia Restrepo [4], Camilo E. López [3], Boris Szurek [1] and Adriana Bernal [2,*]

[1] PHIM, CIRAD, INRAe, IRD, Montpellier SupAgro, University of Montpellier, 34090 Montpellier, France

[2] Laboratorio de Interacciones Moleculares de Microorganismos Agrícolas, Departamento de Ciencias Básicas, Universidad de los Andes, Bogotá 111711, Colombia

[3] Manihot Biotec, Departamento de Biología, Universidad Nacional de Colombia, Bogotá 111321, Colombia

[4] Laboratorio de Micologíay Fitopatología de la Universidad de los Andes (LAMFU), Departamento de Ciencias Básicas, Universidad de los Andes, Bogotá 111711, Colombia

[*] Author to whom correspondence should be addressed.

Academic Editor: Christopher B. Blackwood

Microorganisms **2021**, *9*(2), 315; https://doi.org/10.3390/microorganisms9020315

Received: 15 November 2020 / Revised: 17 December 2020 / Accepted: 24 December 2020 / Published: 4 February 2021

Manuscripts in press:

- Cassinga CM, Wosula EN, Shirima RR, Sikirou M, Nabahungu NL, Munyerenkana CM, Ugentho HU, Mahungu NM, Monde GT, Dhed'a BD and Legg JP. 2021. Genetic diversity of *Bemisia tabaci* whiteflies in the Democratic Republic of Congo and implications for the westwards spread of cassava virus epidemics submitted to PLosOne (PONE-D-21-15709)

Title: CA 3.6. Control of cassava pests

- The ongoing field testing with farmers through cutting absorption of soft chemistry insecticide flupyradifurone indicates this technology has potential for incorporation in IPM for management of whiteflies

- Mycotal a commercial entomopathogenic biopesticide has proved effective at suppressing whiteflies and will be advanced to trials under farmers' fields

- The CRISPRi tool will be used to study the virulence factors Xpm a pathogen causing cassava bacterial blight with aim of developing novel control strategies.

Title: CA 3.6. Control of cassava pests

- Develop IPM packages for management of cassava whiteflies with aim of combining soft chemistry pesticides, entomopathogens, botanical oils and host plant resistance

- Develop IPM techniques for management of African root and tuber scales (ARTs) that are an emerging threat to cassava production in Central Africa

- Use CRISPRi tool to understand the virulence of Xpm with aim of developing novel techniques for control of CBB

Innovations & Progress in FP3

Type	Stage 1: Discovery/proof of concept			Stage 2: Successful piloting			Stage 3: Available/ready for uptake			Stage 4: Uptake by next user		
	Newly Reported	Continous Work	Advanced	Newly Reported	Continous Work	Advanced	Newly Reported	Continous Work	Advanced	Newly Reported	Continous Work	Advanced
Biophysical Research												
Genetic (variety and breeds)												
Production systems and Management practices	2			3			2					
Research and Communication Methodologies and Tools	3			1		1	3	2		1		1
Social Science												
Total	**5**	**0**	**0**	**4**	**0**	**1**	**5**	**2**	**0**	**1**	**0**	**1**

Tumaini: an Artificial Intelligence (AI)-powered banana diseases and pest detection App

From Stage 2 to Stage 4:

app can be used to diagnose 5 banana diseases (Banana Xanthomonas Wilt (BXW), Banana Bunchy Top Disease (BBTD), Fusarium wilt, Black Leaf Streak and Yellow Sigatoka) and one pest (weevil)