

Enhancing food security and nutrition in Africa

-- NextGen Cassava

Salazar, Sandra
Morante, Nelson
Pino Duran, Lizbeth
Delgado Munoz, Luis Fernando
Zhang, Xiaofei

Key Elements of Plant Breeding

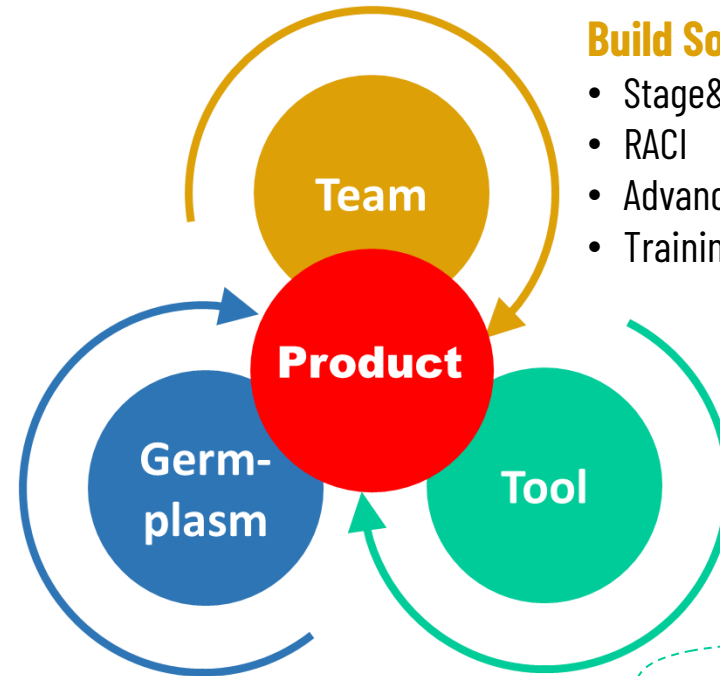


Enhance Global Impact

- Update product profiles
- Essential traits

Create New Opportunities

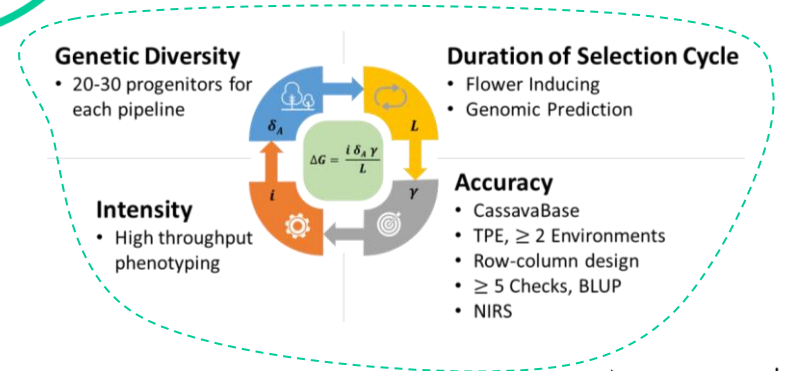
- High and stable dry matter
- CBSD resistance
- Whitefly resistance
- Drought and heat tolerance
- Flowering



Build Solid Foundation

- Stage&Gate
- RACI
- Advancement meetings
- Training workshop

Modernize Breeding Program



Product



BC, Beta-carotene; CQ, cooking quality; WX, waxy starch; SG, small granule starch; PQ, processing quality









- 1) Cassava for **starch** and animal feed
- 2) **Biofortified** cassava for human consumption
- 3) Fresh and dried roots for **human consumption**
- 4) Cassava for **specialty** starch
- 5) Processing- **granulated** and paste for human consumption



Product & Pipeline

WP1, ReFOCUS
WP3, TRANSFORM

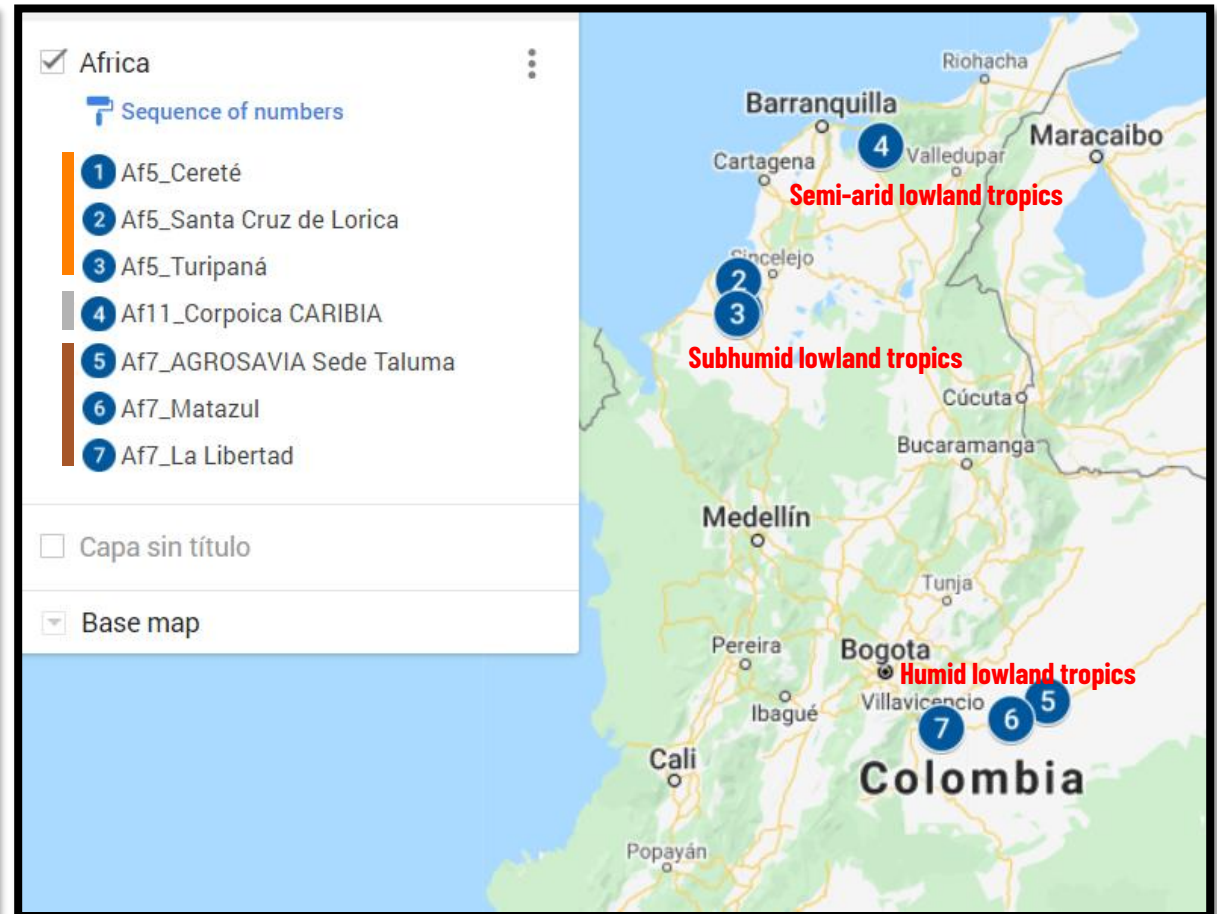
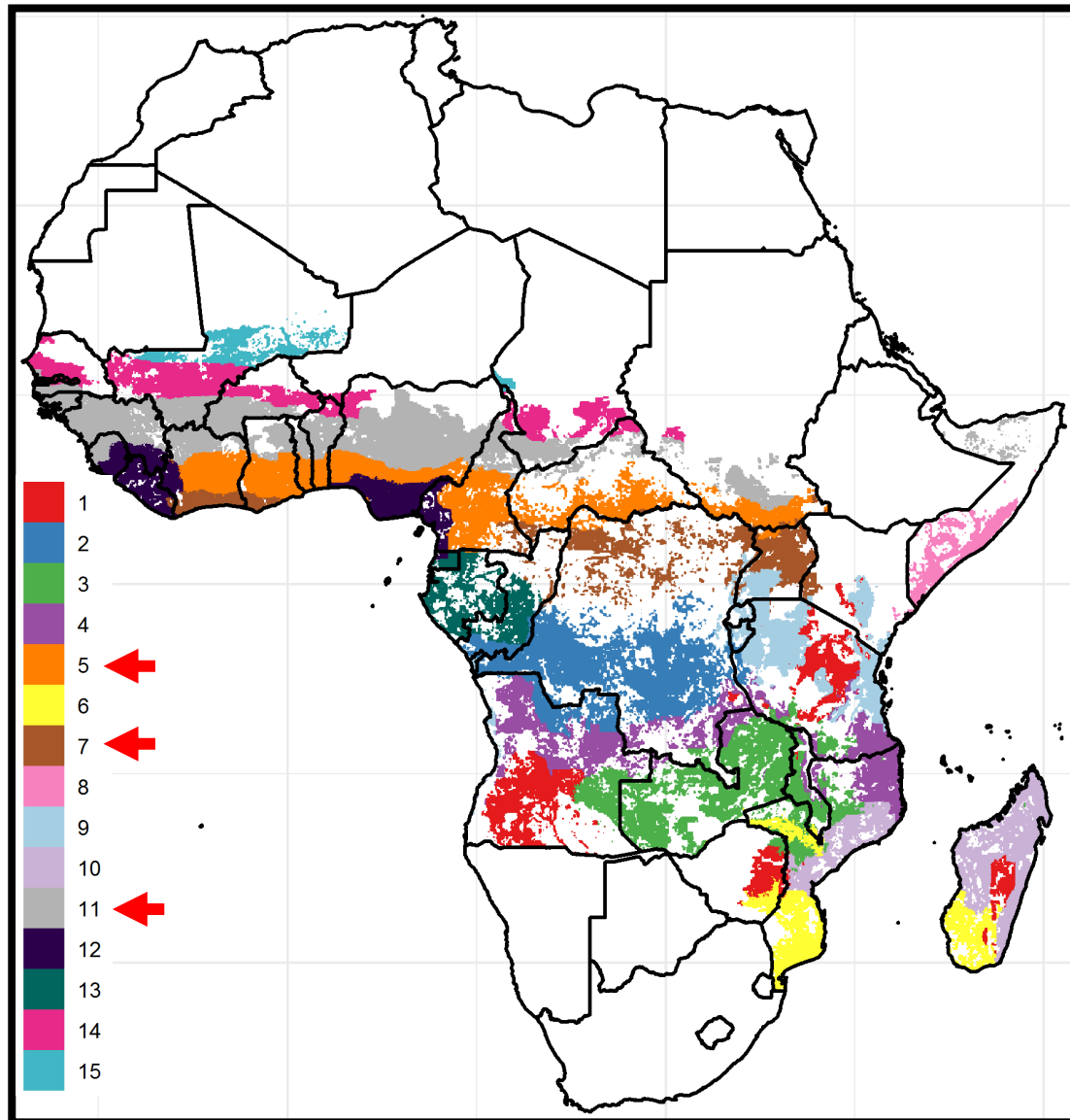


- Dry matter 
- **Dry matter + CMD + CBSD**  
- Boiled cassava 
- **Boiled cassava + CMD + CBSD**  
- Biofortified cassava 
- **Biofortified cassava + CMD + CBSD** 

Update product profiles with the inputs from NARS
Clarify essential traits and their threshold



The Agro-climatic Similarity between Colombia and Africa



Key Elements of Plant Breeding

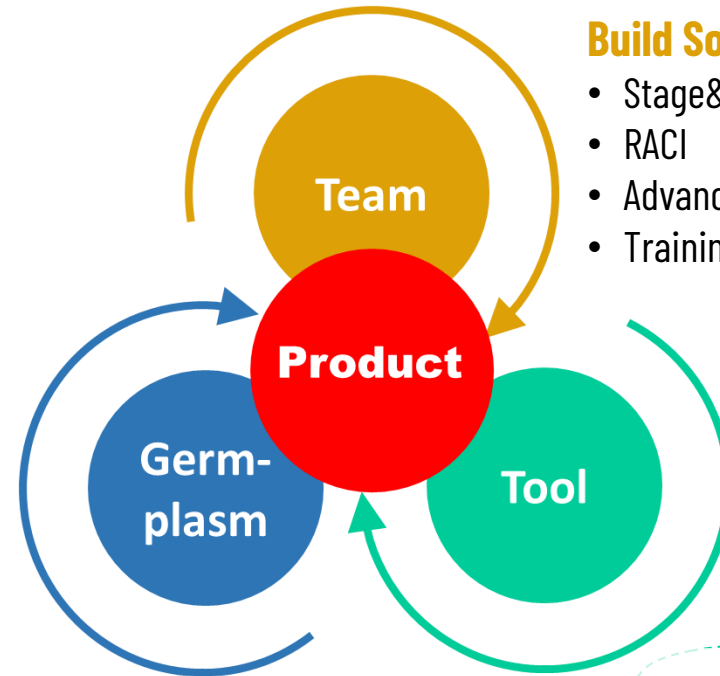


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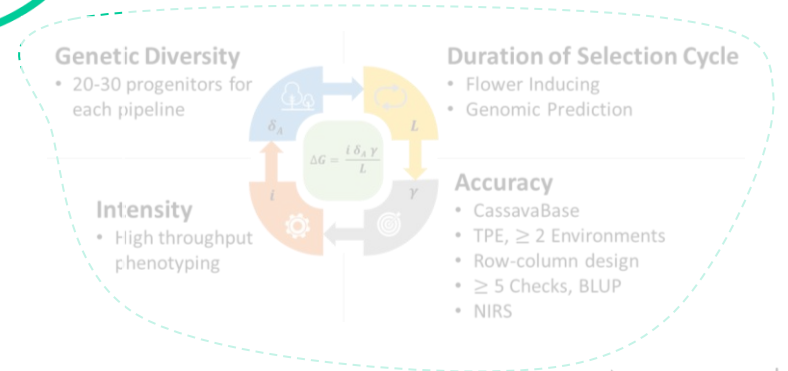
Build Solid Foundation

- Stage&Gate
- RACI
- Advancement meetings
- Training workshop



WP2, ReORGANIZE

Modernize Breeding Program



Operational Excellence



Salazar, Sandra Milena

S.M.Salazar@CGIAR.ORG

Senior Coordinator

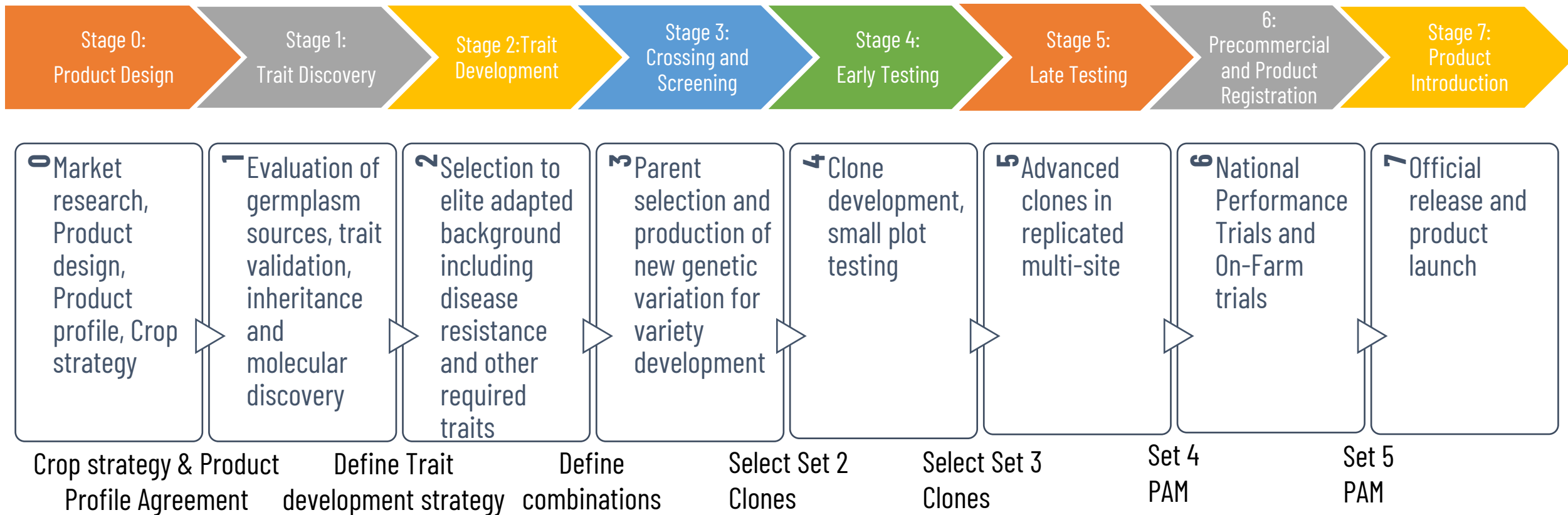
8 years of experience at CIAT

- Lead the field management team
- Process Steward
- Coordinate collaborations in Colombia

Trialing and Nursery Team in Palmira Campus



1. Product Development Process - Stage&Gates



Stakeholder Landscape for Cassava Advancement Decision Making across CIAT and NARES partners

We have now **91** people mapped



64

27

21 unique roles
12 disciplines

Next Step is to include the NARES in Asia



2. Decision Rights Mapping at Discipline level: RACI Model

		Standardized Discipline	Decision Right in Gate 0=>1 Crop strategy & Product Profile Agreement	Decision Right in Gate 1=>2 Define Trait development strategy	Decision Right in Gate 2=>3 Define combinations for Crossing	Decision Right in Gate 3=>4 Select Clones for Early Screening	Decision Right in Gate 4=>5 Select Clones for Late Development Testing	Decision Right in Gate 5=>6 Advance candidates to National Performance and On-Farm Trials	Decision Right in Gate 6=>7 Advance candidates to variety release
CIAT-Colombia	Research & Development	Breeding	R	A	A	A	A	A	A
		Data Science	C		R	R	R	R	R
	Disciplinary expert	Entomologist	C					C	C
		Food Scientist	C			R	R	R	I
		Virologist	C				I	C	I
		Geneticist	C	R	R	R	I	I	I
		Platform	C	C					
		Tissue culture	C			R		I	R
	Seed Supply Chain	Seed System specialist	C		I	I	I	R	R
	CIAT-Asia	Research & Development	Breeding	R	A	A	A	A	A
Disciplinary expert		Agronomist	C	C			C	C	C
		Virologist	C	C			C	C	C
		Physiologist	C	C				C	I
Seed Supply Chain		Seed System specialist	C				I	R	R
Marketing, Outreach & Social Impact		Market-/Socio Economics	A	C	C	I	C	R	R
NARS: Agrosavia		Research & Development	Breeding	C		C	C	C	R
	Disciplinary expert	Agronomist	C					C	C
		Geneticist	C						
		Physiologist	C						

Next Step is to practice advancement meetings

3. Process Management Team _Trialing and Nursery

Purpose

Harmonize Trailing and Nursery Processes across CGIAR/NARES breeding network for efficiency and effectiveness.

Team

Gustavo Teixeira: Process Owner

Theresa Heitman: Process Consultant

Sara Johnson: Process Consultant

Alick Mulenga: Process Steward (IITA)

Prasad Peteti: Process Steward (IITA – cassava)

Princess Dela Cruz: Process Steward (IRRI)

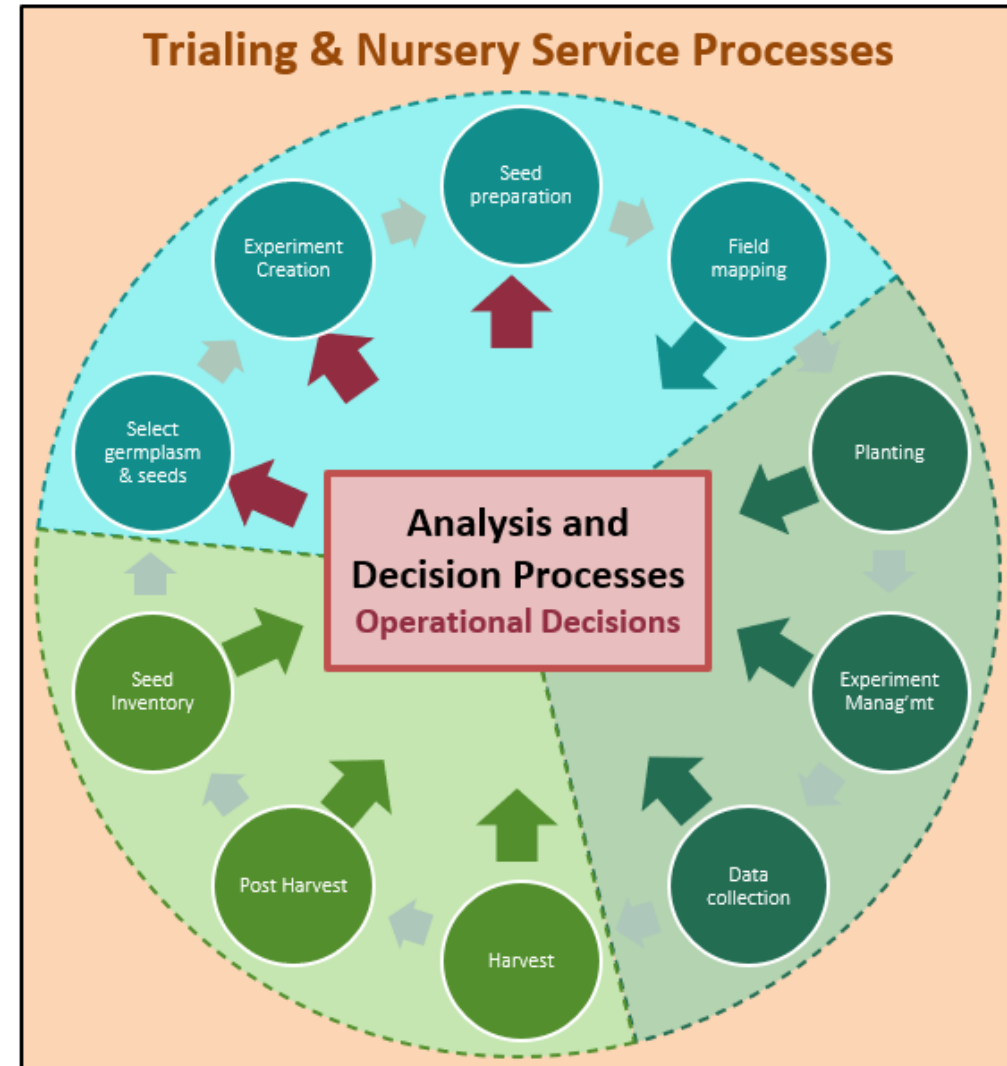
Carolina St. Pierre: Process Steward (CIMMYT – Wheat)

Safaa Kumari: Process Steward (ICARDA – Wheat)

Marcela Pineda: Process Steward (CIAT – Rice)

Sandra Salazar: Process Steward (CIAT – Cassava)

Shailesh Yadav: Process Steward (Africa – Rice)



Trialing and Nursery Service processes Team

- **Vision**

To have a standardized process across the CGIAR centers in the trialing and nursery process that can help maintain a constant flow of information and improve breeding programs.

- **Objectives**

1. Establish the breeding operational teams to define and implement T&N processes/services.
2. Establish structured ways of working to ensure collaboration across CGIAR/NARS T&N processes.
3. Identify and standardize the processes carried out in Trialing & Nursery.
4. Establish Key Performance Indicators for T&N.
5. Define the capabilities needed and implement the capacity development plan for T&N.
6. Improve & standardize CGIAR/NARS phenotyping platform (including data collection).

- **SIPOC** – In process

- **SOPs** – Next step

Trialing and Nursery Service processes Team

Trialing and Nursery SIPOC

<u>S</u> Supplier	<u>I</u> Inputs	<u>P</u> Process	<u>O</u> Output	<u>C</u> Customer
Breeders Purchasing Field Team	Breeder requests/selection Facilities for crossing Field plots Supplies Field Management	Germplasm development Hybridization/crossing/RGA	Germplasm to test Data - performance, costs Phenotypic data	Breeder Germplasm Production Team Seed Processing Team
Field Team Germplasm Development Team Management Team	Germplasm to test Field Equipment Field Management Quality and quantity requirements Budget Planning/schedules	Germplasm production Seed multiplication/br	Requested Seed Amount Quality Seed Phenotypic Data Costs Metrics	Germplasm distribution team Seed Processing Team Management Team
Germplasm production team NARES Seed Health Labs Seed Shipment Team	Data, seed demand, Phenotyping Seed Health Information Shipping Requirements	Germplasm distribution Material logistics/seed	Breeder Seed On time delivery	Seed Companies, NARES CG Centers

It's still in draft

Tools

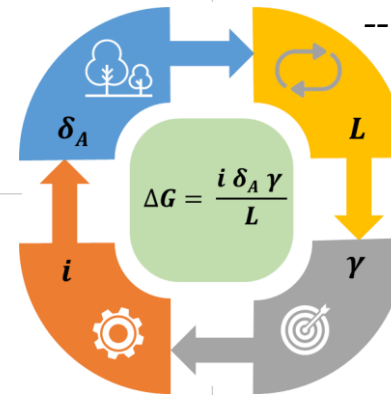


Genetic Diversity

- Variation profiling
- Genome, Pangenome & diversity
- Hybrid Breeding
-- *Selfing*

Duration of Selection Cycle

- **Early flowering**
- Genomewide Prediction
-- *Mate and parent selection*



Intensity

- GeoRadar for yield
- QualitySpec for WAB
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Accuracy

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Cassava Flower-inducing Technology



Morante, Nelson

N.Morante@cgiar.org

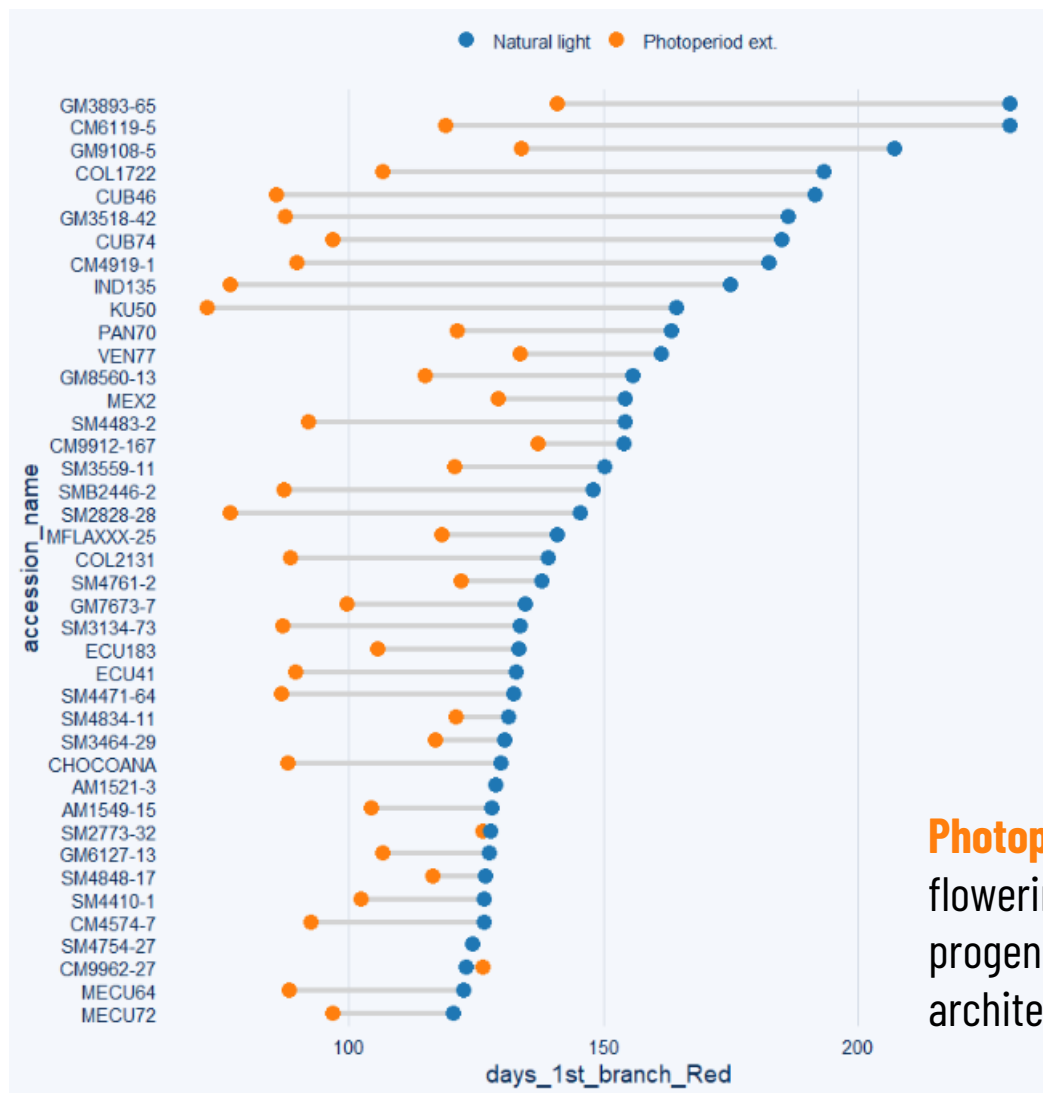
30 years of experience at CIAT

- Lead the cassava pollination team
- Manage F₁ populations and pedigree database
- In charge of germplasm sharing

Flowering Induction

	Traditional System	Flowering Induction (Red light + Pruning + Growth regulators)
Plant age at first branching	6 Months	4 Months
Branching level for Start Pollinations	2 - 3 Level	1 Level
Plant age Start Pollinations	7 - 8 Months	5 Months
Crossing Cycle Duration	6-7 months	1 Month
fruit maturation	3 Months	3 Months
Flower maturation time per inflorescence	1 Day	20 - 30 Days
Number of female flowers per inflorescence	3 - 5	More than 50
area per plant	2 M2	1 M2
Total cycle duration until obtaining hybrid seed	18 Months	10 Months

Flower Inducing Technology



Photoperiod Extension induced early flowering by **2-3 months** for progenitors with erect plant architecture.



NEXTGEN
CASSAVA



Alliance
Bioversity & CIAT



CGIAR

Reaction to Pruning



**Little Reaction to Pruning
(1)**



**Intermediate Reaction to Pruning
(3)**



**Good Reaction to Pruning
(5)**

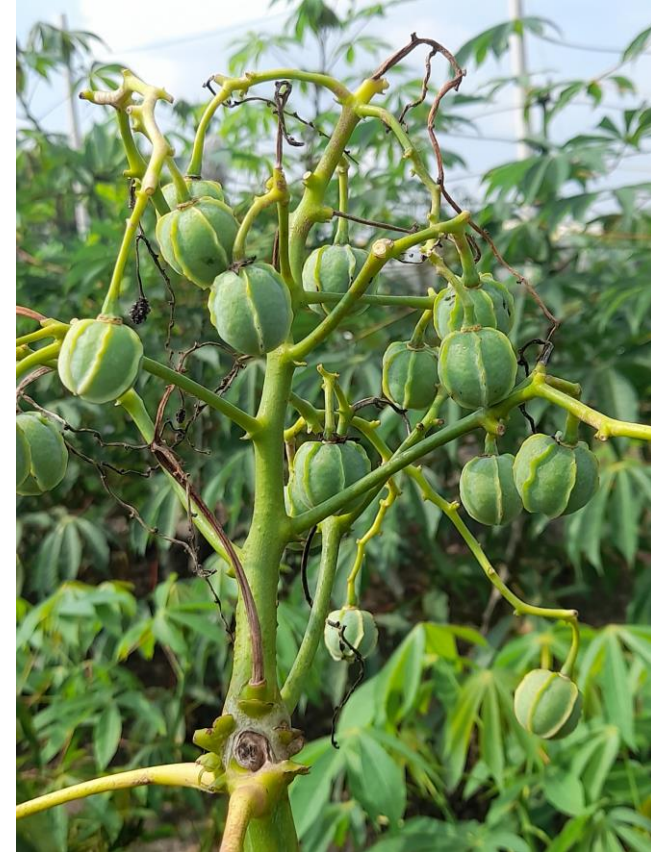
Reaction to the Application of Growth Regulators - BA



BA, cytokinin benzyladenine

**Little Reaction to BA Application
(1)**

Reaction to the Application of Growth Regulators - BA



Intermediate Reaction to BA Application (3)

Reaction to the Application of Growth Regulators - BA



**Good Reaction to BA Application
(5)**

Flowering Induction - Activity summary



Activity	Quantity
Combinations between parents	2273
Number pollinated flowers (Feb. 9/23)	34907
Expected seeds	~25.000
Average pollinated flowers per inflorescence	15.26
Maximum number of pollinated flowers in 1 inflorescence	203
Minimum number pollinated flowers in 1 inflorescence	1

Tools

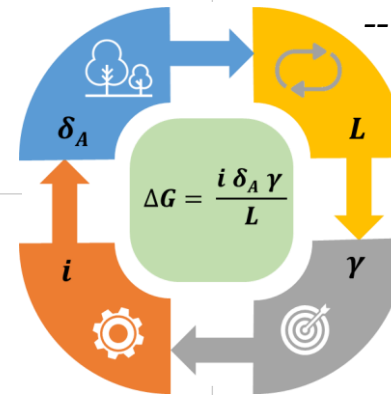


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Data Management



Pino Duran, Lizbeth

l.pino@cgiar.org

10 years of experience at CIAT

- Lead breeding data management
- Monitor trialing status

Cassavabase – 2022 as an example

CASSAVABASE Search Manage Analyze Maps About Lists

Search Wizard

Don't see your data?

Breeding Programs

Search

Select All 1/25 Clear

- + 5CP
- + BTI
- + CARI
- + CH
- + CNRA
- **CIAT**

Match ANY MIN ALL

Years

Search

Select All 1/42 Clear

- + 2018
- + 2019
- + 2020
- + 2021
- + 2023
- **2022**

Match ANY MIN ALL

Trials

2022

Select All 99/103 Clear

- 202242BCF1C_stom
- 202243BCF1C_ciat
- 202244BCMUL_ciat
- 202245BCMUL_ciat
- 202246CQQU1_ciat

Match ANY MIN ALL

Plots

Search

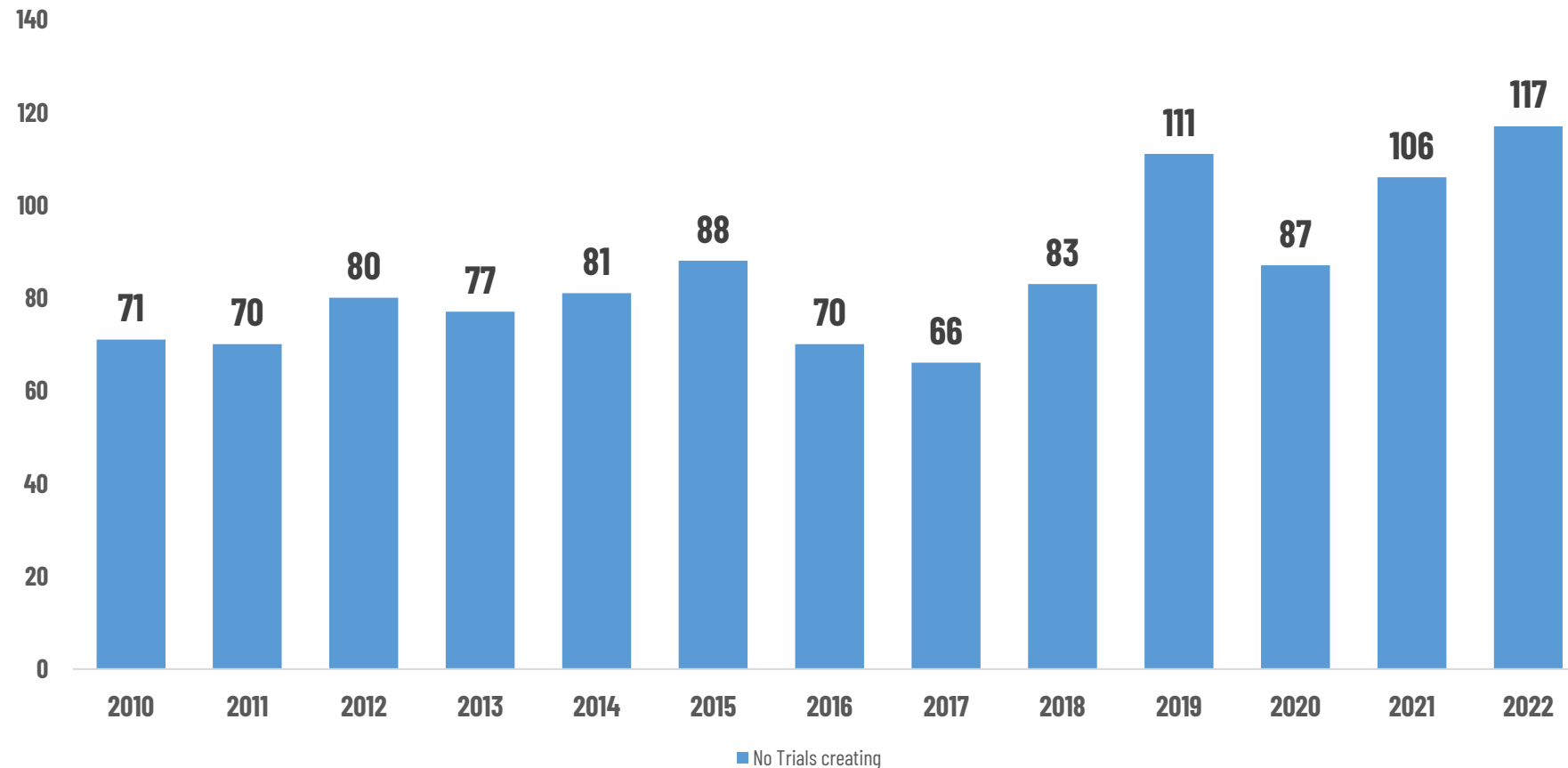
Select All 0/25391 Clear

- + 202201BCMUL_ciat_rep1_GM373
- + 202201BCMUL_ciat_rep1_GM373
- + 202201BCMUL_ciat_rep1_GM373
- + 202201BCMUL_ciat_rep1_GM373
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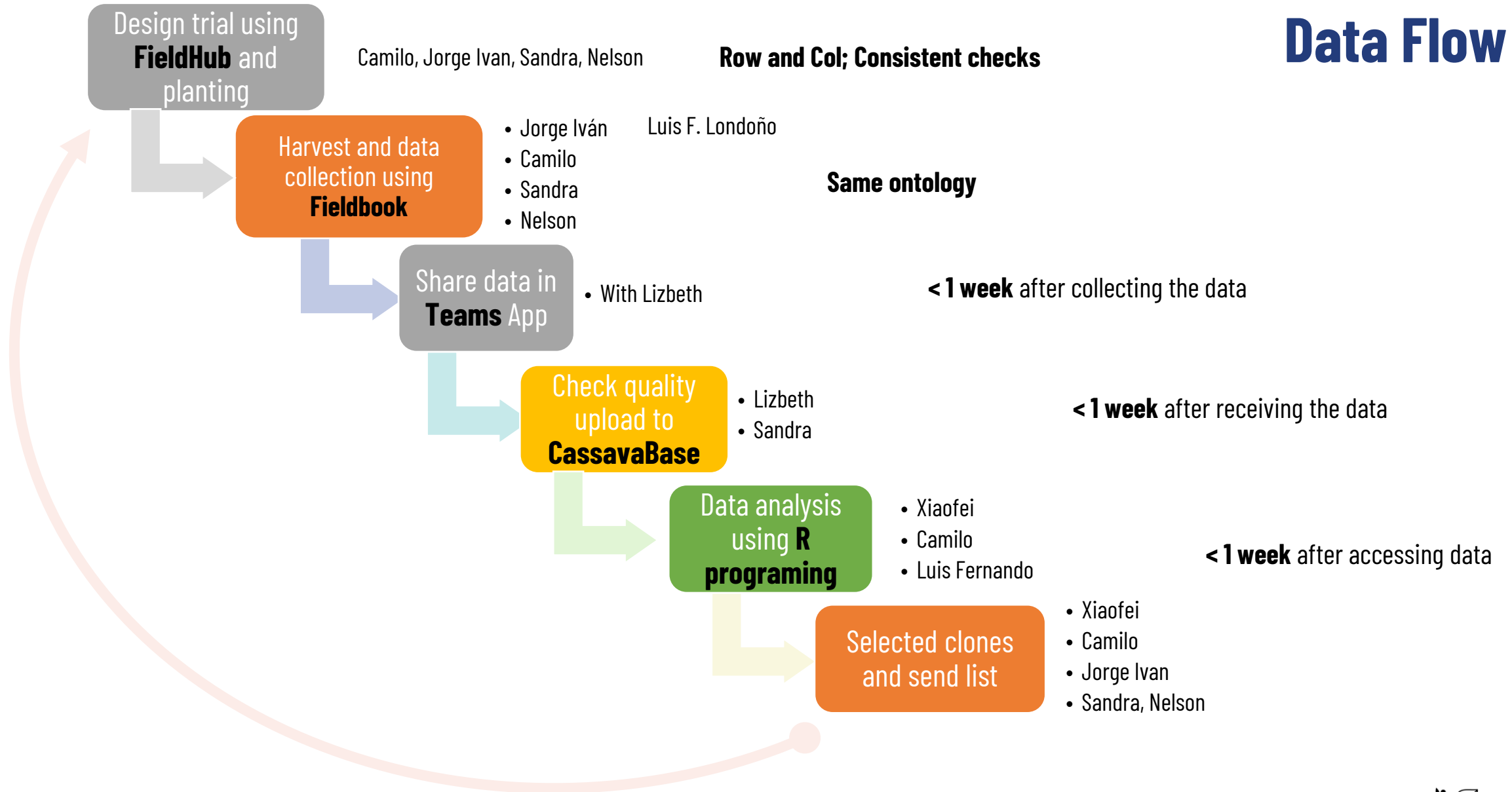
In total, **25,391** plots.

Cassavabase

Trials in Cassavabase, 2010-2022



Data Flow



Scaling -- Workshop on Cassava Trial Operation

TIME	TOPIC and ACTIVITY	RESPONSIBLE	GOAL
8:00 - 9:00	Trial design - Field Hub	Sandra Salazar & Camilo Vargas	All team members can run FieldHub to design a trial
9:00- 10:00	Cassava Ontology - Traits	Sandra Salazar	All team members agree on the ontology and use the ontology in practice.
10:00 - 10:15	Coffee Break		
10:15 - 11:00	Fieldbook demo and practice	Lizbeth Pino	All team member know how to import, collect, and export data, and all use the same .trt file.
11:00 - 12:00	Data flow demo Use one example to show the data management process, from trial design, receiving data, quality check, uploading to CassavaBase.	Lizbeth Pino & Sandra Salazar	All team members understand and agree on the data flow and share data on time
12:00 - 13:00	Lunch		
13:00-15:00	Field trip: 1) show the trial design of GxE and DVGST trials (30min) 2) practice Fieldbook - collecting data (30 min) 3) discuss ontology (30 min) 4) flower inducing (30 min)	Lizbeth Pino, Sandra Salazar, Camilo Vargas & Nelson Morante	Have practice view of trail design, Fieldbook, and ontology.

Next Step

1. **Curate historical data** including Genebank accessions.
2. **Genotypic** data management in CassavaBase
3. **NIRS** spectra, wet chemistry data, and prediction data
4. Train **NARES** for using CassavaBase and Fieldbook
5. Discuss how can **other teams** use CassavaBase

Tools

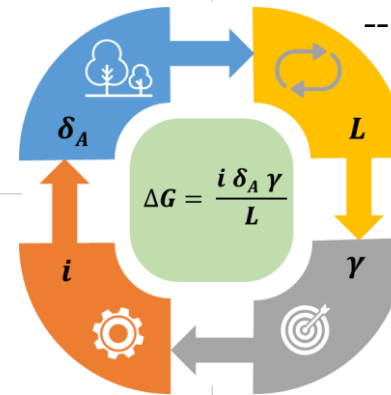


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Data Analysis



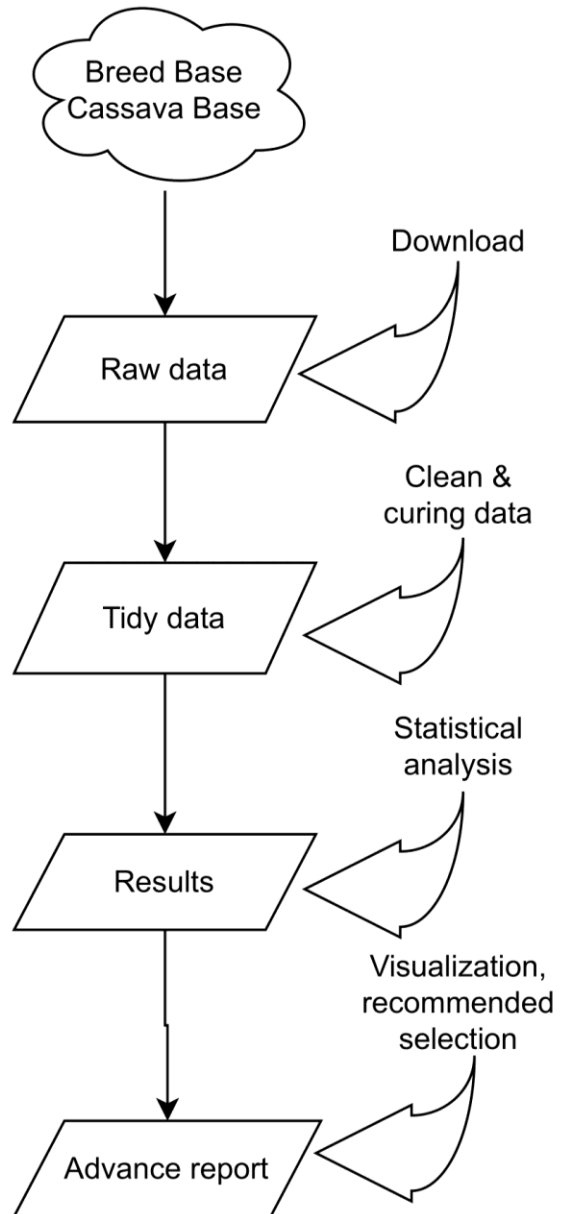
Delgado Munoz, Luis Fernando

Luis.Delgado@cgiar.org

7 months of experience at CIAT

- Lead breeding data analysis and training
- Manage GitHub, Cassava2050

Data analysis steps



Tools

QBMS, Cassava Base



Manually, R script

R script, Mr. Bean app.



R Markdown

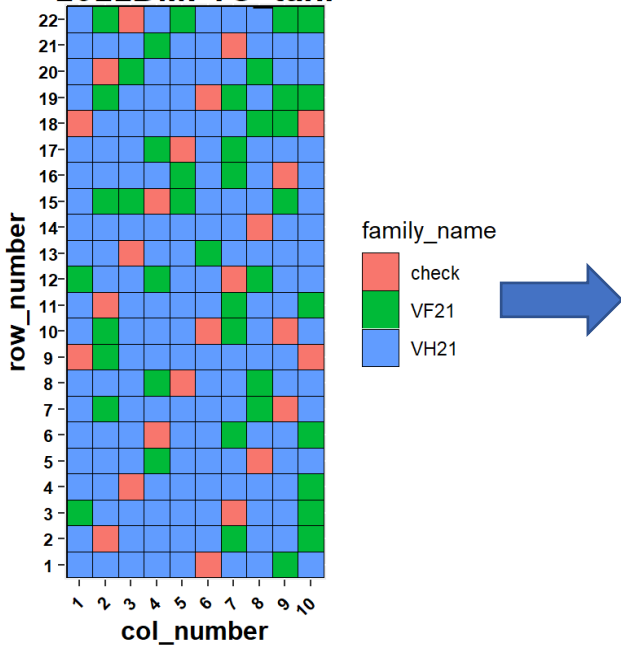
Within-location design of plant breeding trials

	STG 1	STG 2	STG 3	STG 4	STG 5	# Locations
Augmented design	1					1
P-rep design		1.2				1.2
RCBD / alpha-lattice			2			2
RCBD / alpha-lattice				2 - 3		2 - 3
RCBD / alpha-lattice					2 - 3	2 - 3

Replications / location

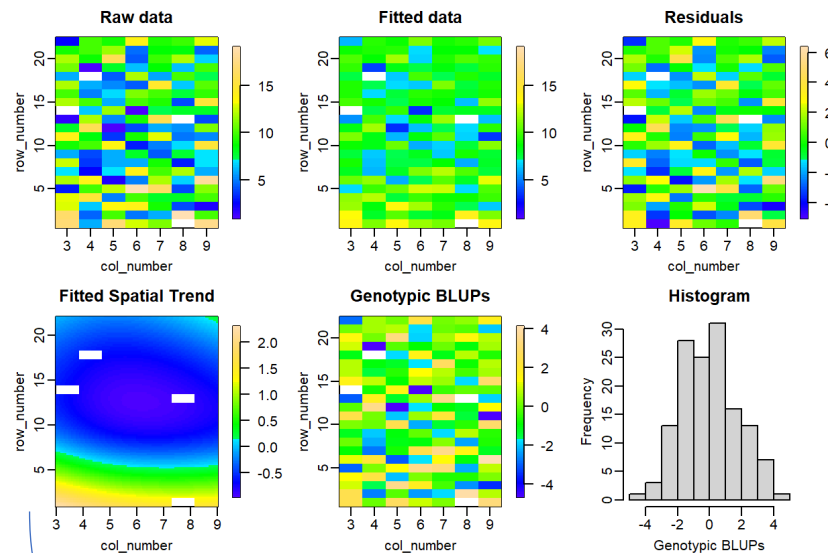
Augmented designs are used in early-generation trial

2022DMF1C *tani*

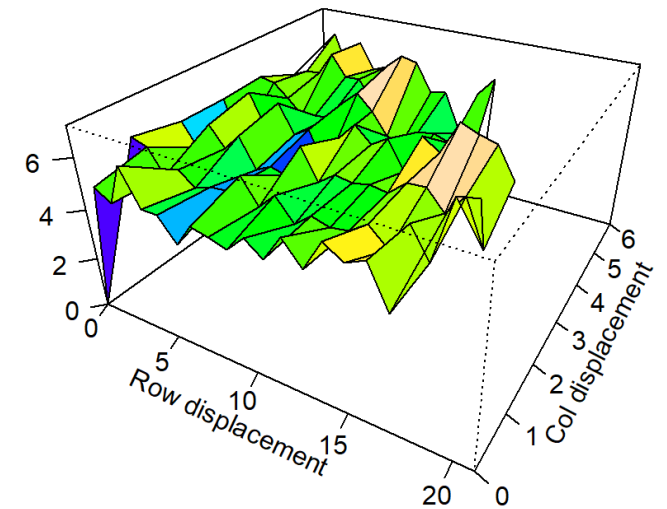


Augmented Trial layout

Trait: Root_Weight

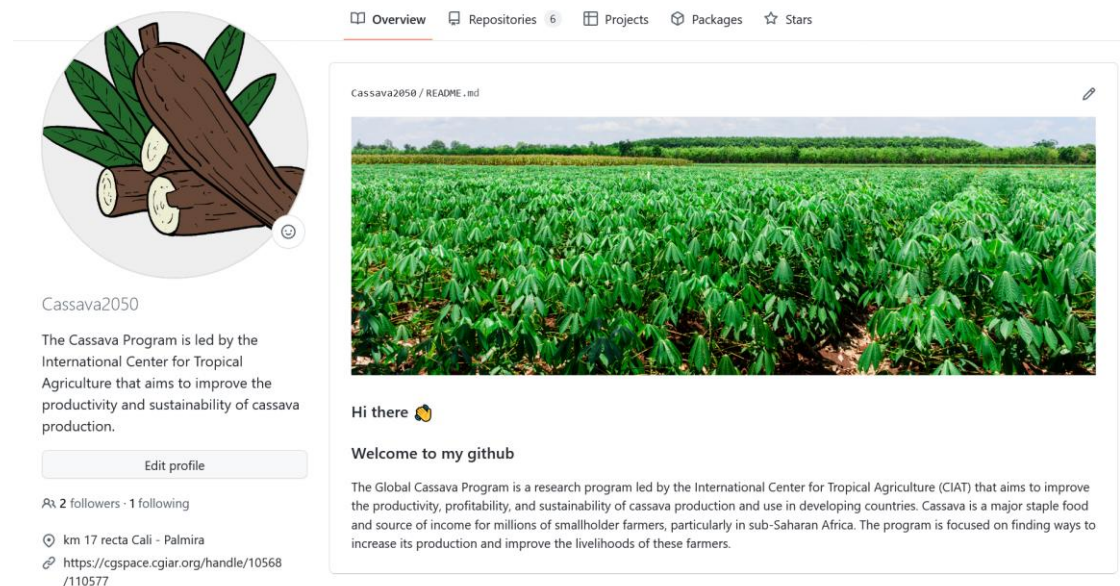


Spatial correction analysis



Achievements

- Pipeline of **augmented** trials data analysis (p rep , augmented)
- Pipeline of **replicated** trials data analysis (RCBD, Row col)
- Manage all data analysis projects through **GitHub** platform.

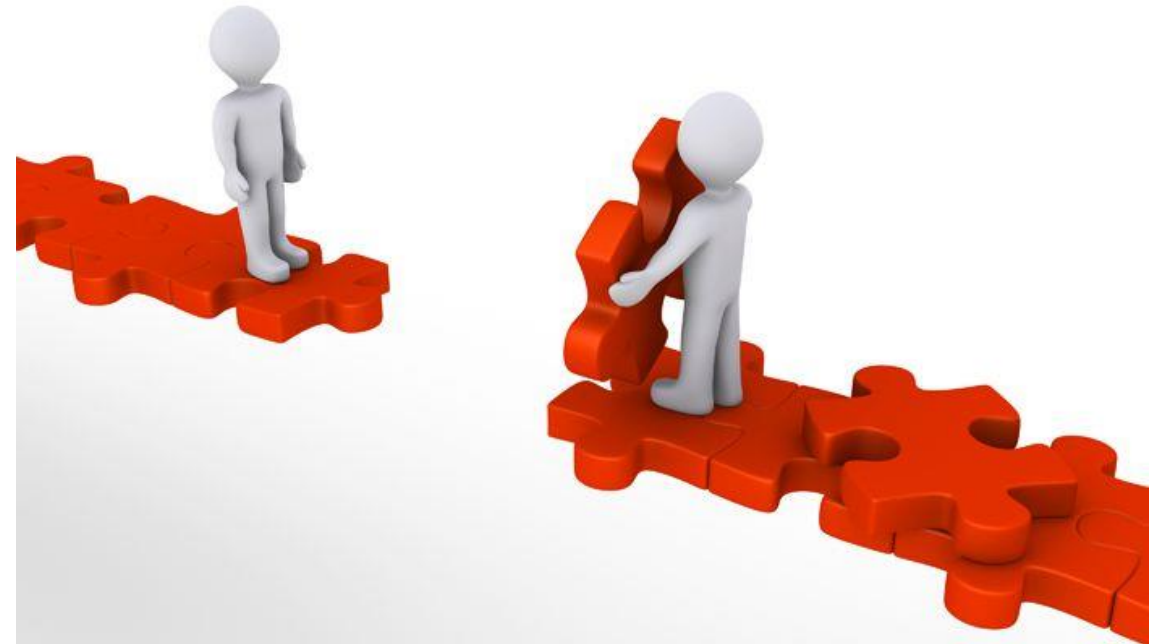


The screenshot shows a GitHub profile for 'Cassava2050'. The profile picture is a circular illustration of cassava roots and leaves. The bio states: 'The Cassava Program is led by the International Center for Tropical Agriculture that aims to improve the productivity and sustainability of cassava production.' Below the bio is an 'Edit profile' button. The profile has 2 followers and 1 following. The location is 'km 17 recta Cali - Palmira' and the website is 'https://cgspage.cgiar.org/handle/10568/110577'. The main content area shows a repository named 'Cassava2050 / README.md' with a large image of a cassava field. A message says 'Hi there 🍌' and 'Welcome to my github'. Below this is a paragraph: 'The Global Cassava Program is a research program led by the International Center for Tropical Agriculture (CIAT) that aims to improve the productivity, profitability, and sustainability of cassava production and use in developing countries. Cassava is a major staple food and source of income for millions of smallholder farmers, particularly in sub-Saharan Africa. The program is focused on finding ways to increase its production and improve the livelihoods of these farmers.'

<https://github.com/Cassava2050>

Scaling and GAPS

- Develop data analysis packages or pipelines for **partners** in Asia and Africa.
- Implement desire gains-based **selection indices**.
- Test **mate selection**



Tools

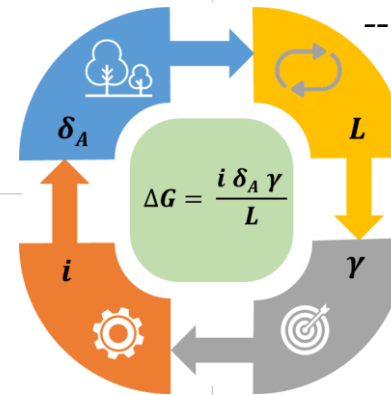


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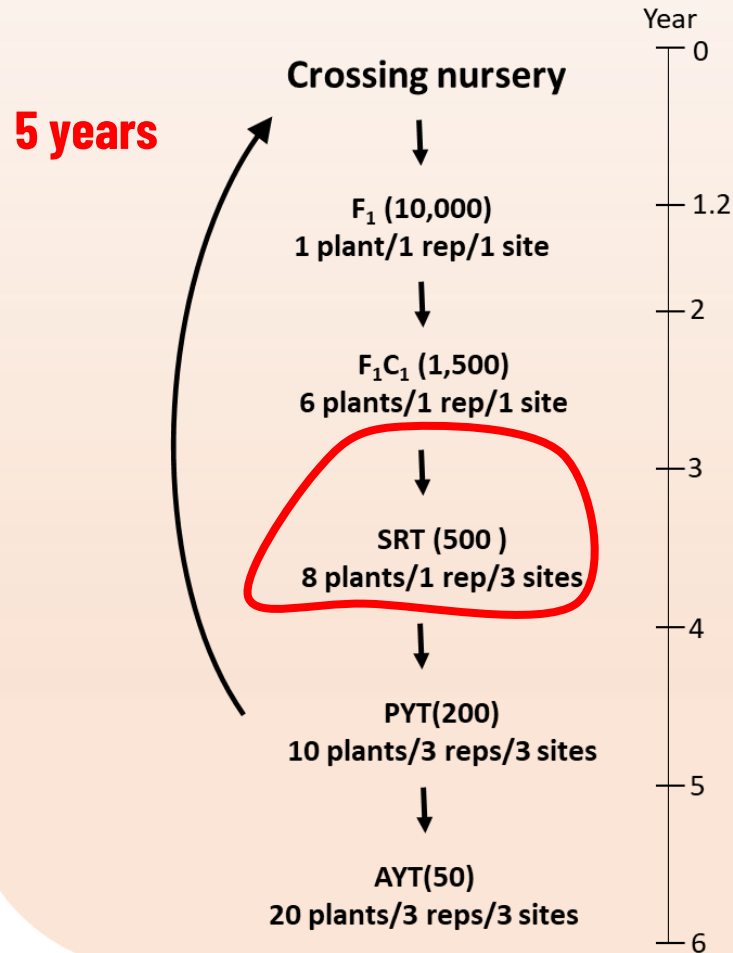
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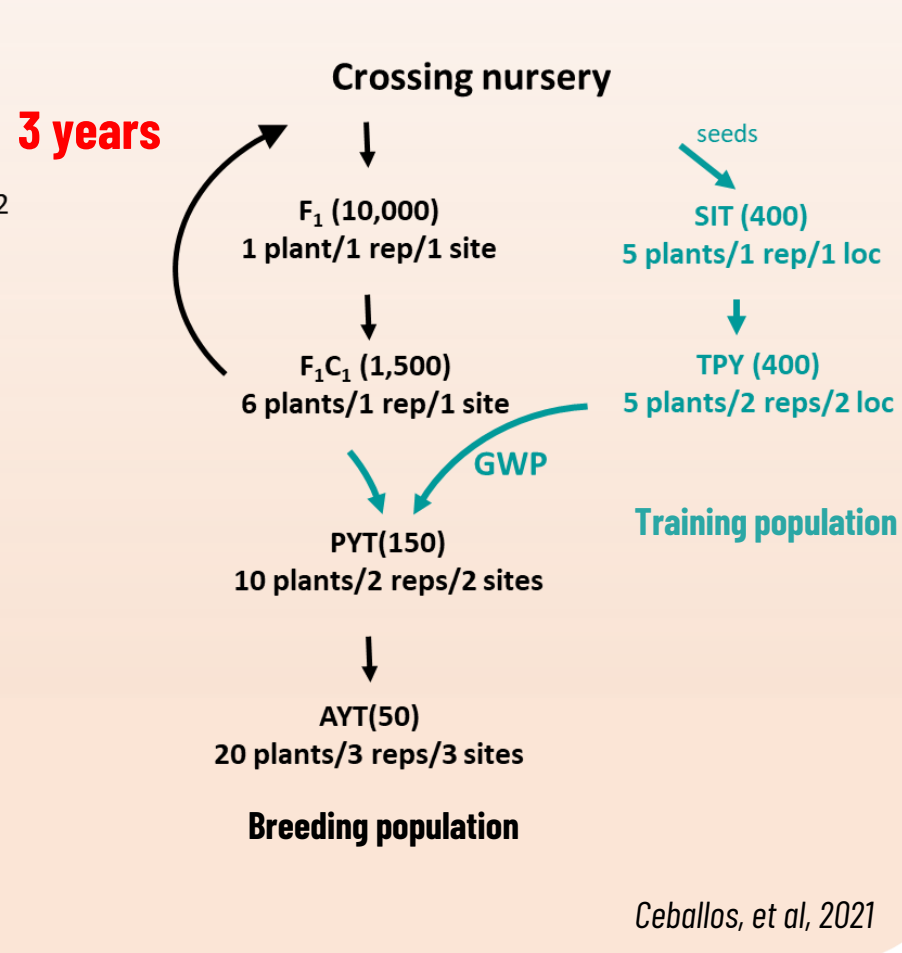
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Genomewide Prediction

Conventional Recurrent Selection



Genomewide Selection

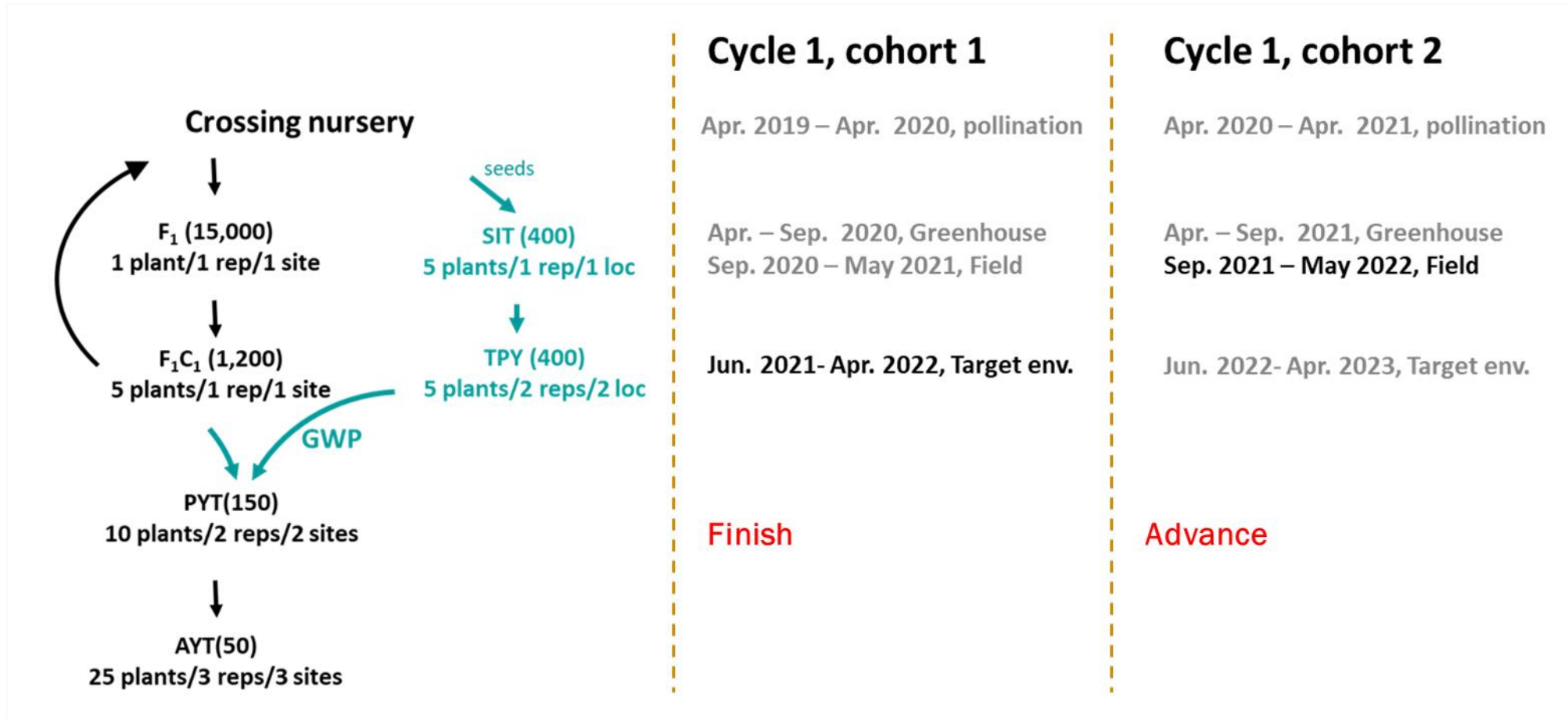


Ceballos, et al, 2021

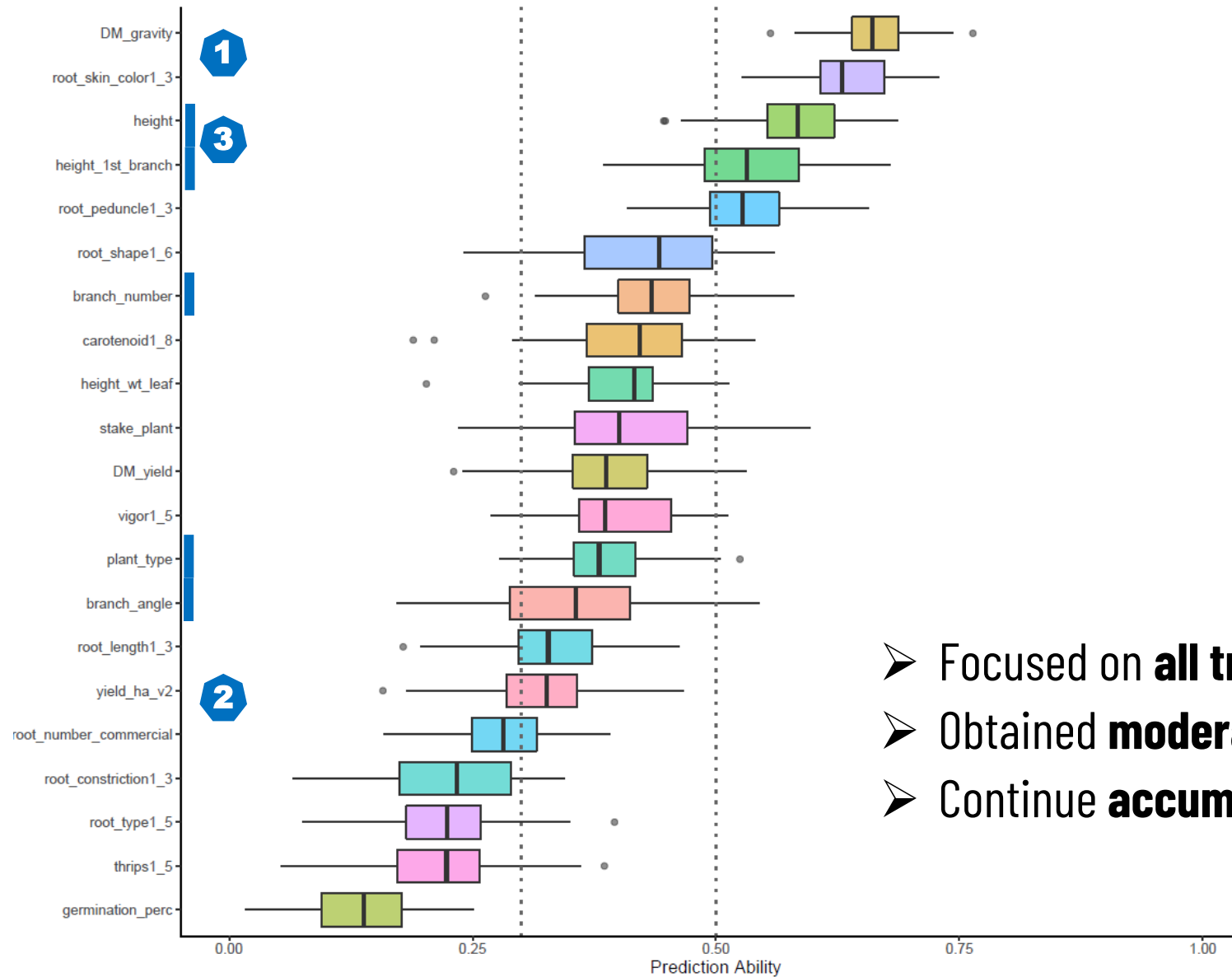
Cycle 1

	Cohort 1	Cohort 2	Cohort 3	Cohort 4	Cohort 5
2016	Cross				
2017	F1	Cross			
2018	F1C1	F1	Cross		
2019	CET	F1C1	F1	Cross	
2020	PYT	CET	F1C1	F1	Cross
2021	AYT	PYT	CET	F1C1	F1
2022	UYT	AYT	PYT	CET	F1C1

Genomewide Prediction

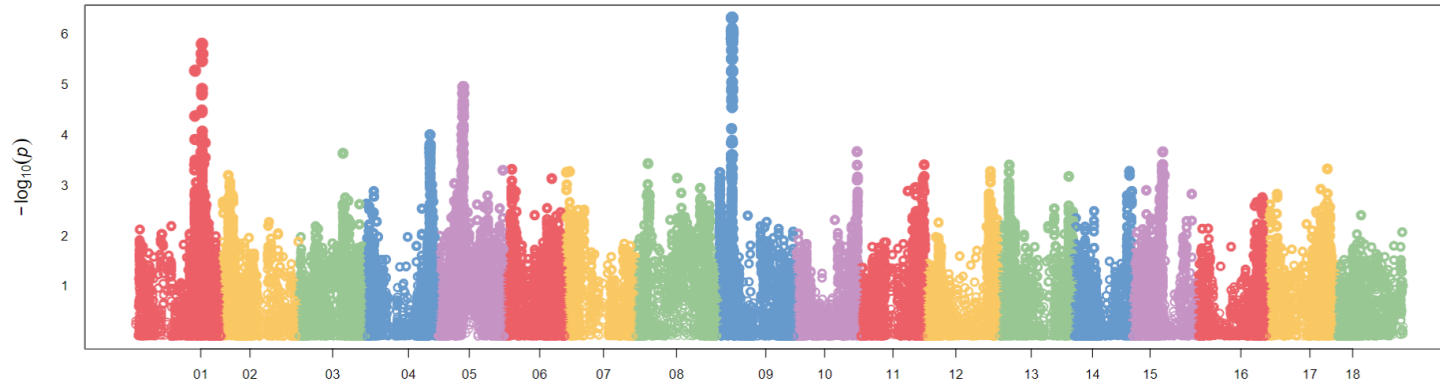


- Genomic selection **models**
- Improved **progenitors with CMD resistance**
- **Genetic architecture** of traits in product profile

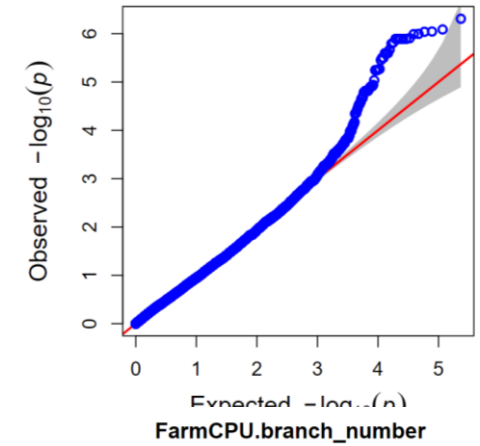


- Focused on **all traits** in product profiles
- Obtained **moderate to high** predictive ability
- Continue **accumulating** data of training populations

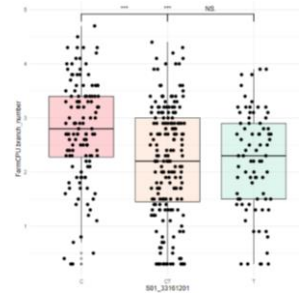
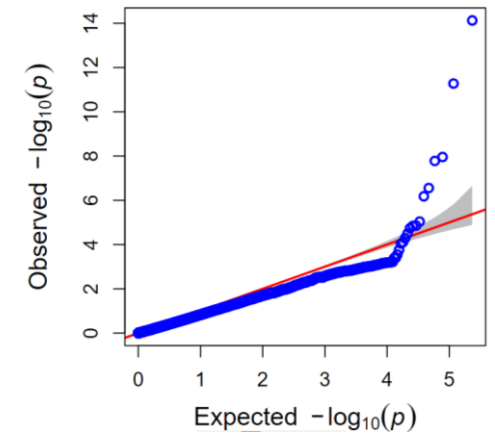
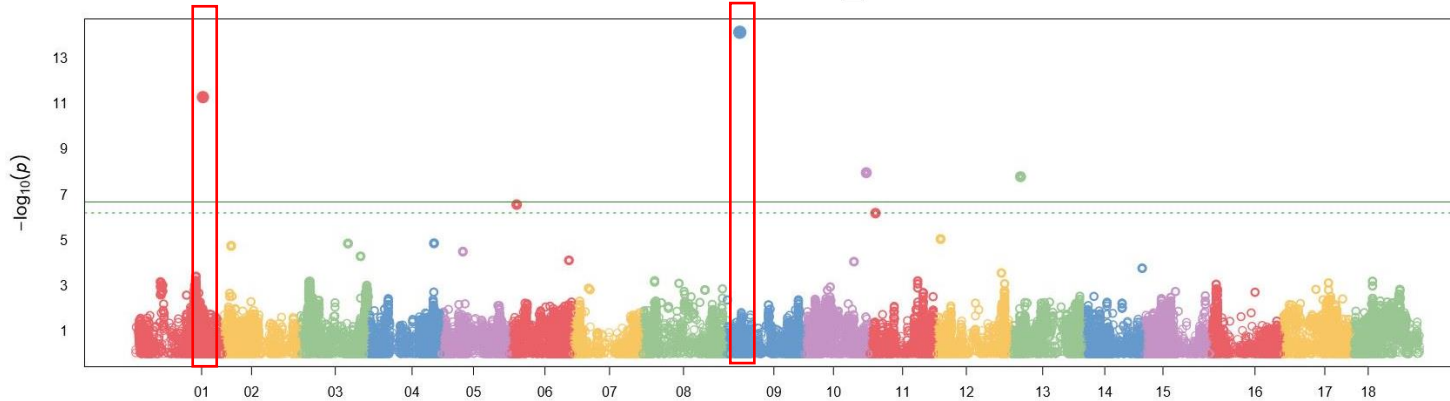
MLM.branch_number



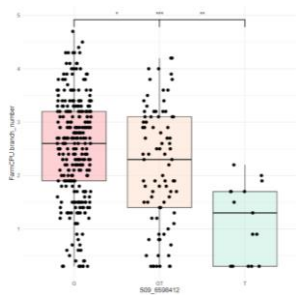
MLM.branch_number



FarmCPU.branch_number



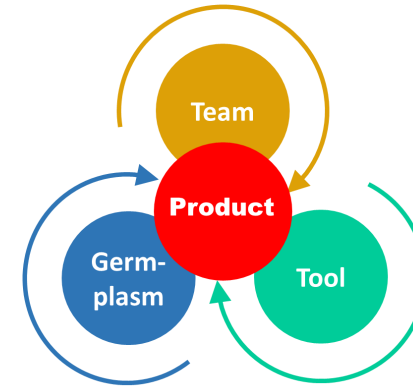
Favorable allele is dominant



Favorable allele is recessive, but might have high inbreeding depression.

Chr	Pos	P.value	MAF	Effect
1	33,161,201	5.29E-12	0.44	-0.45
9	6,598,412	7.46E-15	0.15	-0.66

By Barrera, Vianey Paola
V.Barrera@cgiar.org

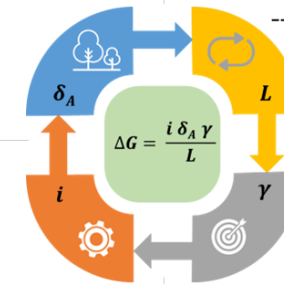


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Accuracy

- **CassavaBase for all traits**
- **GBLUP with one rep**
- Genetic gain-based desire selection Index
- **Operational Excellence (SOP)**
- **QC/QA**
- MAS
- **CMD**, CBSD, DM, carotenoid, HCN, WAB, sprouting, ID, flowering, mites, thrips, small granule, plant type