IITA
Transforming African Agriculture
CGIAR

Cassava Breeding at IITA:

A multi-stakeholder approach for Multiple stress resilience and market segments

Elizabeth Parkes, Kulakow Peter, Ismail Rabbi, Egesi Chiedozie, Ismail Kayondo, Gaby Mbanjo et al.

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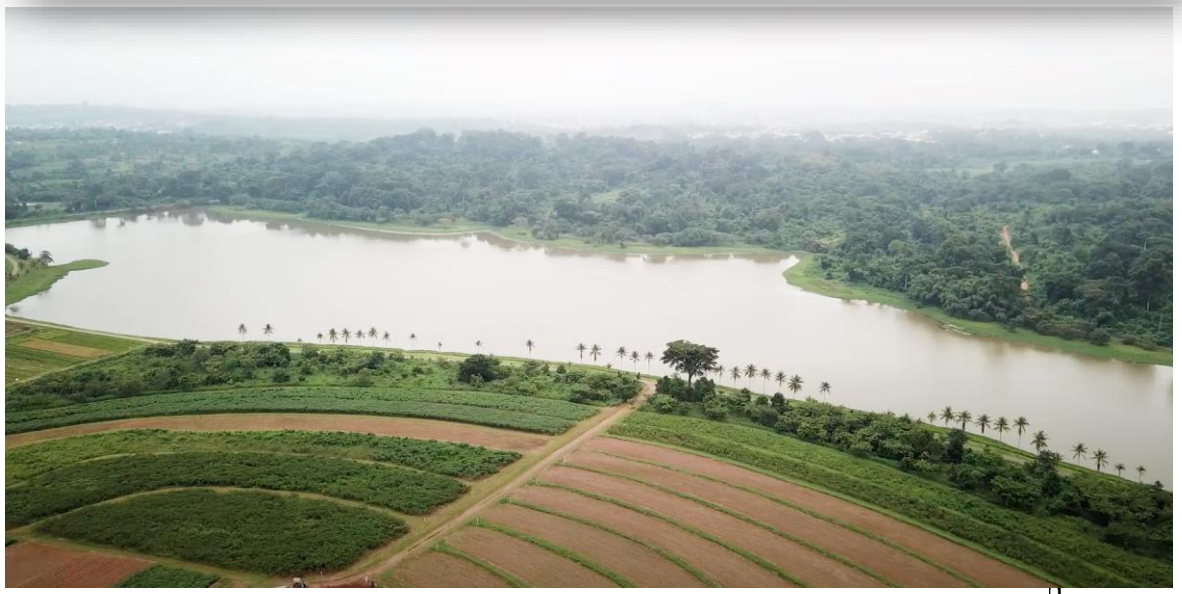
About IITA

- Non-profit agricultural research organization created in 1967
- We work with partners in Africa and beyond to:
  - **Reduce producer and consumer risks,**
  - **Enhance crop quality and productivity,**
  - **Generate wealth from agriculture.**
- IITA is one of the CGIAR centers headquartered in Ibadan.



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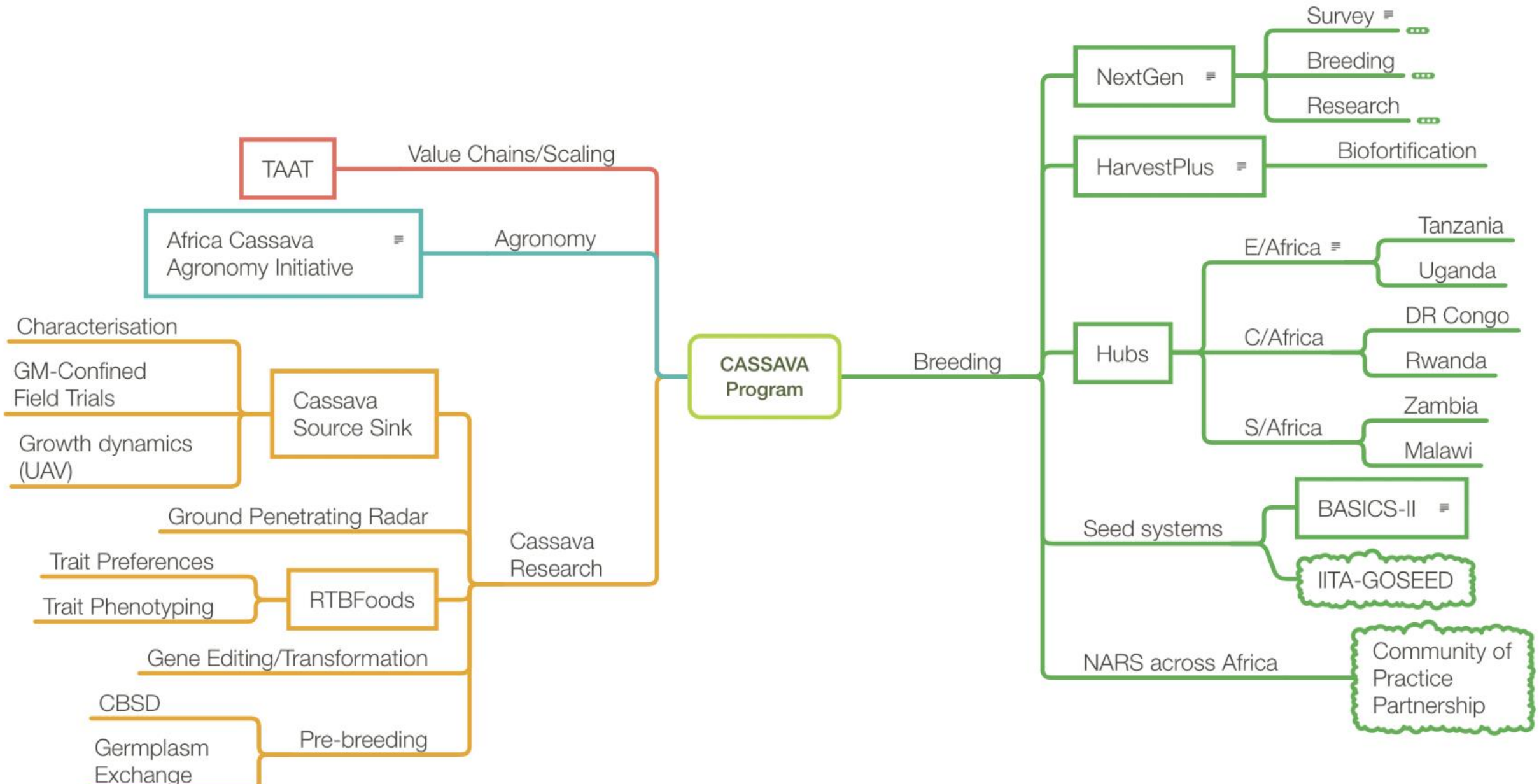
IITA's five Impact Areas ..

Cassava Research agenda for Africa



Who we work with ….

- West Africa (HQ)
- East Africa (Uganda, Tanzania)
- Central Africa (DR Congo)
- Southern Africa (Zambia, Malawi)
- CG-NARES network
  - Nigeria, Uganda, Tanzania, Ghana, DRC
  - Malawi, Zambia, Rwanda, Mozambique, Sierra Leone
  - Many others

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Accelerated Breeding

Cassava mosaic disease

30-90% loss

Cassava bacterial blight

100%

Cassava mealybug

30-90% loss

Cassava green mite

Cassava anthracnose

10-30% loss

Cassava root rot

50-100 %

Constraints

Opportunities for Research

The CBSD challenge

- Must have trait
- 70 – 100% loss annually
- Multiple CBSV strains emerging

Breeding targets Vs Market segments

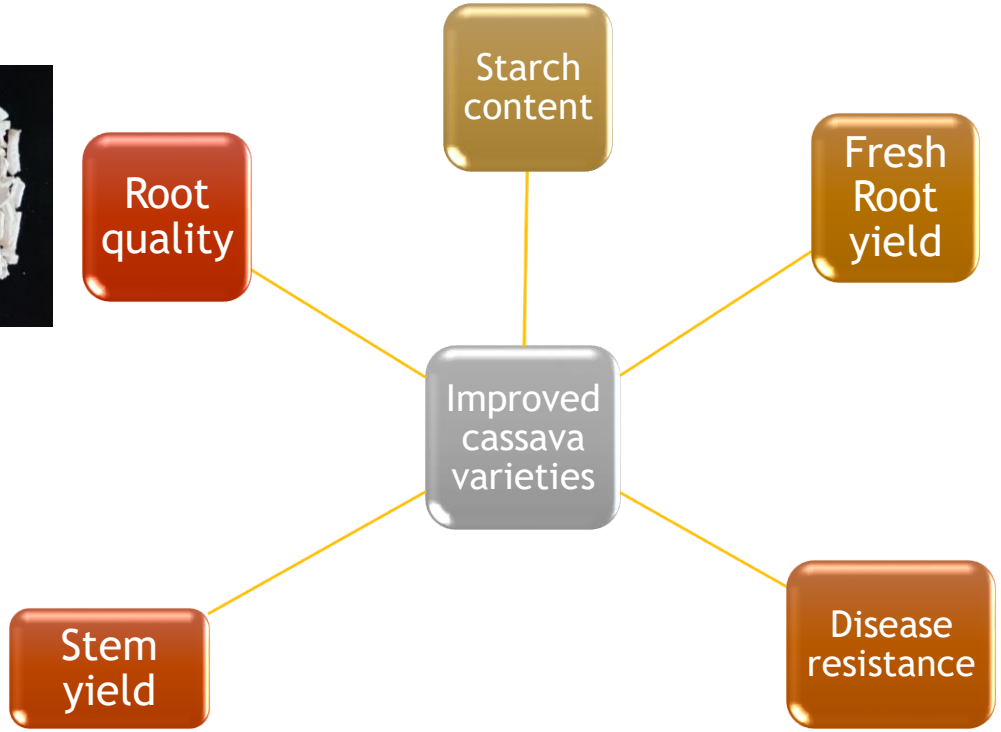
Starch content

High DMC

Fresh root yield

Good plant architecture

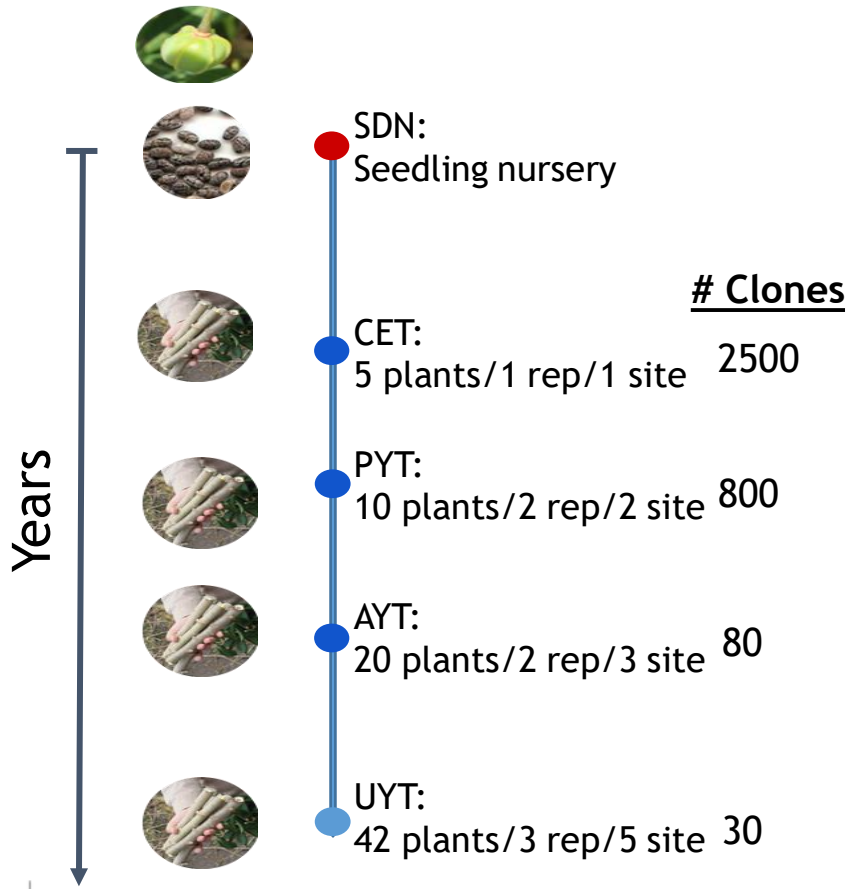
Resistance to major diseases and pests

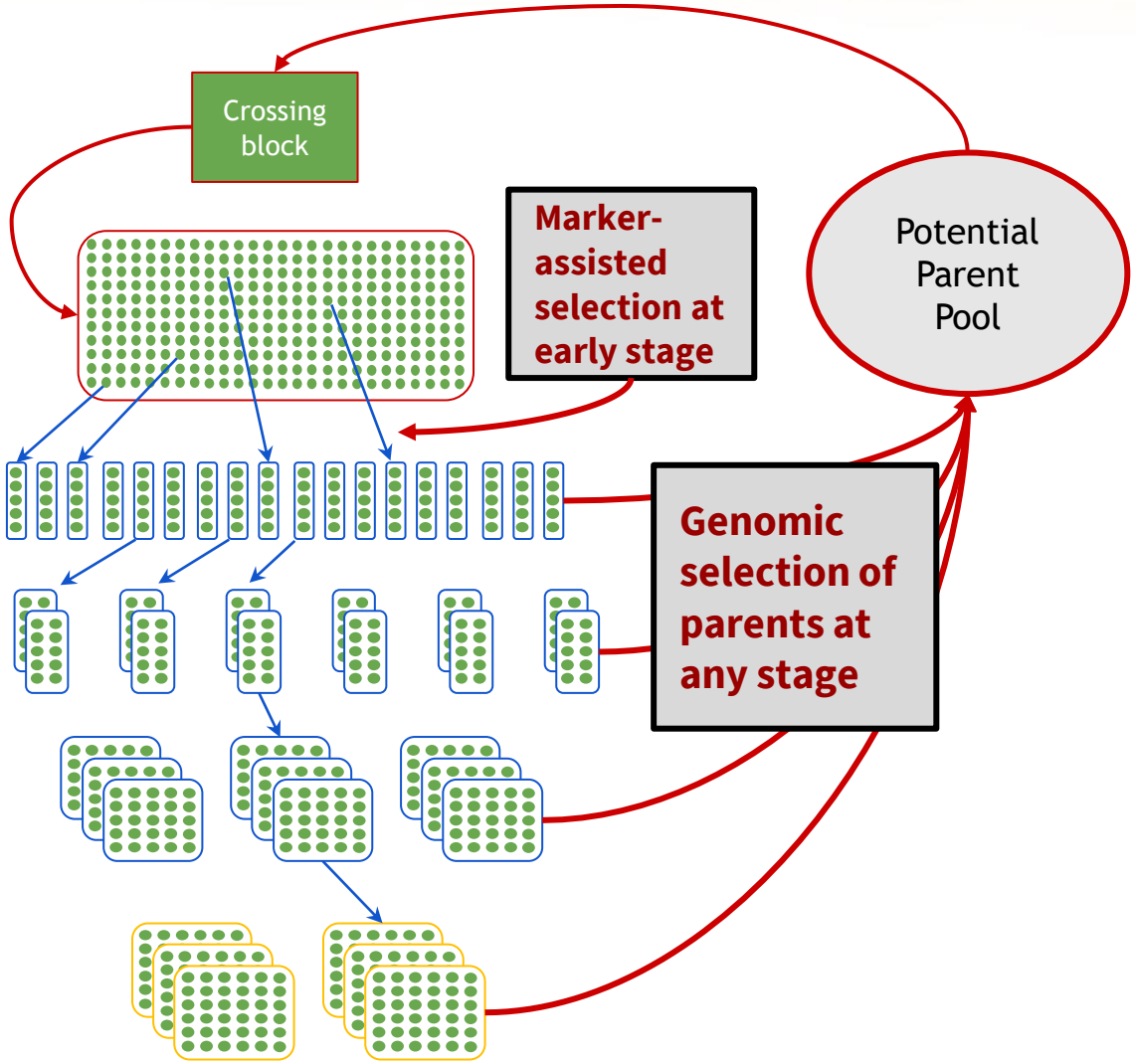


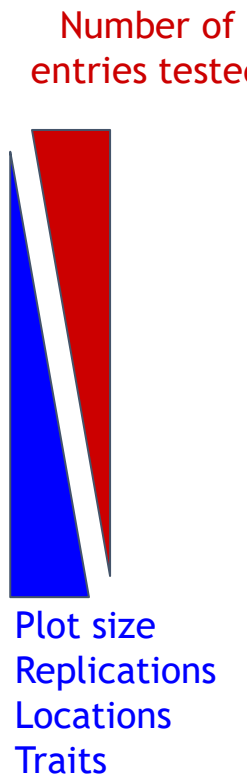
Market Segments and Target Product Profiles

SN	Product Pipeline Name	Traits for product profiles	Baseline traits	Current Breeding Pipeline	Product samples
1	**Processed** Products (Gari and fufu, HQCF)	High quantity and quality of processed product (% conversion rate, colour and texture)	Yield, dry matter, resilience to common biotic and abiotic stresses, flexible time of harvest	**West Africa (Nigeria)** **Central Africa (DRC)**	
2	Cassava for **Fresh Markets**	Root **mealiness** after boiling, Low cyanogenic potential, Sweet taste	Yield, dry matter, resilience to common biotic and abiotic stresses, flexible time of harvest	**East Africa (Uganda and Tanzania)** **Central Africa (DRC)** **Southern Africa (Zambia)** **West Africa (Nigeria, Ghana)**	
3	**Biofortified cassava** for enhanced nutrition	**ß-carotene**, suitability for gari and fufu products	Yield, dry matter, resilience to common biotic and abiotic stresses, flexible time of harvest	**West Africa (Nigeria)** **Central Africa (DRC)**	 
4	**Cassava for Industry**	**High starch** and flour content, **mechanizable** plant architecture.	Yield, dry matter, resilience to common biotic and abiotic stresses, flexible time of harvest	**West Africa (Nigeria)**	

Cassava Breeding scheme







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Cassava breeding stage gates - East Africa

Stages & Gates	Stage 0	Stage 1	Stage 2	Stage 3	Stage 4	Stage 5	Stage 6	Stage 7
Stage Title	**Product Design**	**Trait Discovery**	**Trait Deployment**	**Crossing & screening**	**Early Testing**	**Late Testing**	**Pre-commercial Testing and Product Registration**	**Product Introduction**
Description in Cassava context	Market research, Crop Strategy Review, Product Profile Review	Evaluation of germplasm sources, trait validation, inheritance and molecular discovery	Selection to elite adapted background including disease resistance and other required traits	Parent selection and production of new genetic variation for variety development	Clone development, small plot testing	Advanced clones in replicated multi-site	National Performance Trials and On-Farm trials	Official release and product launch
Duration		**1 to 5 years**	**1 to 5 years**	**2 years**	**1-2 years**	**3 years**	**2 years**	
Dimension		**# Trait Dev. Projects # pre-breeding populations**	**# new trait donors # new parent lines # recycled parents**	**100 families under 3 Product Profiles 5k seedlings**	**900 clones**	**120 clones**	**2-4 candidates**	**3 varieties on market** (increasing-, peak-, declining sales)
Pipeline Process	Market Research & Forecast CG and NARS Mission Objectives Technical Pipeline Strategy	Develop trait Pre-breeding and population improvement A B New trait donor development New parental lines Select parents from Stage 2,4-6	PxP	F1	Clonal eval. Prelim . YT Prelim . YT	Adv YT	Uniform YT National Performance trials	*Range Management*
Stage Gate Decisions		**Crop strategy & Product Profile Agreement**	**Define Trait development strategy**	**Define combinations**	**Select St 2 Clones**	**Select St 3 Clones**	**St 4 PAM**	**St 5 PAM**
Team that decides		**Full CF Team + Funders**	**Ismail Kayondo + NaCRRI + TARI Breeding Services teams**	**Ismail Kayondo + NaCRRI + TARI Market (trait parameters)**	**Breeders**	**Limited CF Team**	**Almost full CF Team**	**Full CF Team**

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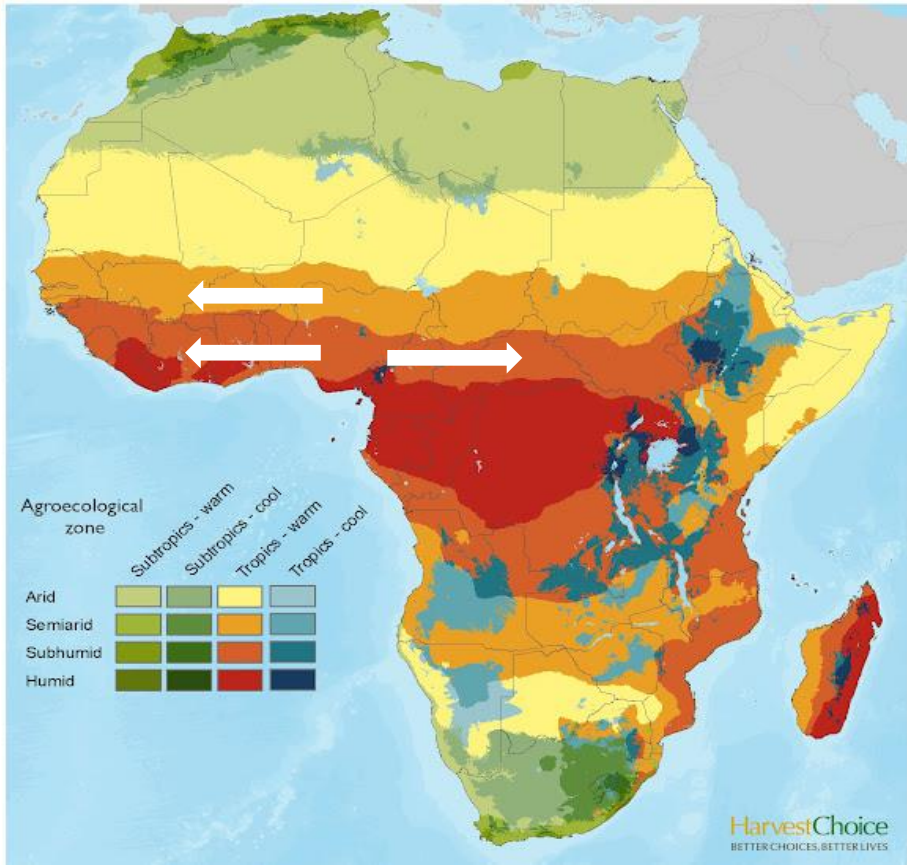
Delivering Cassava Varieties for Impact .....



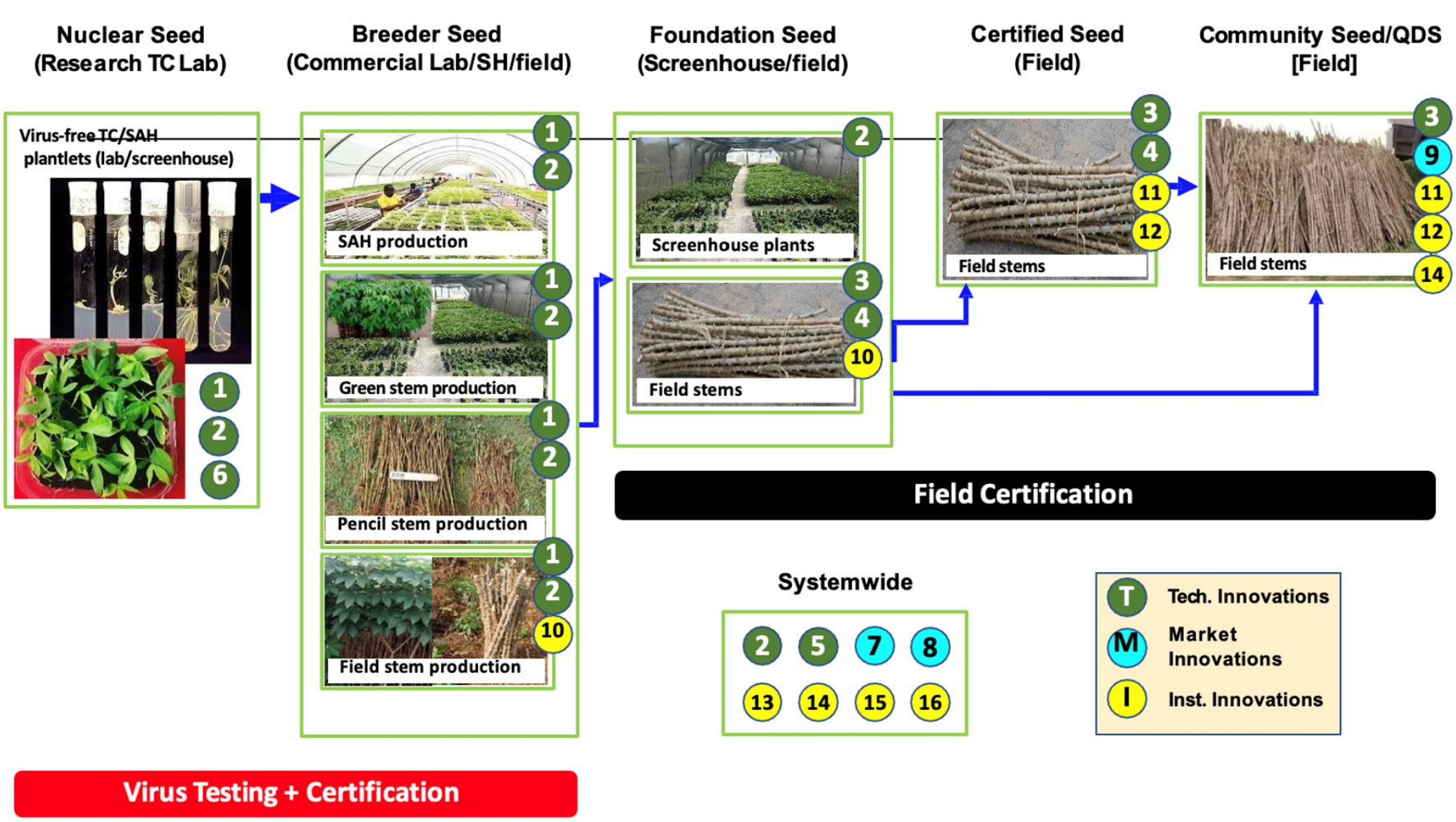
Released GS Varieties: Deployment

Design –Incomplete block
Large plot utilizing trial targeting at 500kg root to feed factory

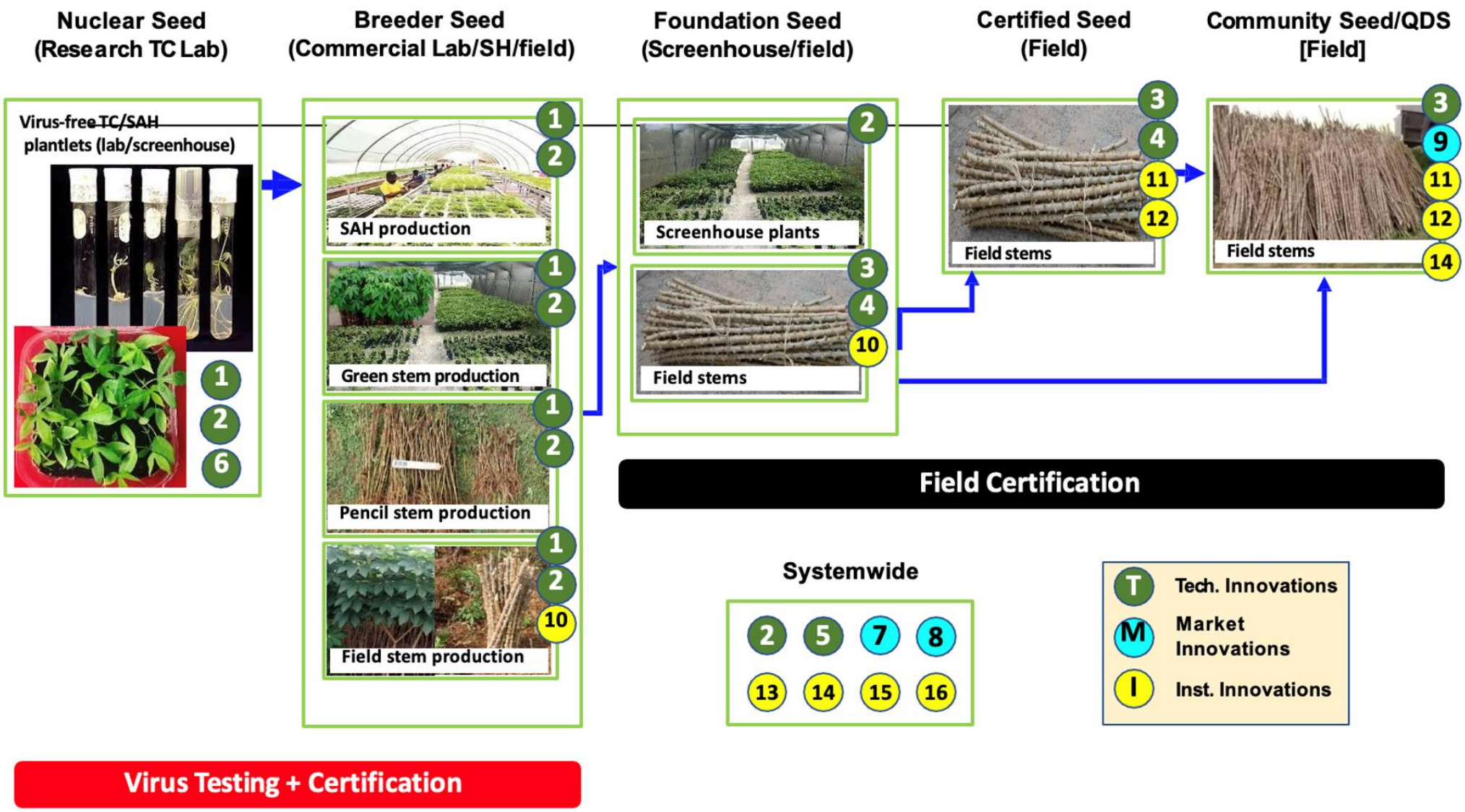
Cassava Varieties Released

Farmer name	Year of release	Yield (t/ha)	Dry matter (%)	Root colour	Resistant to:	Provitamin A (µg g^{-1})	Market segment
GAME CHANGER	2020	31.40	39.3	White	CMD, CAD, CM, CGM and CBB	-	Highly suitable for Gari, Fufu and High-Quality Cassava Flour (HQCF)
OBASANJO-2	2020	30.90	37.5	White	CMD, CAD, CM, CGM, and CBB	-	Highly suitable for Gari, Fufu, and HQCF
HOPE	2020	32.10	30.1	White	CMD, CAD and CM	-	Highly suitable for Gari, Fufu and HQCF
BABA-70	2020	30.00	34.1	White	CMD, CAD, CM CGM and, CBB	-	Highly suitable for Gari, Fufu and HQCF
POUNDABLE	2020	32.00	38.0	White	CMD, CAD, CM CGM and, CBB	-	Highly poundable, best for fresh consumption, and highly mealy
HEADMASTER	2022	35.97	35.3	Yellow	CMD, CAD and CM	16.86	Best for Gari and highly suitable for HQCF
SECURITY	2022	30.22	33.3	Yellow	CMD, CAD, CM CGM and, CBB	15.58	Best for Fufu and highly suitable for HQCF
NO-HUNGER	2022	29.78	30.6	Yellow	CMD, CAD, CM CGM and, CBB	15.65	Highly suitable for gari and HQCF

Cassava Seed Systems



Cassava Seed Systems Innovation Research



Breeding modernization and continuous improvement

Breeding Program Efficiency

- Global level strategies
- Program level strategies
- Protocols and methods

Change Management

- Organizing
- Enabling
- Managing change

Governance for Customer-Centricity

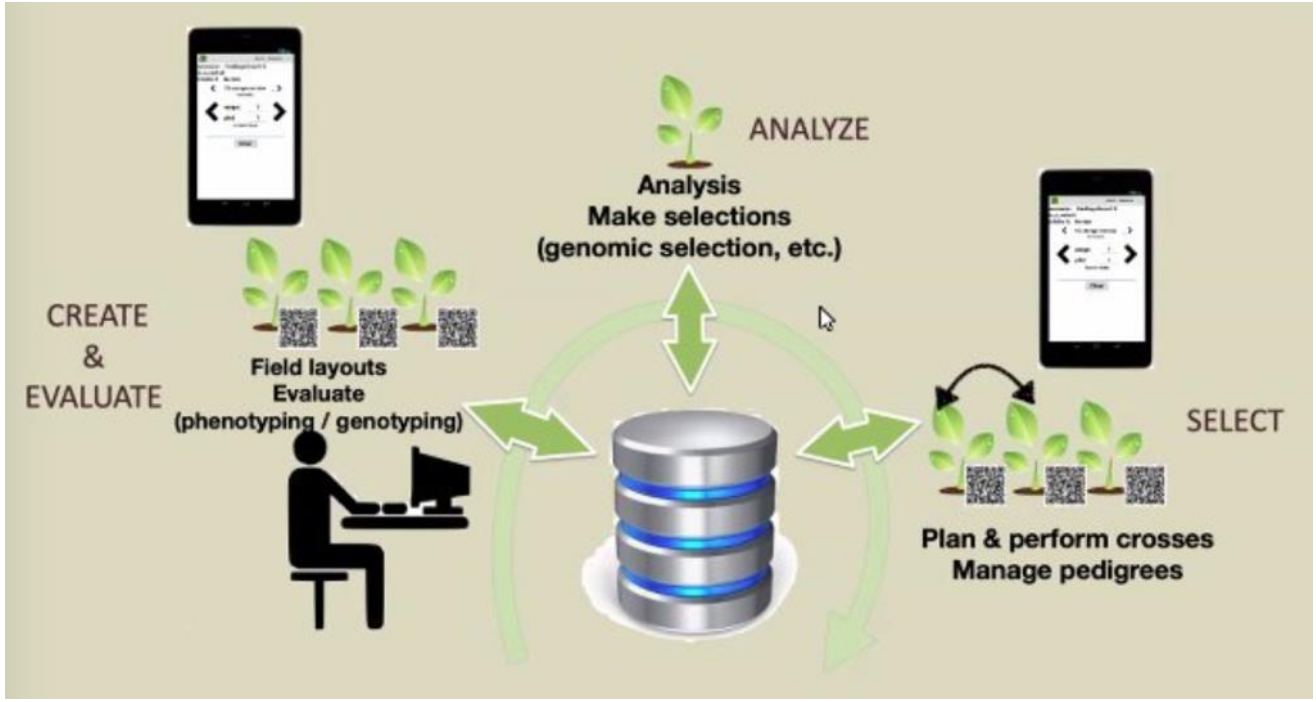
- The environment
- Strategic capability
- Expectations and purposes

Cassava's Path to Continuous Improvement

- Measuring Genetic Gain on-farm
- Improving phenotypic data collection and management
- Tracking Operational costs and resource allocation
- Integrating best practices & protocols (operational excellence)
- Product Pipeline & Advancement Process (Stakeholder inclusive)

Open source database and digitization

- ✓ Fully Open access
- ✓ Data Quality Enhanced
- ✓ Trial Creation, Evaluation, analysis and Selection
- ✓ All data and analysis maintainied in central location



CASSAVABASE

https://cassavabase.org/

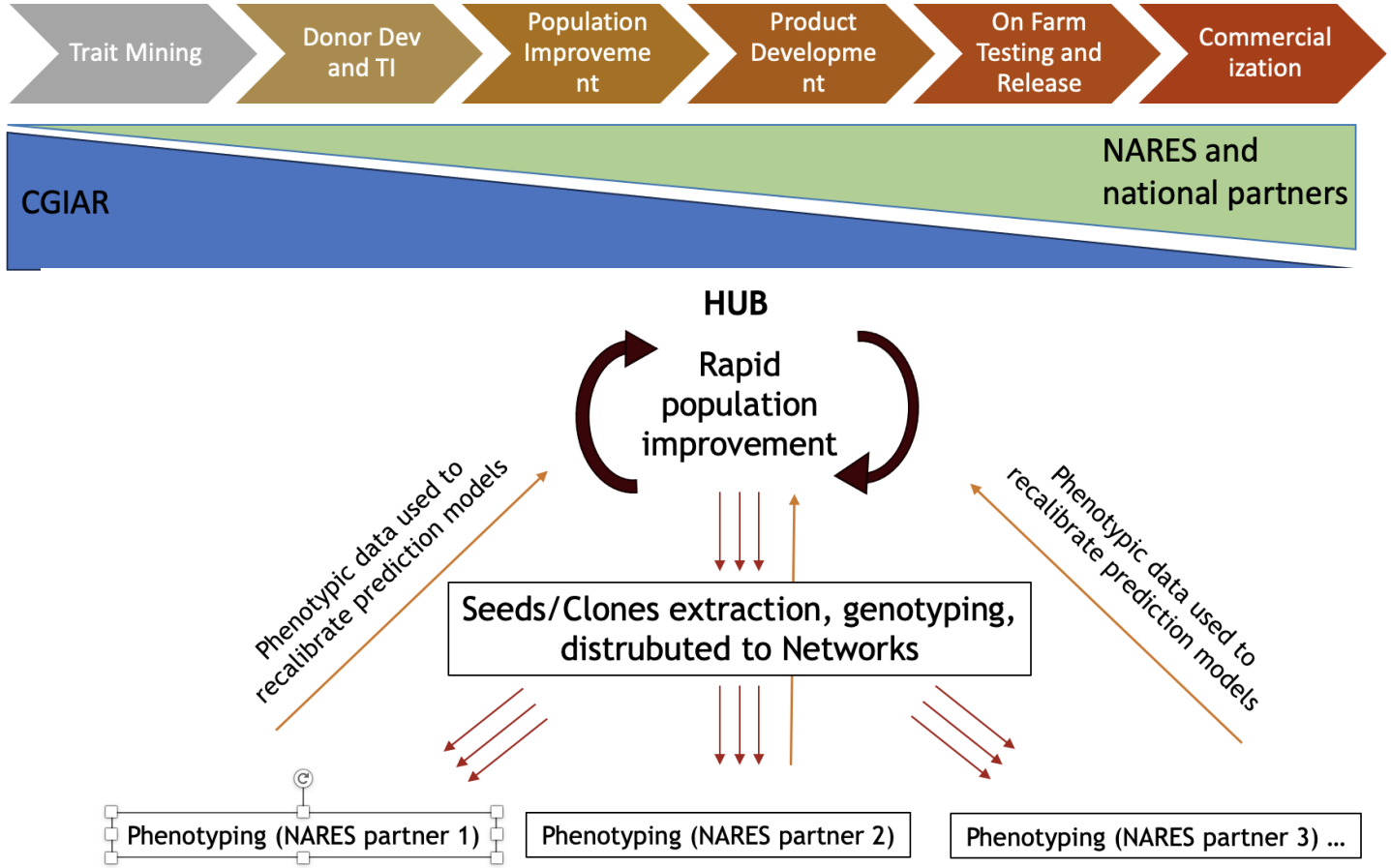
Cassavabase stats

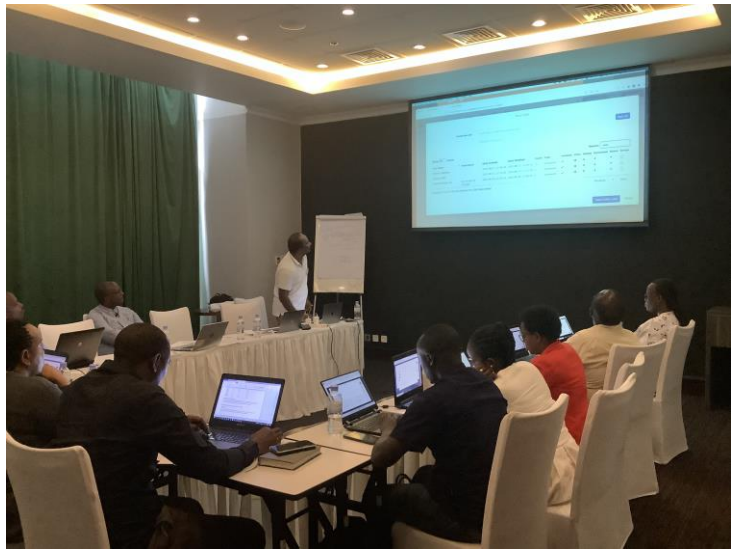
(as of June 2023)

- 25 Breeding programs
- 645K Accessions
- 6091 Phenotyping Trials
- 477 Phenotyping traits
- 53K Genotypes
- 828 Genotyping plates
- 21.8M Phenotypes
- 1485K plots
- 523 locations
- 60 K images

2020-19.GS.C2.UYT.36.setA.AB-rep1-TMS14F1223P0007_101
Pedigree:TMS13F1106P0006/TMS13F1108P0007
Stock:TMS14F1223P0007 rep:1 block:1 plot:101

Partnerships: CG-NARS network





Marker Development and Deployment

Marker Validation

SNP Marker Discovery

GWAS or QTL

Data Analysis & KASPar Marker development

Breeding validation

Technical Validation

Biological Validation

Deployment for MAS

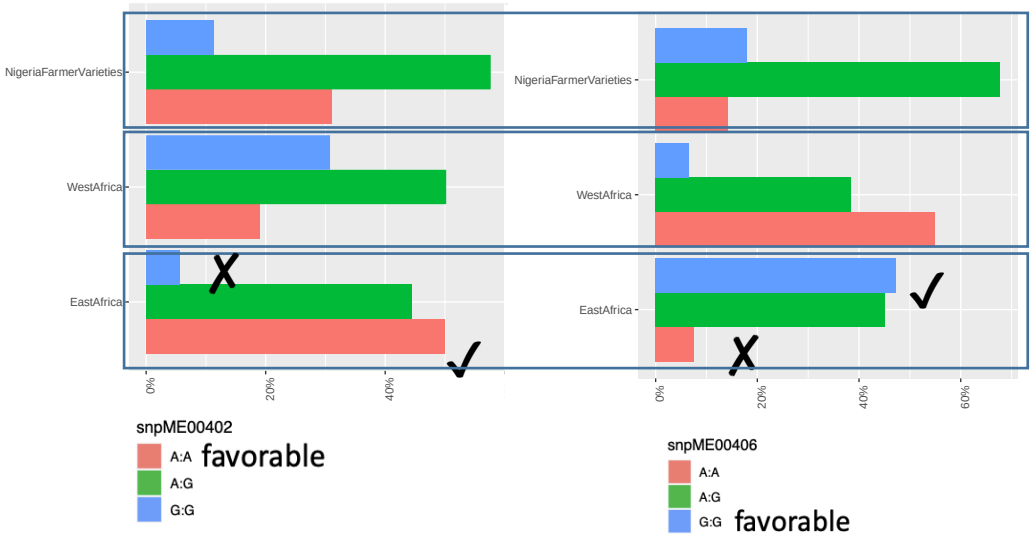
Current status:

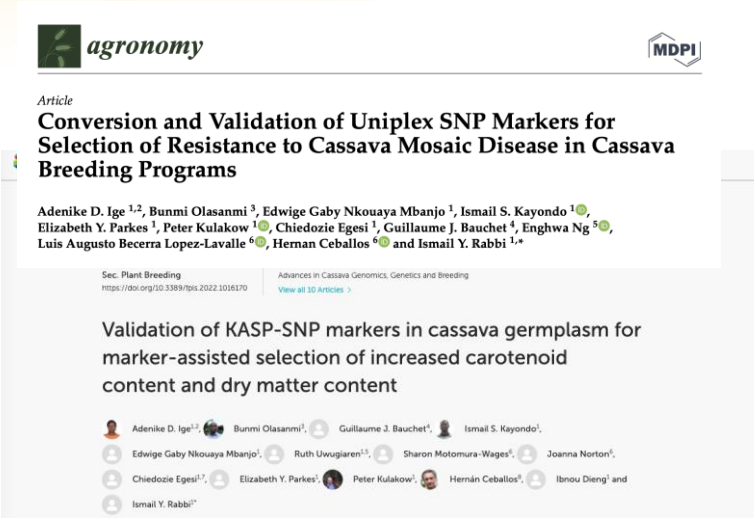
☑ Validation of CMD markers (chrs 12 and 14)

☑ Validation of DMC & PVA content markers (chrs 14 and 16)

☑ Validation of cyanide content markers (chrs 14 and 16) – East Africa

☑ **CBSD markers under development**




agronomy

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Article

Conversion and Validation of Uniplex SNP Markers for Selection of Resistance to Cassava Mosaic Disease in Cassava Breeding Programs

Adenike D. Ige [1,2], Bunmi Olasanmi [3], Edwige Gaby Nkouaya Mbanjo [1], Ismail S. Kayondo [1], Elizabeth Y. Parkes [1], Peter Kulakow [1], Chiedozie Egesi [1], Guillaume J. Bauchet [4], Enghwa Ng [5], Luis Augusto Becerra Lopez-Lavalle [6], Hernan Ceballos [6] and Ismail Y. Rabbi [1,*]

Sec. Plant Breeding

https://doi.org/10.3389/fpls.2022.1016170

Advances in Cassava Genomics, Genetics and Breeding

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Validation of KASP-SNP markers in cassava germplasm for marker-assisted selection of increased carotenoid content and dry matter content

Adenike D. Ige, Bunmi Olasanmi, Guillaume J. Bauchet, Ismail S. Kayondo, Edwige Gaby Nkouaya Mbanjo, Ruth Uwugiaren, Sharon Motomura-Wages, Joanna Norton, Chiedozie Egesi, Elizabeth Y. Parkes, Peter Kulakow, Hernán Ceballos, Ibnou Dieng and Ismail Y. Rabbi


the plant journal

SEB

The Plant Journal (2020)

doi: 10.1111/tpj.15071

Large-scale genome-wide association study, using historical data, identifies conserved genetic architecture of cyanogenic glucoside content in cassava (*Manihot esculenta* Crantz) root

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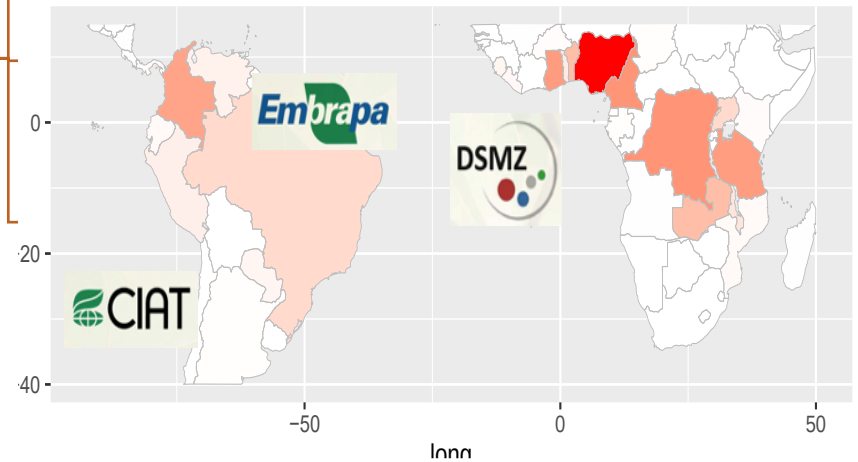
Pre-breeding & Germplasm Exchange

Pre-Breeding & Germplasm

Intercontinental efforts



Steps:

- ☑ Import of additional CBSD resistance sources
- ☑ ☑ Internal Quarantine
- ☑ *In vitro & SAH* multiplication
- ☑ Establishment of the crossing blocks

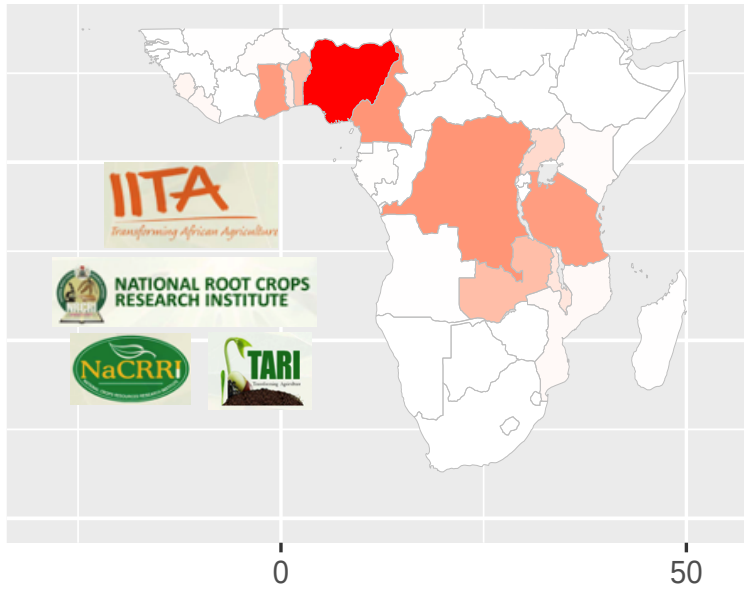
Field evaluation – pre-breeding

nr.	DSMZ Collection No.	Accession	CBSV	UCBSV	CMD
1	DSC118	COL 40	S0	S0	S+ weak
2	DSC167	COL 2182	S0	S0	S+
3	DSC196	ECU 41	S0	S+	S+
4	DSC250	PER 221	S0	S+	S+
5	DSC269	PER 556	S0	S0	S+
6	DSC120	COL 144	S0	S+	S+
7	DSC258	PER 333	S0	S–/+	S+
8	DSC199	ECU 159	S–/+	S+	S+
9	DSC257	PER 315	S–/+	S+	S+
10	DSC272	PER 597	S–/+	S+	S+
11	DSC122	COL 262	S–/+	S+	S+
12	DSC248	PER 206	S–/+	S+	S+
13	DSC251	PER 226	S–/+	S+	S+
14	African	TME 3	S+	S+	S0 CMD 2
15	African	TME 96/1089 A	S+	S+	S0 CMD 3
16	African	TZ130	S+	S+	S0 CMD 2

Pre-breeding & Germplasm Exchange

Pre-Breeding & Germplasm

Intracontinental efforts



Goal:

Share elite cassava clones with durable resistance to CBSD & CMD

Steps:

☑ Screening African sources of CBSD resistance

☑ Intermating promising parents

☑ *Rapid* multiplication for MET

☑ Sharing among CBSD breeding Network Partners

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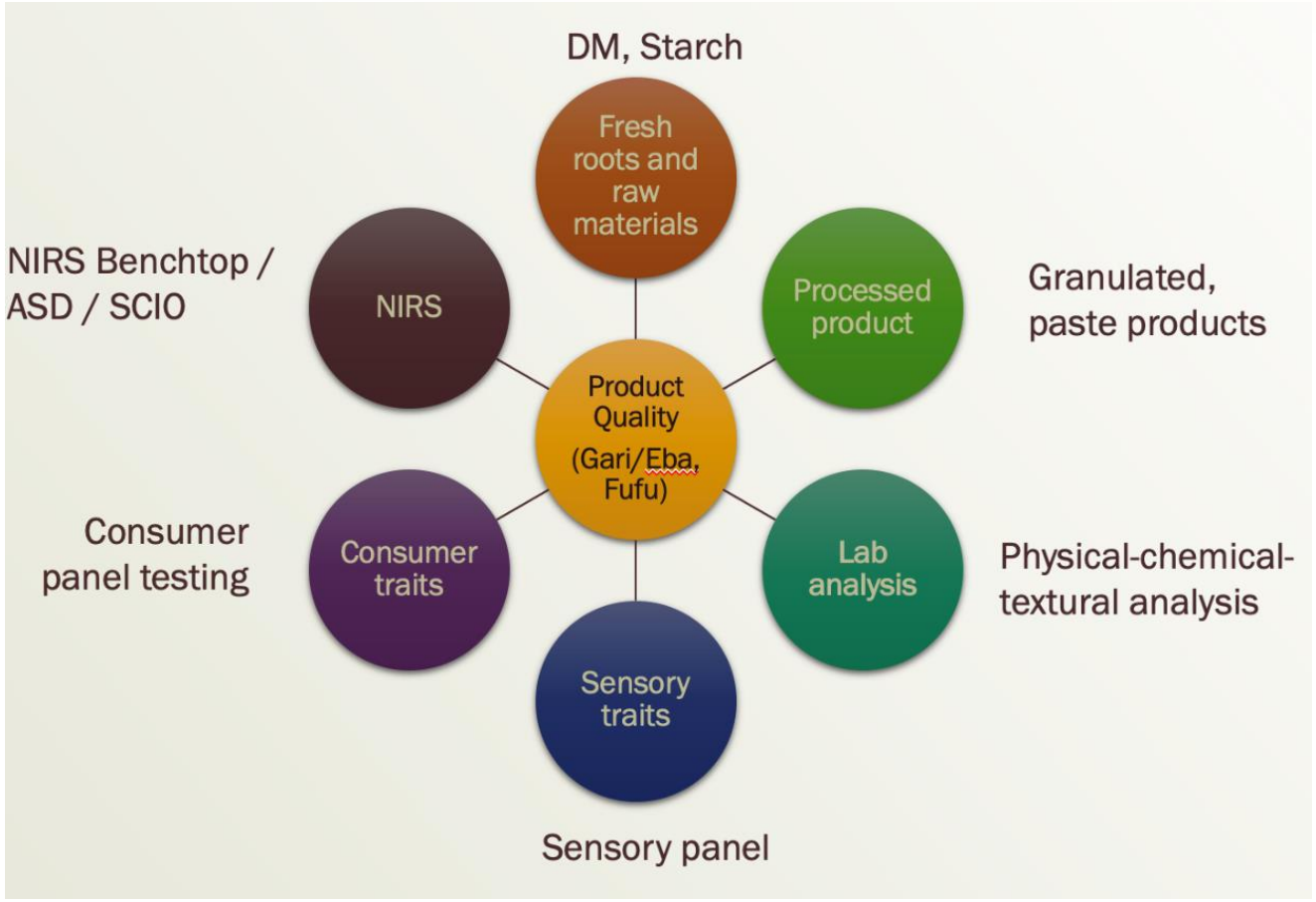
Root Quality Phenotyping



Strong partnerships formed

- RTBFOODs,
- Food Science labs,
- Cassava breeding programs.

African Breeding germplasm screened using standard protocols (RTB SOPs).

Scaling of released varieties through Rapid Multiplication

Semi Autotrophic Hydroponics

Clonal Plantlets Petiole Bud technology at Kwembe

Agronomy at Scale (ACAI)

→ Developed **decision support tools**
→ Supplying **tailored or site-specific recommendations**

Best Fertilizer Blends (FB)

Site-specific Fertilizer Recommendations (FR)

Best Planting Practices (PP)

Optimal Intercropping Practices (IC)

Scheduled Planting (SP)

High Starch Content (HS)

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