ALLIANCE SCIENCE SEMINAR

Hybrid Cassava Breeding

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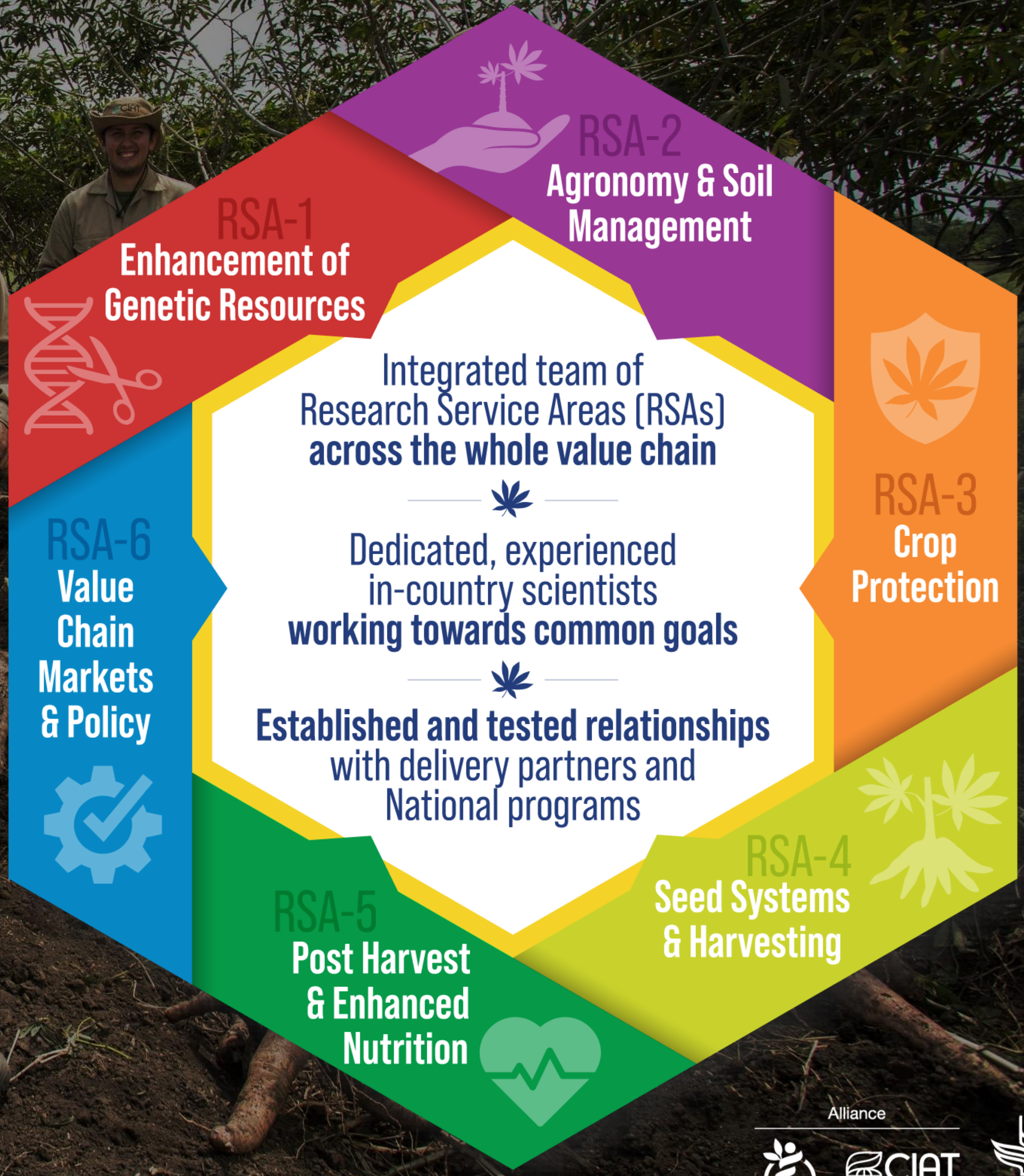
Alliance Bioversity & CIAT

CGIAR RESEARCH PROGRAM ON Roots, Tubers and Bananas

Excellence in Breeding PLATFORM

NEXTGEN CASSAVA

The Cassava Program: The Research Services Areas

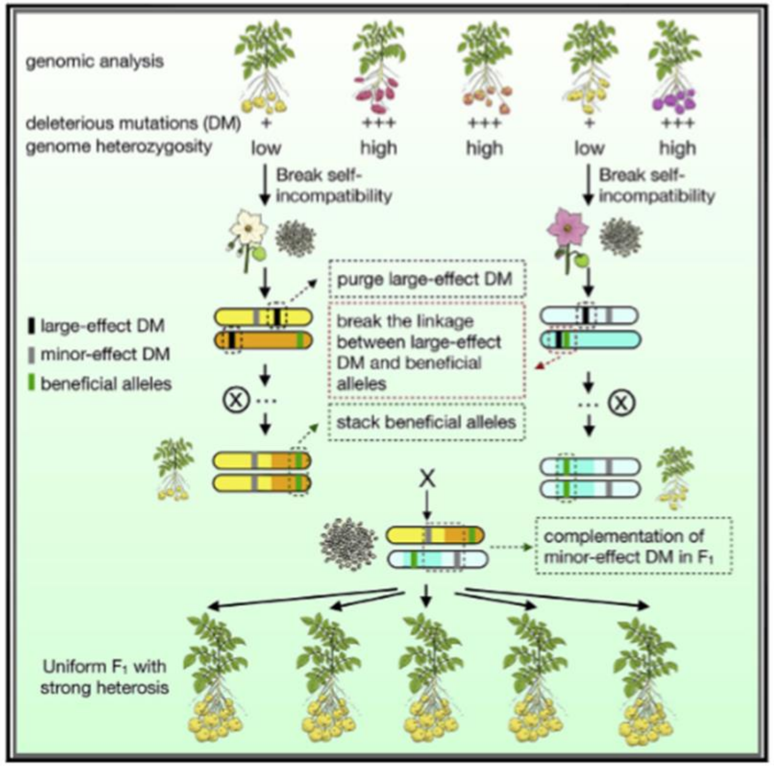


Cell

Article

Genome design of hybrid potato

Graphical abstract



Authors

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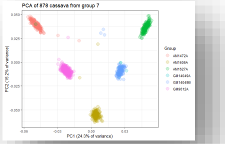
In brief

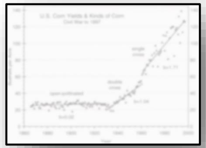
Genome design of the first generation of potato inbred lines with high homozygosity enables the exploitation of heterosis in this tuber crop, and transforms potato breeding from a slow, non-accumulative mode into a fast-iterative one.

Process map

Results

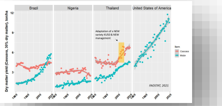


Solution



Pain points

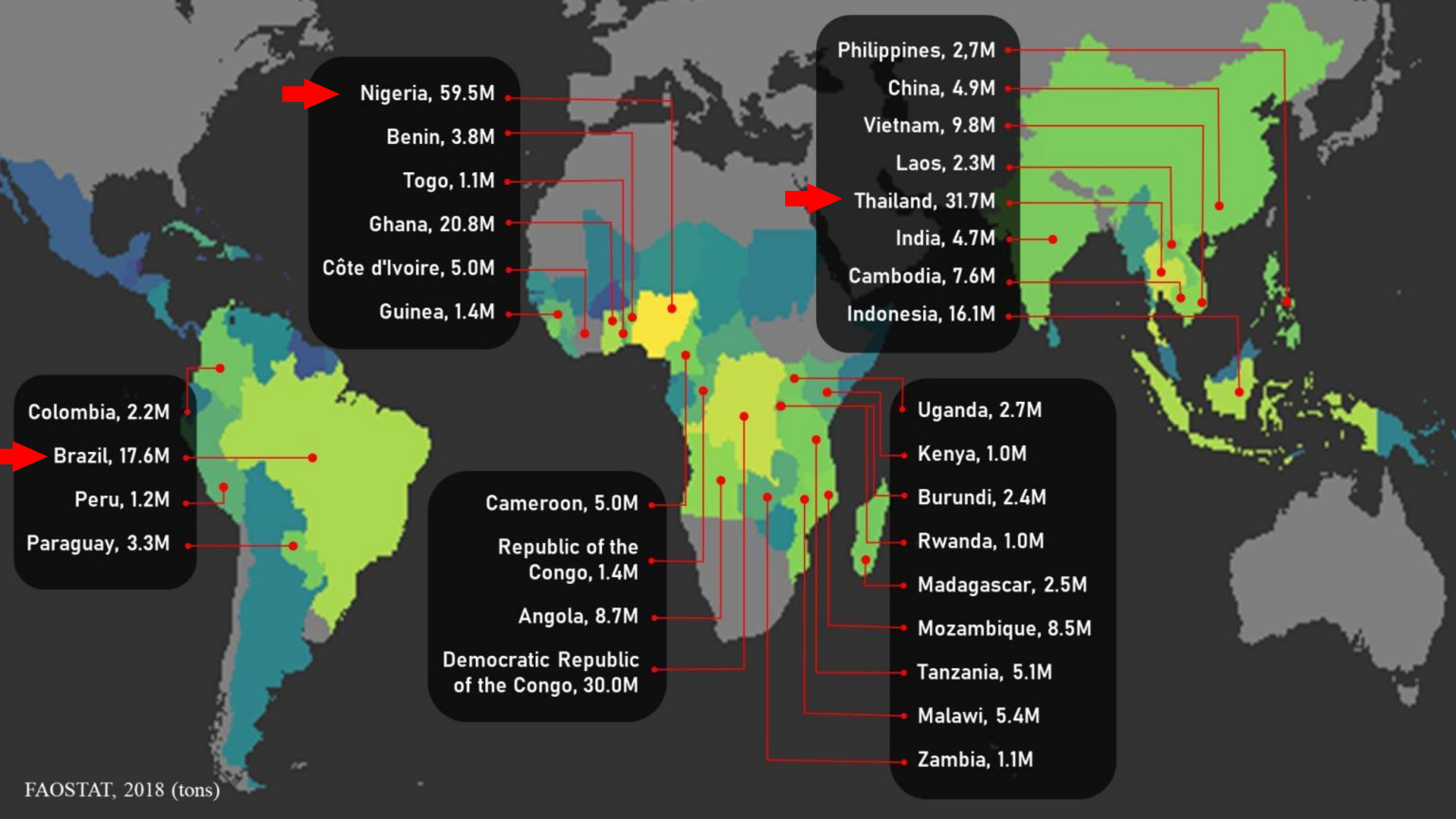
Lag behind



Excellence in Breeding PLATFORM

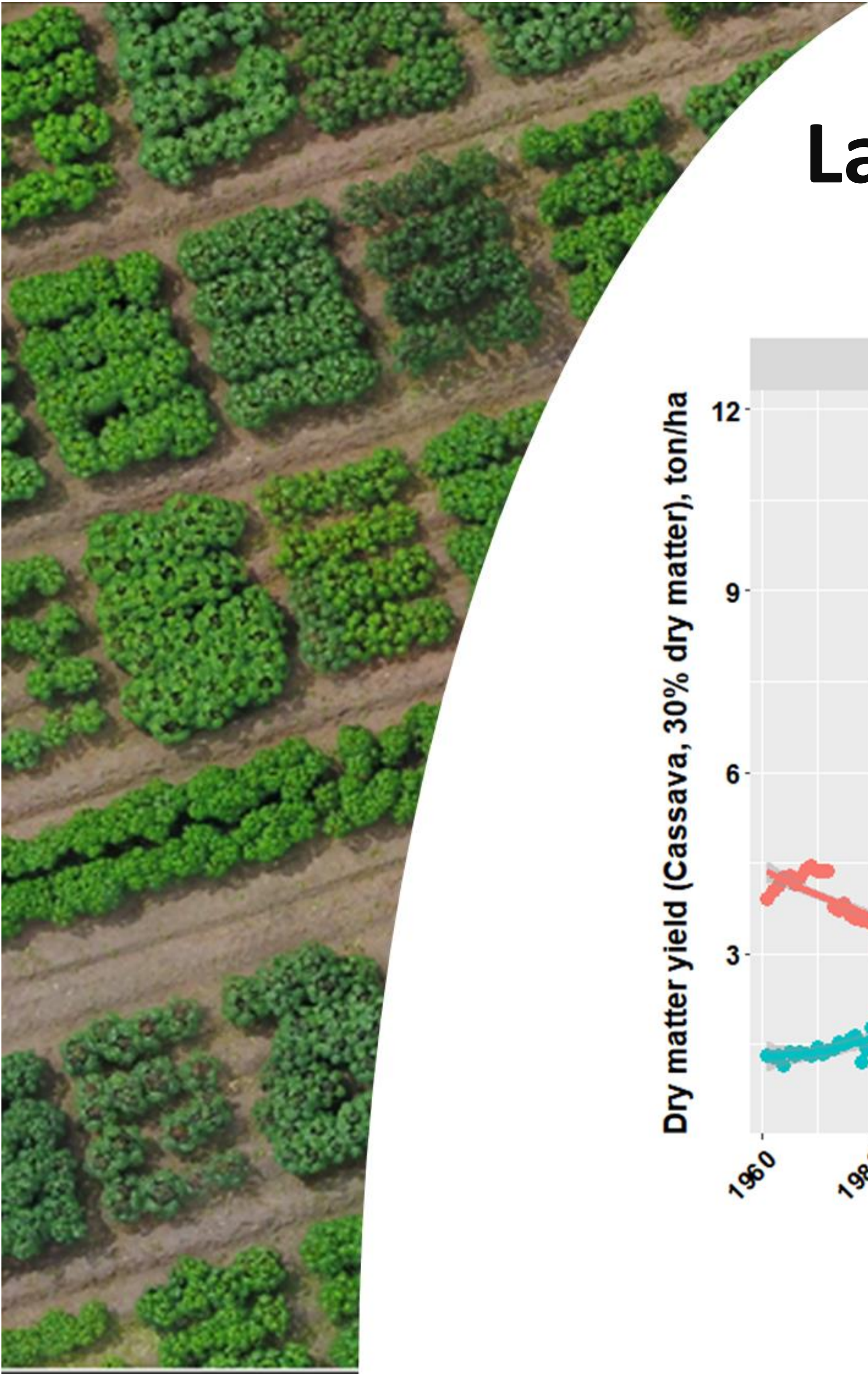
IITA Transforming African Agriculture

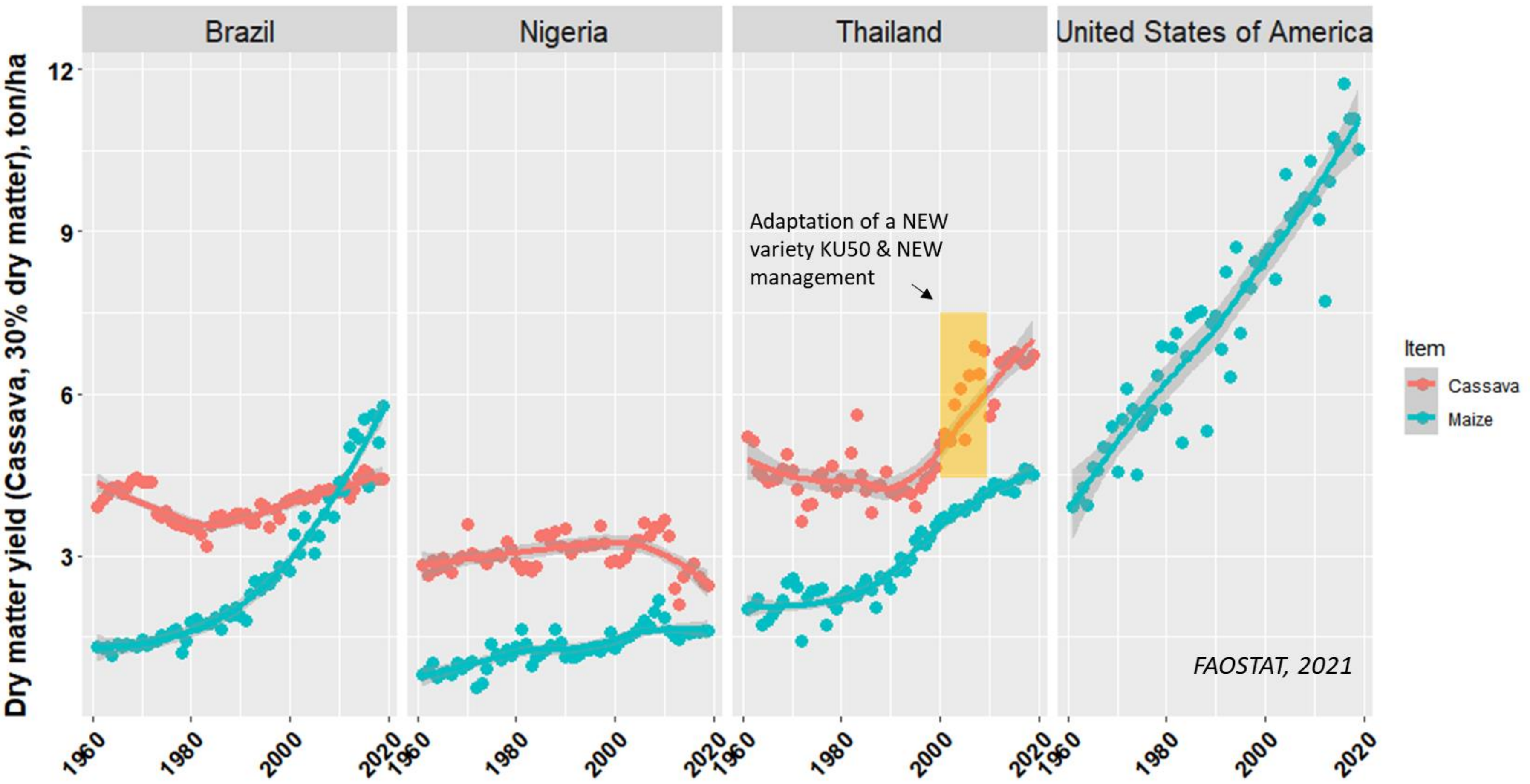
NEXTGEN CASSAVA



FAOSTAT, 2018 (tons)

Lag Behind: Yield of Cassava and Maize





Selection Breeding

Year: 0 – 1.2 – 2 – 3 – 4 – 5 – 6

Crossing nursery

↓

F_1 (10,000)
1 plant/1 rep/1 site

↓

F_1C_1 (1,500)
3 plants/1 rep/1 site

↓

SRT (500)
8 plants/1 rep/3 sites

↓

PYT(200)
10 plants/3 reps/3 sites

↓

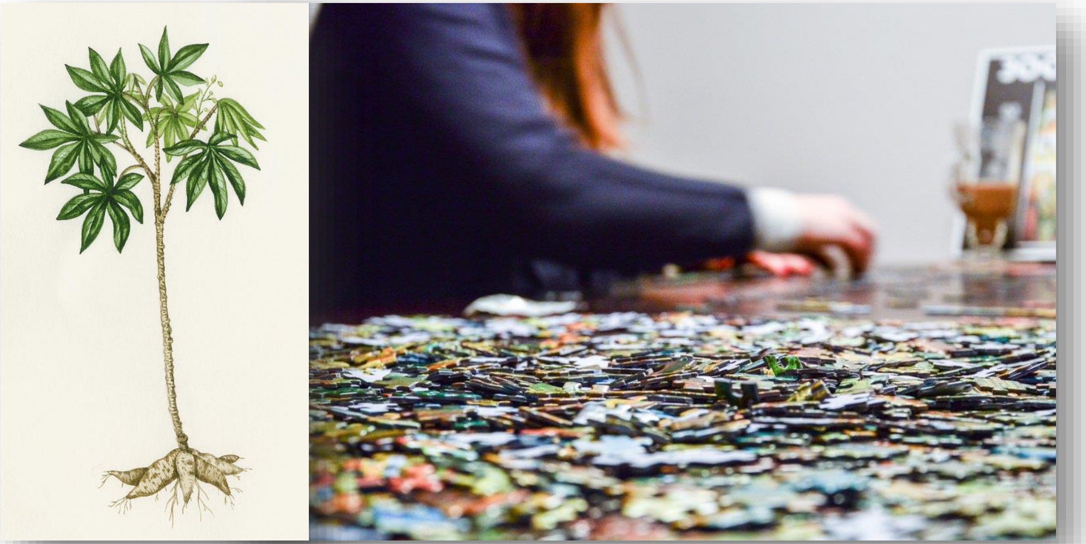
AYT(50)
25 plants/3 reps/4 sites

recombination

clonal propagation

Pain Point #1: LOW efficiency in trait introgression

Heterozygous parents



Mix everything up

Homozygous parents

Targeted improvement

Inbred progenitor is essential to make change quickly.

Selection Breeding ----> Design Breeding

> In a changing world, we must change quickly.

Upgraded NAROCASS1 with CBSD resistance

Upgraded KU50 with CMD resistance

New varieties are similar with the one farmers have been planting.

Pain Point #2: SMALL between-family variance

Table 1 List of progentiors used in the three diallels whose results were reported earlier (Cach et al. 2005, 2006; Calle et al. 2005; Jaramillo et al. 2005; Pérez et al. 2005a, b)

Progenitor	Environment		
	Acid soils	Mid-altitude valleys	Sub-humid
1	CM 4574-7	CM 6740-7	MTAI 8
2	CM 6740-7	SM 1219-9	CM 6754-8
3	CM 7033-3	SM 1278-2	CM 8027-3
4	SM 1219-9	SM 1636-24[a]	SM 805-15
5	SM 1565-15	SM 1673-10[a]	SM 1565-17
6	SM 2058-2[a]	SM 1741-1	SM 1411-5
7	SM 2219-11	HMC 1	SM 1219-9
8	HMC 1	MECU 72	SM 1657-12[a]
9	MPER 183	MPER 183	SM 1665-2
10	MTAI 8		

[a] Progenitor no longer available for the measurement of genetic distances

Euphytica (2016) 210:79-92

Genetic parameter	Fresh root yield (t ha^{-1})		
	Acid soil	Sub-humid	Mid-altitude
σ^2_G (Between)	1.65 (2.95)	13.09 (4.74)	42.78 (13.27)
σ^2_G (Within)	21.08 (2.30)	127.21 (7.65)	288.93 (1918)
σ^2_A	−1.49 (6.32)	17.82 (13.75)	11.88 (24.67)
σ^2_D	9.03 (7.93)	23.87 (11.15)	152.11 (49.08)
Epistasis test	15.05 (6.74)	100.40 (12.74)	168.91 (39.72)

Cassava Hybrid Breeding

Cassava vs. Maize

Starch

Diploid

Cross-pollinated

Self-compatible

Inbreeding depression

Clonal propagation
– no seed production system

Clonal Propagation is a Dream for Hybrid Rice, but a Given for Cassava

UCDAVIS ABOUT US ADMISSIONS ACADEMICS RESEARCH CAMPUS LIFE NEWS

Rice Breeding Breakthrough to Feed Billions

by Andy Fell | January 10, 2023

nature communications

Article https://doi.org/10.1038/s41467-022-35679-3

High-frequency synthetic apomixis in hybrid rice

Received: 2 September 2022

Accepted: 18 December 2022

Published online: 27 December 2022

Check for updates

Aurore Vernet[1,2,11], Donaldo Meynard[1,2,11], Qichao Lian[3], Delphine Mieulet[1,2,4], Olivier Gibert[1,2,5,6], Matilda Bissah[7], Ronan Rivallan[1,2], Daphné Autran[4], Olivier Leblanc[4], Anne Cécile Meunier[1,2], Julien Frouin[1,2], James Taillebois[1], Kyle Shankle[8], Imtiyaz Khanday[9,10], Raphael Mercier[3], Venkatesan Sundaresan[8,9,10] & Emmanuel Guiderdoni[1,2]

Introducing asexual reproduction through seeds – apomixis – into crop species could revolutionize agriculture by allowing F1 hybrids with enhanced yield and stability to be clonally propagated. Engineering synthetic apomixis has

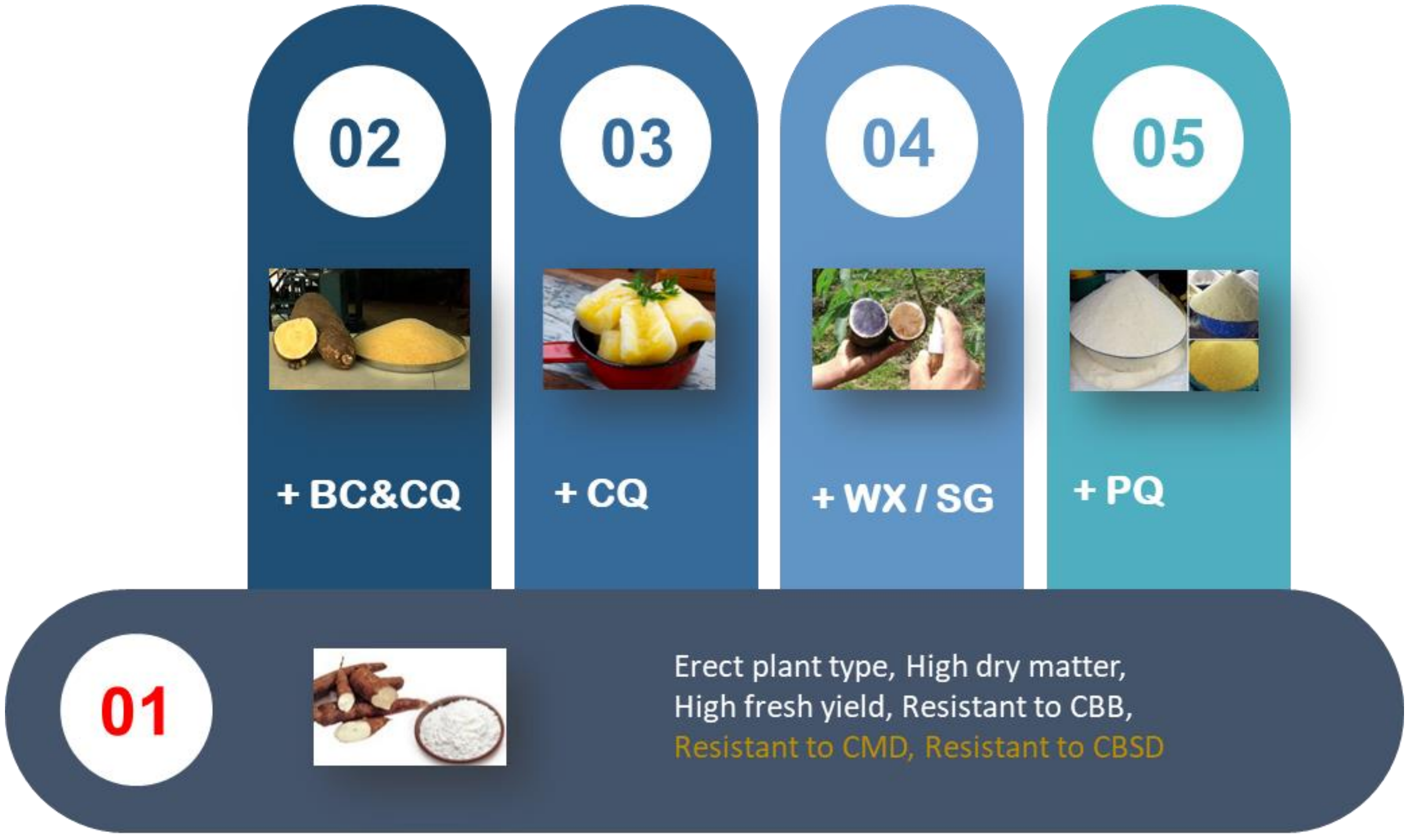
Cassava Product

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

- **1.0 FTE for each market (=1.0 x 450,000 USD)**
- **5.0 FTB in total.**

New Model



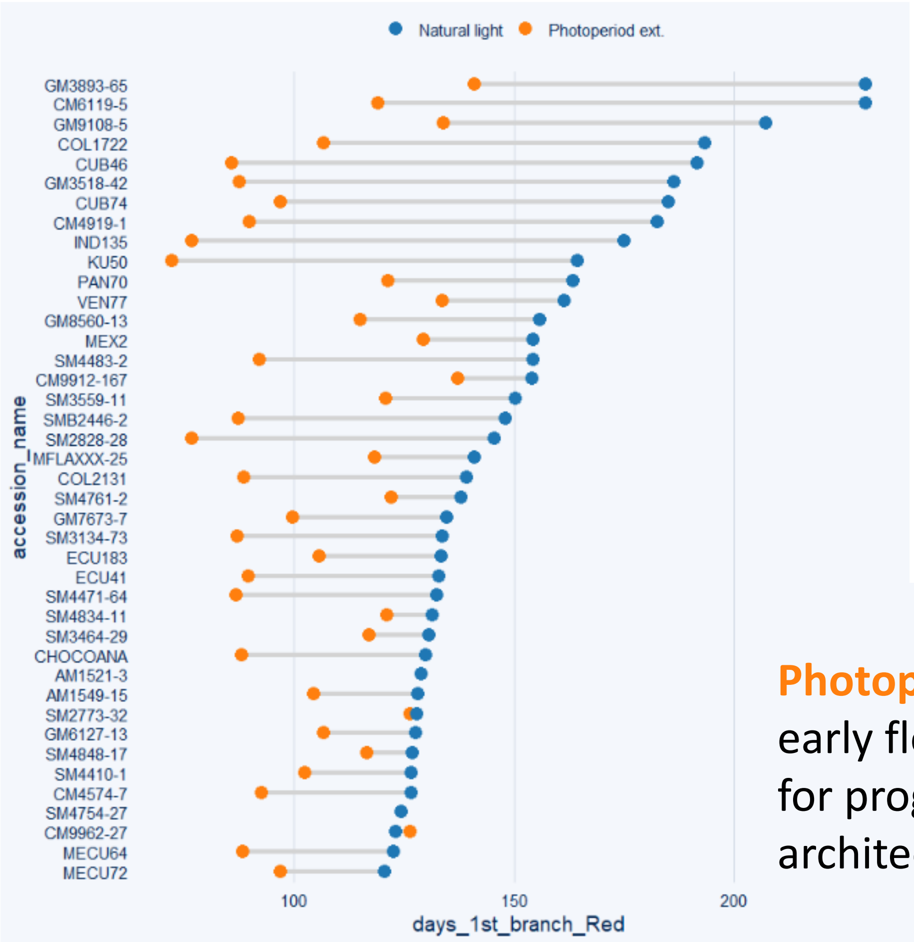
BC, Beta-carotene; CQ, cooking quality; WX, waxy starch; SG, small granule starch; PQ, processing quality

ONE foundation population and **four** conversion population

3.0-3.5 F

Feasibility: Technology #1

Flower Inducing Technology



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

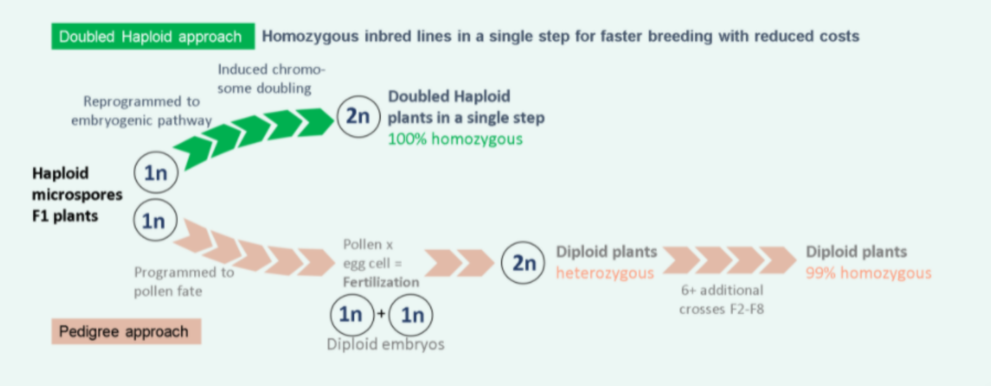
NEXTGEN CASSAVA

Feasibility: Technology #2

Doubled Haploid

ScreenSYS
Screening Cells – Improve Plants

WHAT WE DO | WHAT WE OFFER | CONTACT US | IN THE NEWS | ABOUT US



ScreenSYS industrializes Doubled Haploid plant generation with its unique AI-powered automated platform based workflow. ScreenSYS is the first plant biotechnology digital *in vitro* company that generates Doubled Haploid plants by utilizing algorithms and patented cell handling expertise to measure embryogenic competence of microspores and guide their reprogramming *in vitro*. Our innovative highly automated workflow offers the fastest and the most efficient route to boost production of homozygous inbred lines and broadly applicable to other single plant cells, such as protoplasts. With our technology breeders will benefit on their challenging quest to find and access superior traits quicker and cheaper, be it improved use of water or nutrients, adaptation to climate change, or resistance against pathogens and diseases.

Semi-inbred progenitors with purged genetic load **make DH feasible**.

Cassava Hybrid Breeding

Alliance Bioversity & CIAT

- Understand **inbreeding depression**
- Develop semi-**inbred progenitors**
- Improve **population** using rapid cycling
- Create **heterotic groups**

College of Agriculture & Life Sciences Arizona Genomics Institute — PacBio Certified Service Provider

华大生命科学研究院 BGI·Research — Short-read **sequencing** & Bioinformatics

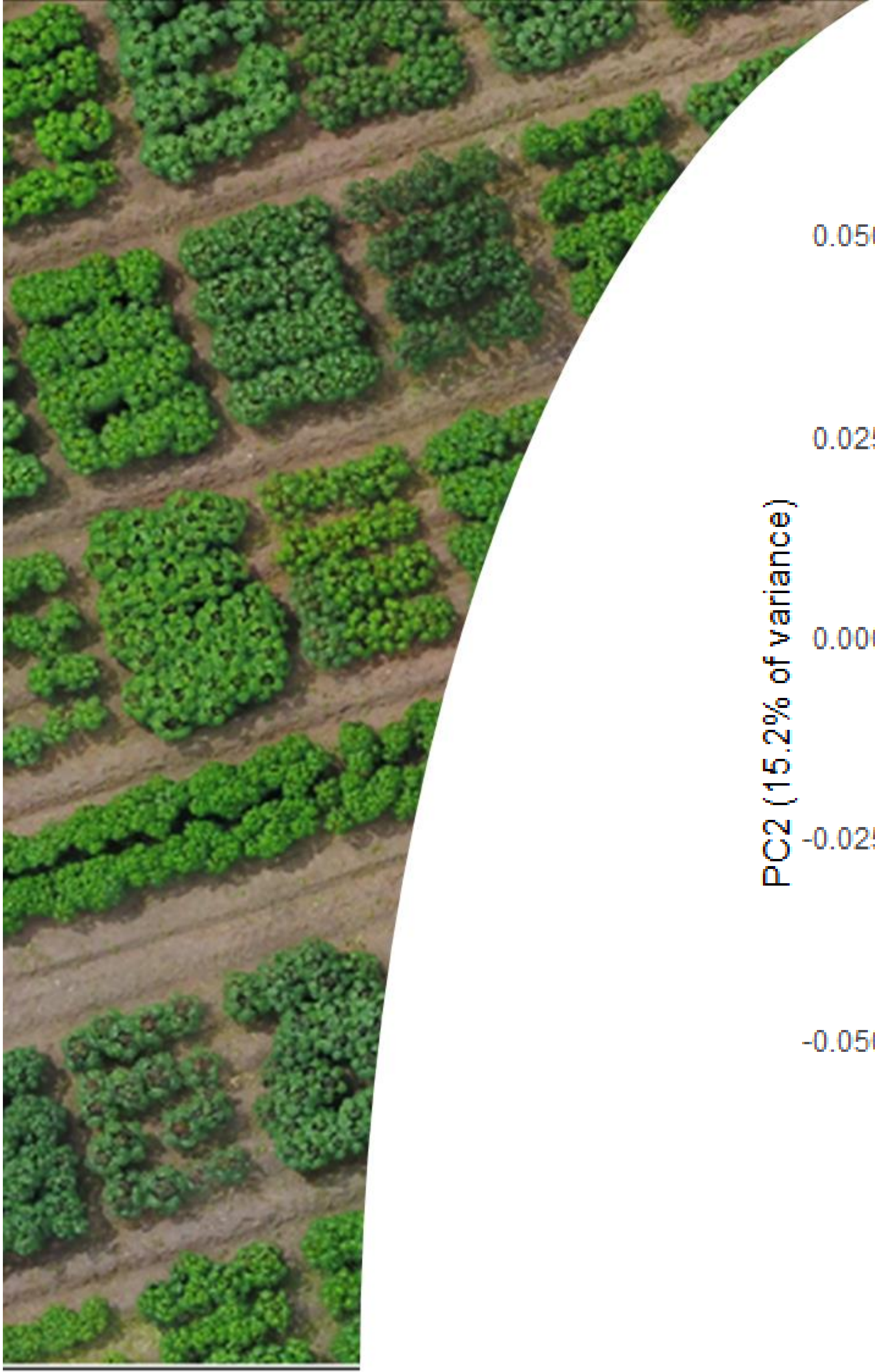
CGIAR Excellence in Breeding Platform — Consulting + QG simulation

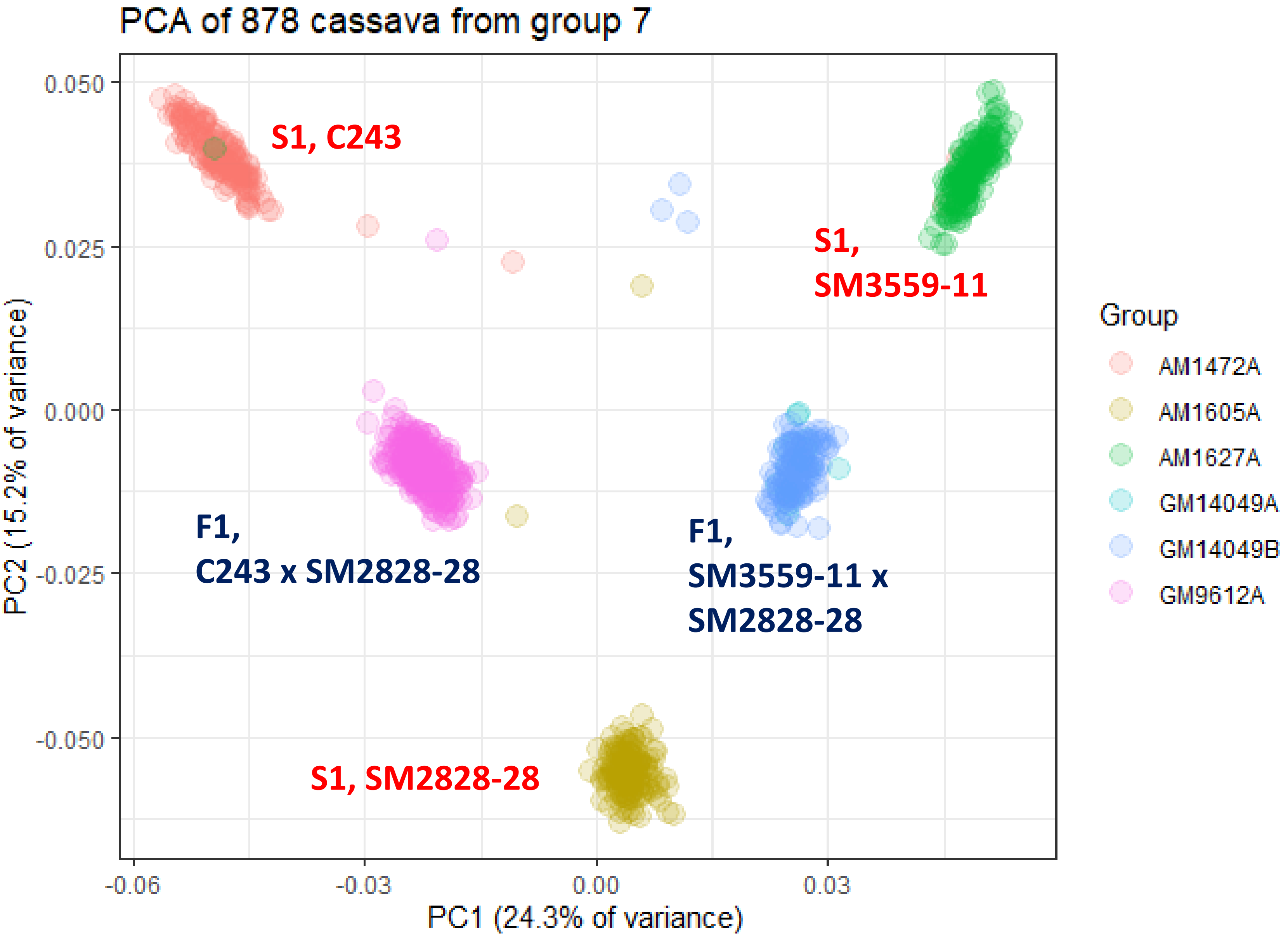
ScreenSYS Screening Cells – Improve Plants — **Doubled Haploid** technology

GEMS Informatics — **Deleterious Mutations** & Database for variation profiling

POP1: Understand Inbreeding Depression

population type	family name	maternal parent	paternal parent	number of seeds germinated
S1	AM 1605A	**SM 2828- 28**	SM 2828- 28	**156**
S1	AM 1627A	**SM 3559- 11**	SM 3559- 11	**176**
S1	AM 1472A	**C- 243**	C- 243	**118**
F1	GM14055B	SM 3559- 11	SM 2828- 28	**136**
F1	GM 9612A	C- 243	SM2828-28	**221**
total				**807**





PCA of 878 cassava from group 7
S1, C243
S1,
SM3559-11
F1,
C243 x SM2828-28
F1,
SM3559-11 x
SM2828-28
S1, SM2828-28
0.050
0.025
0.000
-0.025
-0.050
PC2 (15.2% of variance)
-0.06
-0.03
0.00
0.03
PC1 (24.3% of variance)
Group
AM1472A
AM1605A
AM1627A
GM14049A
GM14049B
GM9612A

POP2: Explore and Implement Hybrid Breeding

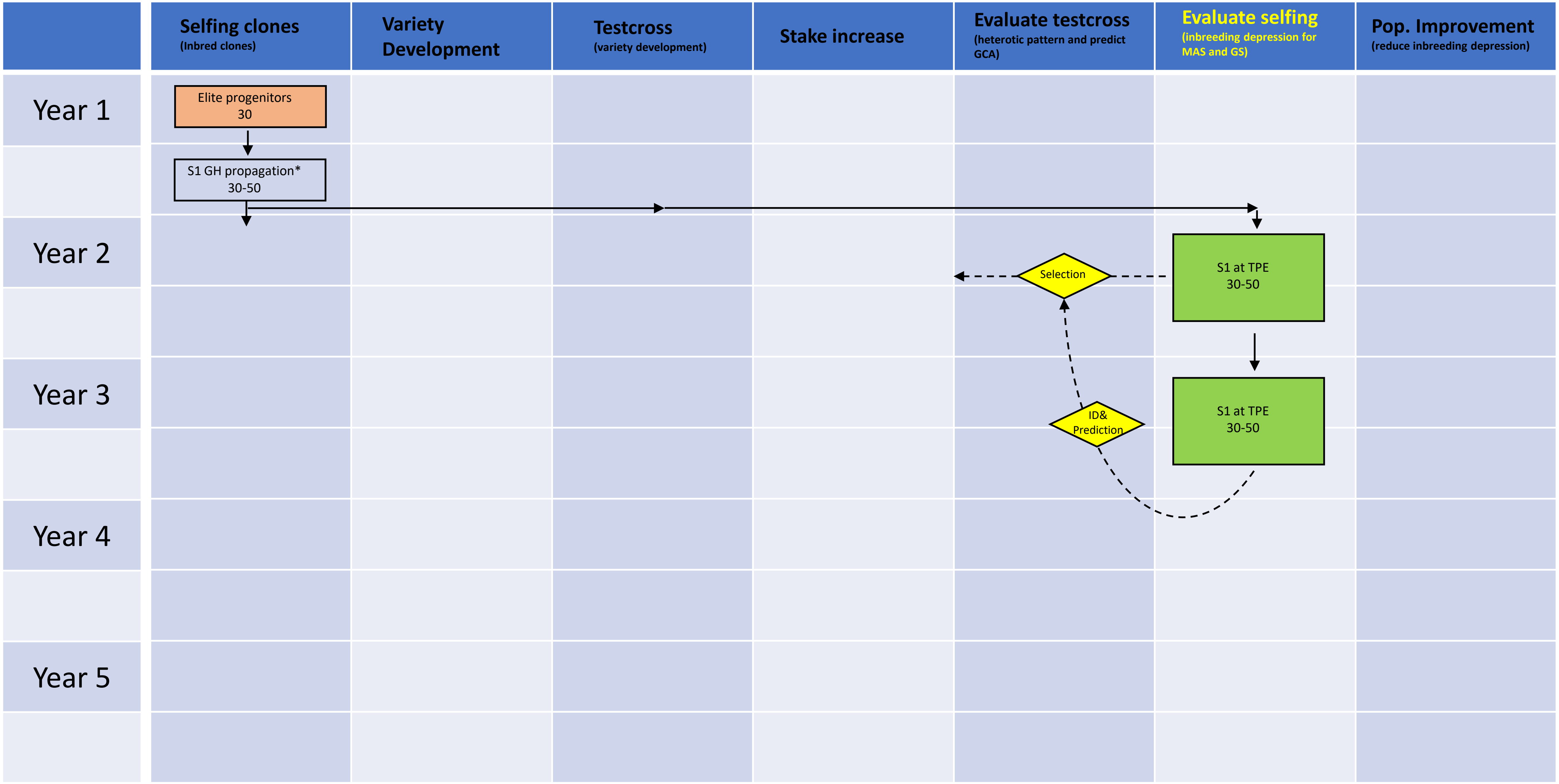
Progenitor	Number of S1	Group
SM1427-1	60	DM
SM1511-6	60	DM
SM3559-11	60	DM
SM3134-73	60	DM
GM8868-85	60	DM
GM9124-12	60	DM
HB60	60	DM
CM9962-27	60	DM
SM3110-15	60	DM
TAI8	59	DM
GM9125-5	41	DM
CM9912-167	31	DM
GM9108-5	30	DM
SMB2446-2	29	DM
SM2828-28	27	DM
GM579-13	24	DM
SM3464-29	22	DM
CM4919-1	21	DM
SM2773-32	16	DM
SM2775-4	16	DM

Progenitor	Number of S1	Group
CR24-3	85	DMMD
CR52A-4	50	DMMD
AR18-1	41	DMMD
C-33	39	DMMD
CR52A-2	22	DMMD
SM2792-31	60	DMTD
ARG73	60	DMTD
SM1219-9	25	DMTD
PAR68	20	DMTD

In total, **33 breeding progenitors** of Cassava for starch and animal feeding.

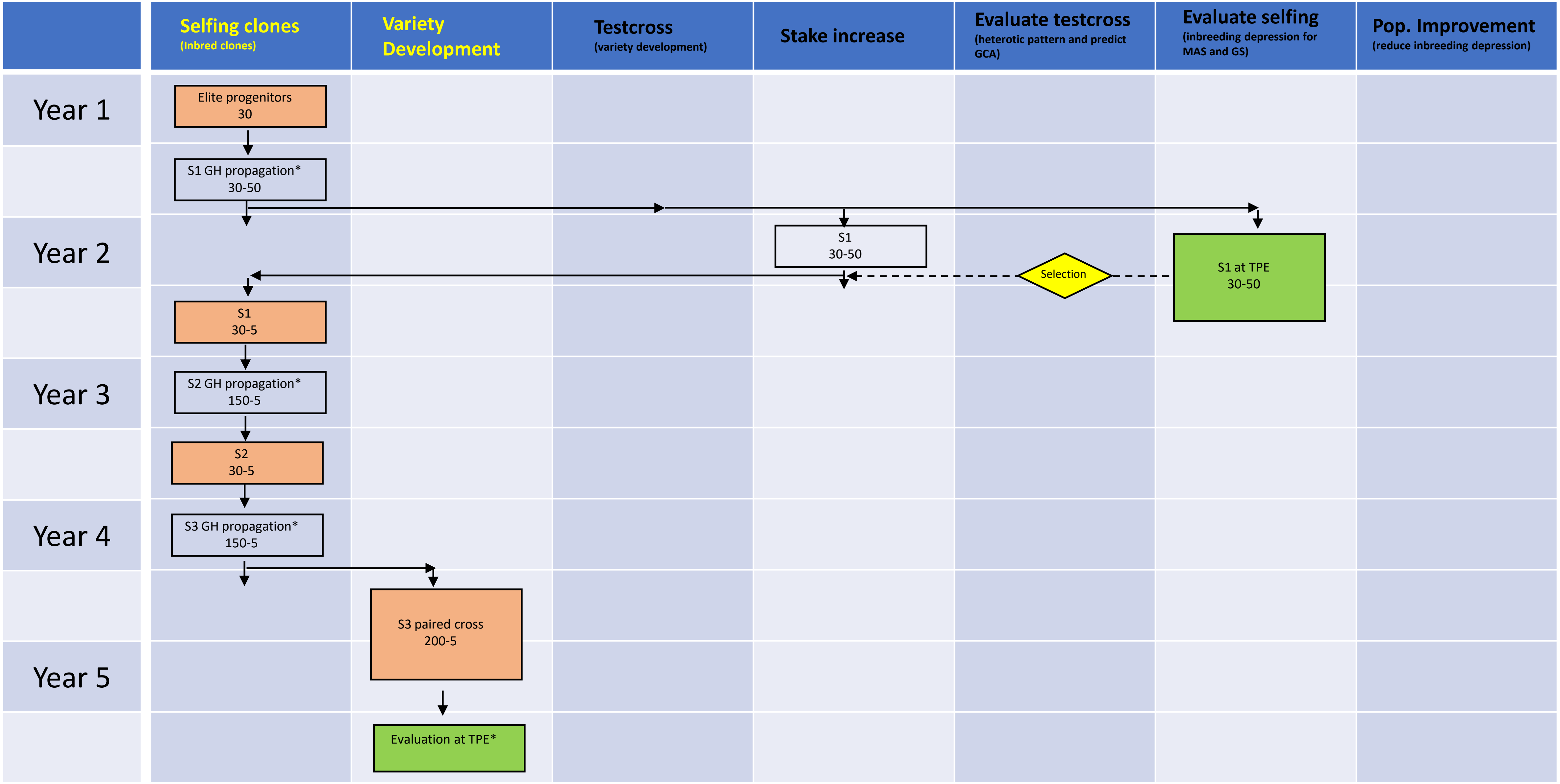
DM, dry matter
MD, cassava Mosaic Disease
TD, Trait Deployment

Cassava Hybrid Breeding – Inbreeding Depression



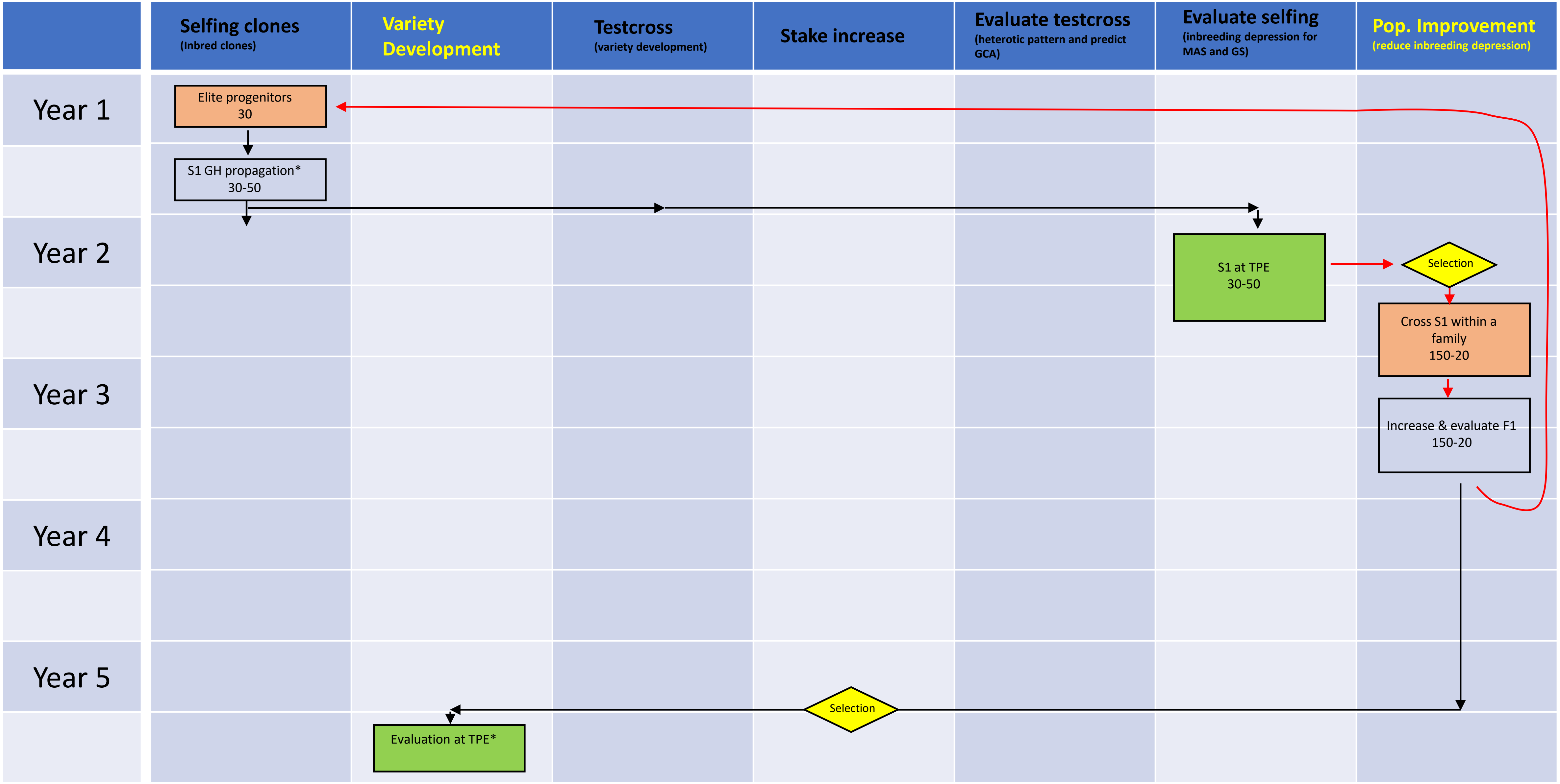
* Genomewide marker for prediction or association; solid arrow, germplasm delivery; broken arrow, information sharing; ID, inbreeding depression.

Cassava Hybrid Breeding – Semi-inbred Progenitors



* Genomewide marker for prediction or association; solid arrow, germplasm delivery; broken arrow, information sharing; ID, inbreeding depression.

Cassava Hybrid Breeding – Population Improvement



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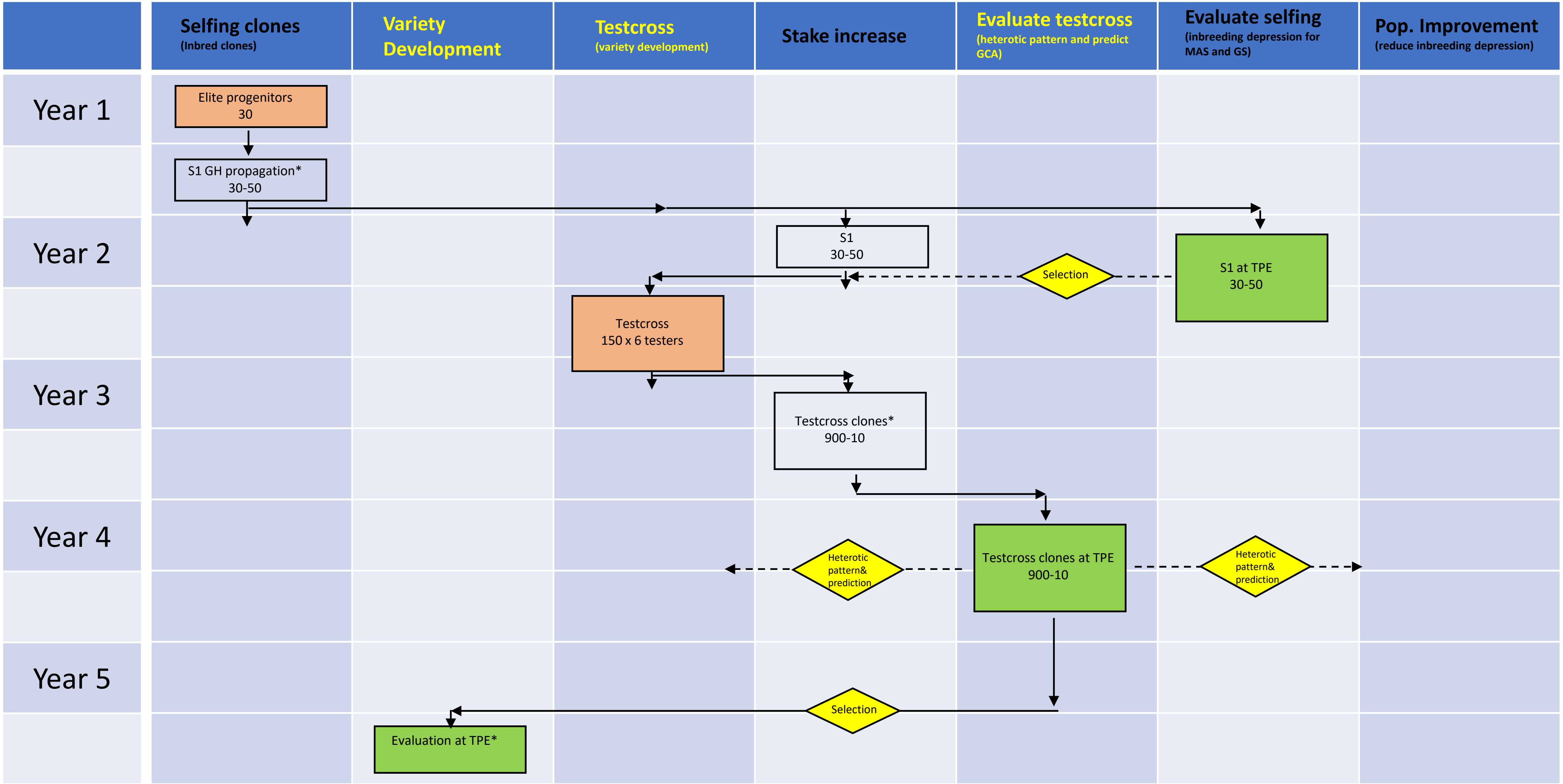
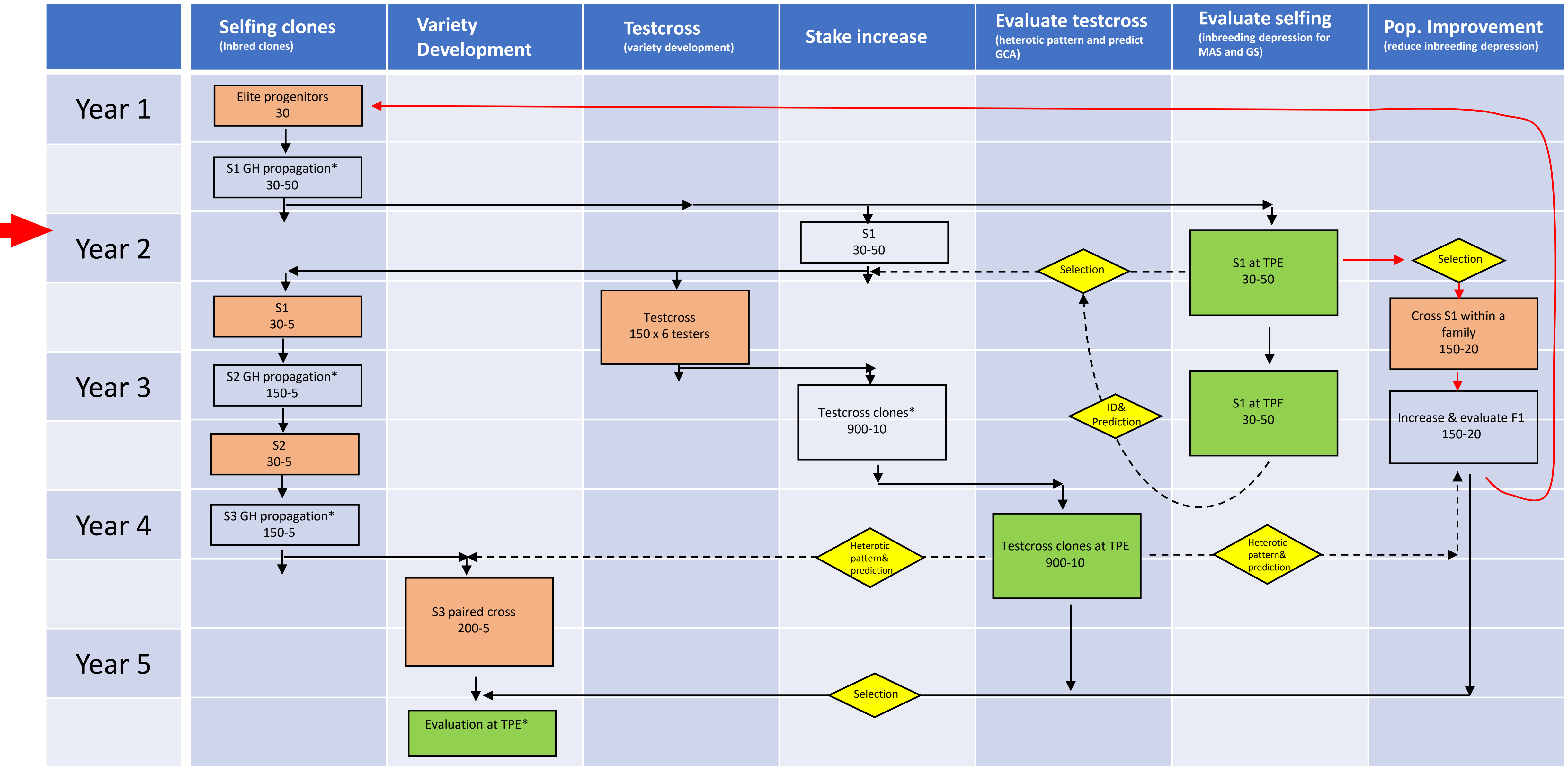
Cassava Hybrid Breeding – Heterotic Groups



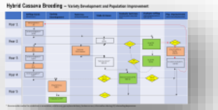
* Genomewide marker for prediction or association; solid arrow, germplasm delivery; broken arrow, information sharing; ID, inbreeding depression.

Cassava Hybrid Breeding – Variety Development and Population Improvement

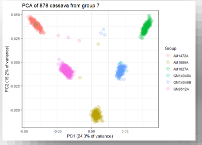


* Genomewide marker for prediction or association; solid arrow, germplasm delivery; broken arrow, information sharing; ID, inbreeding depression.

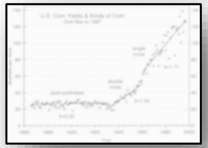
Process map



Results

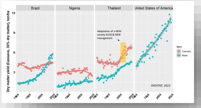


Solution



Pain points

Lag behind



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

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