Webinar:
Keep the faith: Progress in developing commercially viable CMD resistant varieties for Asia

Sources of CMD Resistance in Southeast Asia

Xiaofei Zhang
2020 August

CASSAVA PROGRAM

Alliance

Bioversity International

CIAT
International Center for Tropical Agriculture
Since 1967 Science to cultivate change

BREEDING

Hernan Ceballos PhD

RSA1 — Enhancement of Genetic Resources

BREEDING

Xiaofei Zhang PhD

GENETICS

Augusto Becerra PhD

BIOINFORMATICS

Anestis Gkanogiannis PhD

GENE EDITING

Paul Chavarriaga PhD

TISSUE CULTURE

Adriana Bohorquez PhD

RSA2 — Agronomy and Soil Management

CROP NUTRITION

Inram Malik PhD

PHYSIOLOGY

Michael Selvaraj PhD

RSA3 — Crop Protection

VIROLOGY

Wilmer Cuellar PhD

PATHOLOGY

Nami Minato PhD

ENTOMOLOGY

Maria Isabel Gomez MSc

RSA4 — Seed Systems and Harvesting

CLEAN SEED

Roosevelt Escobar MSc

SEED NETWORKS

Erik Delaquis MSc

RSA5 — Post Harvest & Enhanced Nutrition

PROCESSING

Thierry Tran PhD

ROOT QUALITY

John Belalcazar MSc

RSA6 — Value Chain and Policy

DEVELOPMENT

Jonathan Newby PhD

GENDER

Vanya Slavchevska PhD

IMPACT ASSES.

Ricardo Labarta PhD

FORESIGTH

Steve Prager PhD

Breeding team

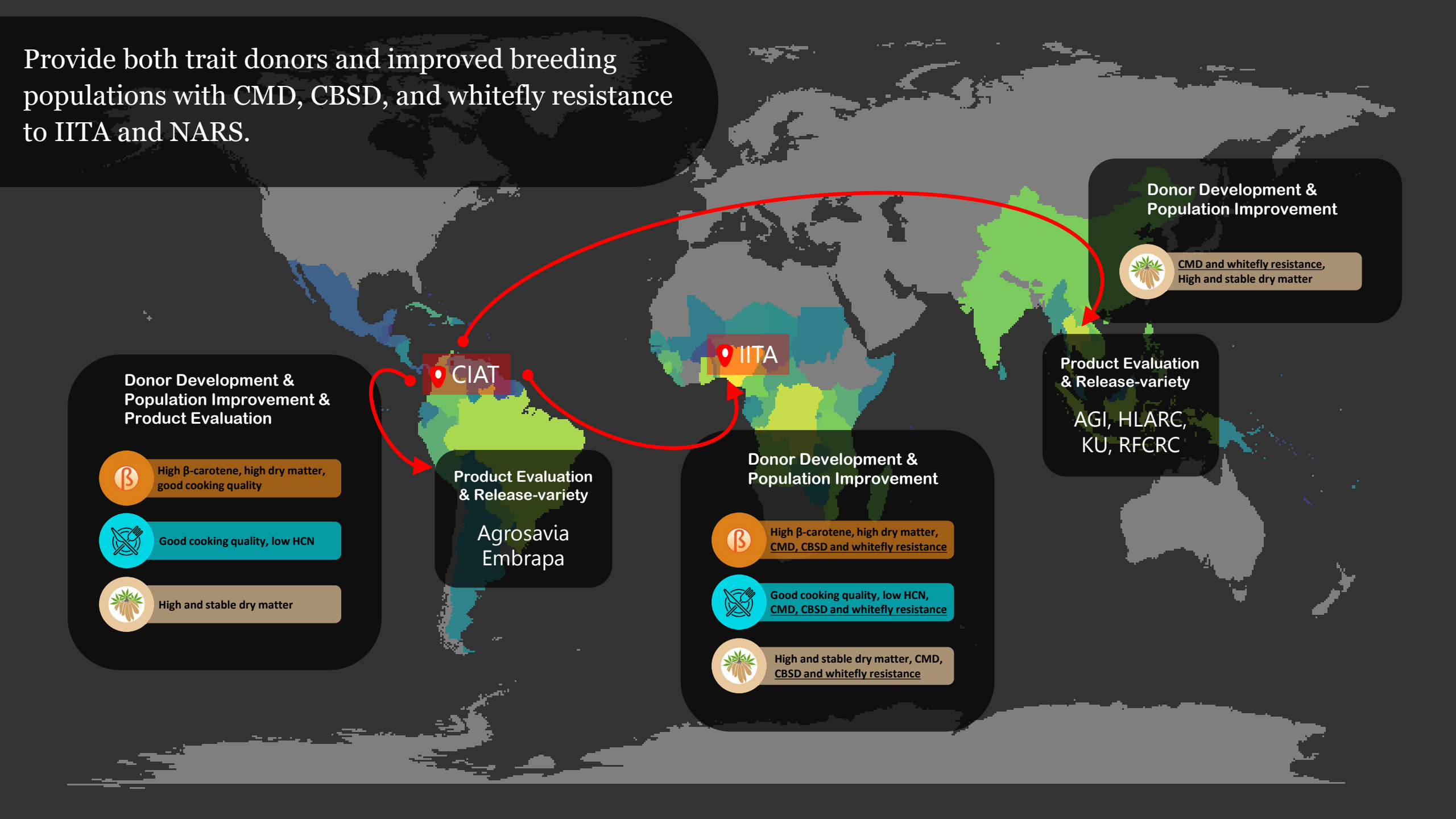
Nelson

Sandra

Jorge Ivan

Thuy

Lizbeth


Provide both trait donors and improved breeding populations with CMD, CBSD, and whitefly resistance to IITA and NARS.
Donor Development & Population Improvement & Product Evaluation
High β-carotene, high dry matter, good cooking quality
Good cooking quality, low HCN
High and stable dry matter
CIAT
Product Evaluation & Release-variety
Agrosavia
Embrapa
IITA
Donor Development & Population Improvement
High β-carotene, high dry matter, CMD, CBSD and whitefly resistance
Good cooking quality, low HCN, CMD, CBSD and whitefly resistance
High and stable dry matter, CMD, CBSD and whitefly resistance
Donor Development & Population Improvement
CMD and whitefly resistance, High and stable dry matter
Product Evaluation & Release-variety
AGI, HLARC, KU, RFCRC

Major Sources of CMD Resistance In South-East Asia

1) 5 IITA clones, all showing high resistance in Tay Nihn;

2) C33, C39, TME3 and other clones from CIAT and IITA

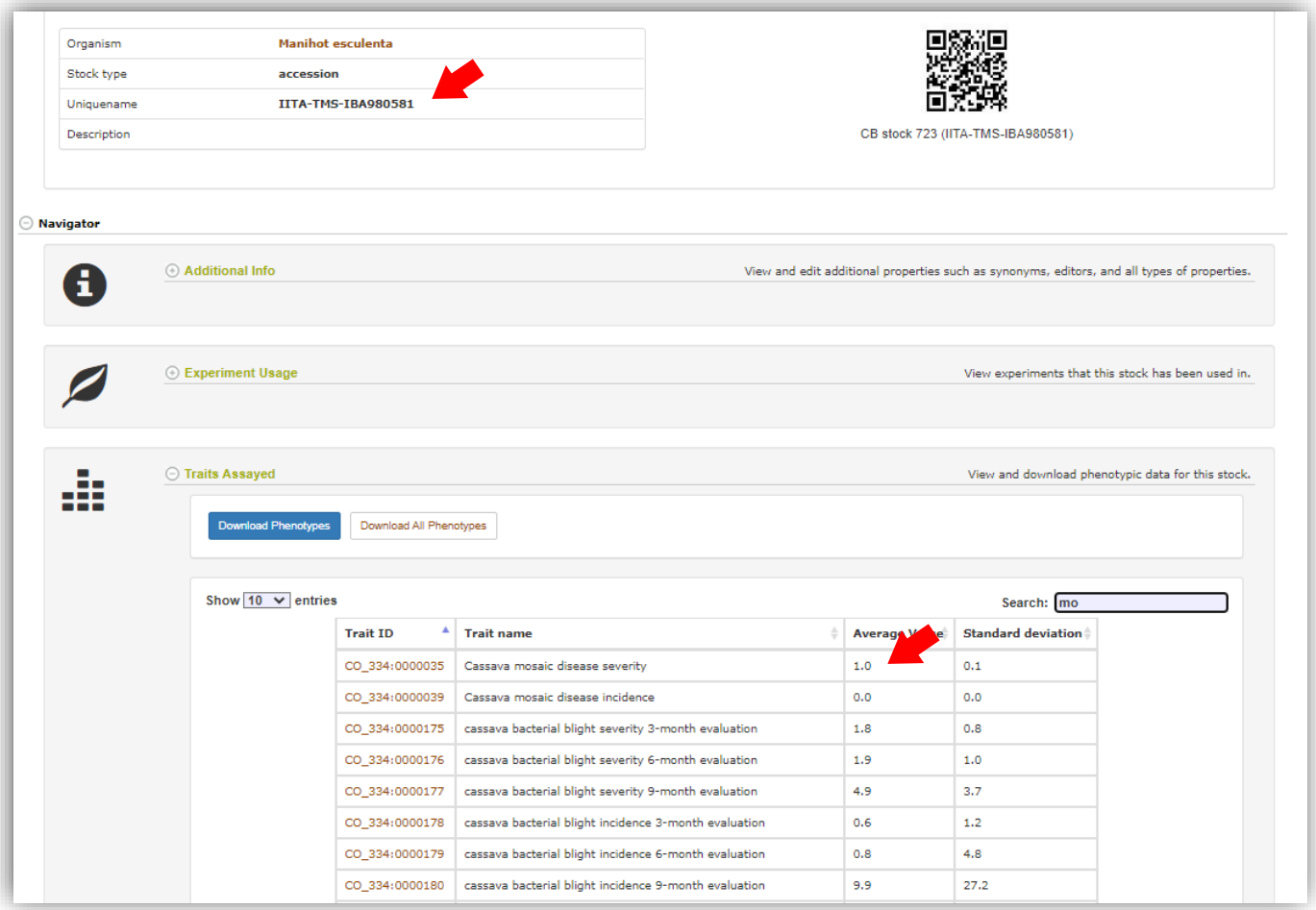
3) 10 resistant varieties from the clones collected in Vietnam

4) 102 CIAT clones containing CMD2 genes according to SSR markers

5) introduced seeds from Hawaii (progenitors from CIAT and IITA)

6) 474 seeds for genomic selection derived from CMD donors at CIAT

https://www.cassavabase.org/

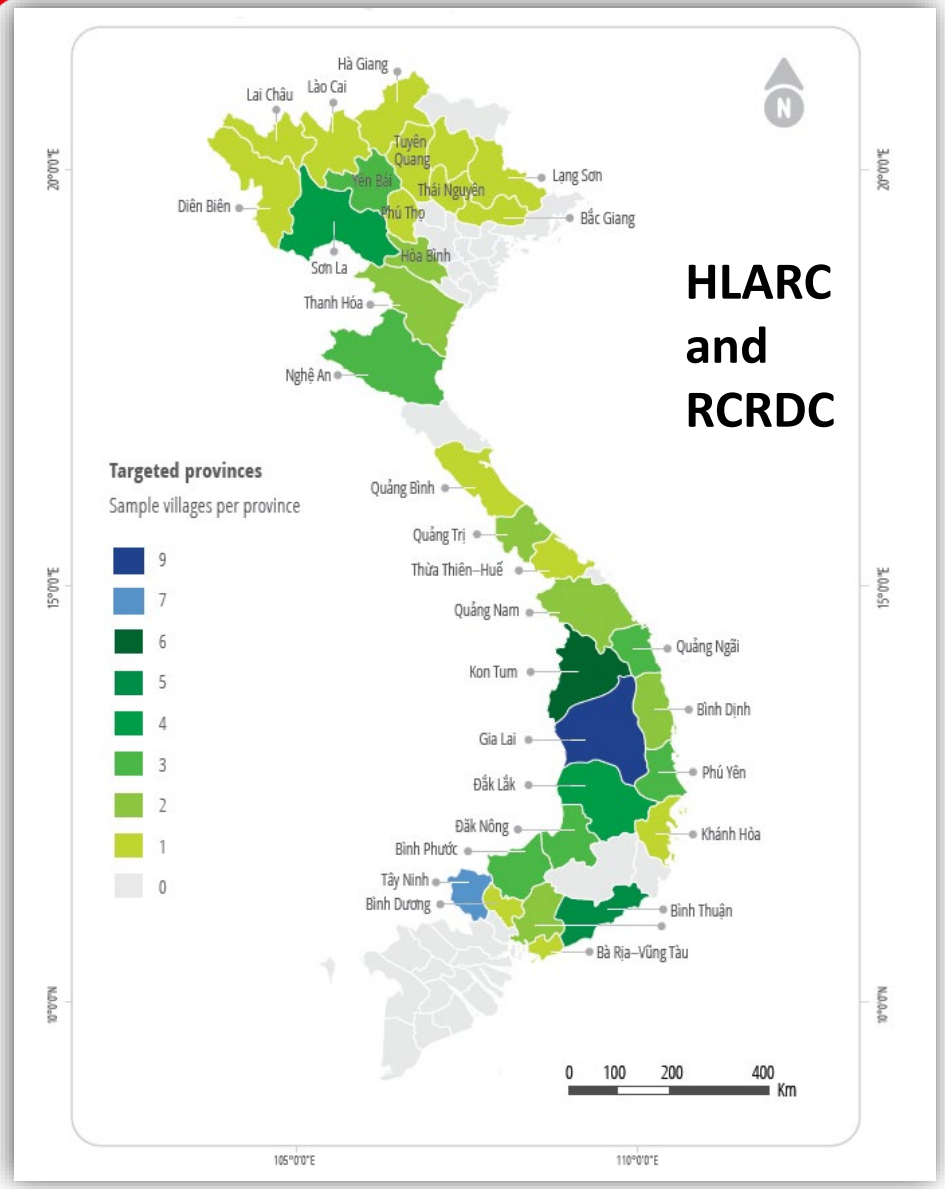


NEXTGEN CASSAVA

Standardization
Accessibility
Collaboration

Video Tutorial https://www.youtube.com/channel/UC3jrvvzGKKEHzOriDBgnj0A

Resistant Varieties from the Clones Collected in Vietnam



1,570 household samples
1,318 intra-plot samples
422 institutional samples

407 plots (2018-2019 season)
163 varieties collected from Vietnam
109 unique varieties based on DNA fingerprint
4 replications

Remove plots with <=3 plants germinated

293 plots
135 varieties collected from Vietnam
94 unique varieties based on DNA fingerprint
4 replications

Variation of CMD Resistance

Trait	Median	Mean	Range	V_g	V_e	Heritability (h^2)
CMD_1.5MAP	1.25	1.40	1.00-4.00	0.040	0.166	0.33
CMD_3MAP	1.50	1.64	1.00-4.00	0.090	0.182	0.52
CMD_6MAP	1.82	1.94	1.00-4.00	0.166	0.195	0.65
CMD_10MAP	2.00	2.49	1.19-4.00	0.364	0.301	0.74
Germination	0.63	0.62	0.25-1.00	0.029	0.026	0.72
yield_plot (kg)	16.00	16.86	0-67.00	34.030	40.490	0.65

High heritability indicated high data quality

CMD symptom increased from 1.5 months after planting to 10 months after planting

Ten Resistant Varieties were Identified

Hanatee

samples	accession_name	6week	3mon	6mon	10mon	germin.	yield_plot
VN19-1432, VN19-1556	PER262/CR63/TAI9	1.1	1.2	1.4	1.4	0.62	15.8
VN19-442	UNK-CI	1.1	1.2	1.3	1.3	1.00	30.0
VN19-1050, VN19-1039	VNM8/KM57	1.0	1.1	1.4	1.5	0.77	15.5
HG2	HG2	1.0	1.2	1.4	1.4	0.68	12.3
VN19-320	UNQ-44	1.0	1.6	1.2	1.5	0.34	26.3
VN19-773	UNQ-115	1.1	1.2	1.3	1.6	0.97	25.8
VN19-1194, VN19-1184	UNK-F	1.1	1.2	1.2	1.7	0.72	24.8
VN19-390	UNK-CH	1.1	1.2	1.5	1.7	0.44	21.5
VN19-2583	UNK-AR	1.2	1.5	1.6	1.9	0.65	11.0
LC1	LC1	1.1	1.4	1.3	1.6	0.75	16.0
	KM140	1.5	1.8	2.3	3.4	0.77	12.4
	KM297	1.6	1.7	1.7	2.5	0.27	17.3
	KM419	1.8	2.2	2.5	2.4	0.89	14.2
	KU50/KM94	1.4	1.4	1.8	2.3	0.61	21.6
	SC8/SC205	1.4	1.5	2.3	3.2	0.34	15.0
	Rayong1	1.5	1.7	1.6	3.0	0.42	17.5
	Rayong60/KM60	1.8	1.9	2.0	3.3	0.58	18.7

accession_name	count	CMD_1	CMD_2	Mean	Mother	Father
AR11-12	50	1.0	1.0	1.0	C-243	CW259-43
AR12-11	48	1.0	1.0	1.0	C-33	CW234-2
AR12-57	72	1.0	1.0	1.0	C-33	CW234-2
AR14-2	89	1.0	1.0	1.0	C-33	CW257-10
AR14-3	92	1.0	1.0	1.0	C-33	CW257-10
AR15-6	42	1.0	1.1	1.1	C-33	CW257-12
AR17-18	64	1.0	1.0	1.0	C-33	CW258-17
AR17-23	54	1.0	1.0	1.0	C-33	CW258-17
AR17-3	75	1.0	1.0	1.0	C-33	CW258-17
AR18-1	33	1.0	1.0	1.0	C-377	CW257-12
AR23-1	93	1.0	1.0	1.0	C-39	CW259-43
AR35-1	54	1.0	1.0	1.0	C-243	CW257-10
AR37-103	70	1.0	1.0	1.0	C-33	CW259-42
AR37-38	77	1.0	1.0	1.0	C-33	CW259-42
AR40-19	74	1.0	1.0	1.0	C-39	CW259-42
AR40-3	80	1.0	1.0	1.0	C-39	CW259-42
AR40-5	57	1.0	1.0	1.0	C-39	CW259-42
AR42-3	33	1.0	1.0	1.0	C-413	CW259-42
AR42-4	69	1.0	1.0	1.0	C-413	CW259-42
AR9-12	55	1.0	1.0	1.0	C-243	CW257-12
AR9-14	82	1.0	1.0	1.0	C-243	CW257-12
AR9-48	91	1.0	1.0	1.0	C-243	CW257-12
AR9-63	86	1.0	1.0	1.0	C-243	CW257-12
CR100-2	88	1.0	1.0	1.0	OW181-2	C-377
CR100-5	63	1.0	1.0	1.0	OW181-2	C-377
CR100-9	45	1.0	1.0	1.0	OW181-2	C-377
CR13-8	85	1.0	1.0	1.0	COL1734	C-33
CR24-16	76	1.0	1.0	1.0	CM7951-5	C-18
CR24-3	90	1.0	1.0	1.0	CM7951-5	C-18
CR25-4	89	1.0	1.0	1.0	CM7951-5	C-33
CR27-20	50	1.1	1.0	1.1	CM7951-5	C-243
CR52A-2	78	1.0	1.0	1.0	C-243	SM1219-9
CR52A-4	77	1.1	1.0	1.1	C-243	SM1219-9
CR60B-10	95	1.0	1.0	1.0	C-18	TAI8
CR61A-1	71	1.0	1.0	1.0	TAI8	C-33
IITA-TMS-IBA920057	91	1.0	1.0	1.0		
IITA-TMS-IBA980505	96	1.0	1.0	1.0		
IITA-TMS-IBA980581	57	1.0	1.0	1.0		
TMEB419	83	1.0	1.0	1.0		
S140	52	2.6	2.6	2.6		
KM419	56	2.6	2.8	2.7		
KM94	41	2.8	2.9	2.8		
KM419	39	3.0	2.9	2.9		
KM94	35	3.2	2.7	3.0		
SDA5	52	3.0	2.9	3.0		
KM419	43	3.5	2.7	3.1		
KM140	80	3.2	3.1	3.1		
SDA30	55	3.9	2.9	3.4		

For detailed results, please ask Vu Nguyen.

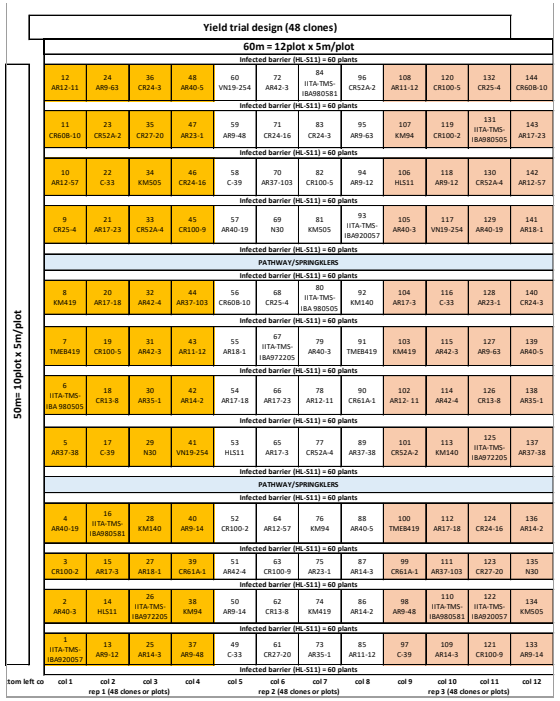
NEW

102 CIAT Clones Containing CMD2 Genes according to SSR markers

43 of 102 clones showed asymptom

Yield trials were established in Tay Nihn and Dong Nai, in May 2020.

48 clones
RCBD
3 replications
20 plants/plot



Prepare in vitro Plantlets for Thailand

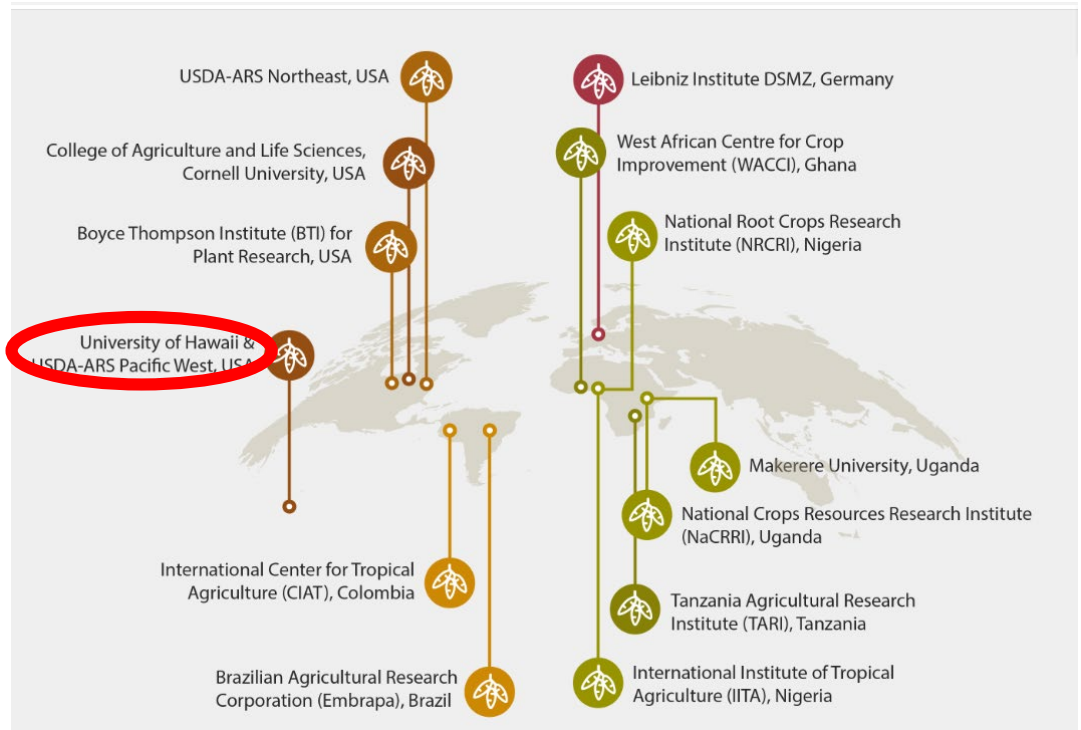
Virus Inspection Results

N. LSG	MUESTRA	Observación	CsFSaV- qPCR		CsNAV-PCR		CsPLV-qPCR		CsTLV-PCR		CsCMV-PCR		CsXV-PCR	
			Resultado	Fecha	Resultado	Fecha	Resultado	Fecha	Resultado	Fecha	Resultado	Fecha	Resultado	Fecha
1	AR9-12	-	Negativo	11/6/2020	Negativo	12/6/2020	Negativo	11/6/2020	Negativo	12/6/2020	Negativo	12/6/2020	Negativo	12/6/2020
2	AR9-14	-	Negativo	11/6/2020	Negativo	12/6/2020	Negativo	11/6/2020	Negativo	12/6/2020	Negativo	12/6/2020	Negativo	12/6/2020
3	AR9-48	-	Negativo	11/6/2020	Negativo	12/6/2020	Negativo	11/6/2020	Negativo	12/6/2020	Negativo	12/6/2020	Negativo	12/6/2020
5	AR11-12	-	Negativo	11/6/2020	Negativo	12/6/2020	Negativo	11/6/2020	Negativo	12/6/2020	Negativo	12/6/2020	Negativo	16/6/2020
6	AR12-11	-	Negativo	11/6/2020	Negativo	12/6/2020	Negativo	11/6/2020	Negativo	12/6/2020	Negativo	12/6/2020	Negativo	12/6/2020
7	AR12-57	-	Negativo	11/6/2020	Negativo	12/6/2020	Negativo	11/6/2020	Negativo	12/6/2020	Negativo	12/6/2020	Negativo	12/6/2020
8	AR14-2	-	Negativo	11/6/2020	Negativo	12/6/2020	Negativo	11/6/2020	Negativo	12/6/2020	Negativo	12/6/2020	Negativo	12/6/2020
9	AR14-3	-	Negativo	11/6/2020	Negativo	12/6/2020	Negativo	11/6/2020	Negativo	12/6/2020	Positivo	16/6/2020	Negativo	12/6/2020
10	AR17-3	-	Negativo	11/6/2020	Negativo	12/6/2020	Negativo	11/6/2020	Negativo	12/6/2020	Negativo	12/6/2020	Negativo	12/6/2020
11	AR17-18	-	Negativo	11/6/2020	Negativo	12/6/2020	Negativo	11/6/2020	Negativo	12/6/2020	Negativo	12/6/2020	Negativo	12/6/2020
12	AR17-23	-	Negativo	11/6/2020	Negativo	12/6/2020	Negativo	11/6/2020	Negativo	12/6/2020	Negativo	12/6/2020	Negativo	12/6/2020
13	AR18-1	-	Negativo	11/6/2020	Negativo	12/6/2020	Negativo	11/6/2020	Negativo	12/6/2020	Negativo	12/6/2020	Positivo	16/6/2020
14	AR23-1	-	Negativo	11/6/2020	Negativo	12/6/2020	Negativo	11/6/2020	Negativo	12/6/2020	Negativo	12/6/2020	Negativo	12/6/2020
15	AR35-1	-	Negativo	11/6/2020	Negativo	12/6/2020	Negativo	11/6/2020	Negativo	12/6/2020	Negativo	12/6/2020	Negativo	12/6/2020
16	AR37-38	-	Negativo	11/6/2020	Negativo	12/6/2020	Negativo	11/6/2020	Negativo	12/6/2020	Negativo	12/6/2020	Negativo	12/6/2020
17	AR37-103	-	Negativo	17/06/2020	Negativo	18/06/2020	Negativo	17/06/2020	Negativo	18/06/2020	Negativo	18/06/2020	Negativo	18/06/2020
18	AR40-3	-	Positivo	11/6/2020	Negativo	12/6/2020	Negativo	11/6/2020	Negativo	12/6/2020	Negativo	16/6/2020	Negativo	12/6/2020
19	AR40-5	-	Negativo	11/6/2020	Negativo	12/6/2020	Positivo	11/6/2020	Negativo	12/6/2020	Negativo	16/6/2020	Negativo	12/6/2020
20	AR40-19	-	Negativo	11/6/2020	Negativo	12/6/2020	Negativo	11/6/2020	Negativo	12/6/2020	Negativo	12/6/2020	Negativo	12/6/2020
21	AR42-3	-	Negativo	11/6/2020	Negativo	12/6/2020	Negativo	11/6/2020	Negativo	12/6/2020	Positivo	16/6/2020	Negativo	12/6/2020
22	AR42-4	-	Negativo	11/6/2020	Negativo	12/6/2020	Negativo	11/6/2020	Negativo	12/6/2020	Negativo	12/6/2020	Negativo	16/6/2020
23	CR13-8	-	Negativo	11/6/2020	Negativo	12/6/2020	Negativo	11/6/2020	Negativo	12/6/2020	Negativo	12/6/2020	Negativo	12/6/2020
24	CR24-3	-	Negativo	11/6/2020	Negativo	12/6/2020	Negativo	11/6/2020	Negativo	12/6/2020	Negativo	12/6/2020	Negativo	12/6/2020
25	CR24-16	-	Negativo	11/6/2020	Negativo	12/6/2020	Negativo	11/6/2020	Negativo	12/6/2020	Positivo	16/6/2020	Negativo	12/6/2020
26	CR25-4	-	Negativo	11/6/2020	Negativo	12/6/2020	Positivo	11/6/2020	Negativo	12/6/2020	Negativo	12/6/2020	Negativo	12/6/2020
27	CR27-20	-	Negativo	11/6/2020	Negativo	12/6/2020	Positivo	11/6/2020	Negativo	12/6/2020	Negativo	16/6/2020	Negativo	12/6/2020
28	CR52A-2	-	Negativo	11/6/2020	Negativo	12/6/2020	Negativo	11/6/2020	Negativo	12/6/2020	Negativo	12/6/2020	Negativo	12/6/2020
29	CR52A-4	-	Negativo	17/06/2020	Negativo	18/06/2020	Negativo	17/06/2020	Negativo	18/06/2020	Negativo	18/06/2020	Negativo	18/06/2020
30	CR60B-10	-	Negativo	11/6/2020	Negativo	12/6/2020	Negativo	11/6/2020	Negativo	12/6/2020	Negativo	12/6/2020	Negativo	12/6/2020
31	CR61A-1	-	Negativo	11/6/2020	Negativo	12/6/2020	Negativo	11/6/2020	Negativo	12/6/2020	Negativo	16/6/2020	Negativo	12/6/2020
32	CR100-2	-	Negativo	11/6/2020	Negativo	12/6/2020	Negativo	11/6/2020	Negativo	12/6/2020	Negativo	16/6/2020	Negativo	12/6/2020
33	CR100-5	-	Negativo	11/6/2020	Negativo	12/6/2020	Negativo	11/6/2020	Negativo	12/6/2020	Negativo	16/6/2020	Negativo	12/6/2020
34	CR100-9	-	Negativo	11/6/2020	Negativo	12/6/2020	Negativo	11/6/2020	Negativo	12/6/2020	Negativo	16/6/2020	Negativo	12/6/2020

28 clones are available for sharing with TTDI

NEW Introduced Seeds from Hawaii

	Harvest Year	Cross Type	total seed 26Apr2019
HIL19PK0201	2017	OP	**80**
HIL19PK0202	2017	OP	**210**
HIL19PK0203	2017	OP	**370**
HIL19PK0204	2017	OP	**550**
HIL19PK0205	2017	OP	**525**
HIL19PK0206	2017	OP	**50**
HIL19PK0207	2017	OP	**574**
HIL19PK0208	2017	OP	**102**
HIL19PK0209	2017	OP	**900**
HIL19PK0210	2017	OP	**250**
HIL19PK0211	2016	OP	**39**
HIL19PK0212	2016	OP	**114**
HIL19PK0213	2016	OP	**49**
HIL19PK0214	2016	OP	**87**
HIL19PK0215	2016	OP	**166**
HIL19PK0216	2016	OP	**76**
HIL19PK0217	2016	OP	**21**
HIL19PK0218	2016	OP	**59**
HIL19PK0219	2016	OP	**22**
HIL19PK0220	2016	OP	**36**
HIL19PK0221	2016	OP	**129**
HIL19PK0222	2016	OP	**90**
HIL19PK0223	2016	OP	**38**
HIL19PK0224	2016	OP	**22**
HIL19PK0225	2016	OP	**34**
HIL19PK0226	2016	OP	**156**
HIL19PK0227	2016	OP	**12**
HIL19PK0228	2016	OP	**49**
HIL19PK0229	2016	OP	**110**
HIL19PK0230	2016	OP	**40**
HIL19PK0231	2016	OP	**31**
Total			**4991**
			Vietnam



NEXTGEN CASSAVA

The seeds for Thailand and Laos are still in process due to the late import permit and COVID-19.

Maternal	Paternal	CIAT
COL1505	COL1722	12
COL1505	VEN25	12
COL1505	MAL3	12
CR138	MEX2	12
CR138	PER183	12
CUB46	CR138	12
CUB46	CM2766-5	12
GM579-13	SM3134-5	12
MAL3	PER183	12
MAL3	VEN25	12
MEX2	PER496	6
PER496	COL1722	5
SM1127-8	PER496	12
VEN25	PER496	12
C33	HB60	12
C33	SM2828-28	12
C413	SM2828-28	12
GM579-13	C39	10
GM7672-5	SM2828-28	12
GM8868-85	C243	12
GM8868-85	GM10055B-1	12
GM9124-12	GM10054B-1	9
GM9125-5	C243	7
HB60	GM7673-3	12
SM2828-28	C19	12
SM3110-15	C243	5
SM3110-15	GM10055B-1	6
SM3134-5	C19	12
SM3134-5	GM10054B-1	12
SM3137-40	GM10055B-1	12
SM3150-17	GM10055B-1	12
SM3150-17	GM7673-3	12
COL1722	HMC1	12
GM7673-3	SM2834-31	12
VENEZOLANA	C243	12
GM11129-11	SM4517-33	12
GM11129-27	SM4517-33	12
GM11129-27	SM4534-37	12
GM11129-35	GM4883-1	12
GM11194-2	SM4524-28	12
SM4516-40	C243	12
SM4516-40	GM11129-11	12
SM4517-30	GM4883-3	12
SM4524-28	GM10054B-1	12
SM4534-37	GM4781-2	12
SM4534-37	GM4781-2	12

Maternal	Paternal	VNM
CR138	PER183	10
COL1722	CR138	11
COL1505	VEN25	12
MAL3	VEN25	12
GM579-13	SM3134-5	14
COL1505	COL1722	14
CR138	MAL3	14
MAL3	VEN25	14
GM6125-13	SM2828-28	8
SM3150-17	C33	8
SM3134-5	GM10054B-1	12
SM3134-5	C19	12
C33	SM2828-28	12
GM7672-5	SM2828-28	12
SM3110-15	C243	12
SM3134-5	GM10055B-1	12
HB60	GM7673-3	12
GM8868-85	C33	12
C19	HB60	12
C413	HB60	12
HB60	GM10054B-1	12
GM10054B-2	HB60	12
GM7673-3	HB60	12
C243	SM2828-28	12
SM2828-28	C39	12
GM7672-7	SM2828-28	12
GM7671-2	SM3137-40	12
SM3150-17	C19	12
SM3134-5	GM10054B-2	12
SM2828-28	GM10055B-1	12
SM3134-5	C243	12
SM3134-5	GM7673-3	12
C33	HB60	12
COL1505	GM7673-3	14
COL1505	C243	14
CR138	GM10055B-1	14

NEW

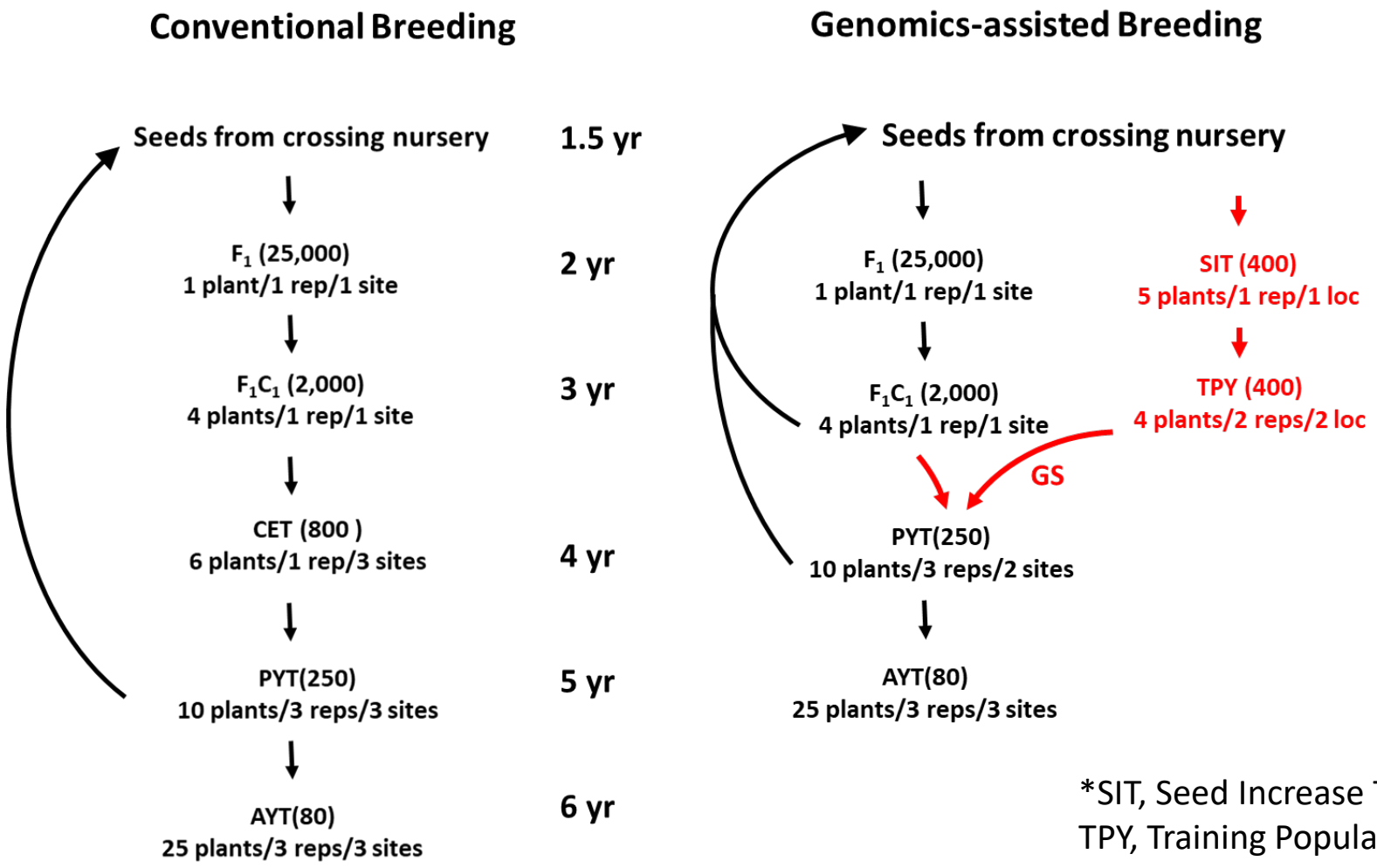
CMD Resistance in the GS Population from CIAT

CIAT

AGI, Vietnam

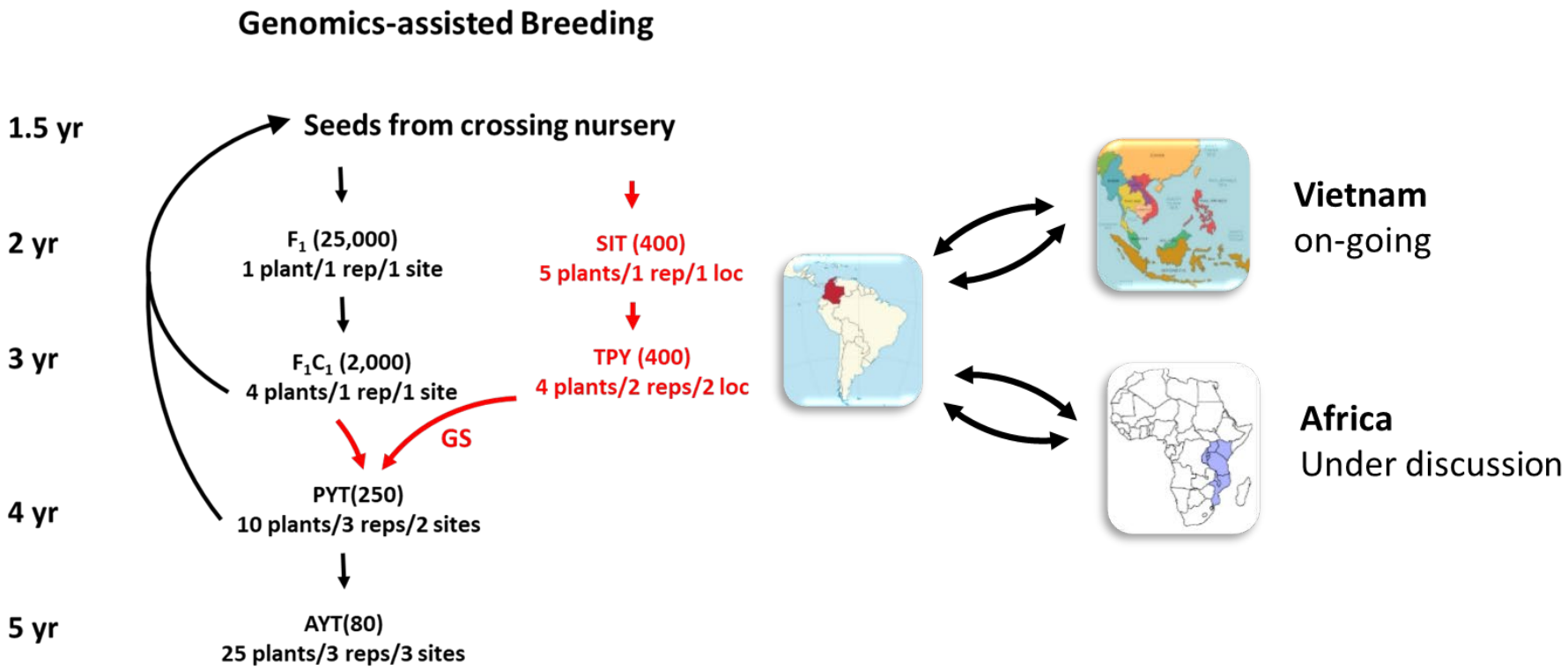
Outcomes:
GS models for CMD and agronomic traits
QTL and diagnostic makers

Implement Genomics-assisted Breeding



*SIT, Seed Increase Trial;
TPY, Training Population Yield trial;
PYT, Preliminary Yield Trial;
AYT, Advanced Yield Trial

GS Facilitates Collaboration



Send seeds of the training populations to partners and develop GS models specific for the TPE of partners.

CIAT positions "upstream" to provide elite parents and adapted progeny to partners.

Acknowledgements

Alliance

Bioversity International

CIAT International Center for Tropical Agriculture Since 1967 Science to cultivate change

IITA Transforming African Agriculture

CGIAR RESEARCH PROGRAM ON Roots, Tubers and Bananas

NEXTGEN CASSAVA

Australian Government

Australian Centre for International Agricultural Research

1) 5 IITA clones, all showing high resistance in Tay Nihn;

2) C33, C39, TME3 and other clones from CIAT and IITA

NEW 3) 10 resistant varieties from the clones collected in Vietnam

NEW 4) 102 CIAT clones containing CMD2 genes according to SSR markers

NEW 5) introduced seeds from Hawaii (originally from CIAT and IITA)

NEW 6) 474 seeds for genomic selection derived from CMD donors at CIAT