

Establishing sustainable solutions to cassava diseases in mainland Southeast Asia

Final Review - Hung Loc Agricultural Research Center (HLARC)

Objective 2:

Enhance the capacity and collaboration between breeding programs in mainland Southeast Asia to develop new product profiles for commercially viable cassava varieties by identifying and incorporating known and novel sources of resistance to Cassava Mosaic Disease (CMD) and Cassava Witches Broom Disease (CWBD) into national breeding programs

Alliance



Report Outline:

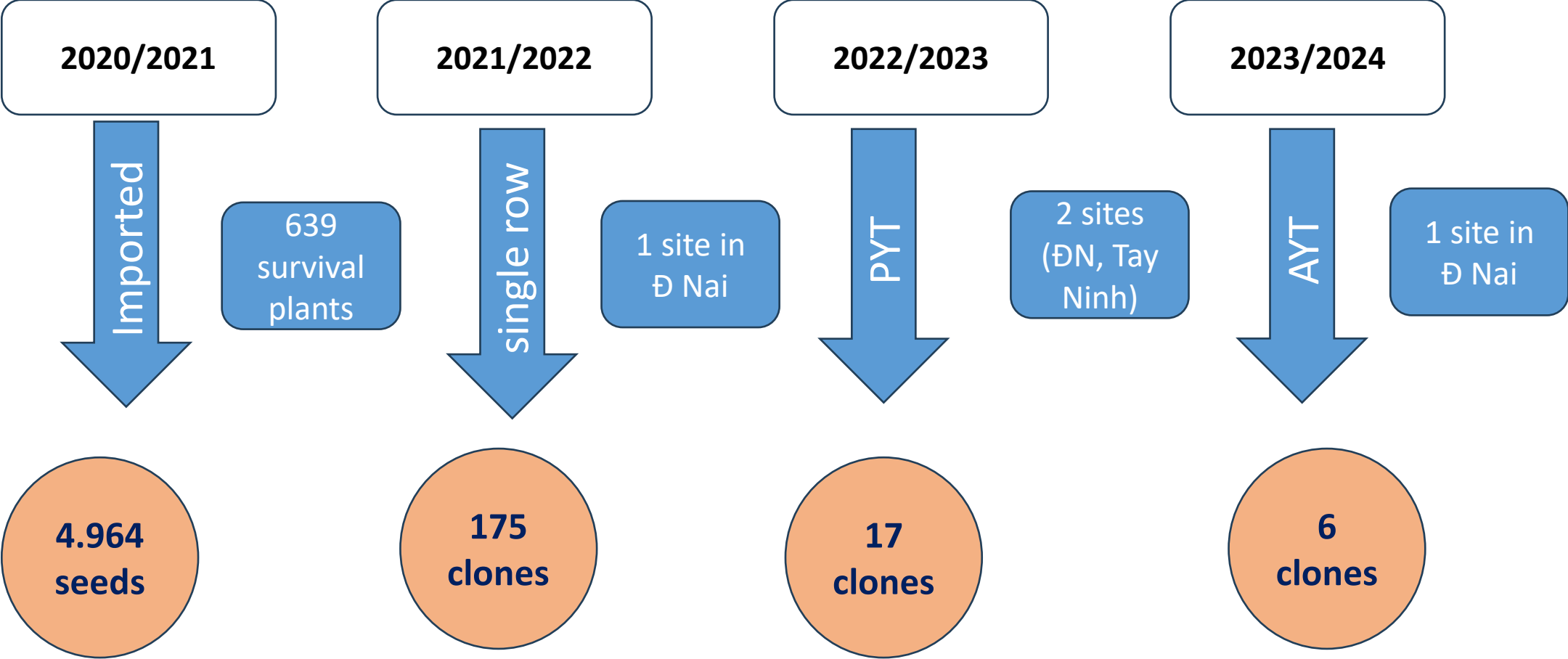
Introduction

- Activity 1: Evaluation of botanical seeds imported from **Hawaii** (NextGen project)
- Activity 2: Multi-environmental evaluation of CMD Resistant clones from **CIAT, IITA and Vietnam local varieties.**

Development

- Activity 3: **Develop CMD resistant varieties** by crossing between Vietnam Elites and CMD resistance varieties with CMD2 marker assisted

Activity 1: Evaluation of botanical seeds imported from Hawaii in 2020-2021



Performance of the Population from Hawaii

genotype			BLUPs_germination_perc		BLUPs_starch		BLUPs_yield_ha		BLUPs_starch_yield	
	check	advanced	Tai Ninh	Dong Nai	Tai Ninh	Dong Nai	Tai Ninh	Dong Nai	Tai Ninh	Dong Nai
KM505	yes		1.0	1.0	23.8	23.8	28.0	17.0	6.5	4.5
KU50	yes		0.9	0.9	21.6	20.9	28.0	23.4	5.8	5.4
TMEB419	yes		1.0	1.0	16.8	21.3	28.8	26.3	4.7	5.8
VN19-1050	yes		0.9	0.9	11.6	17.2	31.5	14.9	3.4	3.2
IBA980581	yes		0.4	0.4	14.9	13.8	15.3	6.8	2.3	1.1
CR24-16	yes		0.5	0.2	20.3	14.5	9.5	-0.5	2.1	0.3
HLH20-H0016		yes	0.9	0.8	20.8	20.2	32.6	13.2	6.5	3.4
HLH20-H0085		yes	0.9	0.4	20.0	18.9	31.9	7.8	6.2	1.8
HLH20-H0108		yes	0.9	0.8	18.6	15.1	34.1	8.1	6.1	1.7
HLH20-H0022		yes	0.8		22.9		26.2		5.8	
HLH20-H0047		yes	0.9	0.9	17.8	18.6	32.4	21.6	5.7	4.3
HLH20-H0075		yes	0.8	0.4	18.7	16.7	30.8	1.3	5.6	0.8
HLH20-H0135			0.8		18.8		27.0		5.1	
HLH20-H0039		yes	0.9	0.9	12.1	9.0	45.5	28.9	4.8	1.8
HLH20-H0036			0.7	0.3	19.0	16.3	22.7	4.9	4.2	1.1
HLH20-H0038			0.9		17.5		23.5		4.0	
HLH20-H0051			0.5	0.3	18.8	15.7	21.6	5.9	4.0	0.4
HLH20-H0082			0.5	0.0	19.4		11.6	0.0	2.5	0.0
HLH20-H0031			0.6	0.2	19.9	16.6	9.3	0.5	2.2	0.3
HLH20-H0050			0.3	0.4	16.6	13.8	10.7	5.6	1.9	0.7
HLH20-H0065			0.5	0.2	20.4	18.4	5.4	1.6	1.2	0.3
HLH20-H0053			0.1	0.0		16.6		1.7		0.6
HLH20-H0083			0.0	0.1				0.0		0.0



HLH20-H0039

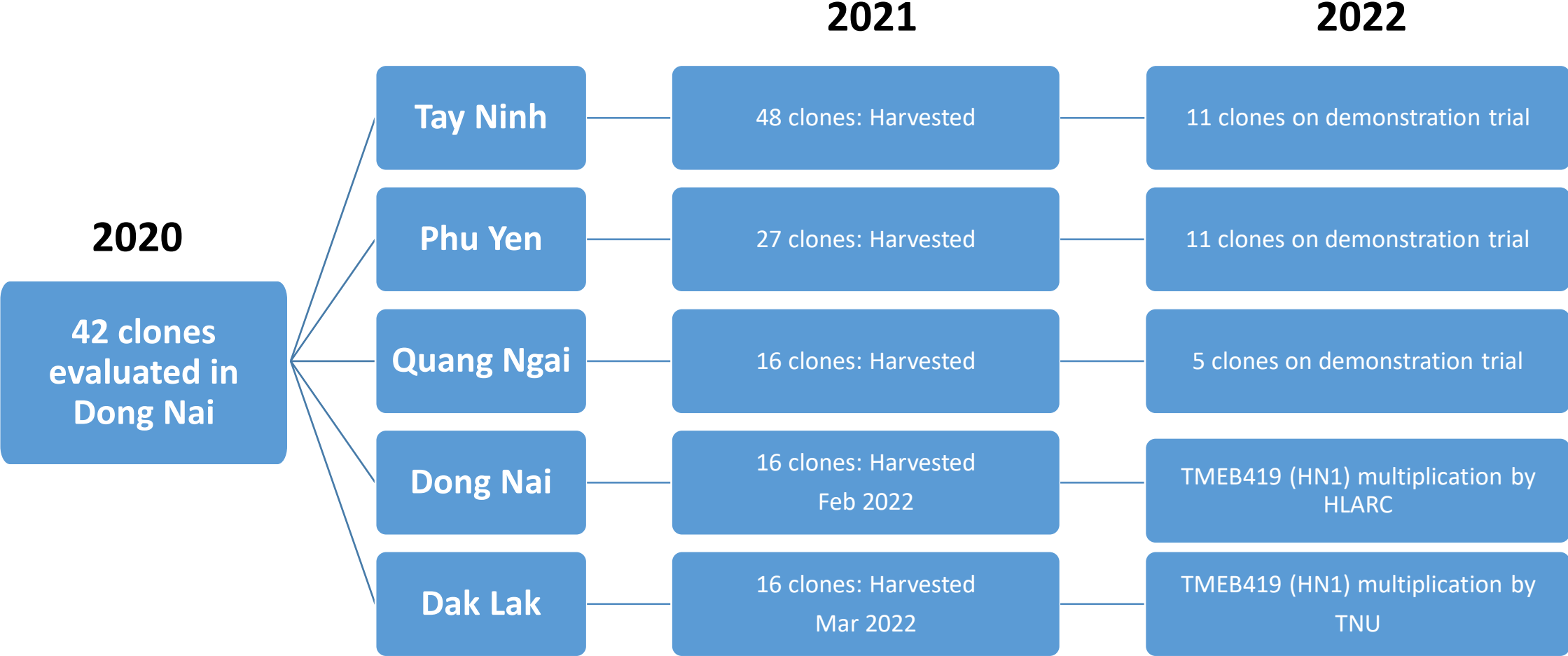


HN1 (TMEB419)



HLH20-H0047

Activity 2: Multi-environmental evaluation of CMD Resistant clones from CIAT, IITA and Vietnam local varieties



Six CMD Resistant Varieties Have Been Released in Vietnam



1. = No visible symptoms (highly resistant)
- 2: =mild chlorotic patterns on entire leaflets or mild distortion at base of leaflets, rest of leaflets appearing green and healthy (moderately resistant).
- 3: = strong mosaic patterns on entire leaf, and narrowing and distortion of lower one-third of leaflets (tolerant)
- 4: = severe mosaic, distortion of two-thirds of leaflets and general reduction of leaf size (susceptible).
- 5: = severe mosaic, distortion of four-fifths or more of leaflets, twisted and misshapen leaves (highly susceptible)

CIAT
&
IITA

	BLUE – single environment mean					BLUP
	2020_donn	2020_tayn	2021_tayn	2021phuy	2021_quan	CMD_10mon
KU50	4.0	4.0	3.4	2.3	1.0	3.0
TMEB419	1.0	1.0	1.4	1.3	1.0	1.1
CR24-16	1.0	1.0	1.1	1.1	1.0	1.0
CR13-8	1.0	1.0	1.0	1.0	1.0	1.0
CR24-3	1.0	1.0	1.0	NA	NA	1.0
CR52A-2	1.0	1.0	NA	NA	NA	1.0
AR9-48	1.0	1.0	1.1	1.1	1.0	1.0
CR52A-4	0.9	0.9	0.9	NA	1.0	0.9
IBA980581	1.1	1.1	1.0	0.9	1.0	1.0
IBA972205	1.0	1.0	0.9	1.1	1.0	1.0
IBA920057	1.1	1.1	1.1	0.9	NA	1.0
IBA980505	1.0	1.0	NA	1.0	NA	1.0
HL-S11	3.1	3.1	4.1	4.0	NA	3.7
KM140	2.7	2.7	3.1	3.9	NA	3.5
KM419	3.7	3.7	3.8	2.8	3.3	3.5
KM505	2.6	2.6	NA	NA	2.1	2.6

The clones were sorted based on **starch yield**.

Six CMD Resistant Varieties Have Been Released in Vietnam

		BLUE – single environment mean					BLUP	BLUE – single environment mean					BLUP	
		2020_donn	2020_tayn	2021_tayn	2021phuy	2021_quan	starch_yield (ton/ha)	2020_donn	2020_tayn	2021_tayn	2021phuy	2021_quan	starch (%)	
CIAT & IITA	HN1	KU50	13.3	2.4	11.0	6.4	7.8	8.0	28.4	28.2	27.2	24.1	29.1	27.1
		TMEB419	7.6	13.5	10.1	4.4	9.0	7.9	26.8	29.7	25.3	20.0	24.1	24.3
	HN36	CR24-16	5.8	10.2	11.7	3.3	8.0	7.6	27.1	30.9	27.0	22.5	27.2	26.0
		CR13-8	7.0	8.5	9.4	4.4	6.1	7.2	25.9	29.5	25.6	20.8	25.3	24.5
		CR24-3	8.7	7.3	12.7	NA	NA	7.1	22.5	27.7	24.7	NA	NA	22.3
		CR52A-2	8.7	8.9	NA	NA	NA	7.1	23.8	30.7	NA	NA	NA	24.2
	HN97	AR9-48	8.1	6.6	9.6	4.5	8.6	6.7	25.8	25.8	25.9	23.2	25.8	25.4
		CR52A-4	7.2	8.1	9.2	NA	6.5	6.7	26.8	29.6	29.3	NA	26.9	27.1
	HN80	CR27-20	8.9	7.4	8.9	NA	4.6	6.5	25.9	30.4	26.5	NA	26.4	26.3
	HN5	IBA980581	4.7	13.1	8.1	2.6	5.9	6.1	21.0	27.1	20.5	18.0	19.8	20.5
	HN3	IBA972205	5.5	7.7	11.6	3.8	3.1	5.9	21.4	26.1	21.0	12.8	14.2	18.5
		IBA920057	5.5	4.8	10.6	4.1	NA	5.8	22.0	25.8	26.6	19.0	NA	22.8
		IBA980505	4.8	6.1	NA	2.1	NA	5.2	21.4	23.5	NA	14.8	NA	18.9
		HL-S11	11.6	1.1	7.0	3.4	NA	5.8	29.0	29.1	27.6	27.1	NA	28.3
		KM140	7.5	6.0	6.4	3.2	NA	5.8	21.3	27.1	23.3	17.9	NA	21.4
		KM419	5.0	3.4	6.5	3.2	5.9	5.7	23.8	30.7	23.8	22.5	23.0	24.7
	KM505	6.4	5.6	NA	NA	6.2	5.3	25.8	31.3	NA	NA	27.9	25.8	

The clones were sorted based on starch yield.

Further improvement required: starch stability, plant type, other pest and disease resistance

Multi-environmental evaluation of CMD Resistant clones

- From 2021-2023, CMD Resistant clones were transferred by HARC to partners for evaluation in many other ecological regions.
- The results of evaluation in many regions show that HN1 (TMEB419) is a widely adaptable line with good resistance to CMD and good fresh tuber yield and starch content.
- From 2022 until now, it is reported by stakeholders that area planted with HN1 variety is about 6-7 thousand hectares.
- Many farmers have achieved high economic benefits thanks to propagating HN1.

Activity 3: Develop varieties with CMD resistance

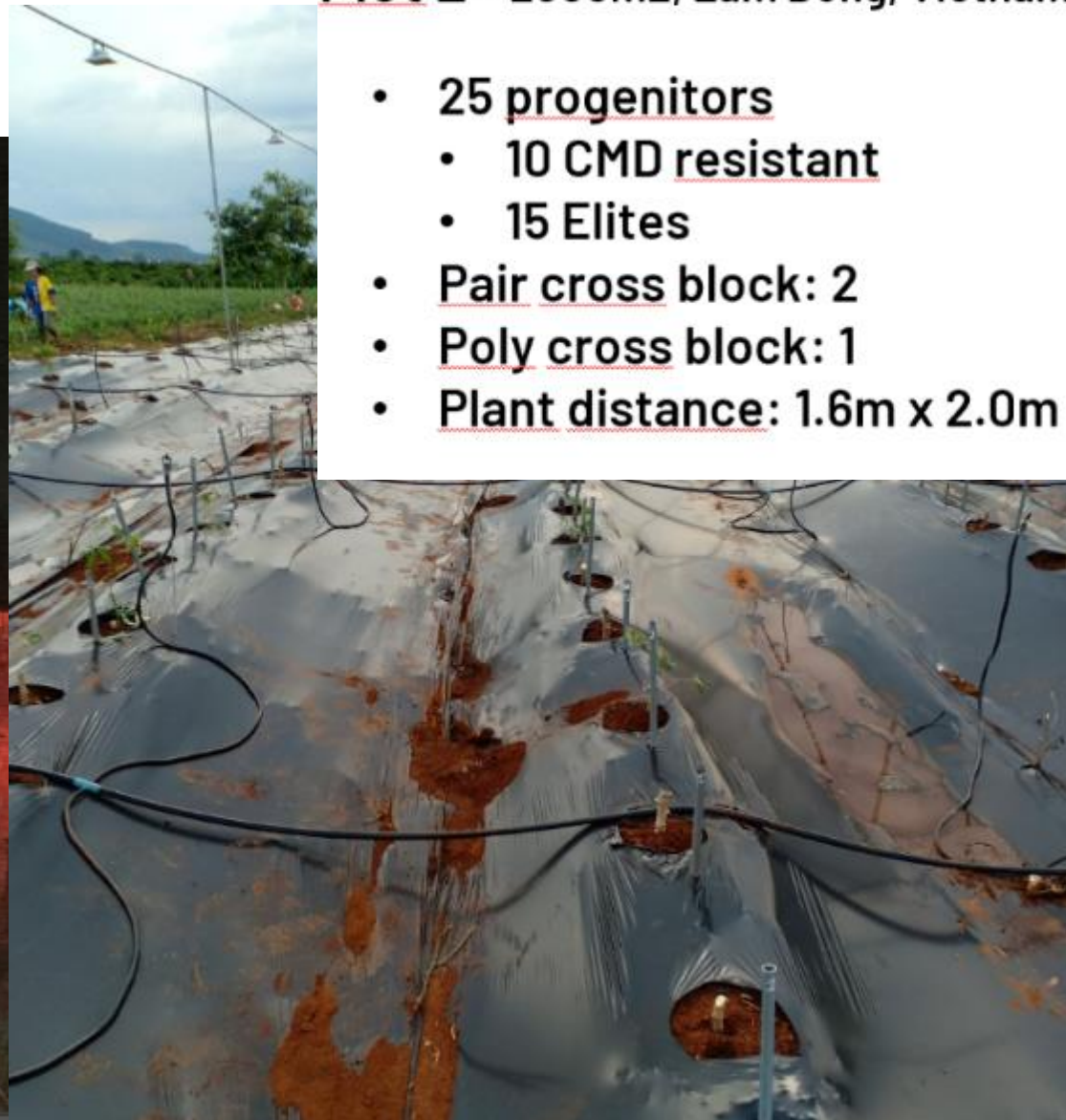
Crossing nursery in Lam Dong – Flower inducing technology



Crossing Nursery 2023

Plot 2 - 2000m², Lam Dong, Vietnam

- 25 progenitors
 - 10 CMD resistant
 - 15 Elites
- Pair cross block: 2
- Poly cross block: 1
- Plant distance: 1.6m x 2.0m



Activity 3: Crossing Nursery in Lam Dong in 2020-2023

Planting

flowering

Crossing

Harvesting

June

Sept

Oct - Dec

Dec-Feb



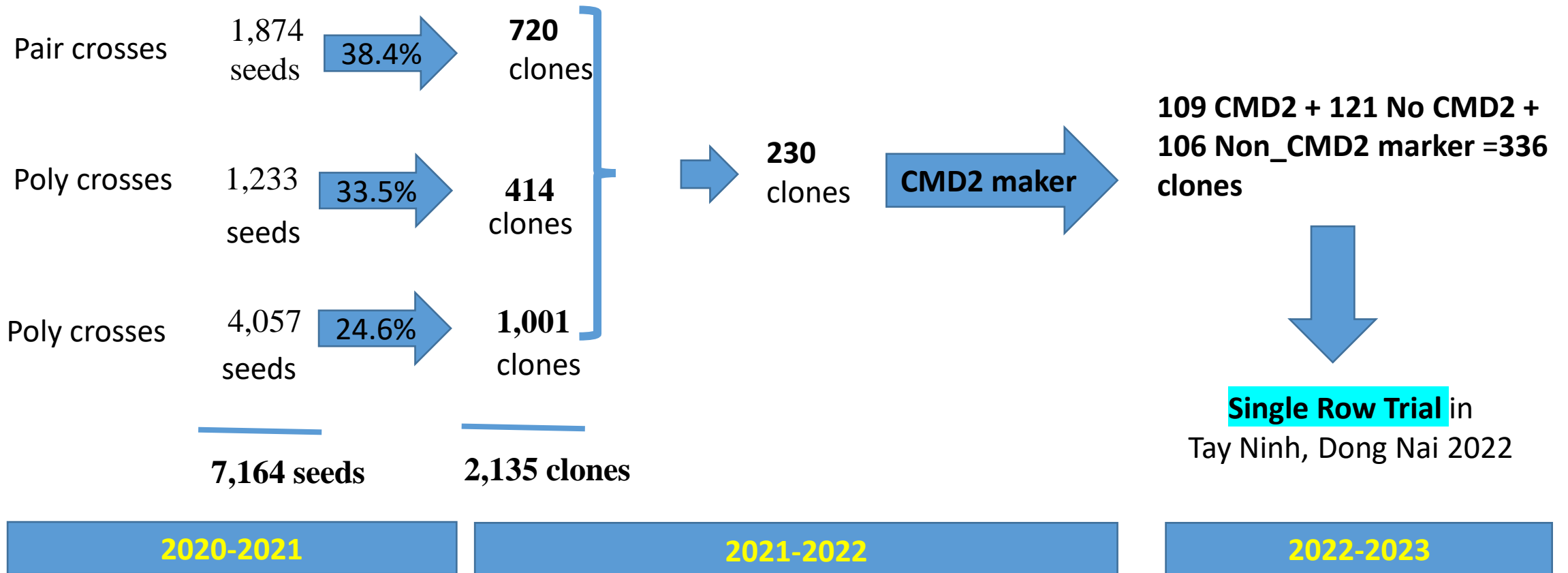
Activity 3: Crossing Nursery in Lam Dong in 2020 - 2023

Item	2020/2021	2022	2023	Total
Progenitors				
CMD resistance (CIAT, IITA)	19	8	7	
Landace, Elite	18	5	14	
Thailand	2	3	3	
Hybrid results				
Full-sibs (seed)	2.194	2.203	5.256	9.653
Half-sib (seed)	8.007	15.246	24.527	47.780
Selfing (seed)			312	312
Managed				
Full-sibs (seed)				
HLARC	2.110	1.556	3.256	6.922
CIAT	320	1.530	2.000	3.850
Half-sib (seed)				
HLARC	5.897	13.476	22.657	42.030
CIAT	1.870	1.770	1.870	5.510
Selfing (seed)				
HLARC				
CIAT			312	312

Activity: Evaluate the seeds harvested from crossing nursery (2021/2022)

Location: Dong Nai

F1 Seedling Field Selection



Breeding Populations of Three Cohort of Cycle 1 (2021-2023)

Item	2021	2022	2023
Number seed sowing			
Full-sibs (seed)	1.874	1.556	1.844
Half-sibs (seed)	5.290	3.712	4.040
Germination (%)			
Full-sibs	38.40	55.40	60.85
Half-sibs	26.74	44.80	45.50
Clones to testing CMD maker	<u>230</u>	<u>802</u>	
Full-sibs (clone)	137	303	
Half-sibs (clone)	93	499	
Showing have CMD2	<u>109</u>	<u>318</u>	
Full-sibs (clone)	61	158	
Half-sibs (clone)	48	160	
Single row evaluation clones	336	319	



Single Row Trial in Tây Ninh



Single Row Trial in Dong Nai

F1C1_V21 of 2021 population Tay Ninh and Dong Nai, Vietnam

- 340 clones + 5 checks
- CMD2 marker
- Design: Row column
- Plot: 4 plants x 1 row
- Rep x col x row: 1 x 16 x 23
- Plant distance: 1.0m x 0.8m
- Record data: 1,3,6,9 months after planting and at harvest by Fieldbook apps on smart phone



The top clones of the cycle 1 and cohort 1 population were selected for further evaluation in two locations

Note: Different performance in two environments
— Severe root rots in Tay Ninh

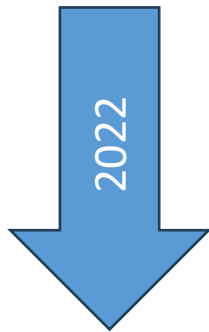
Genotype	Dong Nai			Tay Ninh		
	CMD_9 m	Yield (ton/ha)	Starch (%)	CMD_9 m	Yield (ton/ha)	Starch (%)
HLF21-0014	1	38.75	27.50	1	7.81	25.70
HLF21-0019	1	60.94	26.50	1	45.31	15.50
HLF21-0022	1	65.63	31.00	1	48.44	21.50
HLH21-0035	1	112.50	25.50	1	25.00	21.50
HLH21-0046	1	43.13	30.50	1	6.25	26.50
HLH21-0066	1	64.06	27.30	1	87.50	30.00
HLH21-0112	1	32.81	24.80	1		
VF21-0250	1	37.50	28.70	1	20.63	
VF21-0255	1	18.75	24.10	1	28.75	33.30
VF21-0264	1	47.81	27.70	1	34.38	19.00
VF21-0267	1	6.25	26.70	1	9.06	
VF21-0289	1	37.50	24.90	1	6.25	
VF21-0292	1	32.81	24.70	1	6.25	
VF21-0315	1	34.38	23.80	1	46.88	19.00
VF21-0343	1	29.69	28.50	1	2.50	19.50
VF21-0348	1	29.69	30.40	1	16.88	
VF21-0359	1	38.13	28.30	1	15.63	
VF21-0360	1	27.50	26.70	1	15.63	24.80
VF21-0364	1	43.44	29.50	1	29.69	
VH21-1503	1	65.00	30.70	1	9.06	21.50
VH21-1505	1	31.56	28.00	1	25.00	
VH21-1506	1	37.50	26.80	1	40.63	31.00
VH21-1513	1	51.25	24.10	1	26.56	
VH21-1516	1	60.31	24.00	1	10.94	
VH21-1519	1	37.50	29.00	1	8.75	
VH21-1521	1	34.38	26.00	1	10.94	
VH21-1537	1	18.75	23.70	1	-	20.50
VH21-1549	1	22.50	28.80	1	28.13	25.50
VH21-1573	1	43.75	23.50	1	17.19	-

Activity: Preliminary Yield Trial (2023/2024)

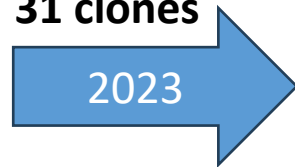
Location: Dong Nai, Tay Ninh

Singer Row Trial
(10 months)
4 plants/2 sites/1 rep

Source materials: 109 CMD2 +
121 No CMD2 marker + 106
Asymptomatic = 336 clones



31 clones



Preliminary Yield Trial
(9-10 months)
10 plants/2 sites/3 rep



Tay Ninh



Dong Nai

109 CMD2:

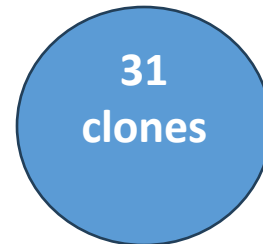
Selected 23 Clones

121 No CMD2 marker:

Selected 0 Clones

106 Asymptomatic :

Selected 9 Clones



2022-2023 season

2023-2024 season

Alliance



PRELIMINARY YIELD TRIAL IN TAY NINH

To Do: To evaluate performance of CMD resistant in grey soil areas in Tay Ninh

Location: Thai Binh commune, Chau Thanh district, Tay Ninh province, Vietnam

Variety: 31 clones + 5 control varieties

Source: 31 clones with high yield and starch content, good plant type, the CMD2 marker and showing resistance in high CMD pressure environments were selected from the evaluation of over 500 clones in single row trials conducted in 2022 by HLARC and CIAT at Tay Ninh and Dong Nai.

Timeline: MARCH 09th 2023

Fertilizer: 100 N, 50 P2O5, 100 K2O

Design	Density	Plot area	Replication
Row-Column	1 m x 1 m	1 m x 5 m	03

Uniform with tractor

Planting method: Vertical 5 - 6 cm underground and buds facing up

Stake: 10 - 15 cm (5-8 buds)

WEED CONTROL: Apply herbicide after planting and hand weeding when weed small.

Harvest: At 9-10 months after planting, pull out the plants in effective plots, cut off roots and weigh fresh roots

RECORD DATA: At 1, 3, 6, 9 months after planting and at harvest (by Fieldbook apps on Smartphones)



Traits List:

- GERMINATION
- VIGOR
- CMD; CWBD; CBB; CRR...
- #MAIN STEMS
- PLANT HEIGHT
- HEIGHT OF THE FIRST BRACH
- # BRANCHING EVENTS
- SHAPE OF PLANTS
- ROOT SHAPE
- EXTERNAL COLOUR OF STORAGE R...
- ROOT PULP COLOUR
- FRESH ROOT YIELDS
- STARH CONTENTS
- #LODGING PLANTS
- # OF PLANTS HARVESTED
- picture
- audio
- location

Future Development

1. **Perform the 2nd cycle of breeding** focusing on starch stability, plant type, and resistance to root rot and witches' broom disease;
2. **Increase capacity** in data management and data analysis;
3. **Leverage DNA markers** in variety development;
4. **Enhance collaboration** in disease diagnosis and screening

Thank for your listening !