



Australian Government

Australian Centre for
International Agricultural Research



Webinar Series

Number 4

Status on assessment of CMD Resistant varieties in Vietnam and Thailand:
Implications for short, medium and long-term plans

Developing CMD Resistant Cassava Varieties for South East Asia

AGI and HLARC, Vietnam
Alliance of Bioversity and CIAT

Xiaofei Zhang

May 18, 2021



RESEARCH
PROGRAM ON
Roots, Tubers
and Bananas

Product and Market Segment



Biofortified cassava with high dry matter,
w/ or w/o CMD, CBSD and whitefly resistance



Good cooking quality, low HCN,
w/ or w/o CMD, CBSD and whitefly resistance



High and stable dry matter,
w/ or w/o CMD, CBSD and whitefly resistance



Low amylose, high and stable dry matter,
w/ or w/o CMD and whitefly resistance



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Market Segments are identified on a regional basis and defined based on a unique combination of customer preferred components.

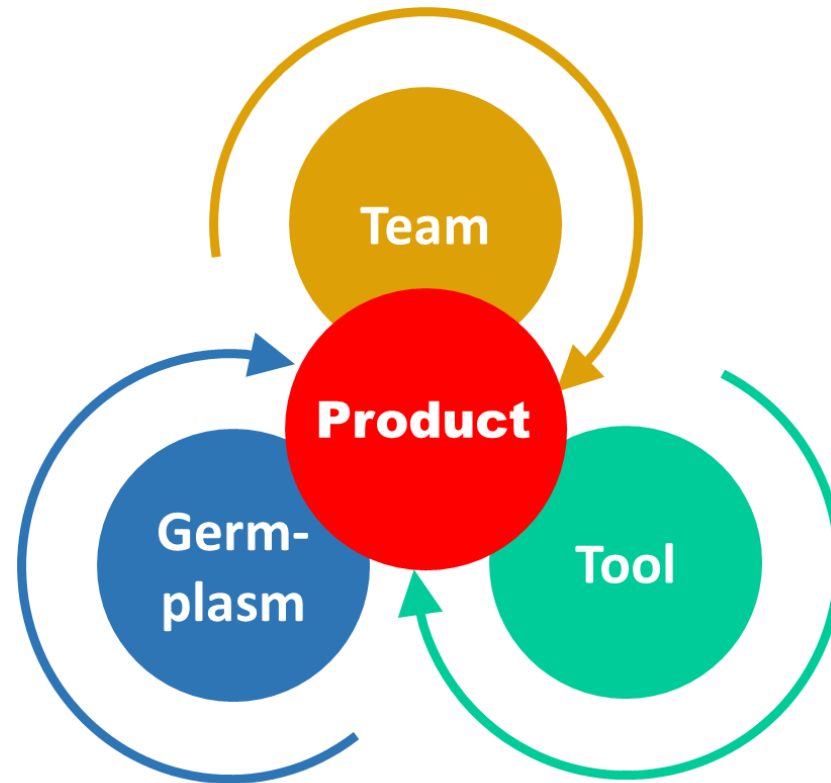
Seven Breeding Pipelines at CIAT



Market Segment	Product Profile		Stage 1.1	Stage 1.2	Stage 2	Stage 3	Stage 4	Stage 5	Stage 6	Existing Products
1.1	high pro-Vitamin A	+ CMD + CBSD + whitefly	6,000	480	180	3,000 seeds of improved populations for Africa IITA CGIAR				
1.2		--	4,000	320	120	50	15	8	2	0
2.1	good cooking quality	+ CMD + CBSD + whitefly	6,000	480	180	3,000 seeds of improved populations for Africa IITA CGIAR and ASIA				
2.2		--	4,000	320	120	50	15	8	2	2
3.1	stable dry matter	+ CMD + CBSD + whitefly	6,000	480	180	3,000 seeds of improved populations for Africa IITA CGIAR and ASIA				
3.2		--	4,000	320	120	50	15	8	2	3
4	special starch	--	10,000	480	180	70	20	10	3	1
			40,000	2,880	1,080	220	65	34	9	

- #1) Develop high **pro-vitamin A cassava populations** with high yield, high dry matter, and high CMD, CBSD and whitefly resistance
- #2) Develop high **pro-vitamin A cassava varieties** with high yield, erect plant type, low cyanide and good cooking quality
- #3) Develop **good cooking quality cassava populations** or clones with high yield, high and moderate dry matter, low cyanide, and high CMD, (CBSD) and whitefly resistance
- #4) Develop **good boiled cassava varieties** with high yield, erect plant type, low cyanide and moderate dry matter.
- #5) Develop **high and stable dry matter cassava populations** or clones with high yield, and CMD, (CBSD) and whitefly resistance
- #6) Develop **high and stable dry matter cassava varieties** with high yield and erect plant type.
- #7) Develop **waxy starch cassava varieties** with high and stable dry matter, high yield and erect plant type.

Components of Plant Breeding



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

Materials

- CIAT102, 34 + 2 = 36 clones
- 5 IITA clones
- 7 varieties or landraces in SEA

	CIAT	CIAT	IITA	SEA
1	C33	CR100-2	IBA920057	HLS11
2	C39	CR100-5	IBA972205	KM140
3	AR11-12	CR100-9	IBA980505	KM419
4	AR12-11	CR13-8	IBA980581	KM505
5	AR12-57	CR24-16	TMEB419	KU50
6	AR14-2	CR24-3		N30
7	AR14-3	CR25-4		VN19-442
8	AR17-18	CR27-20		
9	AR17-23	CR52A-2		
10	AR17-3	CR52A-4		
11	AR18-1	CR60B-10		
12	AR23-1	CR61A-1		
13	AR35-1			
14	AR37-103			
15	AR37-38			
16	AR40-19			
17	AR40-3			
18	AR40-5			
19	AR42-3			
20	AR42-4			
21	AR9-12			
22	AR9-14			
23	AR9-48			
24	AR9-63			

Advanced Yield Trials

Materials: 48 clones including IITA5, R from CIAT102, and elite varieties

Planting time, May 2020

Harvesting time, March 2021

Location, Tay Ninh and Dong Nai, Vietnam

Source of stem cuttings, Tay Ninh

Trial design, row-column design with 3 reps

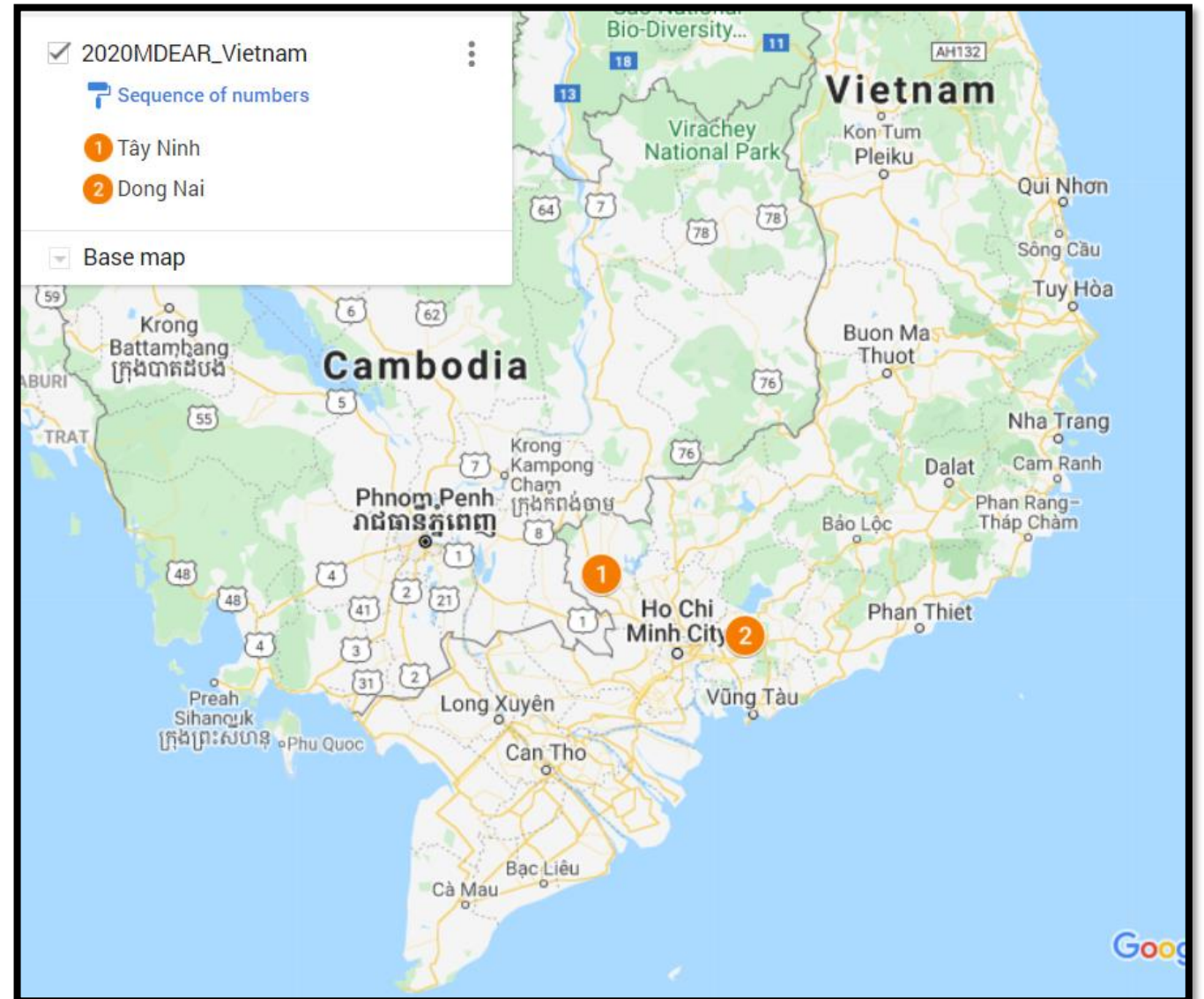
Plot size, 20 plants per plot, 4 rows, harvesting the central 6 plants for yield

Trait recorded: germination, vigor, CMD_1mon, CMD_3mon, CMD_6mon, CMD_10mon, plant height, stem number, height of the 1st branch, branch number, plant type, root number, root neck length, root shape, number of rotted roots, starch, root number, lodging, yield.

Location

- Tay Ninh
- Dong Nai

The major cassava production area

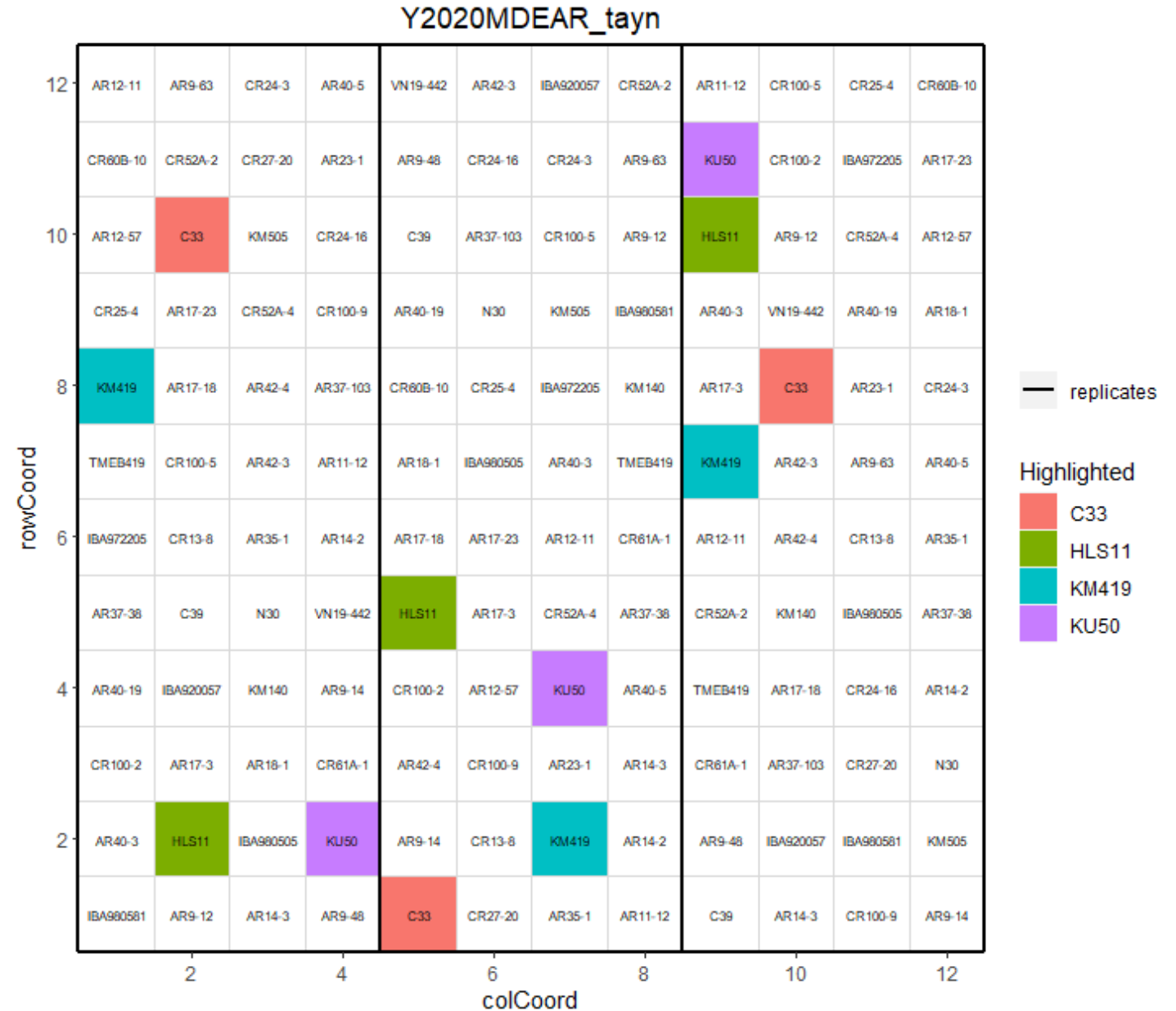


Trial design

- row-column design with 3 reps

Plot size

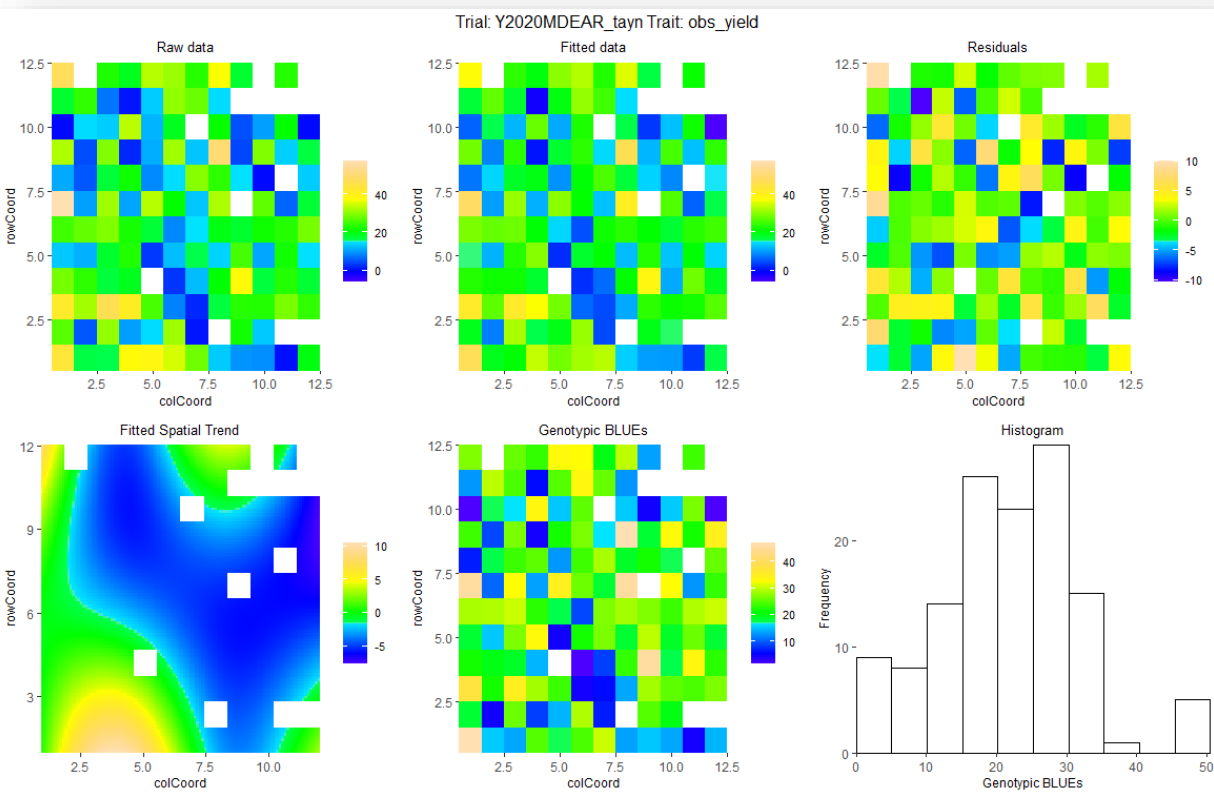
- 20 plants per plot, 4 rows
- harvesting the central 6 plants for yield



Traits recorded

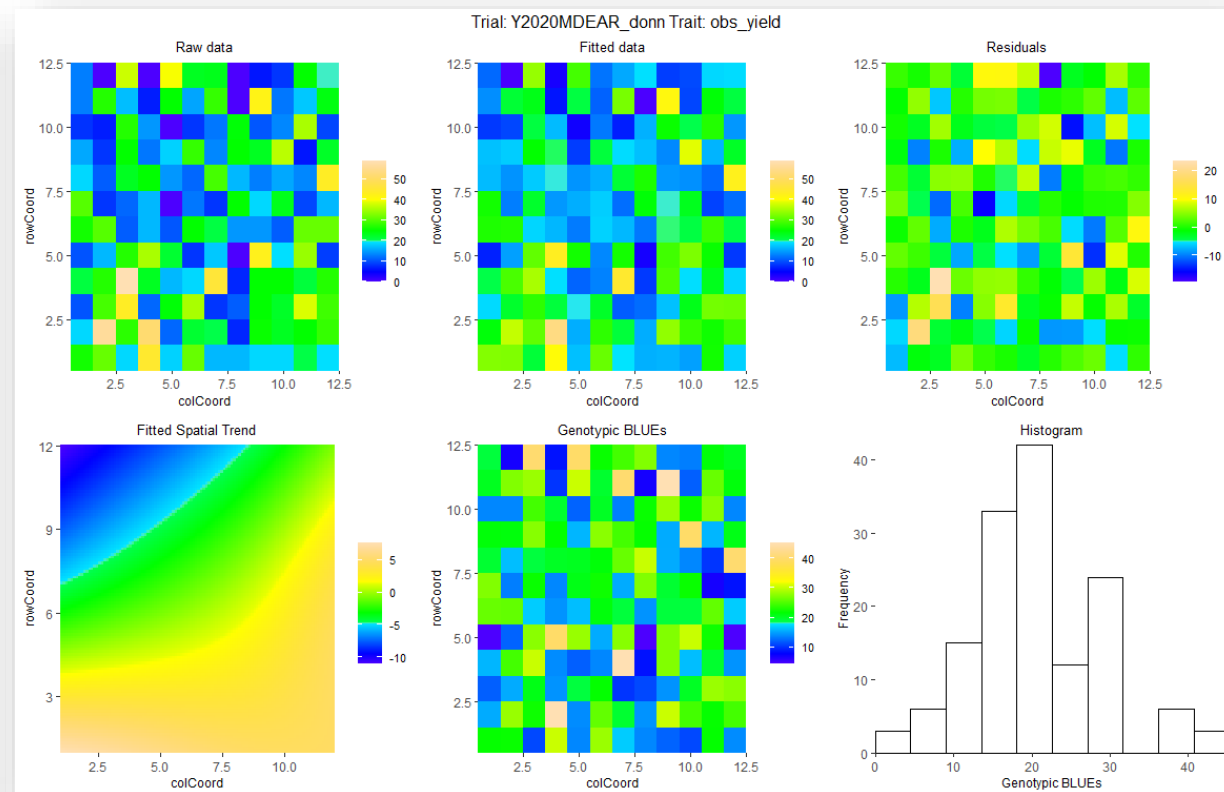
trait	when
germination	1 month
vigor	1 month
CMD_1mon	1 month
CMD_3mon	3 months
CMD_6mon	6 months
CMD_10mon	before harvest
lodging_number	before harvest
stem_number	before harvest
height	before harvest
height_1st_branch	before harvest
branch_number	before harvest
plant_type	before harvest
number_harvested	at harvest
root_peduncle1-3	at harvest
root_shape1-6	at harvest
root_number	at harvest
root_rot_number	at harvest
weight_root_plot	at harvest
starch content	at harvest

Field Spatial Variation _ Yield



Tay Ninh

Visualize the field variation



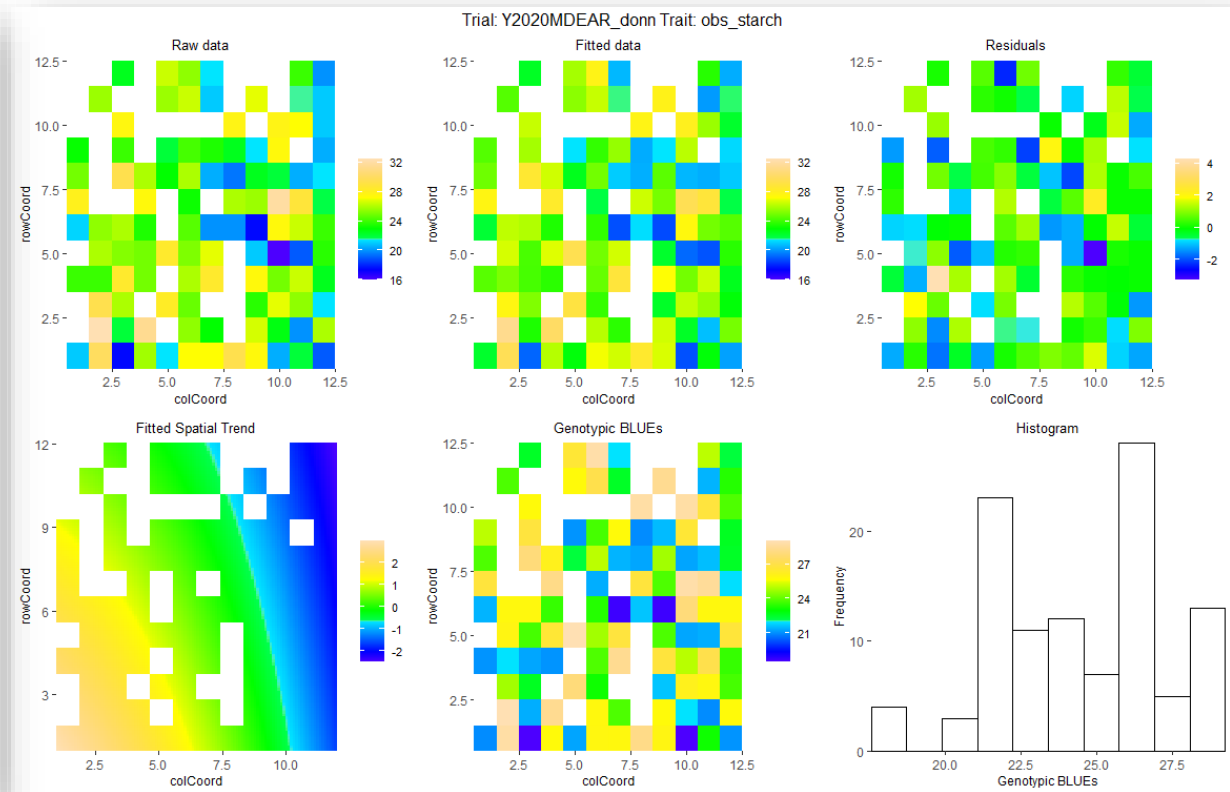
Dong Nai

Visualize the field variation

Field Spatial Variation _ Starch

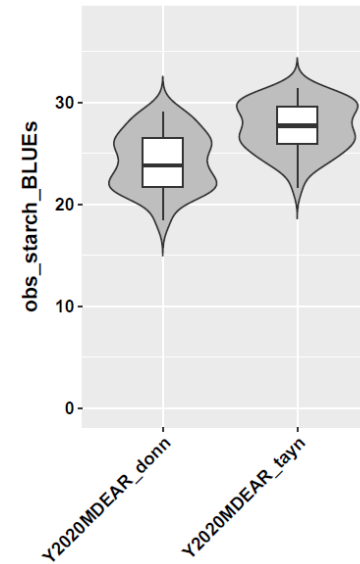
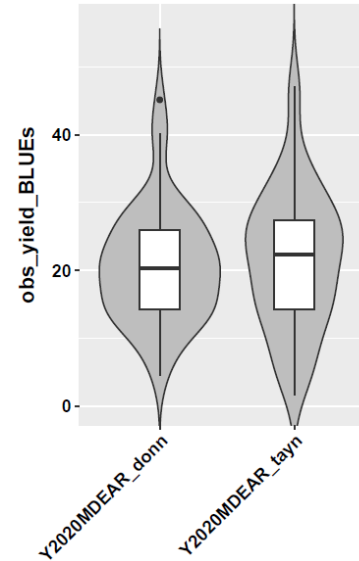
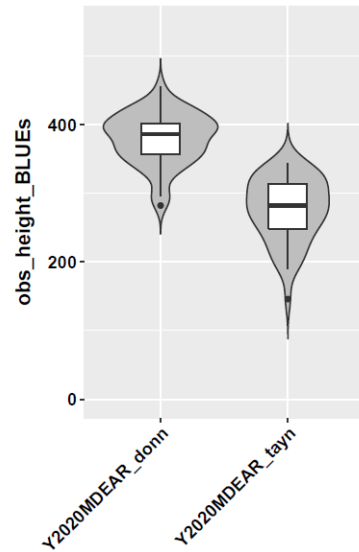
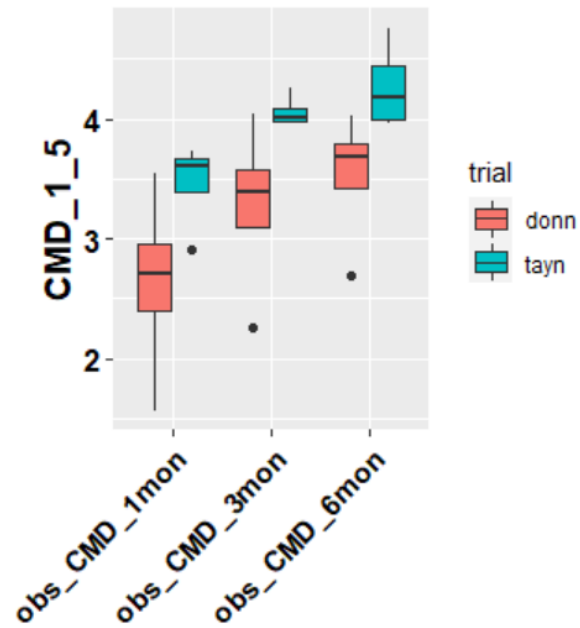


Tay Ninh



Dong Nai

Performance at Two Locations



BLUE
(mean after
correcting the spatial
variation)

Tay Ninh had higher disease pressure.

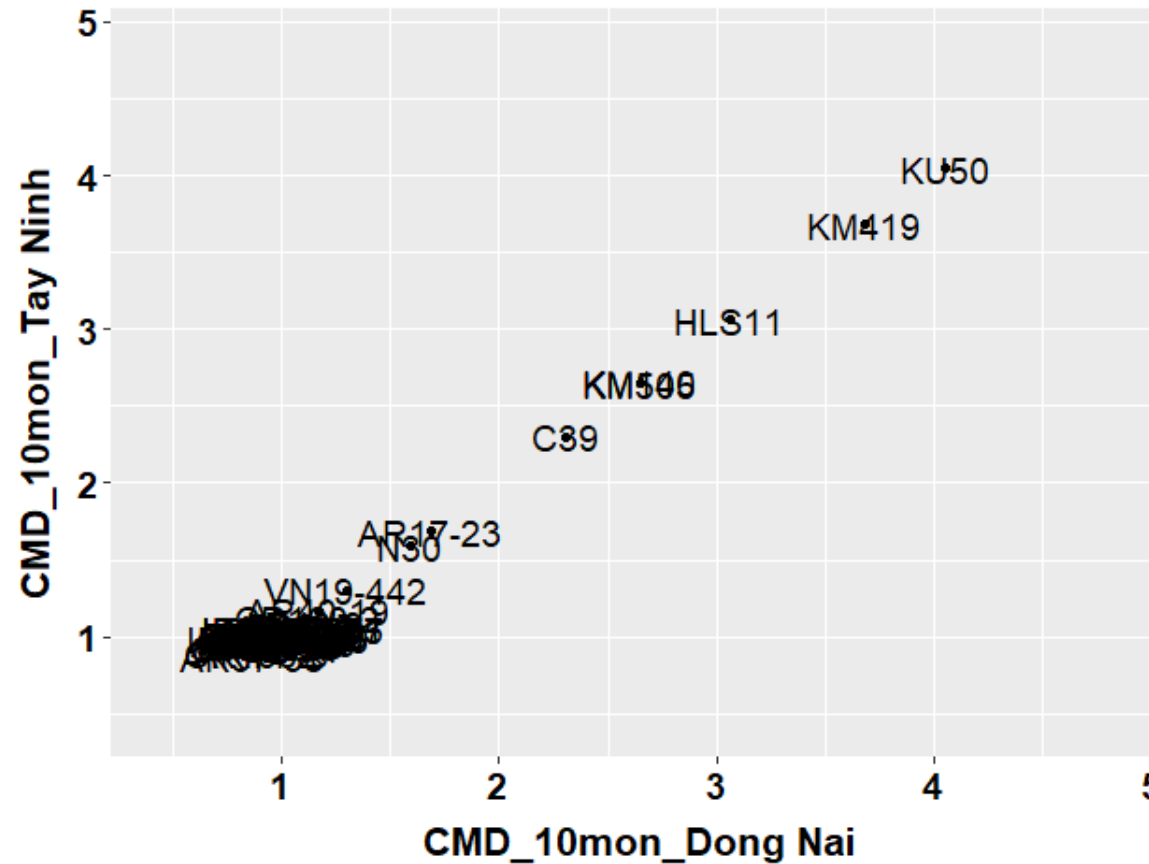
The CMD score of KM505, KM419, KM94, KM140 were shown here.

Broad-sense heritability at two locations

	germination	CMD_10mon	height	height_1st_branch	branch_number
Dong Nai	0.83	0.96	0.49	0.93	0.92
Tay Ninh	0.91	0.96	0.7	0.85	0.87
	root_number	starch	yield	starch_yield	
Dong Nai	NA	0.75	0.67	0.49	
Tay Ninh	0.71	0.49	0.82	0.76	

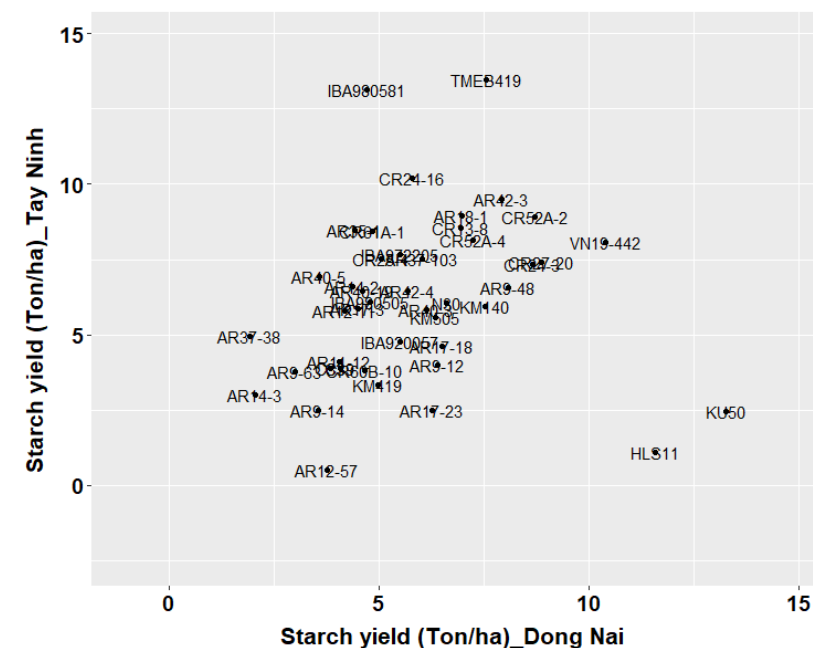
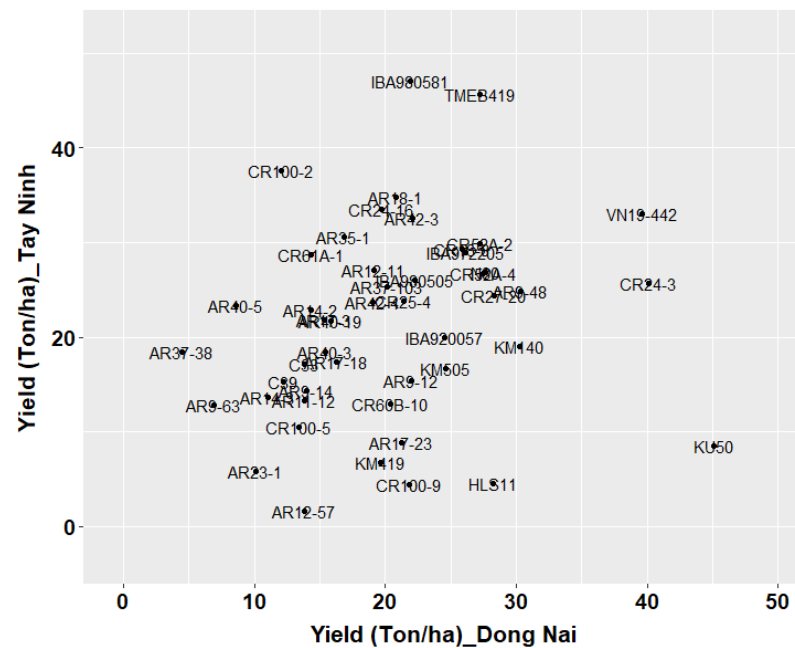
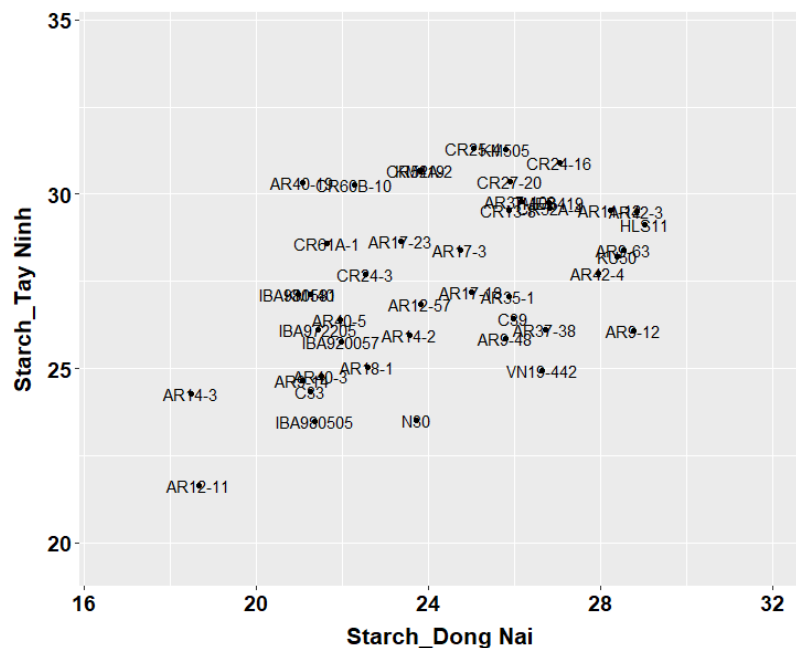
Moderate or high heritability was obtained at two locations, ranging from 0.49 to 0.96.

CMD resistance at two locations (BLUE value)



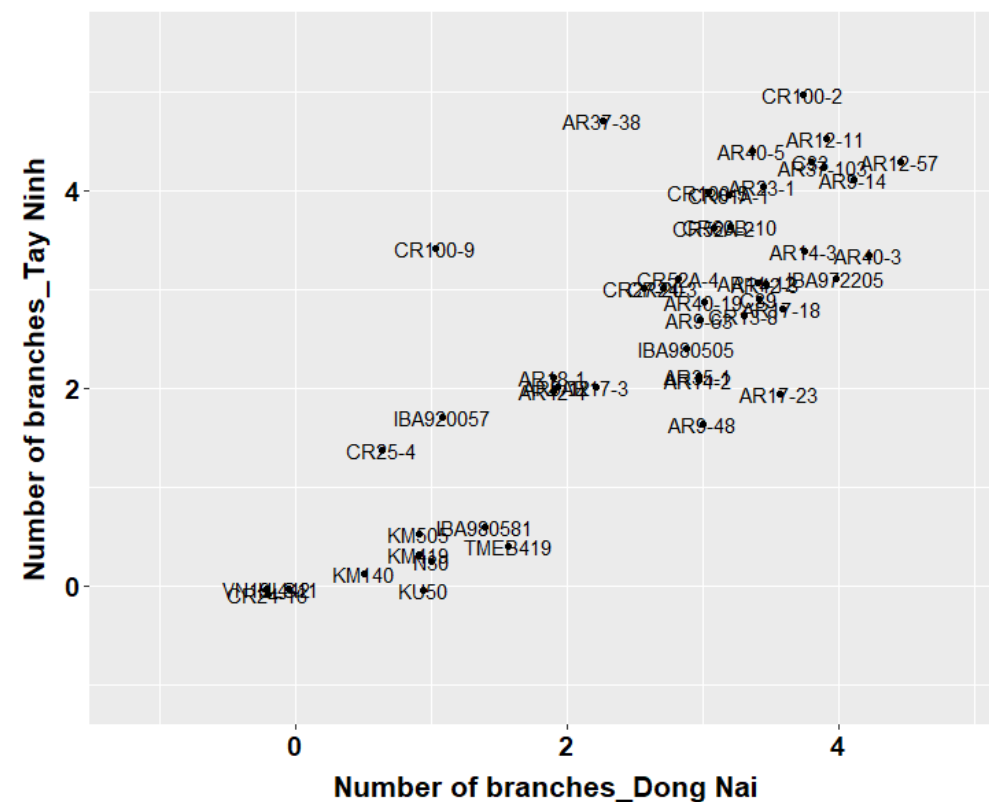
The CMD resistance of introduced clones was confirmed
The local elite varieties showed CMD susceptibility.
Broad sense heritability at individual locations was 0.96

Yield and starch at two locations



KU50 and HLS11 performed good in Dong Nai with low CMD pressure, but both showed low yield in Tay Ninh with high CMD pressure.

Plant type at two locations

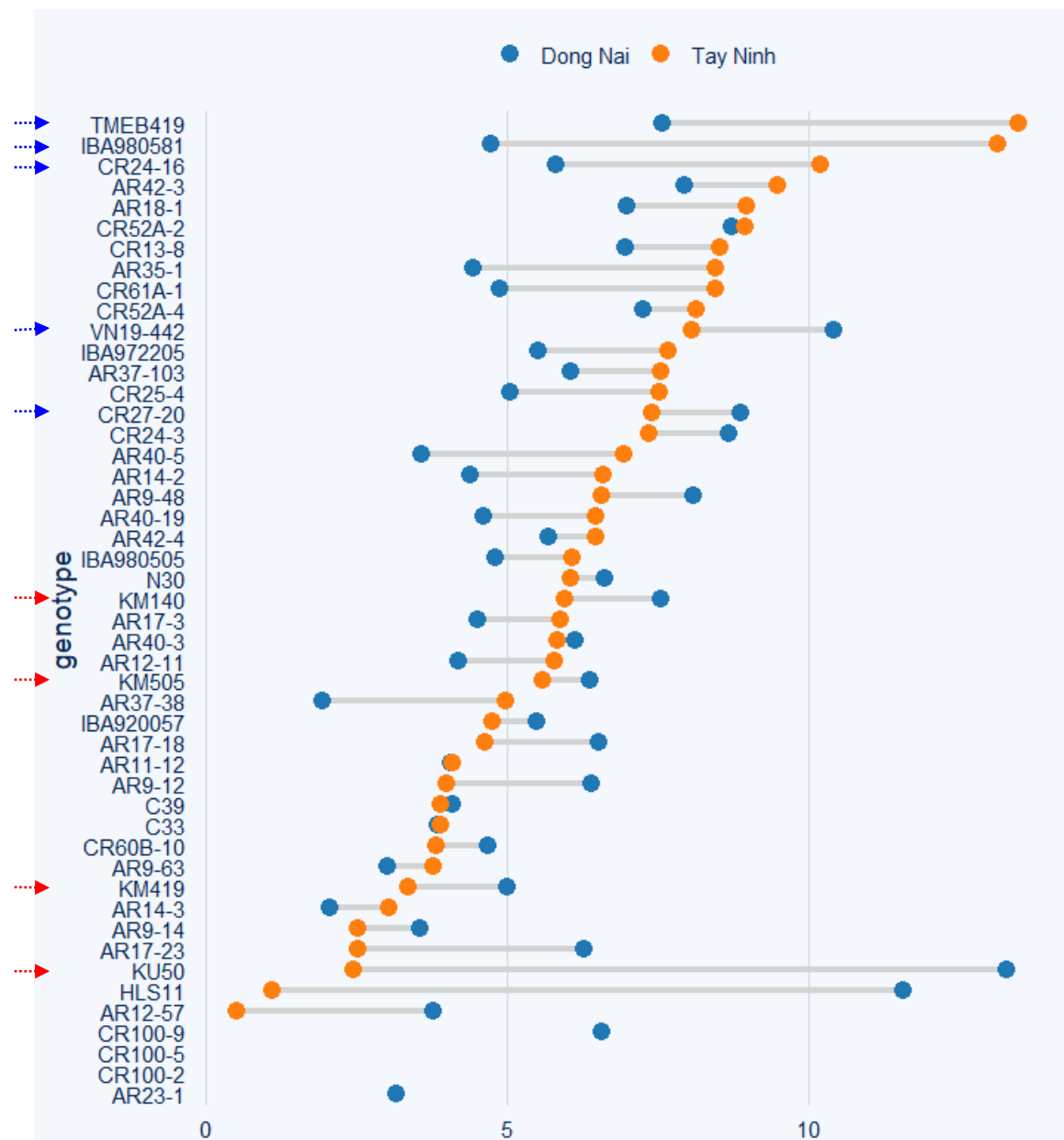


Mean of BLUE in
two trials
-- all 48 clones

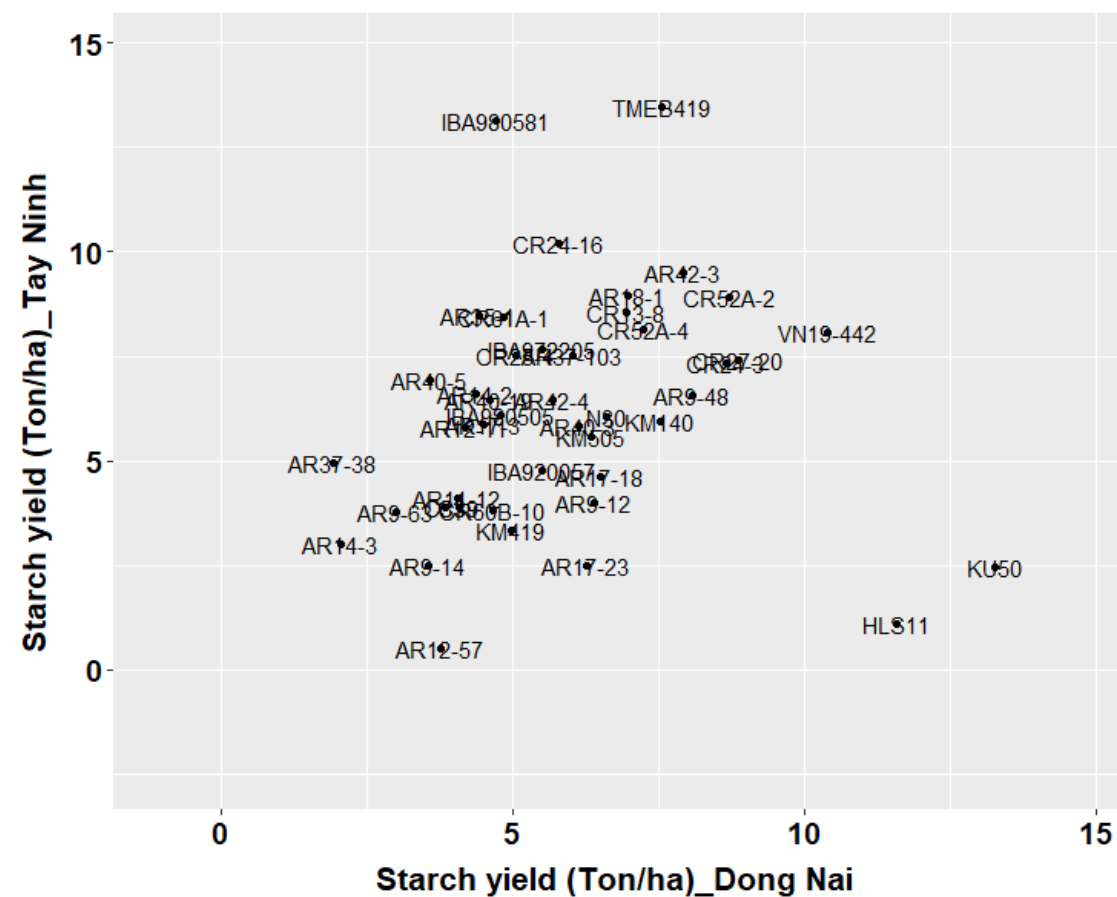
genotype	germination_perc	CMD_1mon	CMD_3mon	CMD_6mon	CMD_10mon	height	height_1st_branch	branch_number	starch	yield	starch_yield
TMEB419	92.3	1.4	1.2	1.2	1.0	333.2	282.5	1.0	28.3	36.4	10.5
VN19-442	98.8	2.0	2.3	2.1	1.3	309.3	319.3	-0.1	25.8	36.4	9.2
IBA980581	97.3	1.0	1.0	1.0	1.1	372.7	205.1	1.0	24.0	34.5	8.9
CR27-20	95.5	1.0	1.0	1.0	0.9	306.8	175.6	2.8	28.1	26.3	8.1
CR24-16	99.1	1.0	1.0	1.0	1.0	335.1	354.8	-0.1	29.0	26.6	8.0
AR18-1	77.0	1.1	1.0	1.0	1.1	354.2	287.5	2.0	23.8	27.8	8.0
CR13-8	96.8	1.0	1.0	1.0	1.0	356.9	190.6	3.0	27.7	27.6	7.7
AR9-48	92.8	1.0	1.0	1.0	1.0	365.6	291.4	2.3	25.8	27.6	7.3
IBA972205	93.3	1.1	1.0	1.0	1.0	352.8	117.4	3.5	23.8	27.5	6.6
AR35-1	96.3	1.0	1.0	1.0	0.9	359.7	210.4	2.5	26.5	23.7	6.5
CR25-4	95.7	1.0	1.0	1.0	1.0	345.9	328.6	1.0	28.2	22.6	6.3
KMS05	84.4	3.2	3.7	4.0	2.6	315.9	286.4	0.7	28.5	20.6	6.0
KM419	100.9	3.1	3.8	4.2	3.7	221.2	200.2	0.6	27.2	13.2	4.2
KU50	100.9	2.6	3.1	3.3	4.0	322.2	241.0	0.5	28.3	26.8	7.9
KM140	99.7	3.2	4.0	4.0	2.7	238.5	221.5	0.3	24.2	24.6	6.7
CR24-3	95.8	1.1	1.0	1.0	1.0	350.4	139.8	2.9	25.1	32.9	8.0
CR52A-4	100.1	1.0	1.0	1.0	0.9	332.2	116.7	3.0	28.2	27.1	7.7
CR52A-2	94.5	1.0	1.0	1.0	1.0	338.5	146.7	3.4	27.2	28.5	8.8
AR42-3	92.8	1.0	1.0	1.0	1.1	316.5	104.9	3.3	29.2	27.3	8.7
AR37-103	76.9	1.0	1.0	1.0	1.0	342.4	73.1	4.1	28.0	22.7	6.8
CR61A-1	92.4	1.0	1.0	1.0	1.0	303.7	69.9	3.6	25.1	21.5	6.6
CR100-9	92.2	1.0	1.0	1.0	0.9	333.6	157.5	2.2	23.1	13.1	6.6
HLS11	100.7	2.9	3.8	4.0	3.1	270.2	267.3	0.0	29.1	16.4	6.3
N30	98.4	2.2	2.9	2.7	1.6	327.1	281.4	0.6	23.6	27.2	6.3
AR42-4	94.6	1.1	1.0	1.0	1.0	371.6	301.7	1.9	27.8	21.3	6.1
AR40-3	84.6	1.0	1.0	1.0	1.1	306.6	78.5	3.8	23.1	16.9	6.0
AR17-18	91.7	1.0	1.0	1.0	1.0	278.6	135.5	3.2	26.1	16.8	5.6
AR40-19	97.7	1.0	1.0	1.0	1.2	360.0	110.3	2.9	25.7	18.8	5.5
AR14-2	95.8	1.0	1.0	1.0	0.9	355.6	131.4	2.5	24.8	18.6	5.5
IBA980505	91.7	1.0	1.0	1.0	1.0	317.6	125.6	2.6	22.4	24.1	5.4
AR40-5	90.5	1.0	1.0	1.0	1.0	324.2	78.6	3.9	24.2	15.9	5.3
AR17-3	92.4	1.0	1.0	1.0	1.0	309.0	113.5	2.1	26.6	18.6	5.2
AR9-12	85.1	1.0	1.0	1.0	1.0	311.4	111.6	2.0	27.4	18.7	5.2
IBA920057	98.2	1.0	1.0	1.0	1.1	383.8	316.1	1.4	23.9	22.3	5.1
AR12-11	58.8	1.0	1.0	1.0	1.0	304.9	78.8	4.2	20.2	23.1	5.0
AR17-23	85.0	1.0	1.0	1.0	1.7	298.6	95.1	2.8	26.0	15.1	4.4
CR60B-10	97.5	1.0	1.0	1.0	1.0	347.1	115.9	3.4	26.3	16.7	4.3
AR11-12	96.2	1.0	1.0	1.0	1.0	274.2	64.9	3.2	28.9	13.6	4.1
C39	98.3	3.4	3.9	3.6	2.3	243.3	76.9	3.2	26.2	13.7	4.0
C33	66.6	1.0	1.0	1.0	1.0	323.1	71.6	4.0	22.8	15.5	3.9
AR37-38	64.1	1.0	1.0	1.0	0.9	331.4	74.0	3.5	26.4	11.5	3.4
AR9-63	97.3	1.0	1.0	1.0	1.0	319.1	183.7	2.8	28.5	9.9	3.4
AR23-1	95.9	1.0	1.0	1.0	1.0	333.9	95.6	3.7	21.5	8.0	3.2
AR9-14	83.7	1.2	1.0	1.0	1.0	356.4	103.7	4.1	22.9	14.2	3.0
AR14-3	81.7	1.0	1.0	1.0	1.0	398.7	123.2	3.6	21.4	12.3	2.5
AR12-57	65.9	1.0	1.0	1.0	1.0	357.7	71.5	4.4	25.3	7.7	2.1
CR100-2	77.8	1.2	1.0	1.0	1.1	372.4	64.3	4.4		24.8	
CR100-5	57.5	1.0	1.0	1.0	1.0	351.0	119.7	3.5	30.3	12.0	

The best clones _mean of BLUE in two trials

genotype	germination_CMD_10mon	height	height_1st_branch	branch_number	starch	yield	starch_yield	
TMEB419	92.3	1.02	333.2	282.5	1.0	28.3	36.4	10.5
VN19-442	98.8	1.30	309.3	319.3	0.0	25.8	36.4	9.2
IBA980581	97.3	1.05	372.7	205.1	1.0	24.0	34.5	8.9
CR27-20	95.5	1.00	306.8	175.6	2.8	28.1	26.3	8.1
CR24-16	99.1	1.00	335.1	354.8	0.0	29.0	26.6	8.0
AR18-1	77.0	1.05	354.2	287.5	2.0	23.8	27.8	8.0
CR13-8	96.8	1.00	356.9	190.6	3.0	27.7	27.6	7.7
AR9-48	92.8	1.00	365.6	291.4	2.3	25.8	27.6	7.3
IBA972205	93.3	1.05	352.8	117.4	3.5	23.8	27.5	6.6
AR35-1	96.3	1.00	359.7	210.4	2.5	26.5	23.7	6.5
CR25-4	95.7	1.00	345.9	328.6	1.0	28.2	22.6	6.3
KM505	84.4	2.65	315.9	286.4	0.7	28.5	20.6	6.0
KM419	100.0	3.68	221.2	200.2	0.6	27.2	13.2	4.2
KU50	100.0	4.05	322.2	241.0	0.5	28.3	26.8	7.9
KM140	99.7	2.65	238.5	221.5	0.3	24.2	24.6	6.7
CR24-3	95.8	1.00	350.4	139.8	2.9	25.1	32.9	8.0
CR52A-4	100.00	1.00	332.2	116.7	3.0	28.2	27.1	7.7



Stability of Starch Yield



Validated *CMD2* Markers for MAS

Variation of CMD severity of VNM142 and CIAT102 populations in two growth seasons, 2018–2019 and 2019–2020.

Population	Trial	Trait	Mean	Median	Rang	V_g	V_e	H^2
VNM142	201801MDEAR	CMD_1.5MAP	1.56	1.43	1.00-4.00	0.10	0.21	0.50
		CMD_3MAP	1.87	1.75	1.00-4.00	0.18	0.22	0.63
		CMD_6MAP	2.23	2.20	1.00-4.00	0.27	0.19	0.75
		CMD_10MAP	2.82	2.86	1.19-4.00	0.40	0.19	0.82
	201901MDEAR*	CMD_10MAP	2.65	2.33	1.00-4.12	1.30	0.04	0.99
	201902MDEAR [#]	CMD_10MAP	2.83	2.63	1.70-4.10	0.62	0.11	0.94
CIAT102	201903MDEAR	CMD_3MAP	1.73	1.64	1.00-3.77	0.42	0.12	0.91

V_g , total genetic variance among unique clones; V_e , the variance of residue. The calculation of genetic variance was performed by using the mixed models by fitting replications and clones as random effects.

*the trials with 3 clones from VNM142 and four checks, HLS11, KM419, KU50 and C33. MDEAR, cassava mosaic disease advanced yield trial.

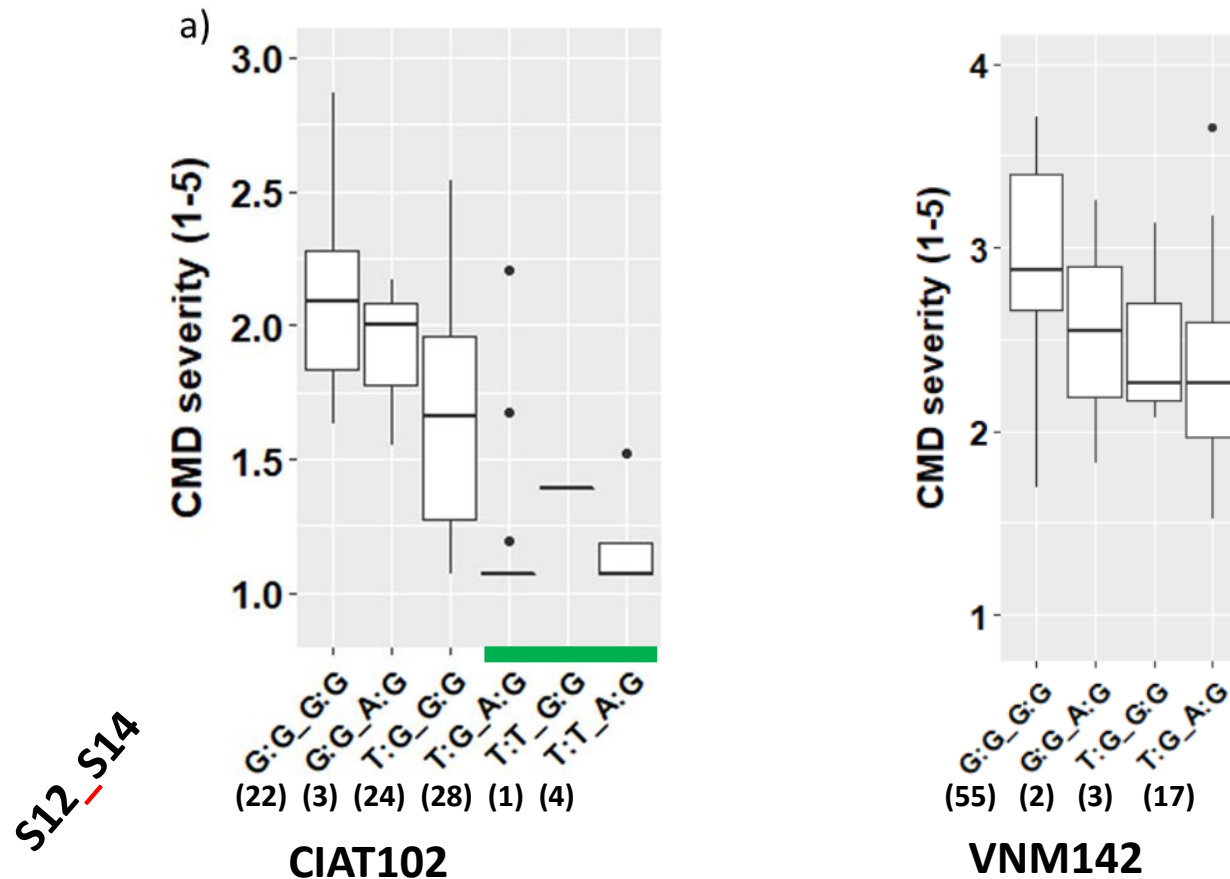
[#]the trials with 9 clones from VNM142 and three checks, HLS11, KM419 and KU50.

The CMD score of the top resistant clones from VNM142 and the check clones

Genotype/group	Clone	2018-2019	2019-2020
UNK-CI-2	VN19-442	1.5	2.3
CR63_PER262_TAI9	VN19-1432, VN19-1556	1.6	1.9
KM57_VNM8_Xanh Vinh Phu	VN19-1039, VN19-1050	1.6	1.9
UNQ-115	VN19-773	1.7	2.1
UNK-F	VN19-1184, VN19-1194	2.0	2.6
UNQ-44	VN19-320	1.7	1.8
UNK-AF-2	VN19-1805	1.8	NA
UNK-CH	VN19-390	1.9	2.2
KU50_KM94_TAI16	11 clone samples (e.g., VN19-1739	2.6	3.5
KM140	4 clone samples (e.g., VN19-2659)	3.6	NA
KM419	2 clone samples (e.g., VN19-2202)	3.0	4.0
C33	C33	NA	1.1

BLUP of the CMD score at 10 month after planting was provided here for each unique clone (or group)

Validation of *CMD2* markers in CIAT102 and VNM142

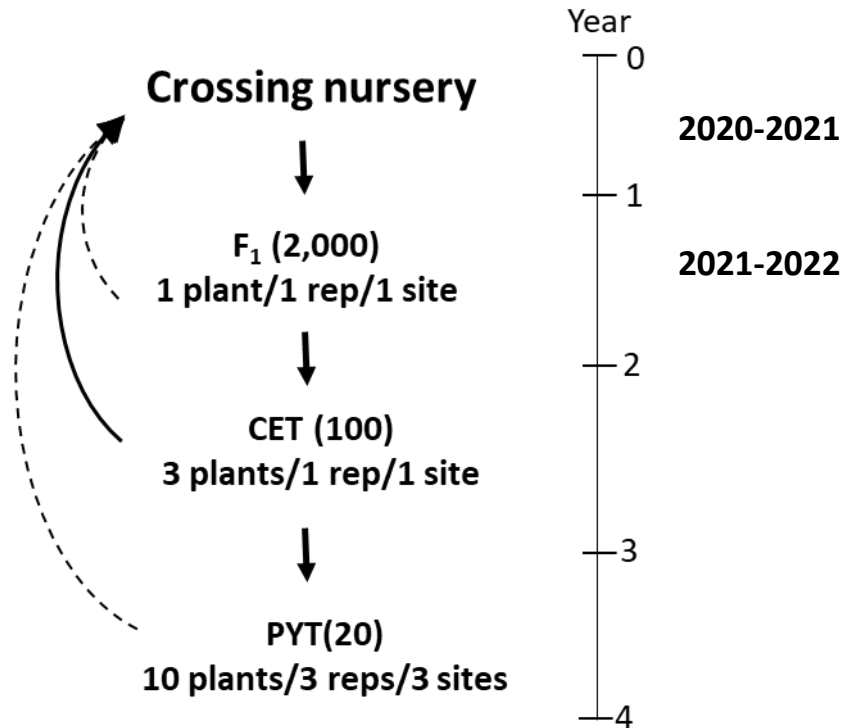


S12_7926132 and S14_4626854

For marker S12, T is the resistant allele; For marker S14, A is the resistant allele

S12_7926132 and S14_4626854 worked well for segregation populations, but not for diversity populations

Recurrent Selection for Improving the Breeding Population



Two cycles of quick recurrent selection to introgress CMD resistance to elite variety to provide improve breeding populations to NARS.

MAS for *CMD2* locus increased the selection efficiency.

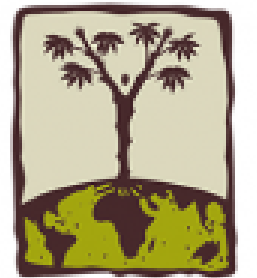
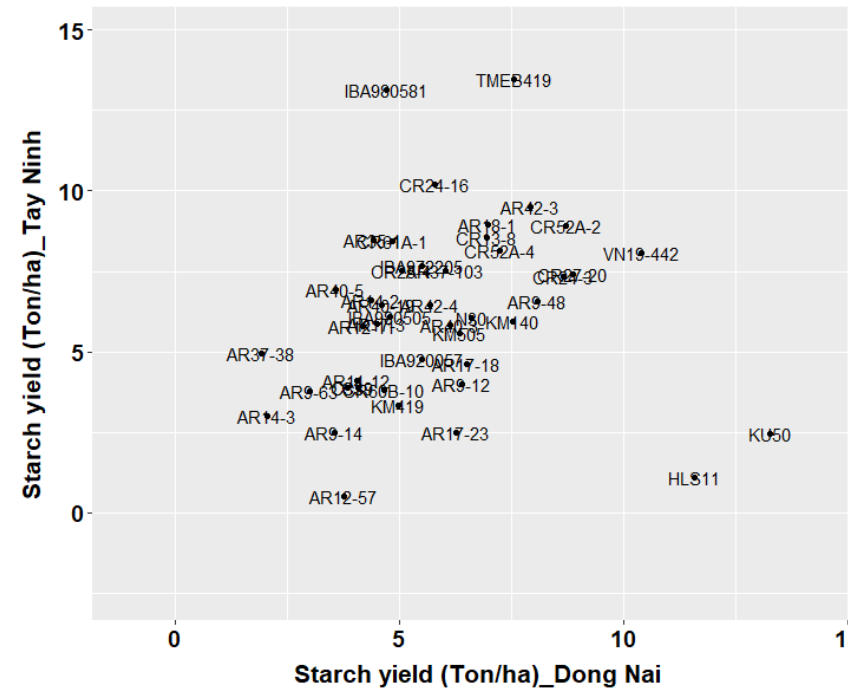
Acknowledgements



Alliance



**RESEARCH
PROGRAM ON
Roots, Tubers
and Bananas**



**NEXTGEN
CASSAVA**



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