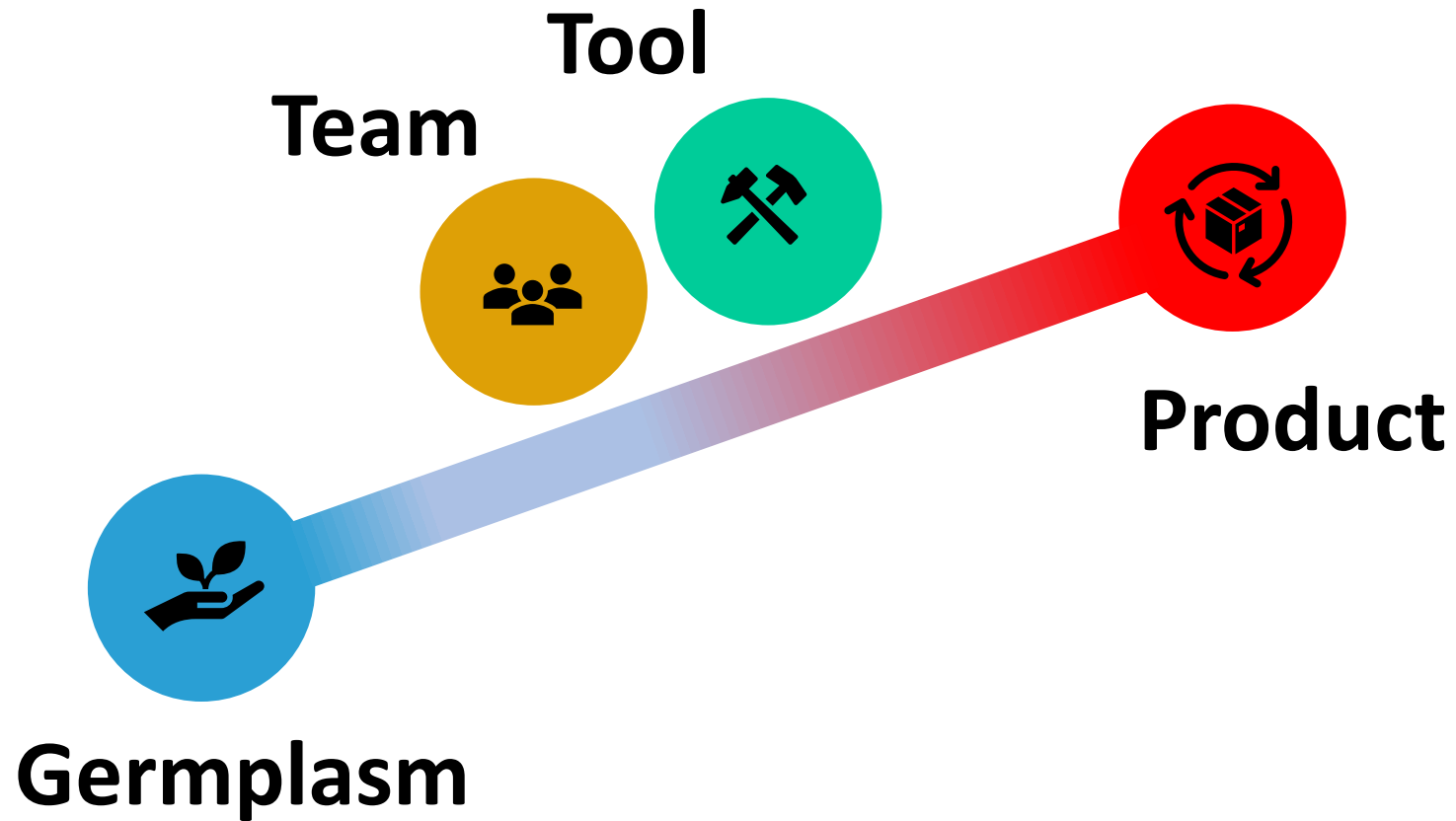


Establishing sustainable solutions to cassava diseases in mainland Southeast Asia

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**





Plant Breeding is the **genetic improvement** of **plants** for **human benefits**.



Product

- CO_334:0000114
- CO_334:0000013
- CO_334:0000071
- CO_334:0000138
- CO_334:0000220
- CO_334:0000301
- CO_334:0000099
- CO_334:0000079
- CO_334:0000018
- CO_334:0000106
- CO_334:0000123
- CO_334:0000225
- CO_334:0000223
- CO_334:0000001

High and stable dry matter cassava for South East Asia (with CMD resistance)						
Target Product Profile						
Industrial cassava starch and animal feed South East Asia						
Cassava, SEA, SEA, Industrial starch and animal feed, NA, ??, ??, NA						
Cassava						
South East Asia						
South East Asia						
Laos (86,269), Cambodia (554,651), Vietnam (441,405), Thailand (1,224,459), Indonesia (128,105), Philippines (33,366)						
2,468,257						
Variety						
Subhumid lowland tropics and semi-arid lowland tropics						
	Trait	Scale	Min Score	Trait requirement	Improve trait	Threshold trait
Color	Flesh color	1 to 3	<=2 (1, white)	Essential		Y
Yield	Fresh yield	ton/ha	10% greater than commercial checks	Essential	Y	
	Starch content	%	>=25	Essential		Y
Agronomic traits	Germination	%	>80	Essential		Y
	Plant vigor	1 to 5	>=3 (5, vigorous)	Essential		Y
	Lodging	1 to 3	<=2 (3, complete lodging)	Essential		Y
	Plant type	1 to 5	<=3 (1, erect plant)	Essential		Y
	Branch number	count	<=5	Essential		Y
	Plant height	cm	150-350	Nice to have		
	Height of the 1st branch	cm	>100	Essential		Y
	Stem length with leaves	cm	>30cm	Nice to have		Y
	Easy harvest	1 to 3	<=2 (3, difficult to harvest)	Nice to have		
	Peduncle length (visual)	1 to 3	2 (3, long)	Essential		
	Root skin color	1 to 3	<=2 (3, brown)	Essential		
	Root type	1 to 5	<=3 (1, good root type)	Essential		
	Root			<=2 (3, heavy constr		



Product

CMD Resistance

High and Stable Yield

High and Stable Starch Content

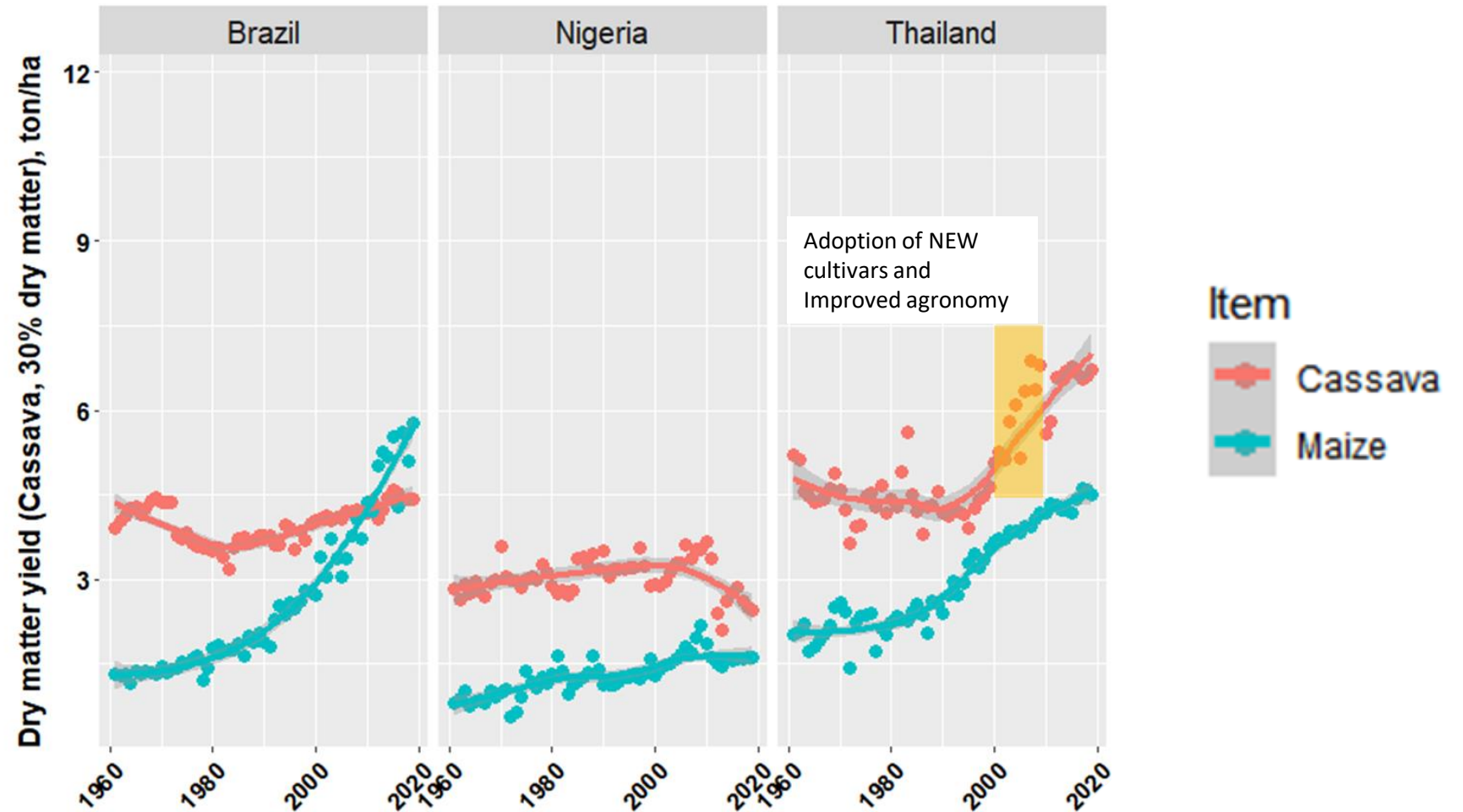
Erect Plant

Root rot, Cassava Bacterial Blight, germination,
lodging...



Germplasm

Superior Varieties in Southeast Asia



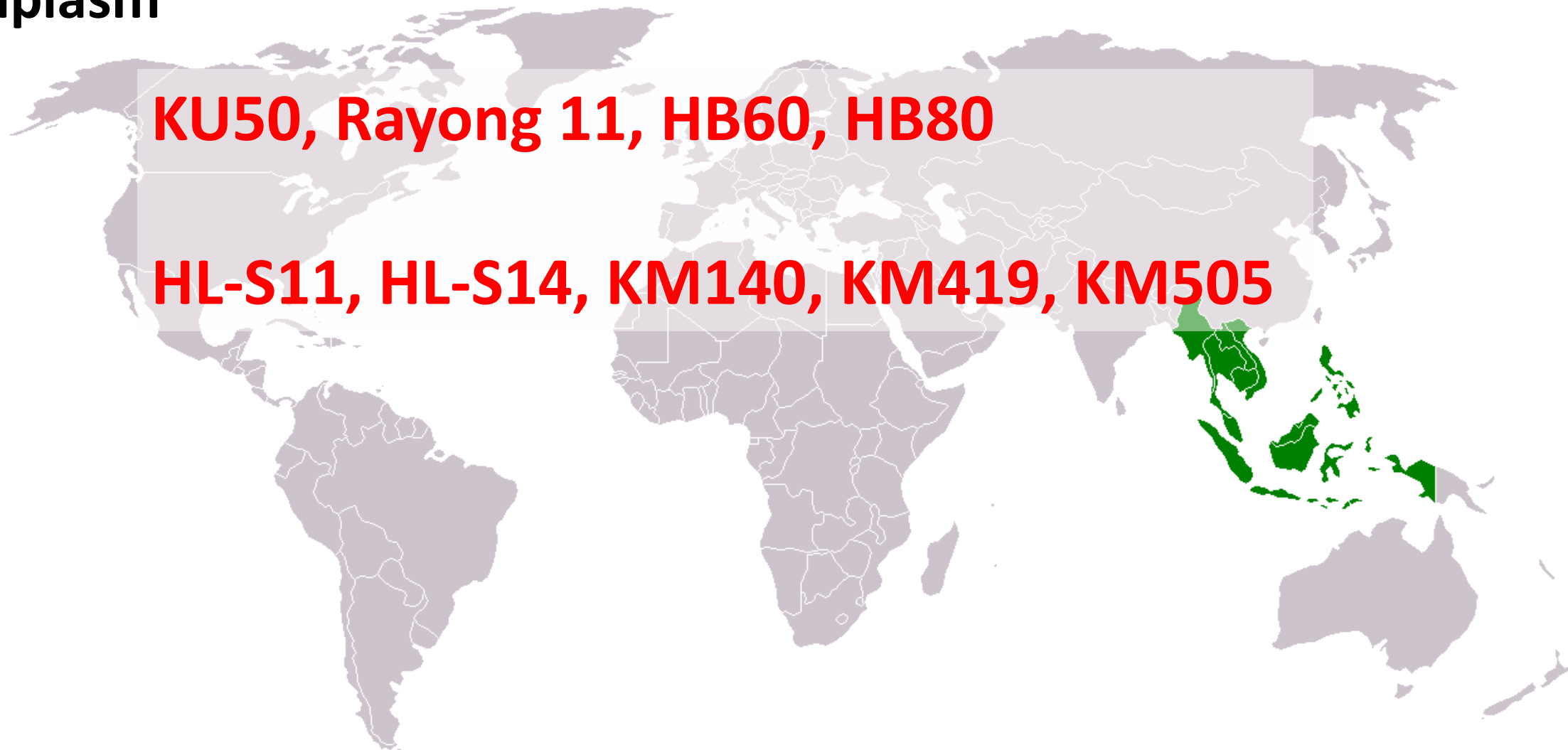


Germplasm

Use Elite Varieties in Southeast Asia

KU50, Rayong 11, HB60, HB80

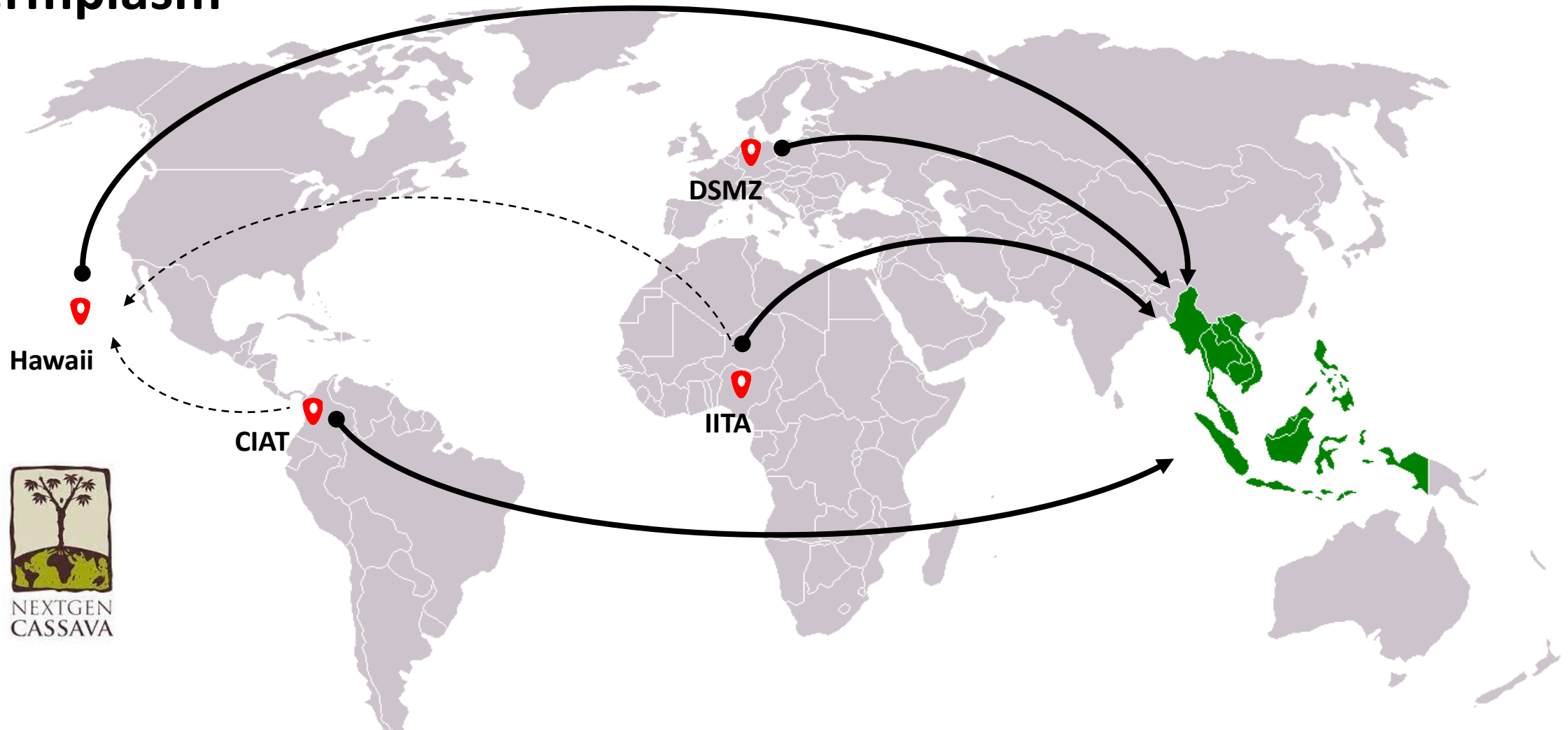
HL-S11, HL-S14, KM140, KM419, KM505





Introduce CMD-resistant Germplasm

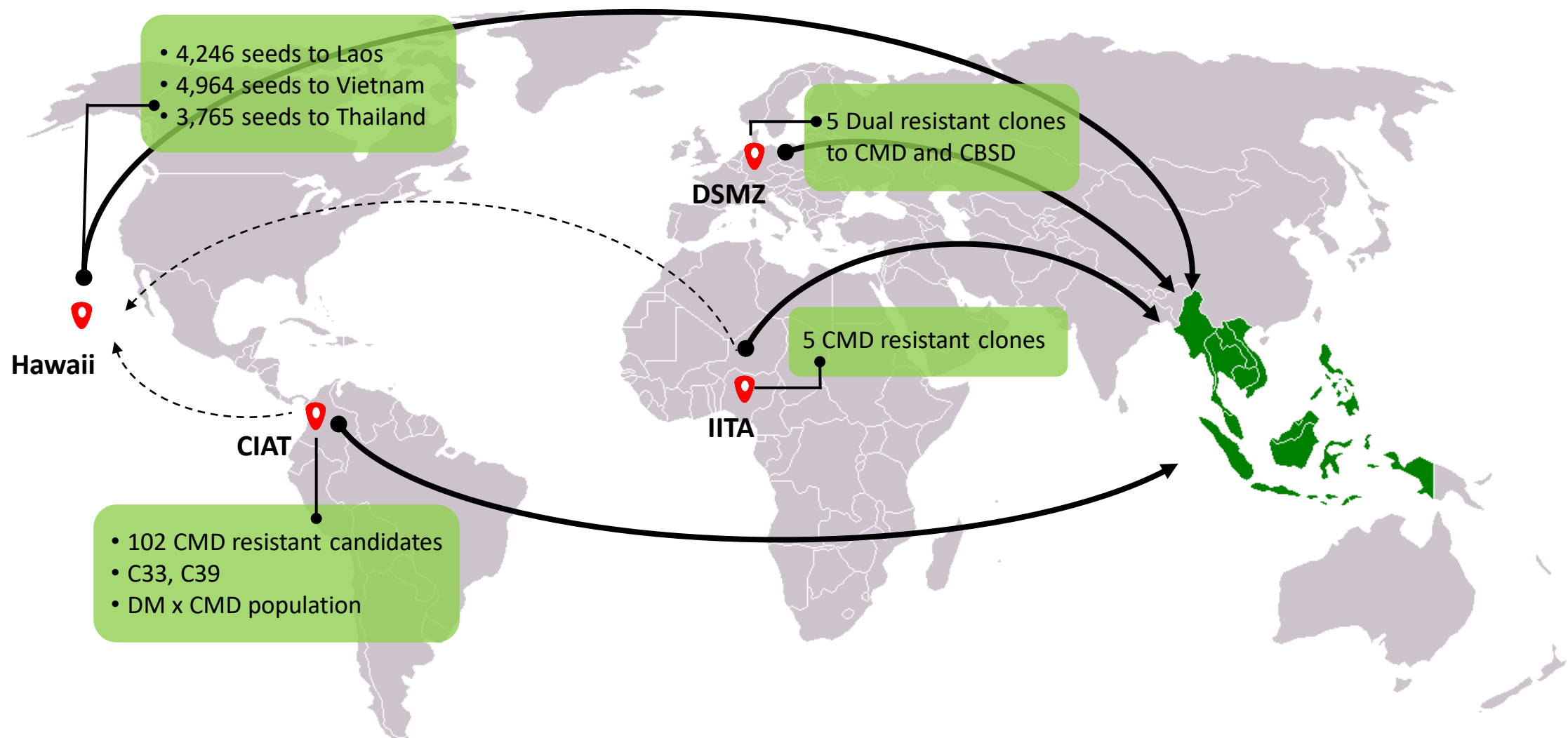
Germplasm



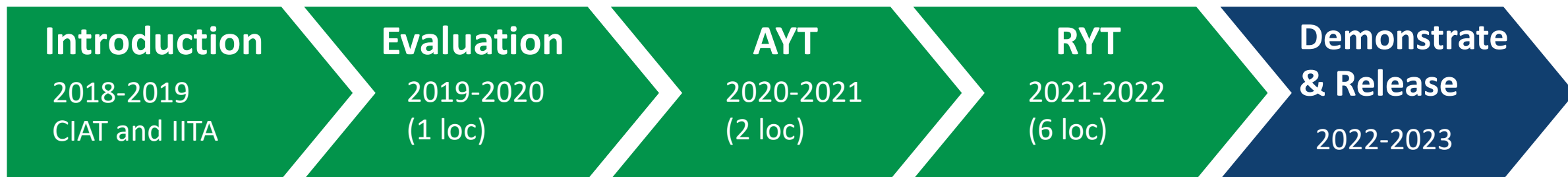
NEXTGEN
CASSAVA



Introduce CMD-resistant Germplasm

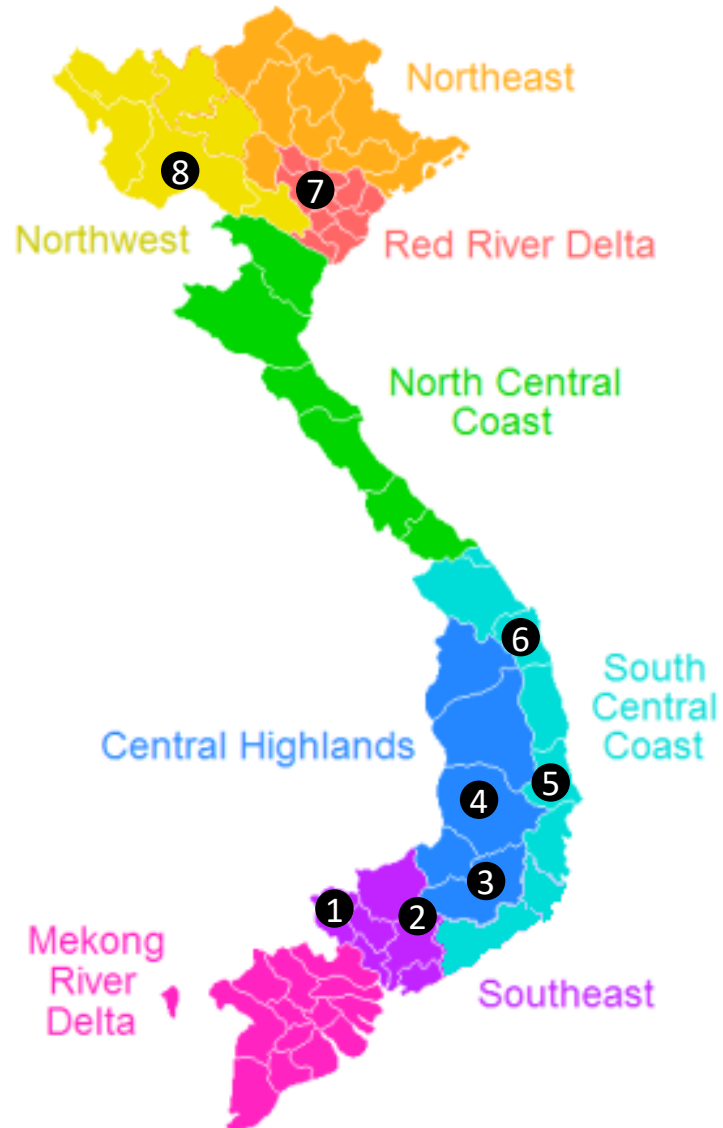


Introduce CMD-resistant Germplasm in Vietnam



<p>AGI Ha Noi</p>	<p>Tay Ninh</p>	<p>*Multiplication</p>	<p>Tay Ninh Son La</p>	<p>Tay Ninh Dong Nai Quang Ngai Gia Lai Thanh Hoa Quang Tri Son La</p>
<p>HLARC Tay Ninh</p> <p>*Evaluated 142 collections from farmers' field</p>	<p>Tay Ninh</p> <p>*Evaluated collections from farmers' field</p>	<p>Dong Nai Tay Ninh</p> <p>*Imported seeds from Hawaii</p>	<p>Tay Ninh Dong Nai Dak Lak Phu Yen Quang Ngai</p>	<p>Tay Ninh Dong Nai Dak Lak Phu Yen Quang Ngai</p>

Breeding Trialing Network in Vietnam



- ① Tay Ninh
- ② Dong Nai (HLARC)
- ③ Lam Dong
- ④ Dak Lak
- ⑤ Phu Yen
- ⑥ Quang Ngai
- ⑦ Ha Noi (AGI)
- ⑧ Son La

HLARC, Hung Loc Agricultural Research Center
AGI, Agricultural Genetics Institute



High-Quality Data

– Moderate and High Repeatability

trial	CMD_1mon	CMD_3mon	CMD_6mon	CMD_10mon	height	height_1st_branch	branch_number	starch	yield_v2	starch_yield	harvest_index
Y2020MDEAR_donn	0.99	0.98	0.99	0.96	0.49	0.93	0.92	0.75	0.67	0.49	NA
Y2020MDEAR_tayn	0.98	1	0.99	0.96	0.7	0.85	0.87	0.49	0.82	0.76	NA
Y2021MDEAR_phuy	0.9	0.94	NA	0.98	0.87	0.8	0.94	0.95	0.61	0.5	0.91
Y2021MDEAR_quan	1	1	NA	0.99	0.53	0.72	0.89	0.92	0.77	0.76	0.95
Y2021MDEAR_tayn	0.91	0.98	0.98	0.96	0.88	0.81	0.97	0.88	0.54	0.4	0.78



Multi-environment Performance

-- Summary of the best clones and checks

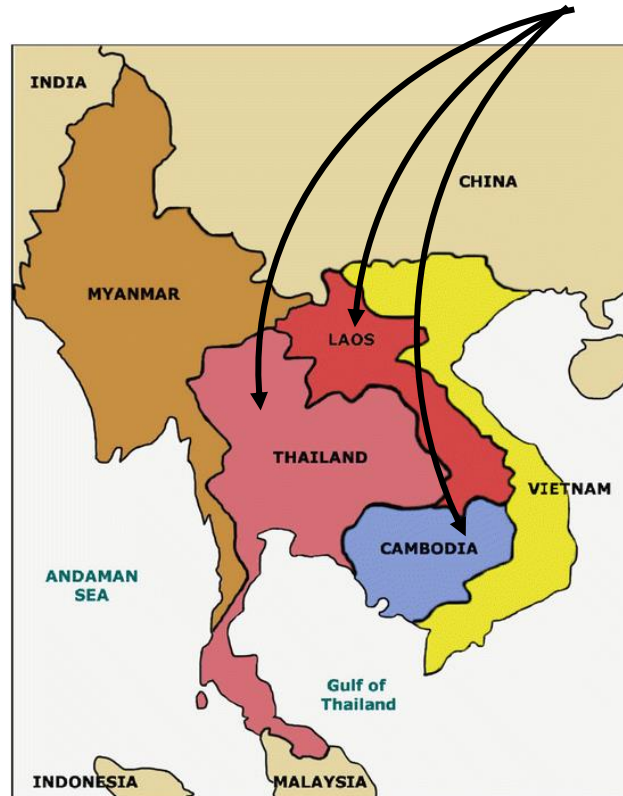
	clone	CMD_ 10mon	height_1st_ branch	branch_ number	starch (%)	yield (ton/ha)	starch_yield (ton/ha)	
	KU50	3.0	200	0.4	27.1	28.0	8.0	
HN1	TMEB419	1.1	212	0.7	24.3	30.5	7.9	
HN36	CR24-16	1.0	249	0.0	26.0	25.5	7.6	
HN97	AR9-48	1.0	204	2.4	25.4	27.5	6.7	
HN80	CR27-20	1.0	119.7	2.7	26.3	22.7	6.5	
HN5	IBA980581	1.0	159	0.7	20.5	29.1	6.1	
HN3	IBA972205	1.0	98	2.8	18.5	29.1	5.9	
	HL-S11	3.7	225	0.0	28.3	19.2	5.8	
	KM140	3.5	191	0.2	21.4	22.9	5.8	
	KM419	3.5	147	0.9	24.7	19.8	5.7	
	KM505	2.6	215	0.6	25.8	19.9	5.3	

Good

Poor

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

Share CMD-resistant Germplasm in Southeast Asia



- The CMD-resistant clones with the best agronomic performance from CIAT and IITA were shared with **Thailand, Laos and Cambodia**.
- The tissue culture plantlets were sent from **AGI or CIAT**
- **Yield trials** were established in 2023.

Population from Hawaii



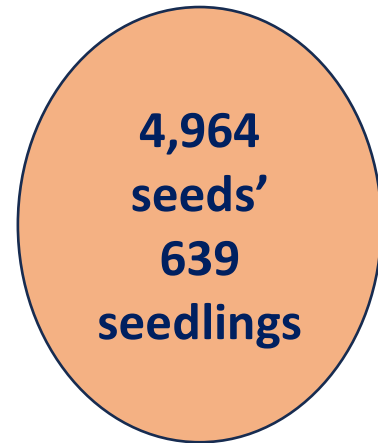
2020-2021

2021-2022

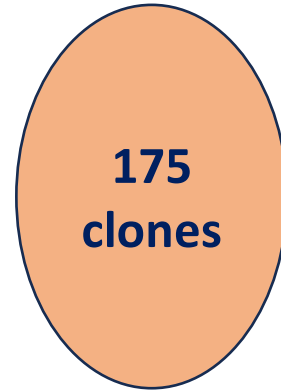
2022-2023

2023-2024

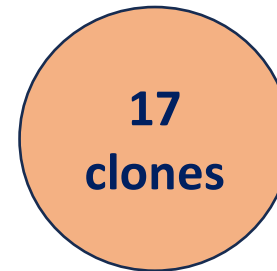
Seedlings



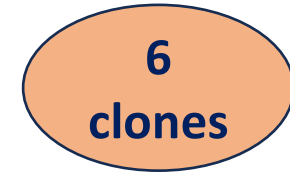
Single-row plot



PYT



AYT





Performance of the Population from Hawaii in PYT

genotype	check advanced	germination	starch	yield	starch_yield
KM505	yes	96	24	28	6.5
KU50	yes	88	22	28	5.8
TMEB419	yes	98	17	29	4.7
HLH20-H0016	yes	93	21	33	6.5
HLH20-H0085	yes	91	20	32	6.2
HLH20-H0108	yes	95	19	34	6.1
HLH20-H0022	yes	83	23	26	5.8
HLH20-H0047	yes	91	18	32	5.7
HLH20-H0075	yes	79	19	31	5.6
HLH20-H0039	yes	86	12	46	4.8
HLH20-H0036		71	19	23	4.2
HLH20-H0038		91	17	24	4.0
HLH20-H0051		48	19	22	4.0
HLH20-H0082		54	19	12	2.5

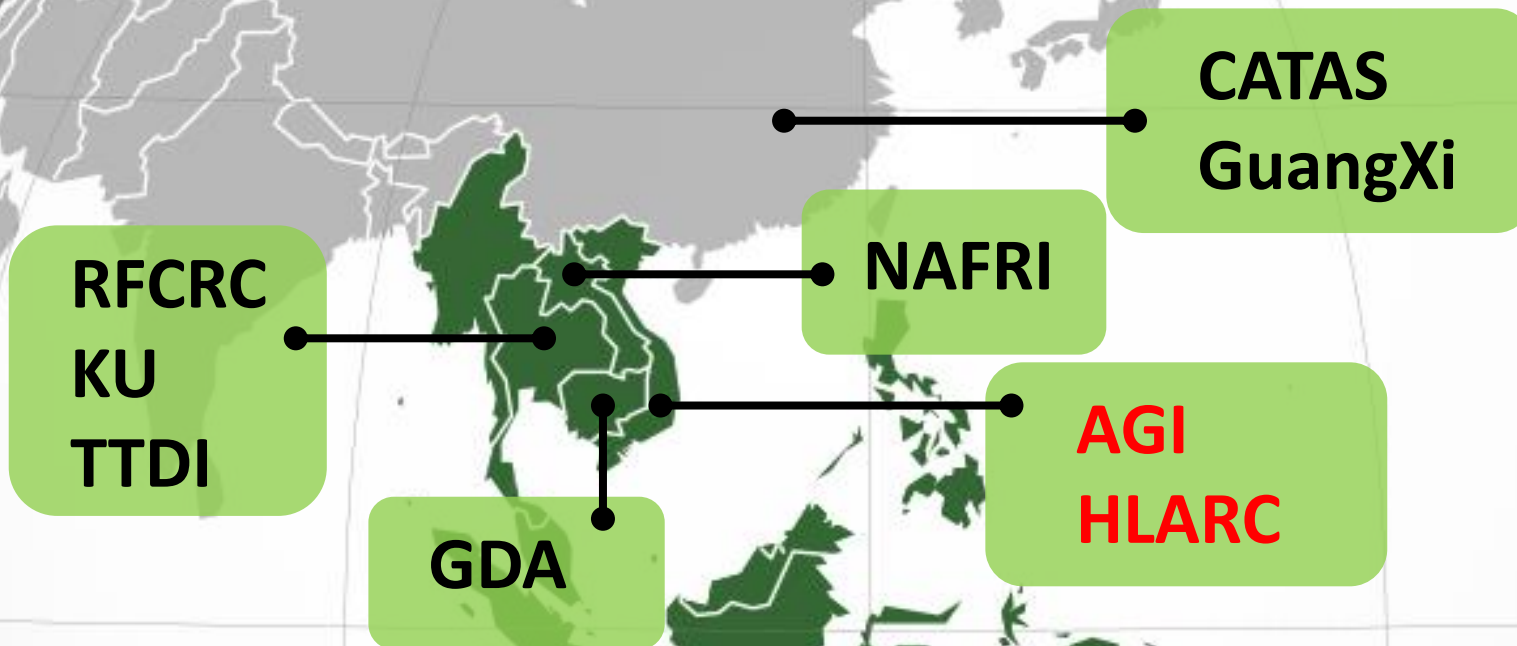
Summary of Introduced Germplasm

- *HN1 (TMEB419) is a widely adaptable line* with good resistance to CMD and good fresh tuber yield and starch content.
- From 2022 until now, HN1 (TMEB419) has been planted in more than *6,000 hectares*.
- *Further improvement is required* in starch stability, plant type, other pest and disease resistance



Team

CGIAR-NARES Breeding Network



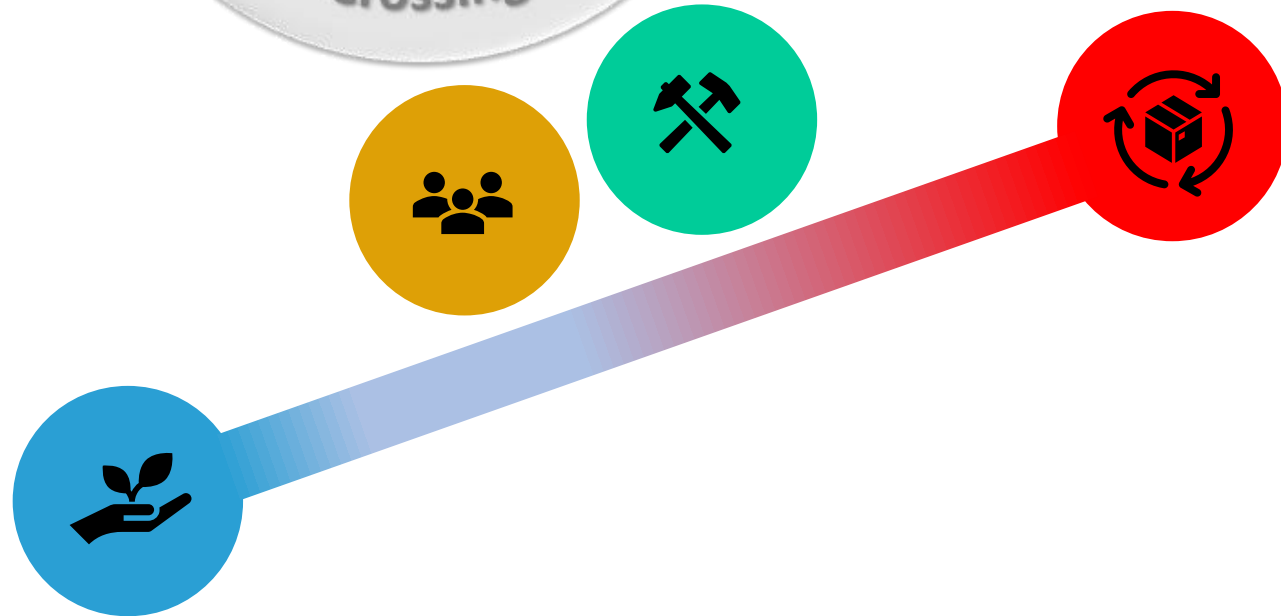
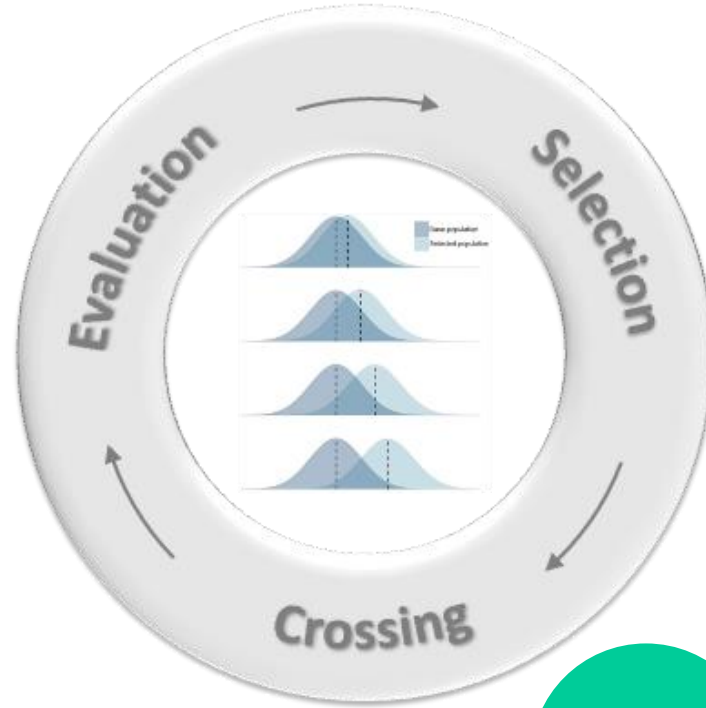
Capacity Building

— Workshop + Training-by-doing

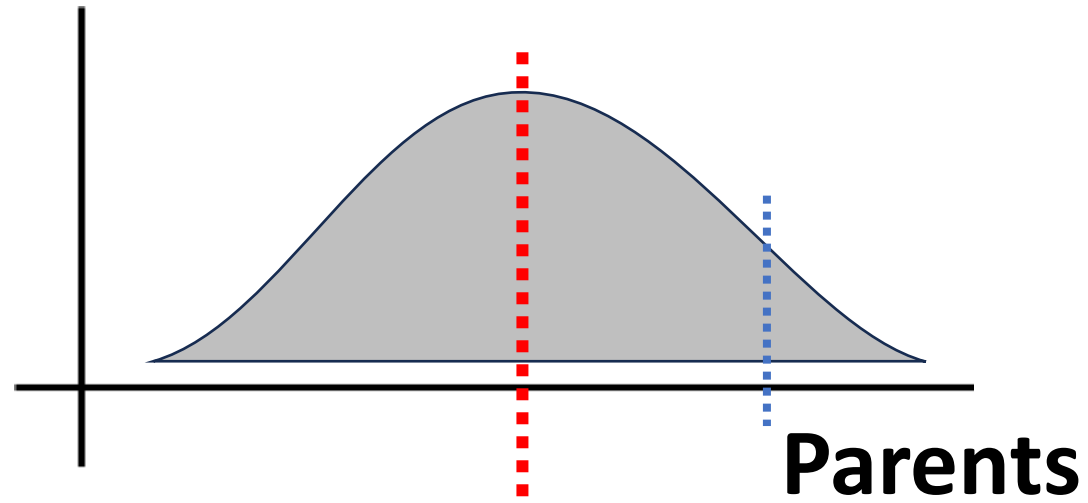




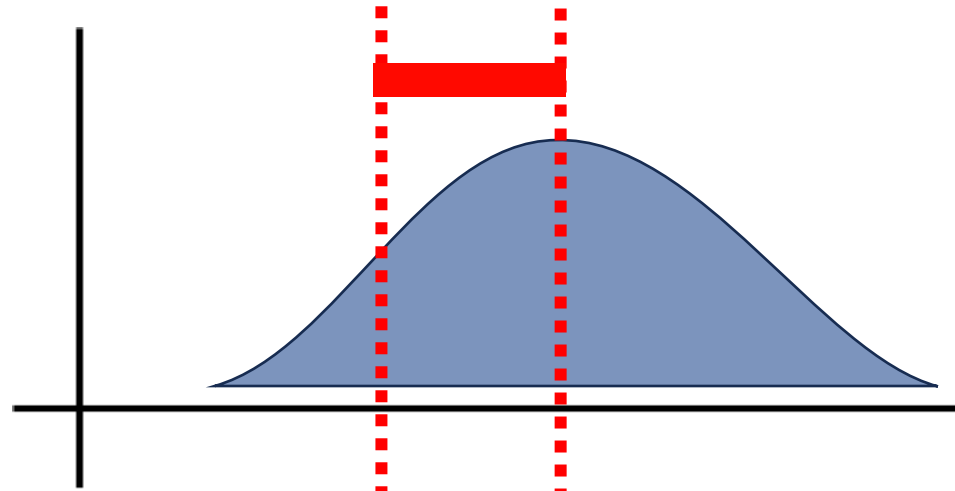
Tool



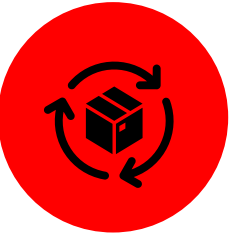
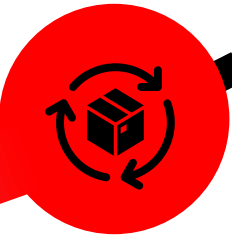
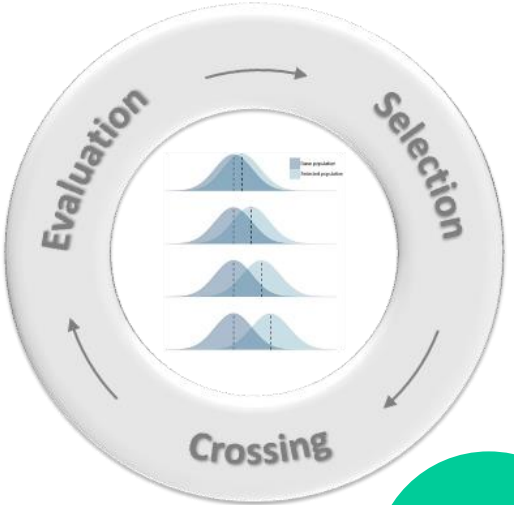
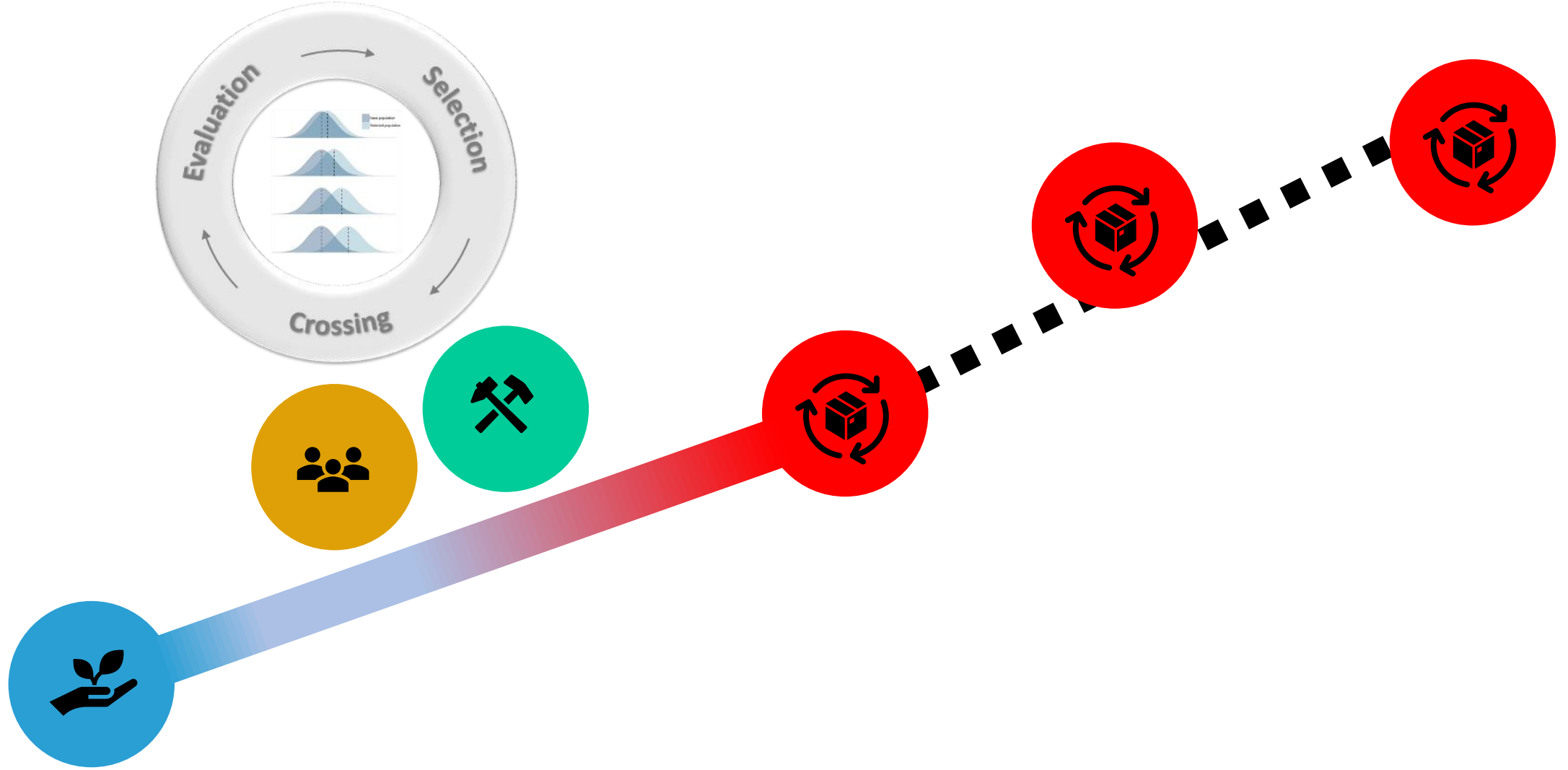
**Parental
generation**

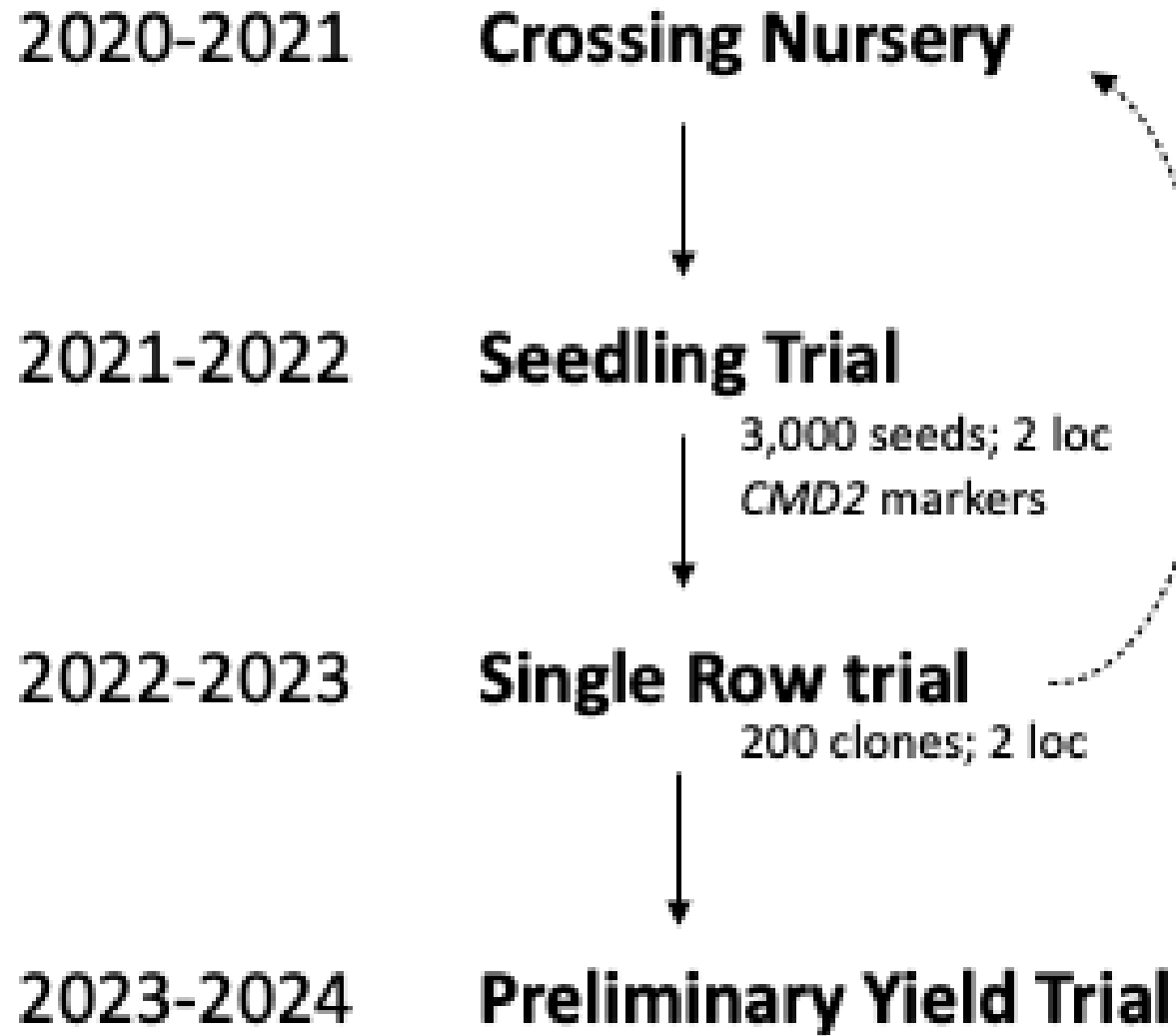


**Progeny
generation**



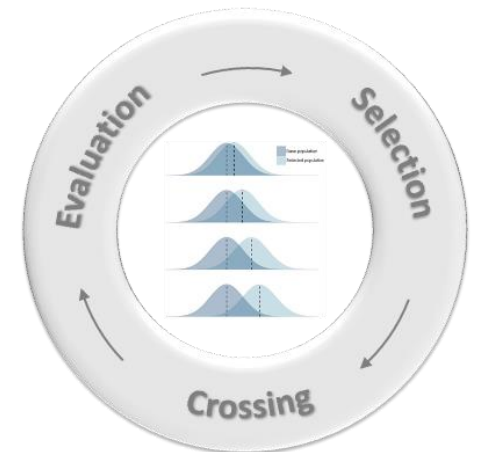
Improvement





Crossing

**Evaluation +
Selection**



Single-Row Trial Evaluation of the Breeding Population

Repeatability at Two Locations

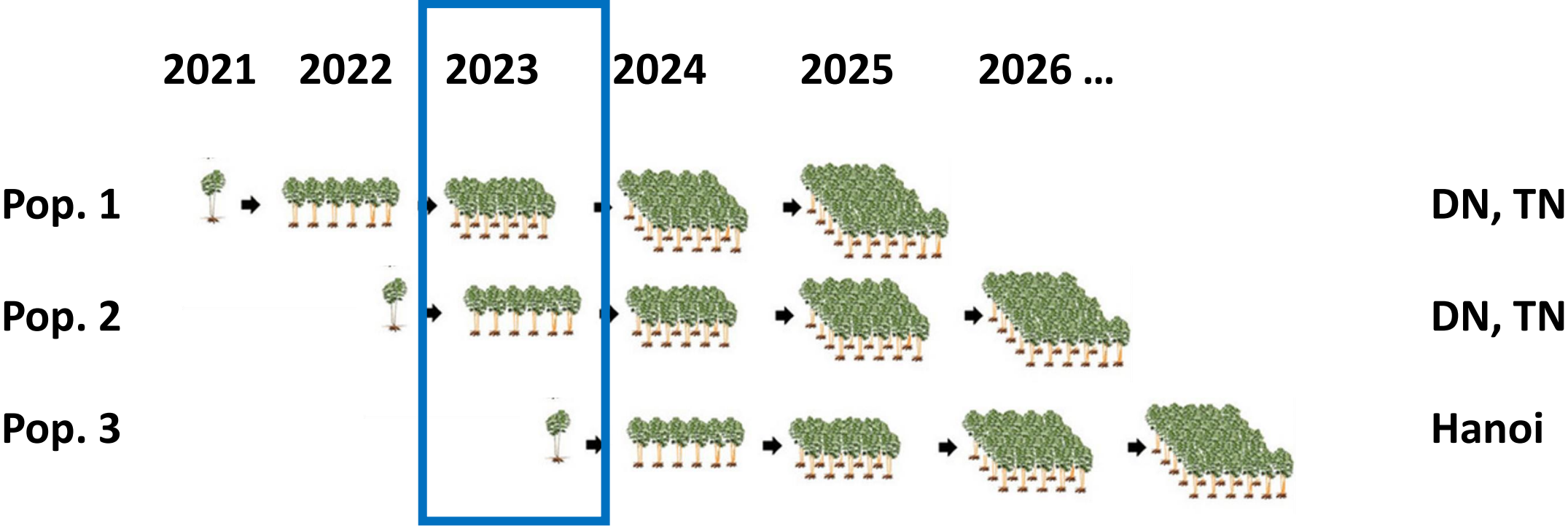
	CMD (6 mon)	Branch number	Starch content	Yield per ha
Two loc.	0.87	0.66	0.7	0.38

2022-2023 growth season

Selected Progenitors for the Next Cycle

accession_name	pedigree	height_1st_branch (cm)	yield (ton/ha)	starch_content (%)	starch yield (ton/ha)
VH21-0127	IBA980505	200.4	34.6	22.0	7.63
VH21-0779	KU50	160.4	30.4	24.2	7.37
VH21-0097	IBA972205	150.1	28.9	23.9	6.91
VF21-0055	HLS14_AR9-18	184.0	28.9	22.9	6.60
VF21-0005	HLS13_CR24-3	214.3	26.5	24.7	6.54
VH21-0061	IBA972205	260.0	29.1	22.2	6.46
VH21-0447	AR9-18	235.2	27.0	23.9	6.46
VH21-0402	KM140	177.8	28.3	22.7	6.43
VF21-0197	KM419_AR9-18	167.5	29.7	21.7	6.43
VF21-0146	KM140_AR9-18	262.7	27.7	23.1	6.40
VH21-0016	IBA920057	229.9	27.6	22.4	6.18
VH21-0729	KU50	303.3	25.5	23.6	6.01
TMEB419		285.9	25.9	24.9	6.45
KU50		253.6	26.3	23.4	6.14

Three Populations of Cycle 1 in the Field



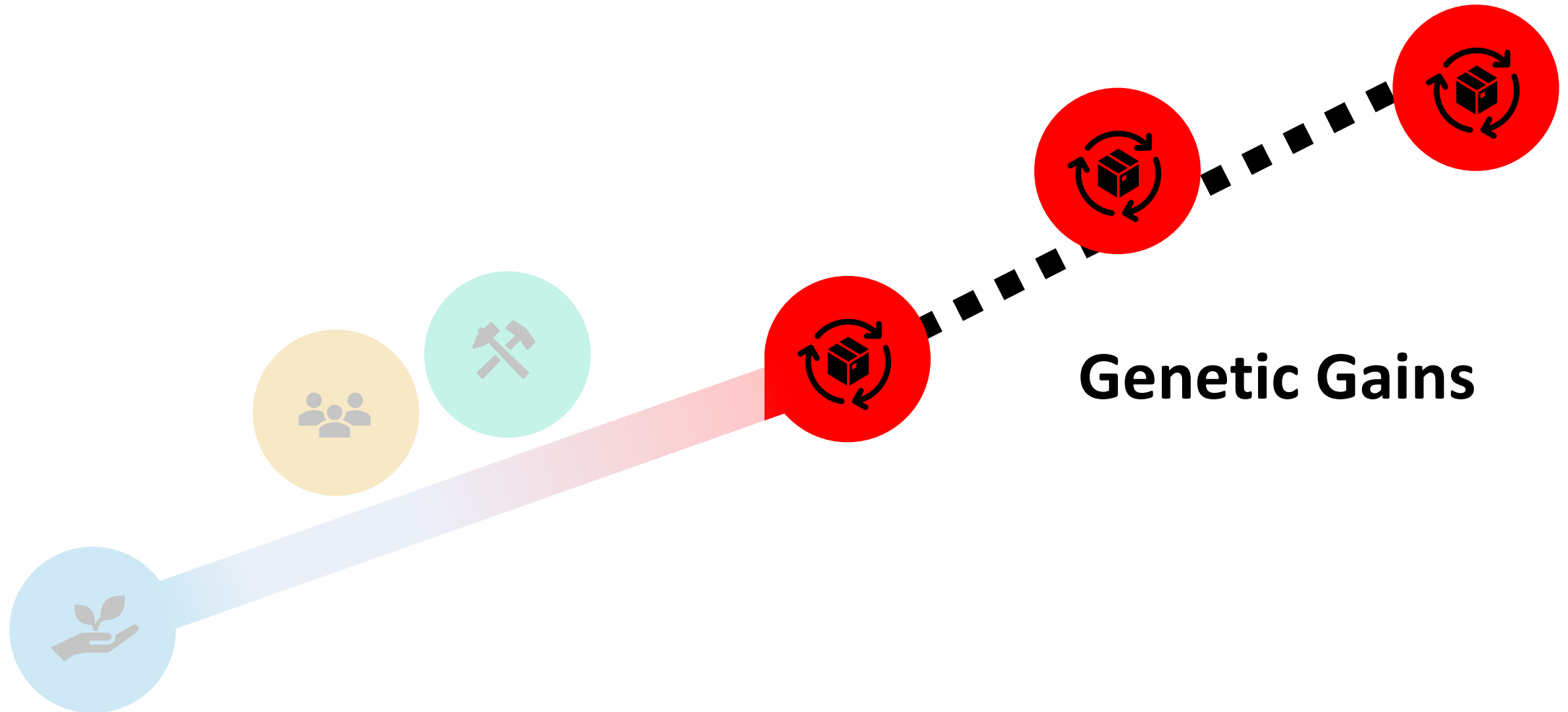
The crossing nursery for cycle 2 is in Lam Dong.

Breeding Populations of Three Cohorts of Cycle 1

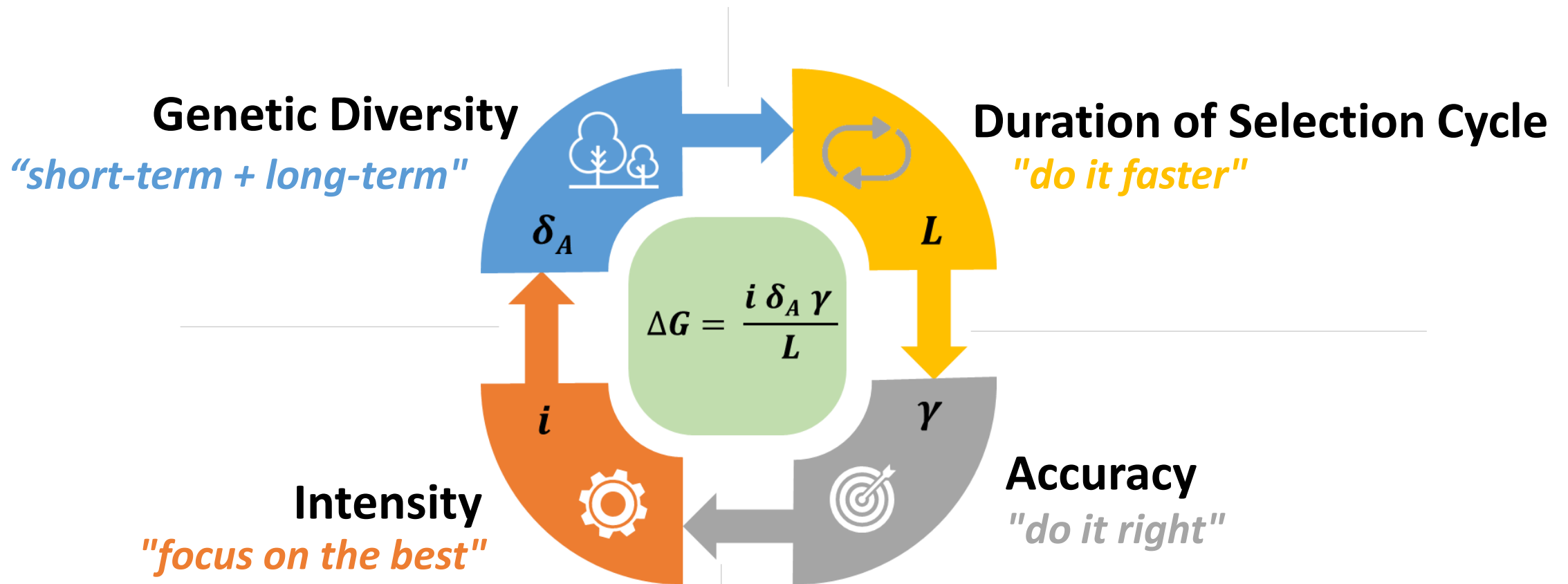


Item	2021	2022	2023
Number seed sowing			
Full-sibs (seed)	1.874	1.556	1.844
Half-sibs (seed)	5.290	3.712	4.040
Germination (%)			
Full-sibs	38.40	55.40	60.85
Half-sibs	26.74	44.80	45.50
Clones to testing CMD marker			
Full-sibs (clone)	137	303	
Half-sibs (clone)	93	499	
Showing have CMD2			
Full-sibs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

Tools and Breeding Program Efficiency



Increase **Genetic Gains** through **Continuous Improvement**



Continuous Improvement

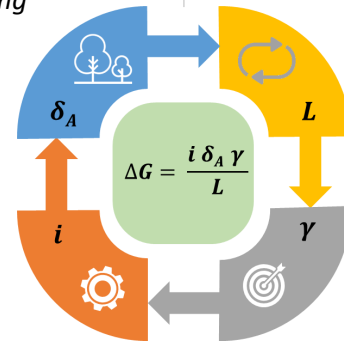


Genetic Diversity

- Variation profiling (2022-)
- Hybrid Breeding (2019-)
-- *Selfing*

Duration of Selection Cycle

- **Early flowering** (2016-)
- Genomic Selection (2019-)
-- *Mate and parent selection*



Intensity

- GeoRadar for yield (2022-)
- QualitySpec for WAB (2022-)
- Hyperspectral imaging (2022-)
- Drone imaging for early vigor (2022-)
- Imaging for whitefly (2018-)
- Imaging for PPD (2019-)

Accuracy

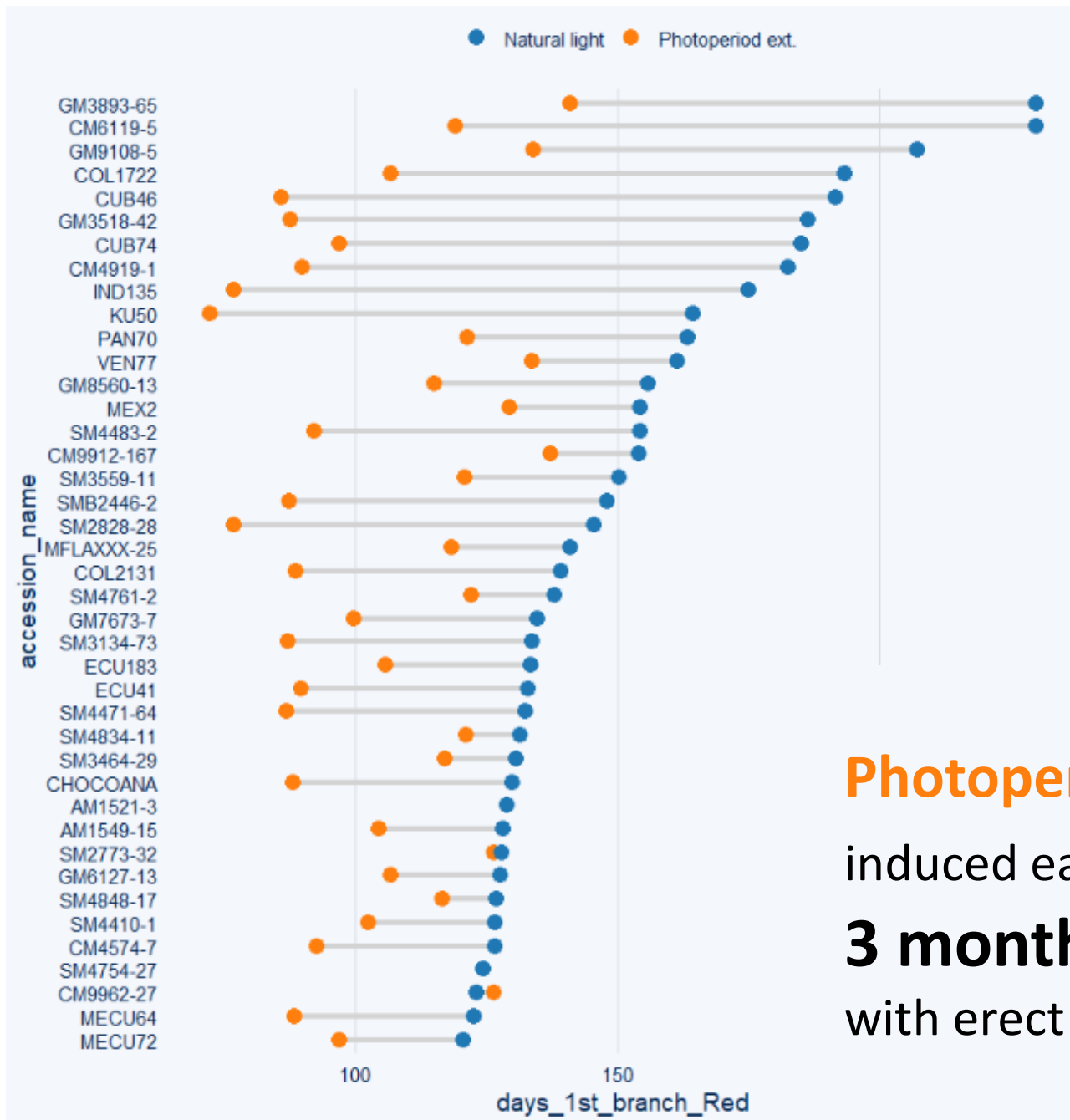
- **Digitalization** (2019-)
- **≥ 5 Checks, BLUP and GBLUP** (2020-)
- **Selection Index** (2012-)
- NIRS & Image Analysis (2012-)
- Operational Excellence (SOP) (2019-)
- QC/QA (2020-)
- **MAS** (2020-)

-- **CMD**, CBSD, DM, **carotenoid**, HCN, WAB, sprouting, ID, flowering, mites, thrips, small granule, plant type



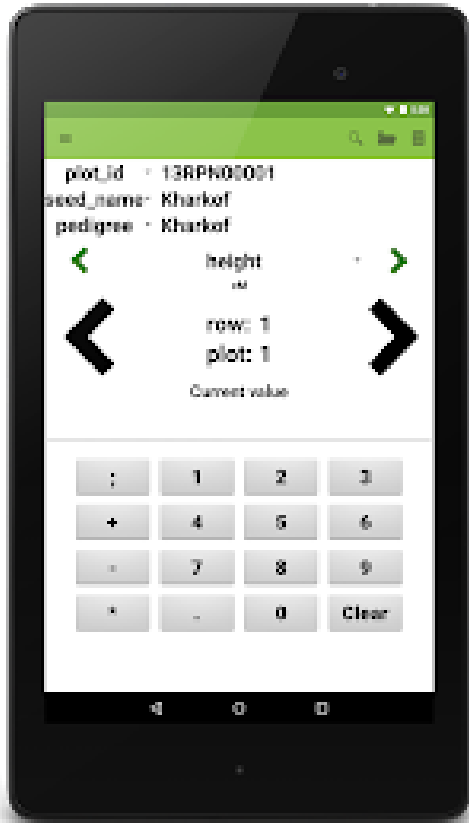


Lam Dong



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

Data Management



CASSAVABASE Search Manage Analyze Maps About

Double click trial (🌿) or folder (📁) to view detail page.

Breeding programs (📁)

Analyses (📊)

Sampling trials (📍)

Folders

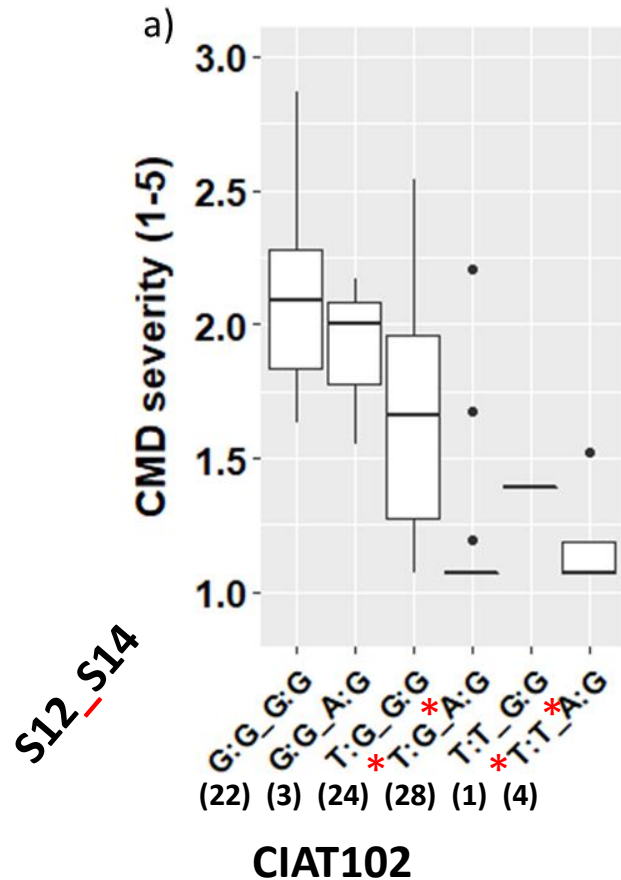
Create new folder

Move trial(s) to folder

Move folder

- 📁 Vietnam_2019
 - 🌿 201901MDEAR_tayn
 - 🌿 201902MDEAR_tayn
 - 🌿 201903MDEAR_tayn
- 📁 Vietnam_2020
 - 🌿 202088MDAYT_dona
 - 🌿 202089MDAYT_tani
- 📁 Vietnam_2021
 - 🌿 2021100MDAYT_phuy
 - 🌿 2021101MDAYT_sola
 - 🌿 2021102MDAYT_tani
 - 🌿 2021103MDAYT_quan
 - 🌿 2021104MDAYT_dona
 - 🌿 2021105MDAYT_dakl
 - 🌿 2021106MDAYT_tani
- 📁 Vietnam_2022
 - 🌿 202210DMAYT_dona
 - 🌿 2022110DMEAR_laog
 - 🌿 2022118DMAYT_phuy
 - 🌿 202247DMAYT_tani
 - 🌿 202284DMF1C_dona
 - 🌿 202285DMF1C_tani
 - 🌿 202286DMF1C_dona
 - 🌿 202287DMF1C_tani
- 📁 Vietnam_2023
 - 🌿 202301DMEPR_tani
 - 🌿 202307DMF1C_tani
 - 🌿 202308DMF1C_tani
 - 🌿 202356DMEPR_dakl

Validation of CMD2 Marker



>80% of clones with Resistant alleles showed Immunity

>95% of clones without Resistant alleles showed symptom

Capacity Building

- Flower inducing technology
- SOP in evaluation
- Data management and analysis
- Genomics-assisted breeding
- Advancement decision making

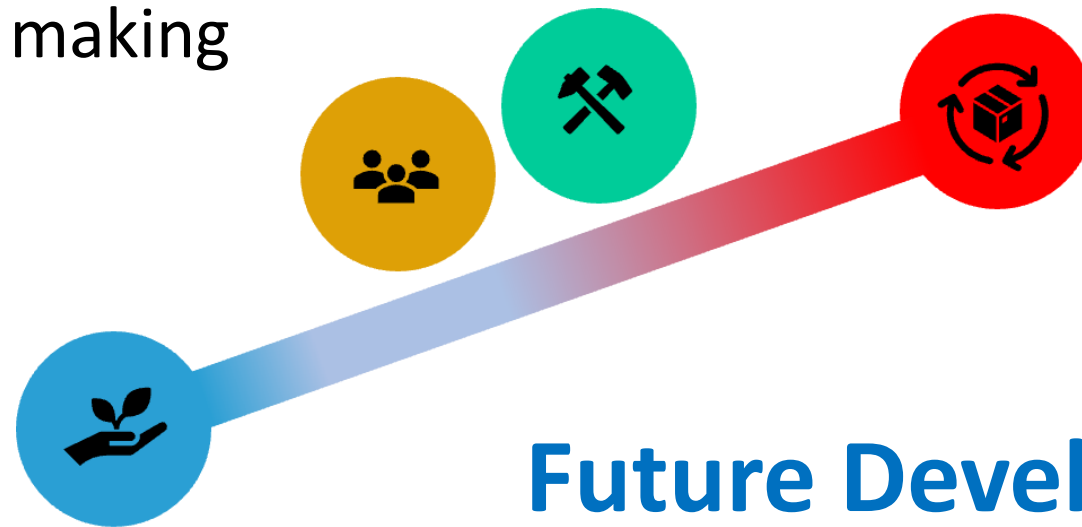
Disease Resistance

- Resistance to cassava witches' broom
- CBSD resistance
- Root rot tolerance

*core collections and local varieties

Continuous Improvement

- Genomic selection
- MAS
- Hybrid breeding



Future Development in South East Asia

Cassava Brown Steak Disease

Score 1

Score 2

Score 3

Score 4

Score 5

**CBSD
foliar
symptoms**

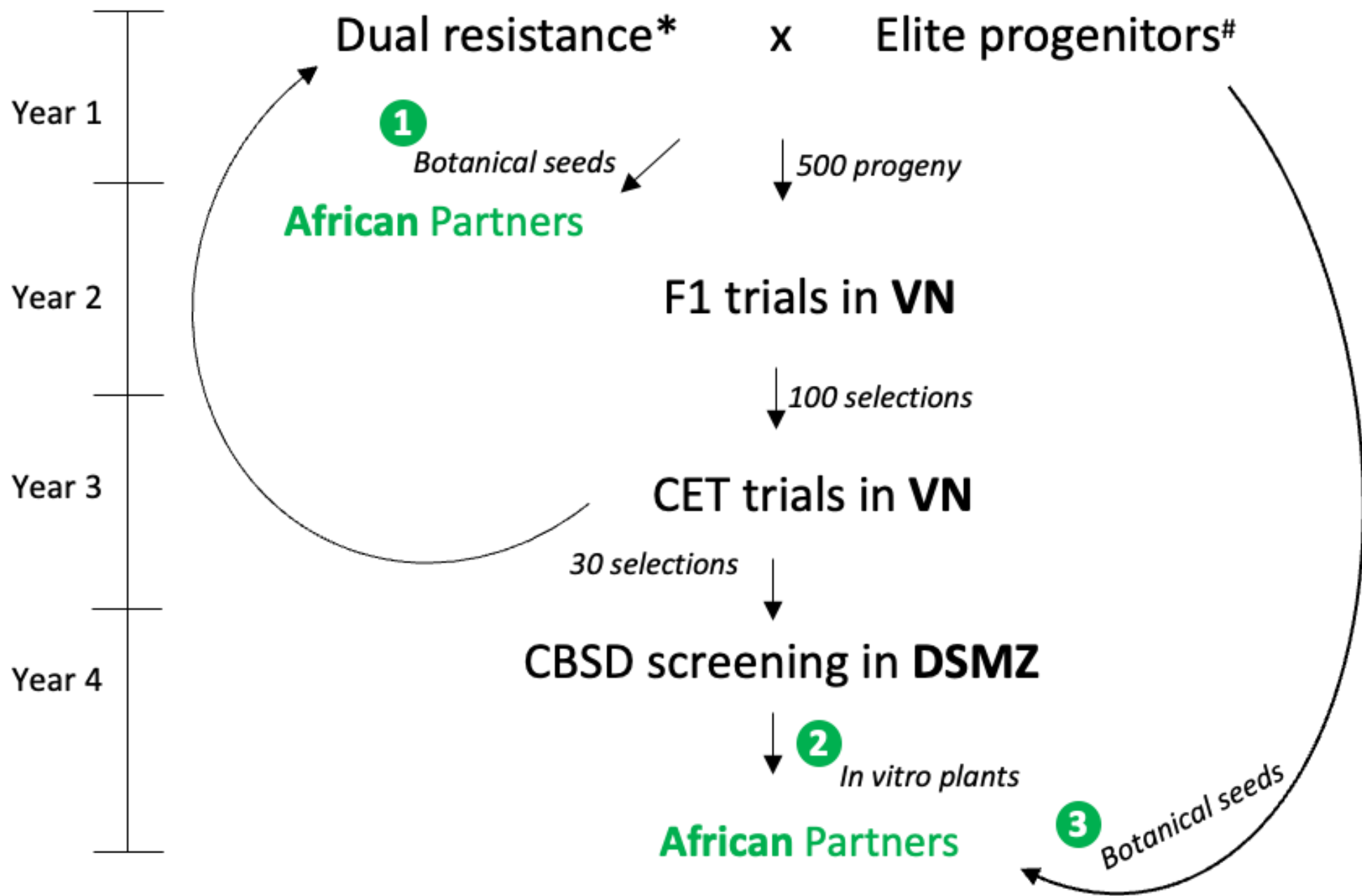


**CBSD root
necrosis**



Dual Resistant clones to CMD and CBSD from Dr. Winter

standard name	female parent	male parent	
POP112-1	COL40	C33	CBSD & CMD resistance; seeds from CIAT
POP101-1	PER353	GM7673-3	CBSD & CMD resistance; seeds from CIAT
POP108-1	C33	PER353	CBSD & CMD resistance; seeds from CIAT
POP108-10	C33	PER353	CBSD & CMD resistance; seeds from CIAT
POP118-8	COL144	C39	CBSD & CMD resistance; seeds from CIAT



Summary of Variety Development

- **The 1st cycle breeding population** was advanced to the preliminary yield trial stage.
- **The 2nd cycle breeding population** was initiated in the crossing nursery in 2023.
- **Continuous improvement** focused on flower-inducing, digitalization, and marker-assisted selection.
- **CBSD and CMD dual resistance** serves the African cassava community

