MPOB

Ganoderma Resistant Material

Screening Programme

Shamala Sundram, PhD
Head
Plant Pathology and Biosecurity Unit
Biology and Sustainability Research Division
Malaysian Palm Oil Board

BASAL STEM ROT DISEASE

History of BSR disease incidences in Malaysia

1930

Old palms
> 25 years old

1957

Mature palms
10 -15 years
ol

1990

Immature palms
1- 2 years old

BSR causes death in more than 80% of plantings midway through their economic life.

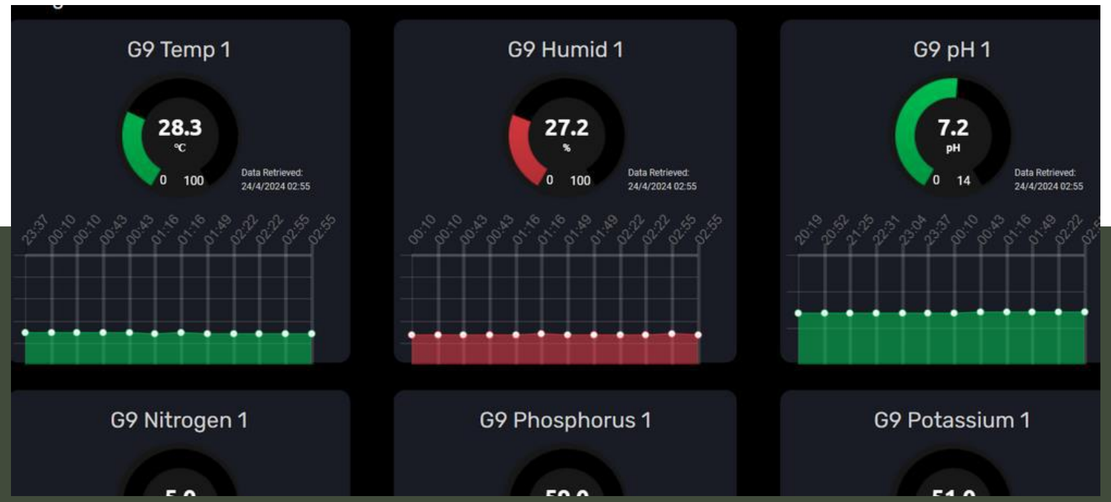
Ganoderma screening facility in MPOB Research Station, Keratong,

Ganoderma Resistant Materials

- Pathology
- Molecular
- Proteomic
  Metabolomic

MPOB: THE SCREENING PROGRAMME SINCE 2016

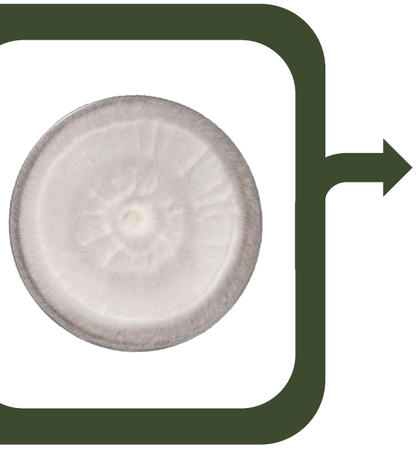
Ganoderma screening facility in MPOB Research Station, Keratong, Pahang



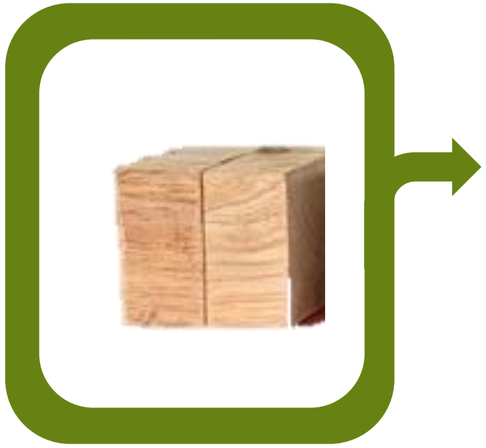
Ganoderma Resistant Material

- Resistant or partially resistant planting material → most sustainable long-term solutions, reducing yield and replanting losses.
- Screening identifies progenies with partial resistance at nursery or seedling stages, reducing the time and cost of evaluating full life-cycle resistance in the field.
- Enables breeders to discard highly susceptible material early, saving resources.
- Strategic investments that ensure the oil palm industry remains productive, sustainable, and resilient against its most serious disease threat.

Screening Programme: Preparation of Inoculum



Pure culture
7 days old Ganoderma on potato dextrose agar (PDA)



Sterilised rubber woodblock (RWB) (6x6x6 cm) inoculated with *Ganoderma* and incubated 8 weeks in the dark at room temperature

Fully colonized RWB
8 – 10 weeks of incubation mature RWB will appear crusty with the formation of melanised mycelia

In soil
Inoculum is placed in the centre of the polybag (1:1 – topsoil and sand)

Seed germinating Technique

Sitting Technique

Seed Germinating Technique

OP seeds

Germinated seed

2 weeks old purchase from nursery

Planting hole

Soil

1:1 – topsoil:sand
Hole to fit in the seed

Sowing

Sowing

Plumule must be facing upward and radical fully covered in soil

After 2 weeks

First leaf

First leave will emerge after 2-3 weeks of sowing

After 2 months

2 - 3 leaves

After 2 months of sowing, development of 2 – 3 leaves will be observed

Seedling Sitting Technique

Inoculum

- Inoculum will be placed in the middle of the polybag

Sitting

- 2 months old seedling will be placed on the inoculum

Planting

- Soil is added to fully cover the inoculum and roots

After 1 month

- Development of new leaves

Disease Assessment

Disease assessment recorded at monthly basis on all the test seedlings

Disease severity index (DSI)

- To determine the severity of disease infection

Severity of Foliar Symptoms (SFS)

- To determine the progression of disease

Epidemic rate (unit/week)

- To determine the rate of infection and extent of disease progression

Disease Severity Bole Index (DSBI)

- To determine the rate of infection and extent of disease progression based on bole sectioning

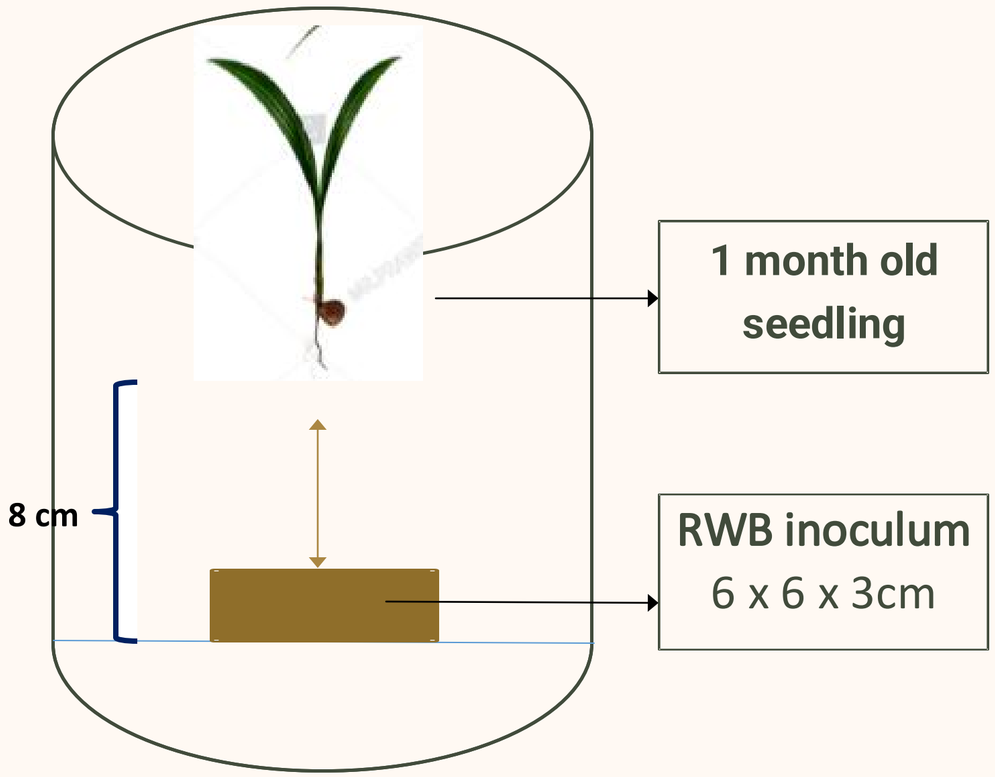
Disease Incidence (DI)

- To determine presence of disease via visual assessment

Screening of Commercial Progenies

No.	Progeny Background
1.	ZRE: Zaire
2.	CMR: Cameroon
3.	NGA: Nigeria
4.	YG: Yangambi
5.	AV: AVROS
6.	E: Elmina Dura
7.	JL: Johor Labis Dura
8.	BD: Banting Dura
9.	UR: Ulu Remis Dura
10.	SD: Serdang Dura
11.	CD: Chemara Dura

- Screening of *Ganoderma* resistant material was initiated in the 1980s (Breton et al., 2006).
- Screening program in MPOB → commercial progenies only.
- Male x Female (← Table) backgrounds
- Multiple testing on potential progenies to identify partial –resistance and susceptible backgrounds



Artificial inoculation – seed germinating technique using 1 month old seedling (optimised with Asian Agri, Indonesia). Test *Ganoderma* isolate: PER 71

Results of second batch

BATCH	NUM. OF PROGENIES	STATUS
1	14	COMPLETED
2	9	COMPLETED
3	8	COMPLETED
4	12	COMPLETED
5	7	COMPLETED
6	20	COMPLETED
7	23	COMPLETED
8	15	COMPLETED
9	18	COMPLETED
10	22	COMPLETED
11	25	COMPLETED
TOTAL	**173**	

Screening Programme To Date...

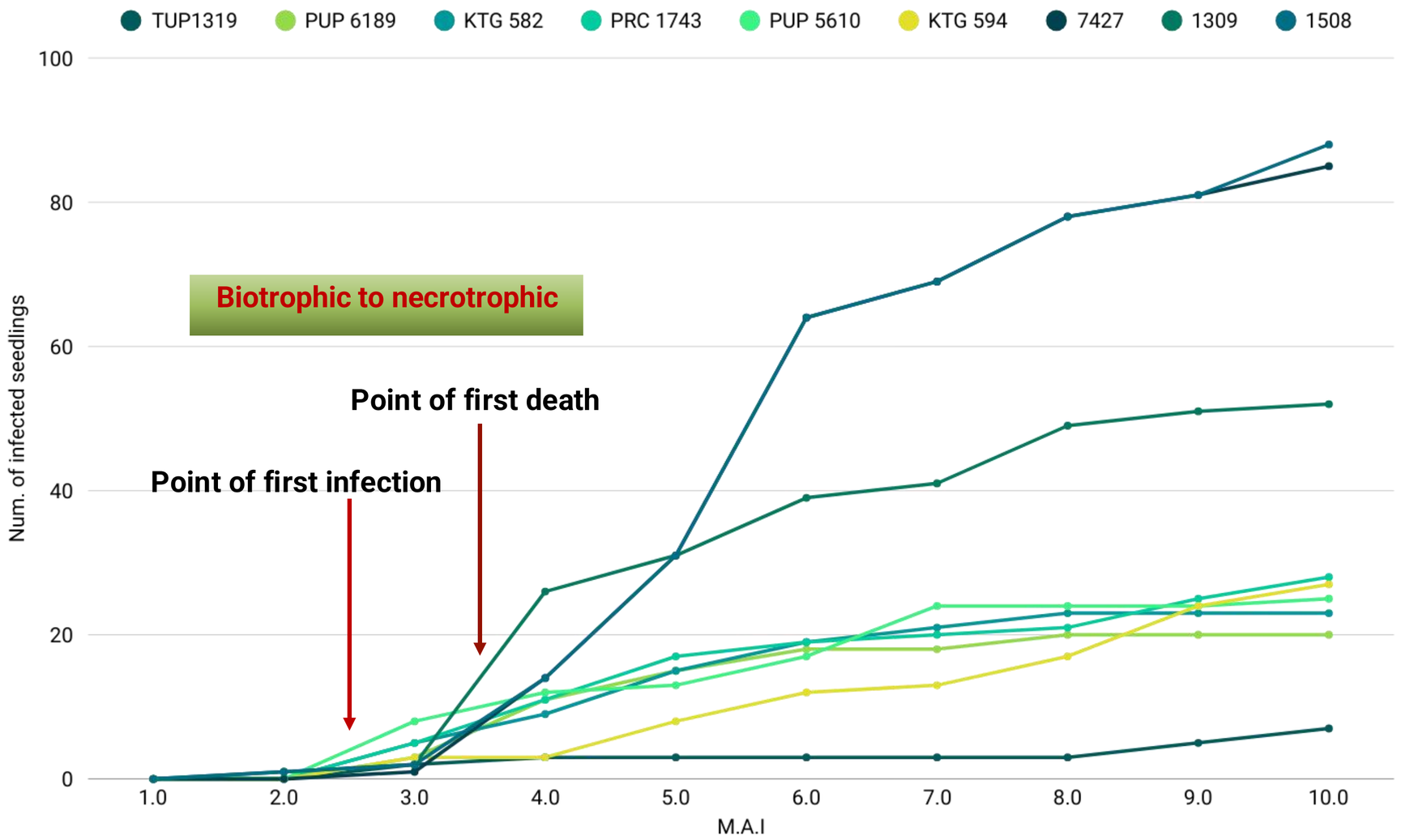
Num.	Cross Code	Batch	Cross Type	Background	Number of Samples Screened	% of dead seedlings	Total N Sample	N Repeat	Average Mortality %
1.	KTG 586	6	DxP	CD x (ZRExAV)	100	32.0	300	3	**36.0**
	KTG 586	7	DxP	CD x (ZRExAV)	100	47.0			
	KTG 732	11	DxP	CD x (ZRExAV)	100	29.0			
2	KTG 576	7	DxP	CD x (CMRxAV)	100	47.0	200	2	**35.5**
	KTG 718	11	DxP	CD x (CMRxAV)	100	24.0			
3	KTG 594	6	DxP	CD x (ZRExAV)	100	27.0	300	3	**34.7**
	KTG 594	7	DxP	CD x (ZRExAV)	100	48.0			
	KTG 753	11	DxP	CD x (ZRExAV)	100	29.0			
4	KTG 590	6	DxP	CD x (CMRxAV)	100	30.0	300	3	**36.3**
	KTG 590	7	DxP	CD x (CMRxAV)	100	54.0			
	KTG 759	11	DxP	CD x (CMRxAV)	100	25.0			
5	KTG 574	6	DxP	CD x (ZRExAV)	100	29.0	200	2	**26.5**
	KTG 726	11	DxP	CD x (ZRExAV)	100	24.0			

A few interesting pedigree were observed as partial resistance materials. The potential progenies are now undergoing further testing in the nursery and have been planted in *Ganoderma* hot spot areas.

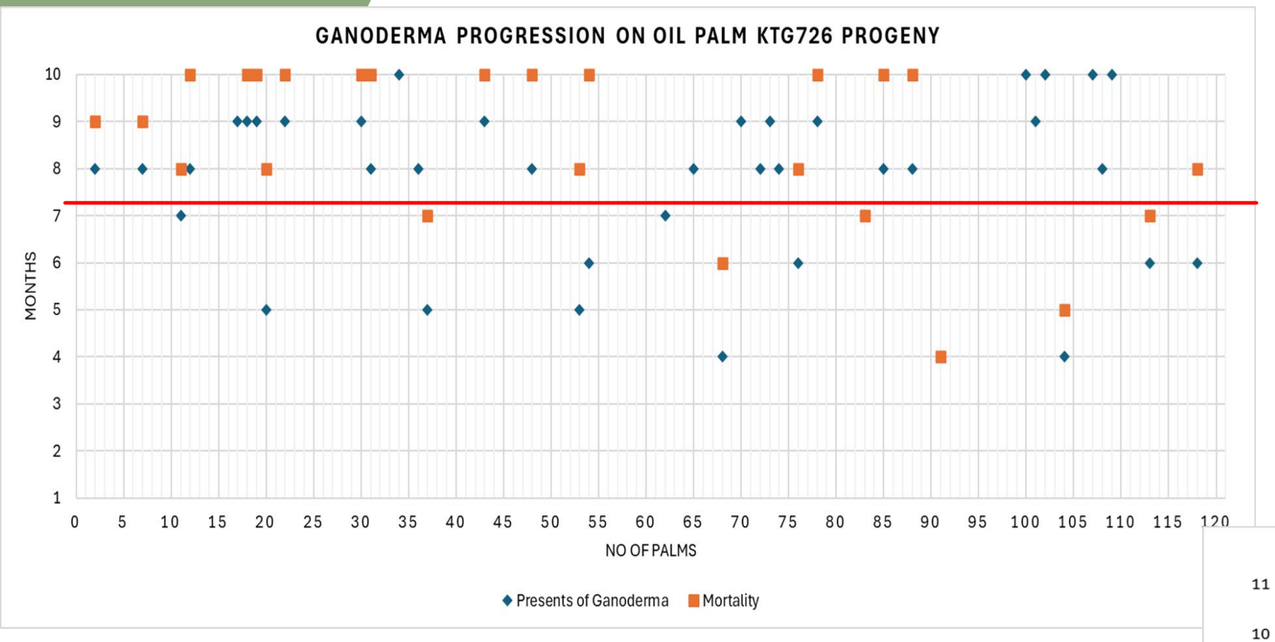
Screening Programme To Date...

No.	Cross Code	Batch	Cross Type	Background	Number of Samples Screened	% of dead seedlings	Total N Sample	N Repeat	Average Mortality %
6	KTG 594	6	DxP	CD x (ZRE x AV)	100	27.0	300	3	**34.7**
	KTG 594	7	DxP	CD x (ZRE x AV)	100	48.0			
	KTG 753	11	DxP	CD x (ZRE x AV)	100	29.0			
7	KTG 590	6	DxP	CD x (CMR x AV)	100	30.0	300	3	**36.3**
	KTG 590	7	DxP	CD x (CMR x AV)	100	54.0			
	KTG 759	11	DxP	CD x (CMR x AV)	100	25.0			
8	KTG 612	8	DxP	CD x (CMR x AV)	120	44.2	220	2	**33.1**
	KTG 752	11	DxP	CD x (CMR x AV)	100	22.0			
9	KTG 609	8	DxP	CD x (ZRE x AV)	120	55.8	220	2	**34.4**
	KTG 720	11	DxP	Cd x (ZRE x AV)	100	13.0			
10	KTG 574	6	DxP	CD x (ZRE x AV)	100	29.0	200	2	**26.5**
	KTG 726	11	DxP	CD x (ZRE x AV)	100	24.0			
11	KTG 568	7	DxP	CD x (CMR x AV)	100	47.0	200	2	**25.5**
	KTG 727	11	DxP	Cd x (CMR x AV)	100	4.0			

The progress of *Ganoderma* infection



Ganoderma progression

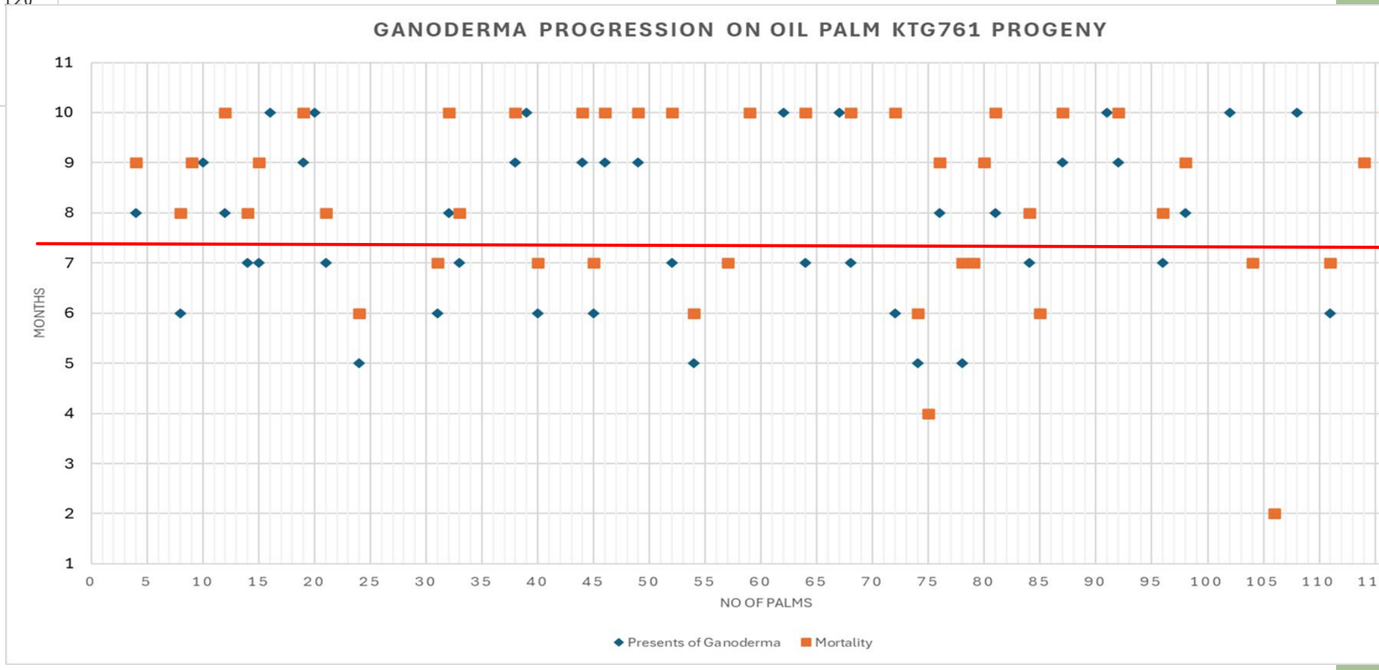


KTG726 PROGENY – PARTIAL RESISTANCE

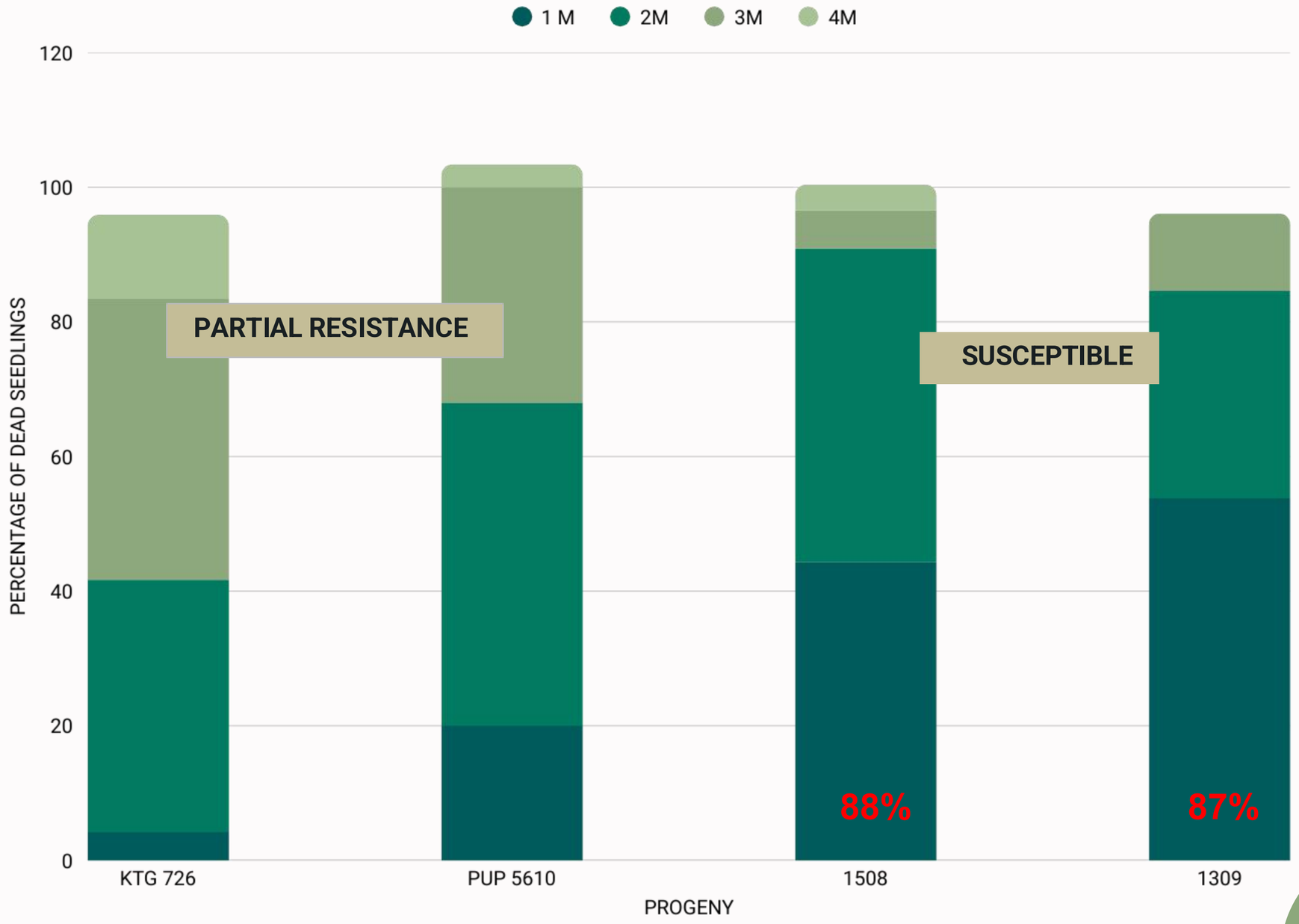
- 5 death of seedlings by the 7th month of screening
- 9 seedlings with first point of infection

KTG761 PROGENY - SUSCEPTIBLE

- 15 death of seedlings by the 7th month of screening
- 20 seedlings with first point of infection



Partial resistance / susceptible infection pattern



NOTE:

- Partial resistance progenies: 10 – 15% infected seedlings continue to live on throughout the trial duration

Screening of Commercial Progenies

Progeny	% of dead seedling due to *Ganoderma* infection	
	GB Aggressive	PER71
TUP 1269	64	40
TUP 1299	69	48
TUP 1310	61	48
TUP 1249	72	60
TUP 1273	72	63
TUP 9211	69	65
TUP 1260	70	67
TUP 1217	65	75
PKC 9197	66	82
Control Tolerant	19	
Control Susceptible	80	

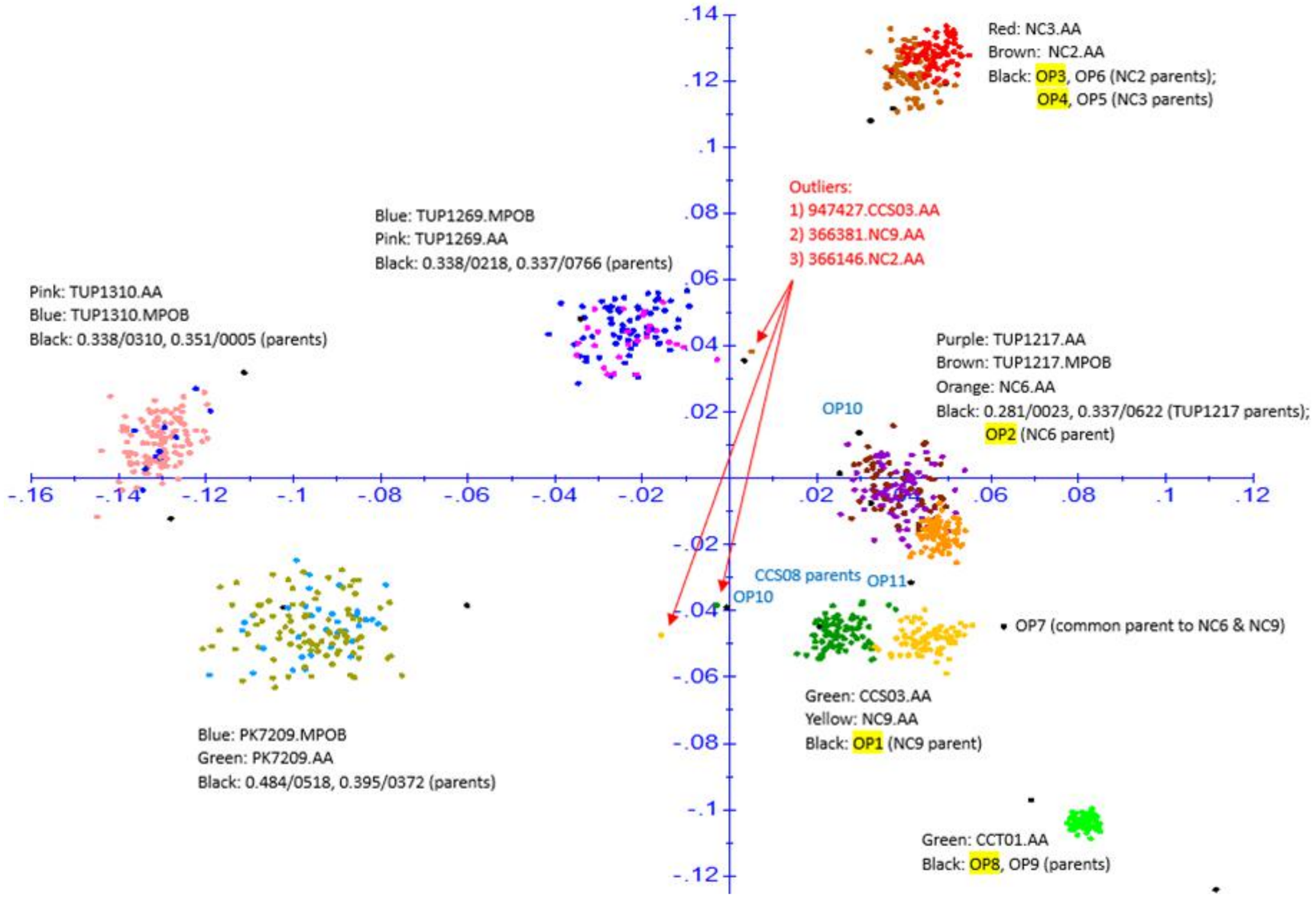
- **MPOB collaborates** with a commercial partner in Indonesia, **Asian Agri**.
- Potential partial resistant and susceptible progenies were concurrently tested with **Asian Agri's standard *Ganoderma*** isolate.
- The **results' pattern** was **similar**, albeit higher infections were observed with Indonesian aggressive isolate.

Samples genotyped* and phenotyped

*genotyped with 50K Axiom SNP Array

No	Progeny	Number of sample screened at MPOB		Number of sample screened at AA	
		Genotyped	Phenotyped	Genotyped	Phenotyped
1	TUP1217	52 (4 not phenotyped)	60 (12 not genotyped)	99	100 (1 not genotyped)
2	TUP1269	27	30 (3 not genotyped)	100	100
3	TUP1310	59	60 (1 not genotyped)	99	99
4	PK 7209	36	60 (24 not genotyped)	99	99
Total		174	210	397	398
5	CCS 03			100	100
6	CCT 01			100	100
7	CCS 08			0	100
8	NurCode 2			80	80
9	NurCode 3			79	79
10	NurCode 6			80	80
11	NurCode 9			80	80
Total				519	619

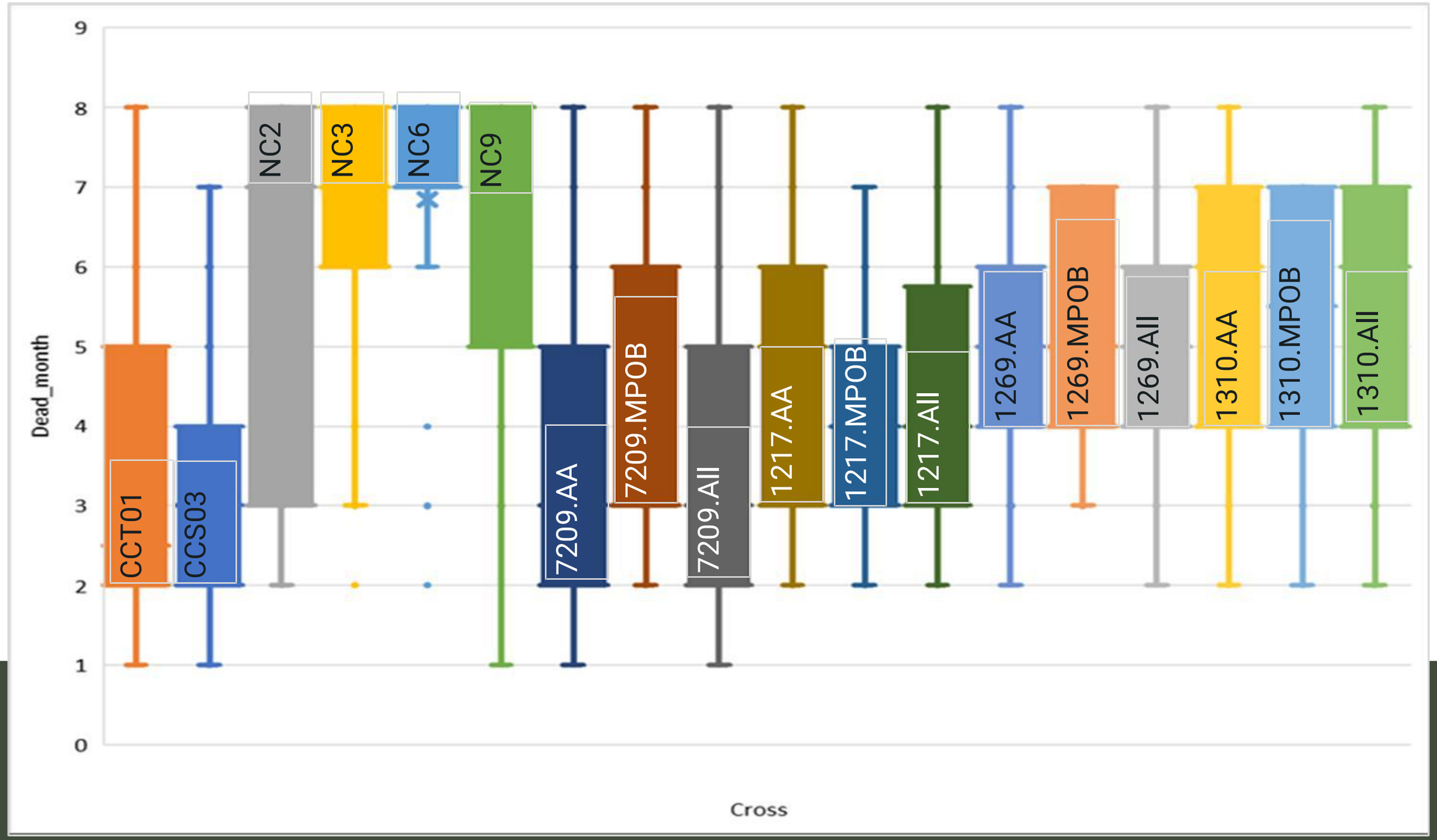
Genotypic data evaluation



Factorial analysis

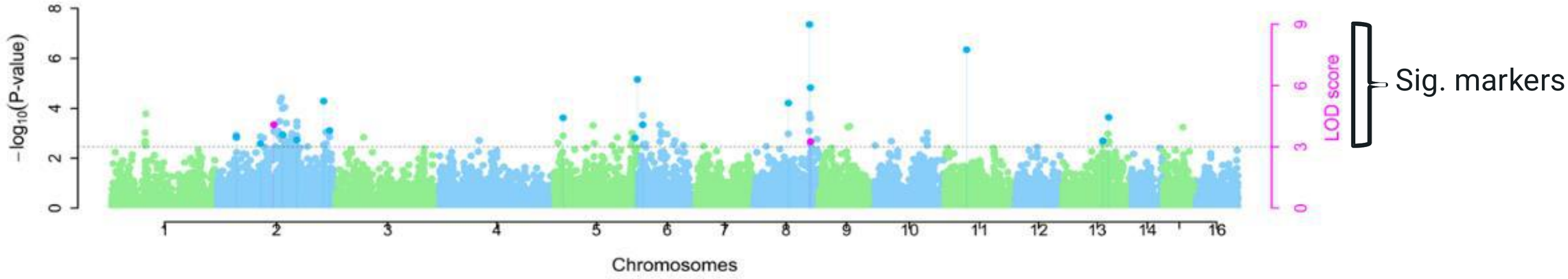
- Distribution of samples
- Identified 3 outliers each from CCS03, NC9 and NC2

Phenotypic data evaluation

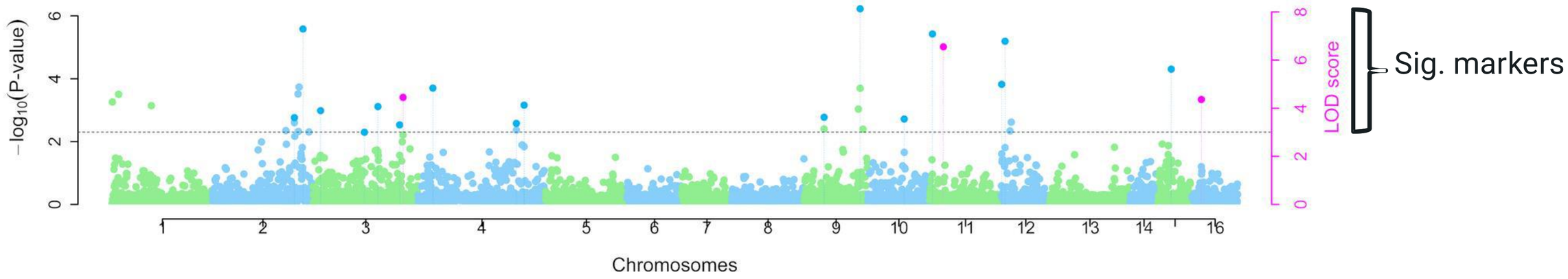


GWAS (Genotype + Phenotype data analysis) Identification of quantitative trait nucleotide (QTNs)

Dead at month (DoM)



Dead/Alive (DA)



Resistance related genes

Moment of Dying (MoD)					Dead or Alive (DA)			
36K K3 LOD	Method	SNP	Pos	EG11_Chr	Pos	SNP	Method	36K K3 LOD
				1	4,695,461	Affx-1289698206	mrMLM	4.3
							pLARmEB	4.6
4.6	pLARmEB	Affx-1289694142	95,270,314	2				
3.5	pKWmEB							
3.3	pKWmEB	Affx-952087898	112,529,276					
	mrMLM				118,271,241	Affx-952095051	FASTmrMLM	5.3
					122,970,803	Affx-952099729	pLARmEB	7.2
				3	24,895,668	Affx-1289685211	mrMLM	3.2
							pKWmEB	
					103,897,617	Affx-1289700101	pLARmEB	4.3
					118,573,412	Affx-257679660	pLARmEB	3.2
							mrMLM	
					120,339,768	Affx-1289698543	pLARmEB	3.7
							pKWmEB	3.8
							mrMLM	
				4	126,414,425	Affx-1290516698	pKWmEB	3.6
4.4	pKWmEB	Affx-1111256132	4,887,983	5				
3.4	pLARmEB	Affx-952513234	128,796,719					
5.0	mrMLM	Affx-1111380230	28,307,362					
				9	94,155,435	Affx-1289703892	mrMLM	4.6
				10	36,655,882	Affx-952467473	pKWmEB	3.8
							pLARmEB	
				11	24,378,928	Affx-1295098379	mrMLM	4.4
							pLARmEB	
				12	489,851	Affx-1292620776	pLARmEB	3.6
4.4	pKWmEB	Affx-1289686295	58,104,994	13				
	pLARmEB							
				15	53,195,171	Affx-1289709354	pLARmEB	5.4
							mrMLM	5.2

- Disease resistance protein RGA4
- GATA Transcription Factor 19 (abiotic stress resistance)
- Phosphomannomutase (immune defenses)
- Nudix hydrolase homolog 8 (immune responses)
- Elongator complex protein 6 (resistance against pathogens)
- Glycine-Rich RNA-Binding Protein 2 RBG2 (stress responses)
- Probable serine/threonine-protein kinase PBL8 (defense signaling)

PROGRESS

Crossing Program

- Initially **10 control crosses were identified** as screening programme **controls**.
- **7 crosses** are currently **available as controls**
  - ✓ 4 tolerant controls
  - ✓ 3 susceptible controls.
- These will serve as **positive and negative controls** for upcoming screening programs.
- Screening of 24 crosses under Batch 14 is ongoing, with germinated seeds expected by March 2026.

No	Cross Code	Cross Type	Genetic Background	No. of tests	Seedling Mortality (%)	Remarks
1.	PK 7417	DxP	CD x AV	1	68.0	Based on seedling mortality percentage
2.		DxP	DE x AV	-	-	
3.		DxD	DE x DE	-	-	
4.	PRC 1735	DxP	CD x NGA	1	28.3	Based on potential Ganoderma partial resistance parents
5.	PRC 1749	DxP	CD x NGA	1	30.8	
6.	KTG 586	DxP	CD x (ZRExAV)	3	32.0	Based on number of tests conducted
7.	KTG 594	DxP	CD x (ZRExAV)	3	27.0	

Notes: CD – Chemara Dura; AV- AVROS; DE- Dumpy Elmina; NGA- Nigeria; ZRE- Zaire

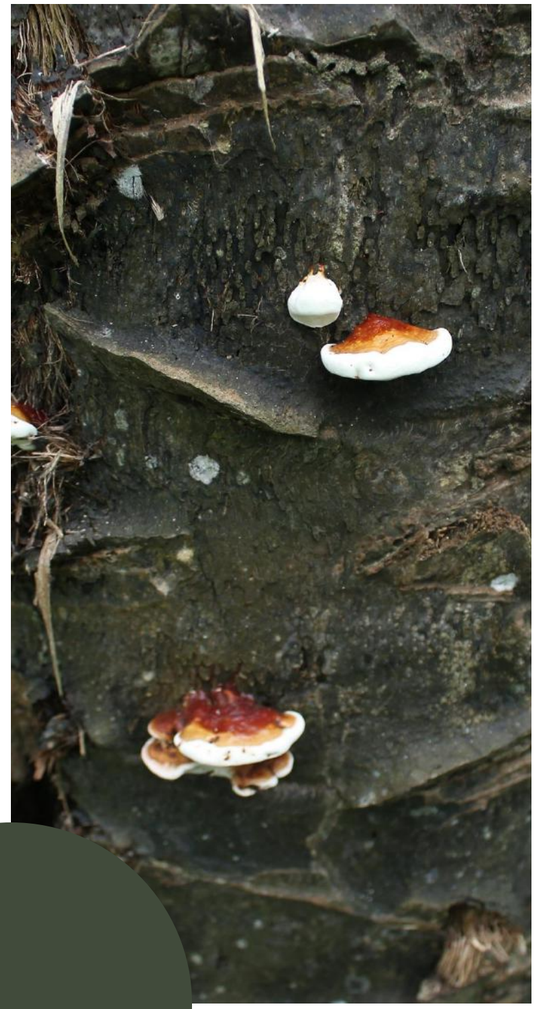
PROGRESS

Marker Analysis:

- Based on the screening programmes conducted to date, a total 8000 SNP markers have been generated. These markers will be tested across the breeding materials to validate its significance in tolerance/resistance of the materials.

***Ganoderma* Progression Study:**

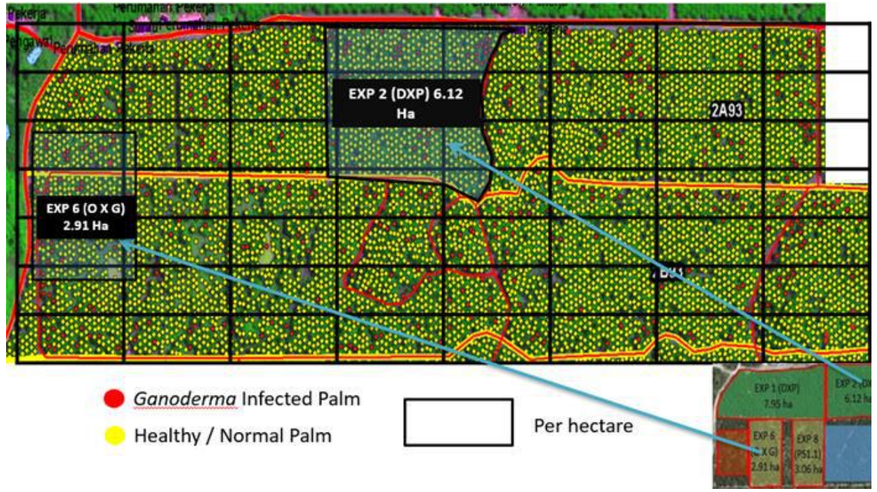
- Early infections (3–4 months) were observed in progeny KTG 719 and KTG 717, while KTG 726 showed delayed infection (9–10 months), indicating potential tolerance. Evaluation is still on-going.



CONCLUSION

- Four potential *Ganoderma* partially tolerant and three susceptible progenies have been identified and will be TOT next year.
- Markers will be developed based on SNP array analysis results.
- Batch 11 marks the end of second generation of *Ganoderma* resistant material screening programme.
- Another replanting area at MPOB Research Station, Keratong, Pahang with 25% BSR disease incidences will be planted with partially tolerant and susceptible progenies identified.
- The next batch (Batch 12) will be using MPOB's most aggressive isolate ET61.

FIELD EVALUATION IS ON GOING – No infection after 18 months

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THANK YOU

Shamala Sundram, PhD
shamala@mpob.gov.my