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21th International Oil Palm Conference

# INTEGRATED GANODERMA MANAGEMENT IN OIL PALM PLANTATION IN MALAYSIA


## Dr. Mohd Hefni Rusli

MPOB


fedepalma | cenipalma

CON EL APOYO DEL FONDO DE FOMENTO PALMERO

# OIL PALM INDUSTRY IN MALAYSIA

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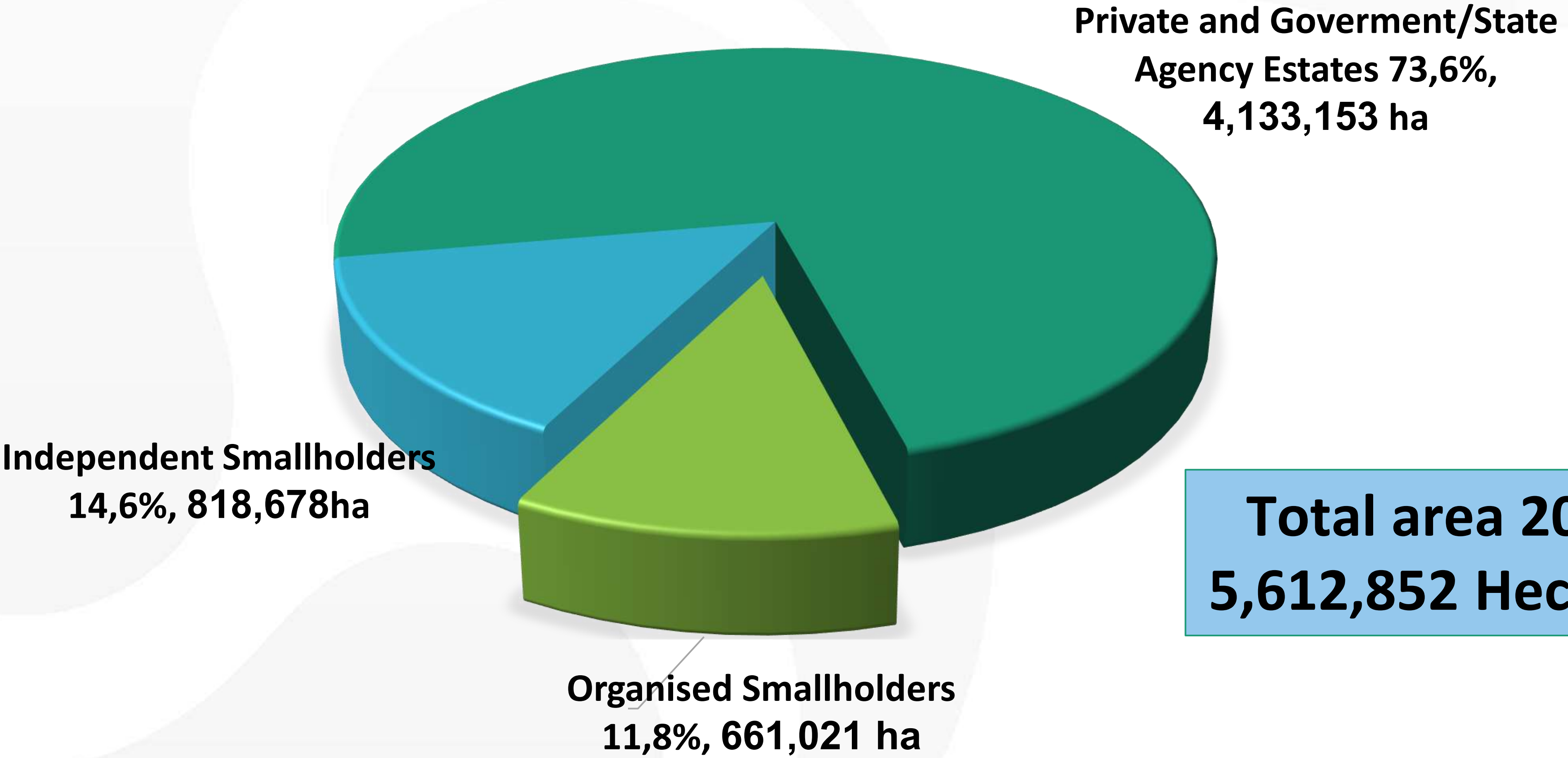
- The oil palm is an important commodity in Southeast Asia (SEA).

- Oil palm is the major commodity crop for Malaysia and the fourth-largest contributor to Malaysia's national revenue.

- The total area of oil palm in Malaysia is 5.6 million hectares, with a total export revenue of palm oil and palm-based products valued of more than USD 20 billion in 2024.

# OIL PALM INDUSTRY IN MALAYSIA

**MALAYSIA: OIL PALM PLANTED AREA BY CATEGORY, 2024**




**Total area 2024: 5,612,852 Hectares**

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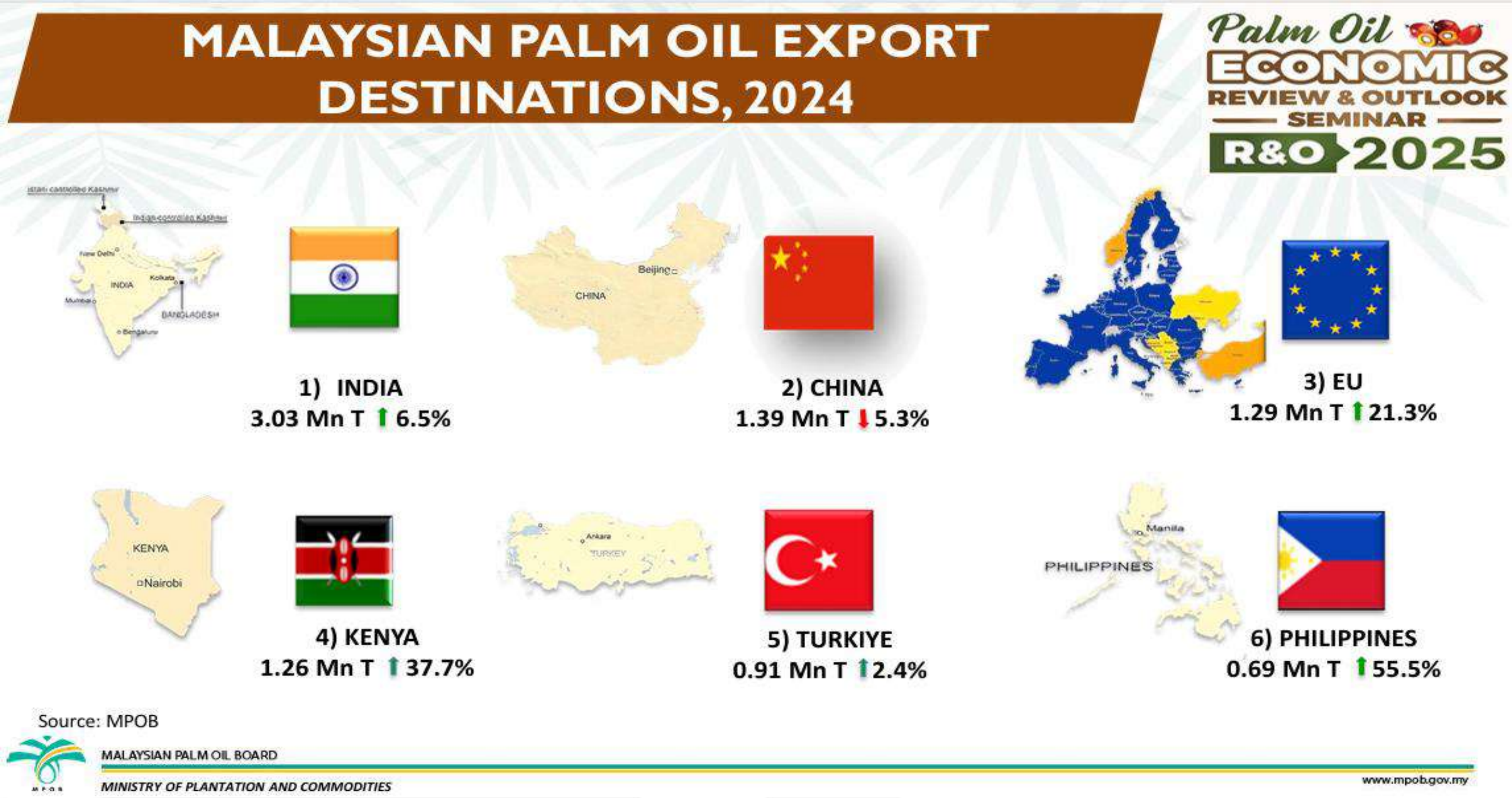
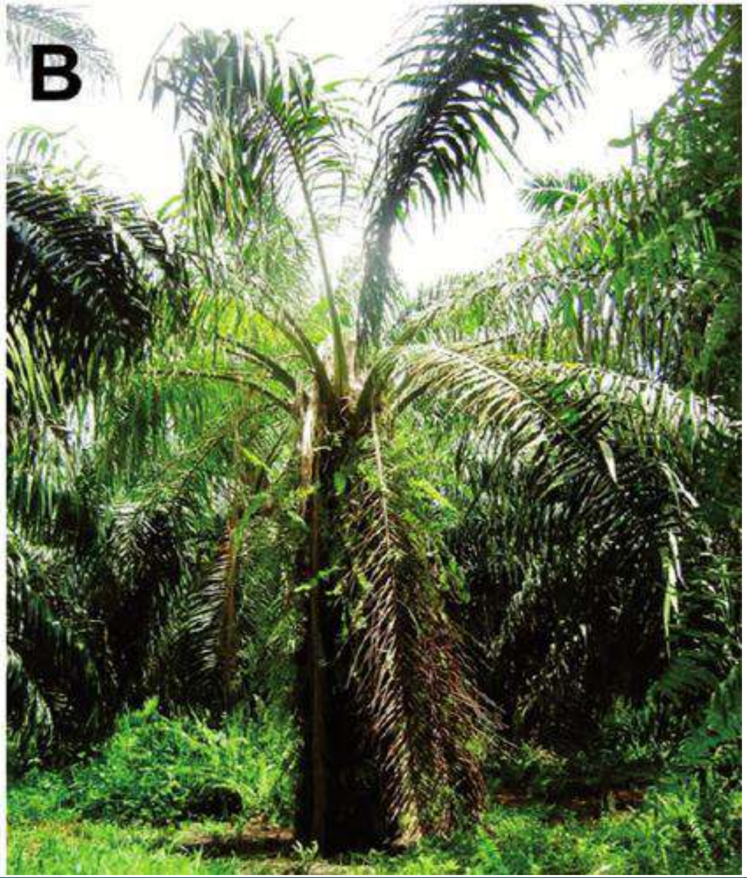


# MAJOR OIL PALM DISEASES



Basal Stem Rot Disease

Local disease




Bud Rot Disease

Vascular Wilt Disease

Exotic diseases

# OIL PALM DISEASES IN MALAYSIA

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## Field diseases

Basal Stem Rot disease

## Nursery Diseases

Leaf Spot disease

Anthracnose disease

## Seed Diseases

Biji benih yang dijangkiti dilitupi dengan miselium putih

Biji benih dijangkiti dengan miselium putih dan bintik kehijauan (spora)

# EMERGING DISEASES IN MALAYSIA

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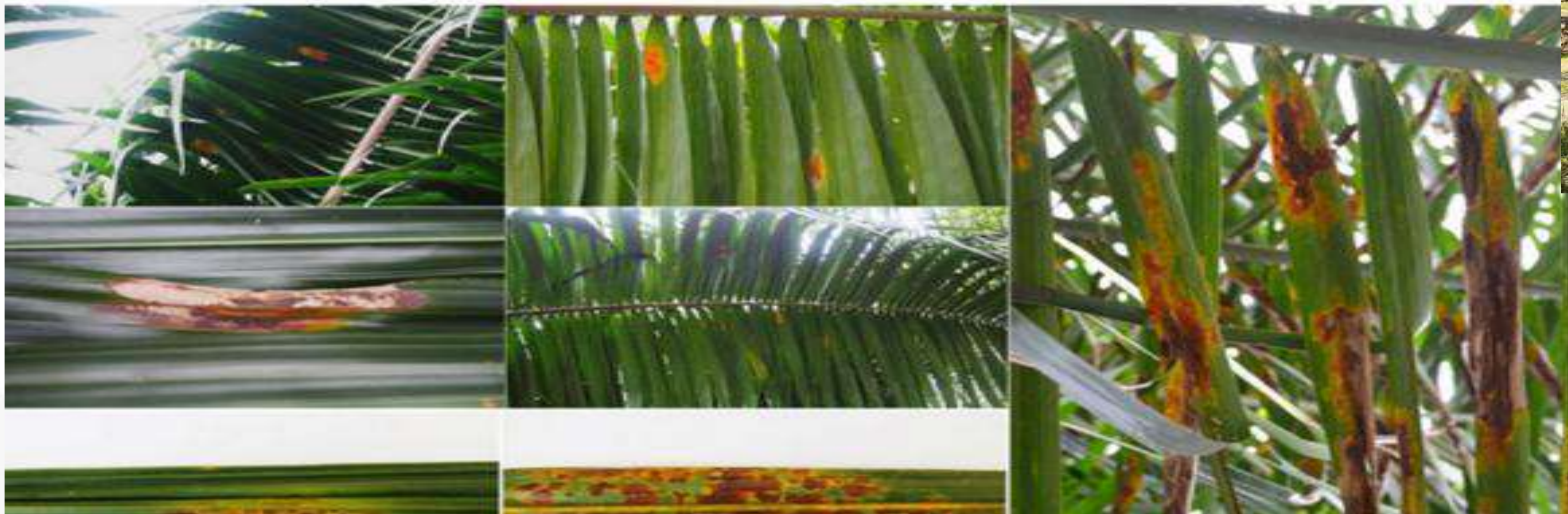
Algae leaf spot

Sootymold

Stem Wet Rot



Bunch Rot

# BASAL STEM ROT DISEASE

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## History of BSR disease incidences in Malaysia

1930

Old palm > 25 years old

1957

Mature palms, 10 -15 years old

1990

Immature palms, 1- 2 years old

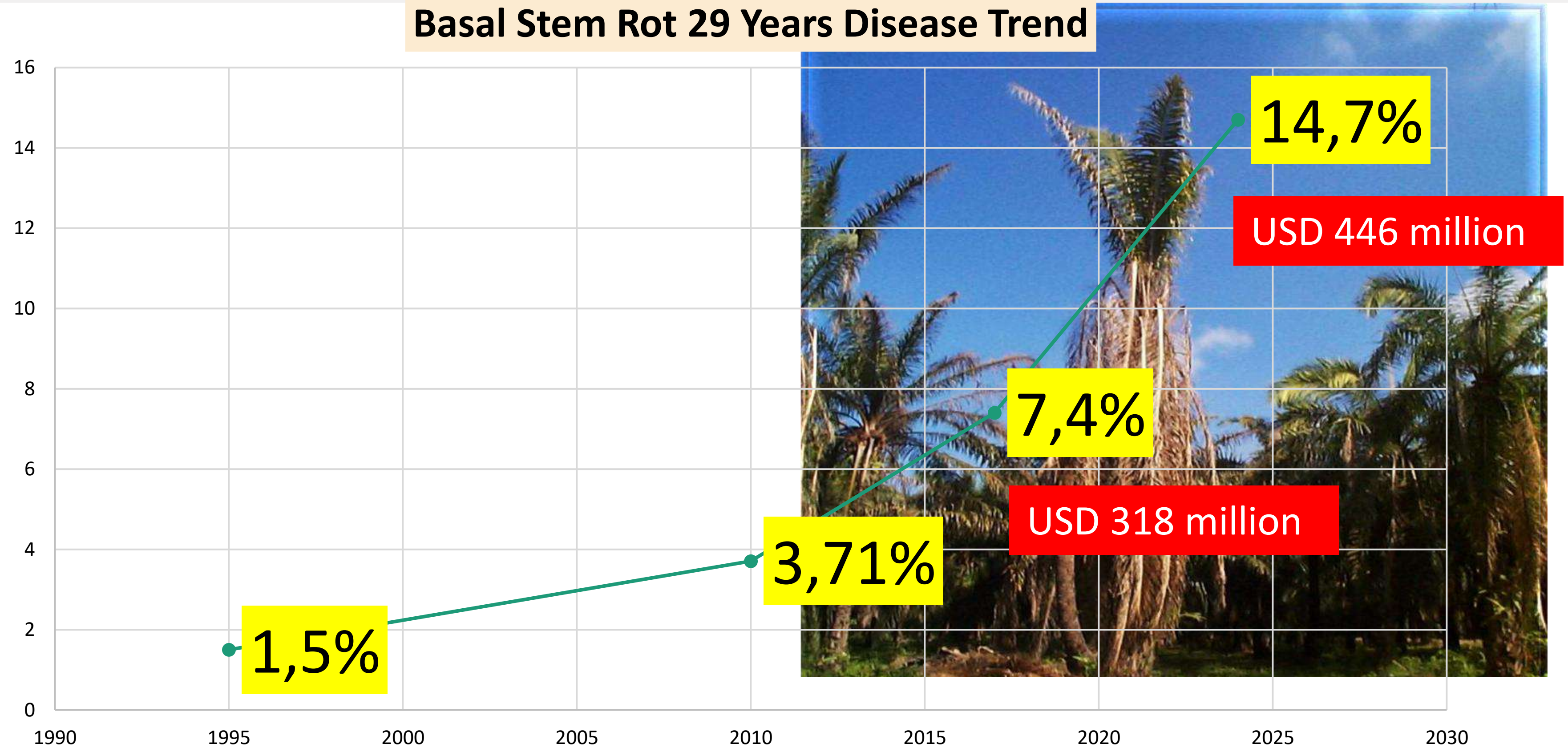
# BASAL STEM ROT DISEASE


## Updated status of Basal Stem Rot (BSR) disease incidence in oil palm plantations in Malaysia

199, 633 hectares affected

29,545,684 trees infected

Basal Stem Rot 29 Years Disease Trend



# BASAL STEM ROT DISEASE

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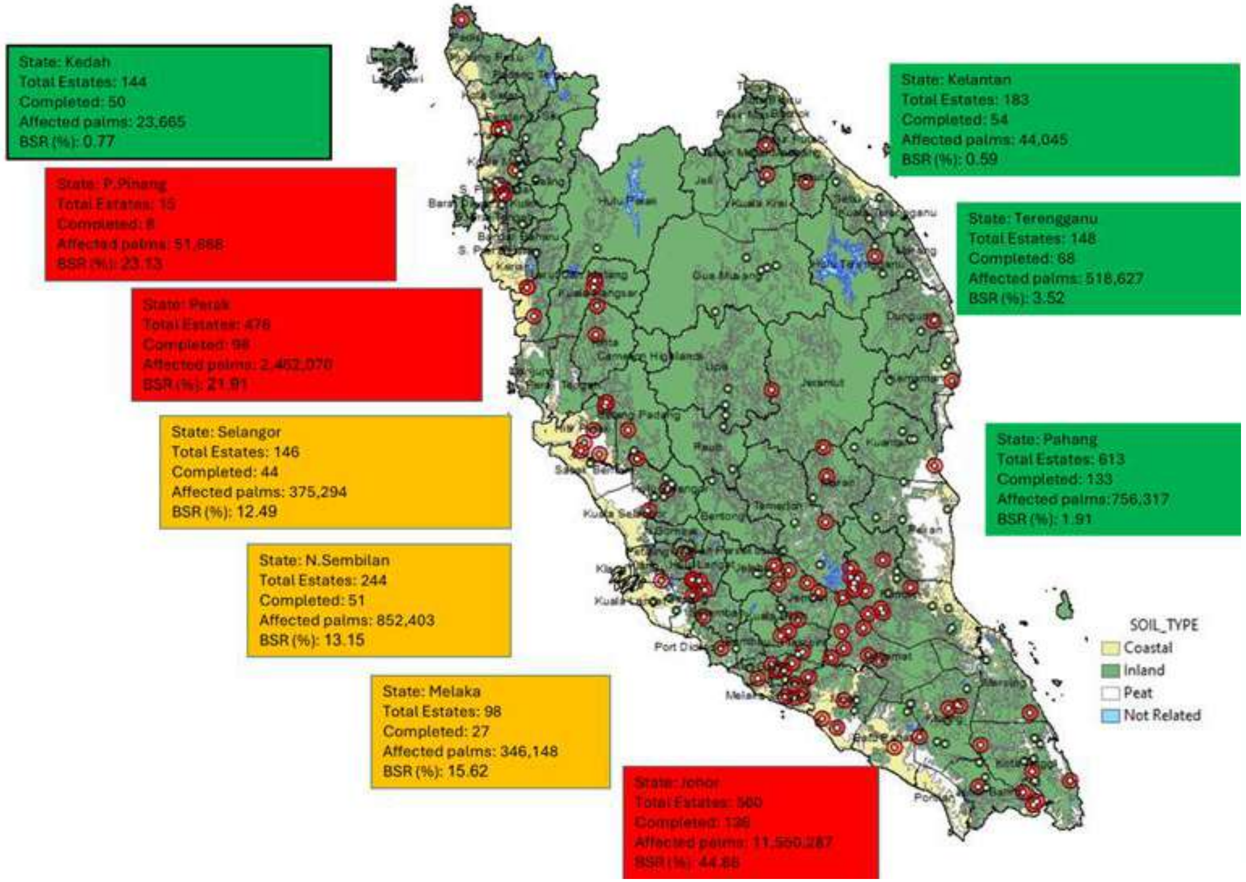
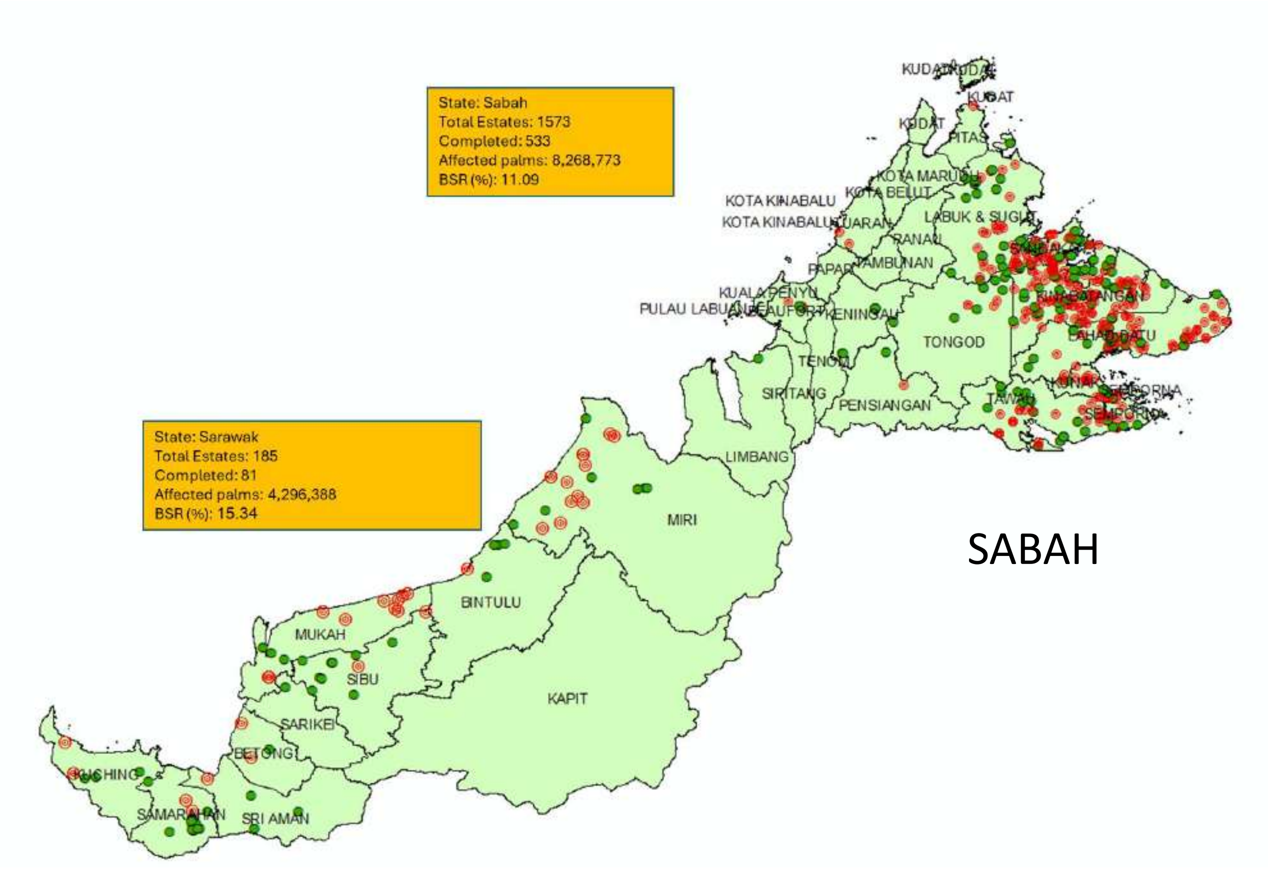
PENINSULAR MALAYSIA



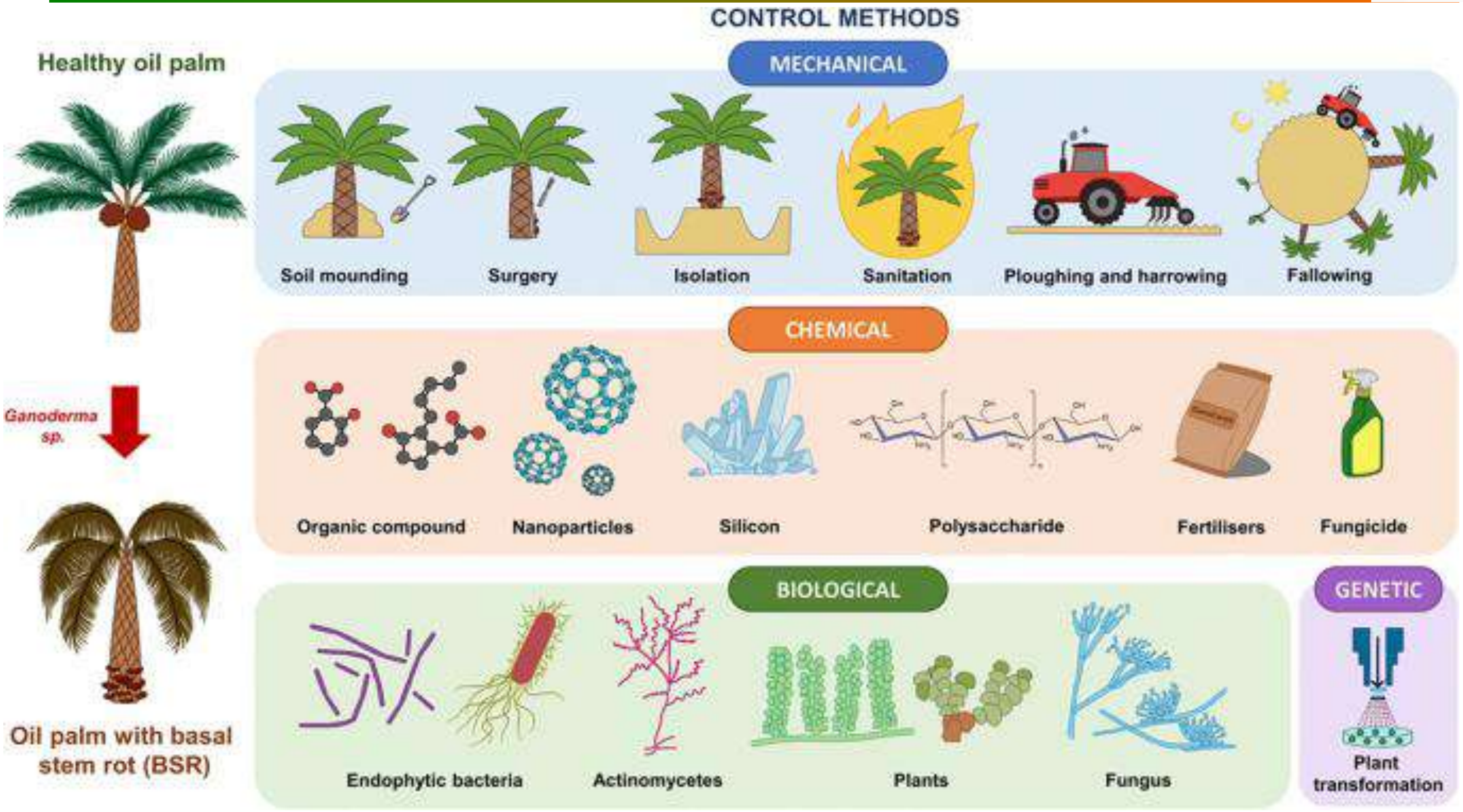




SABAH

SARAWAK

# BASAL STEM ROT DISEASE

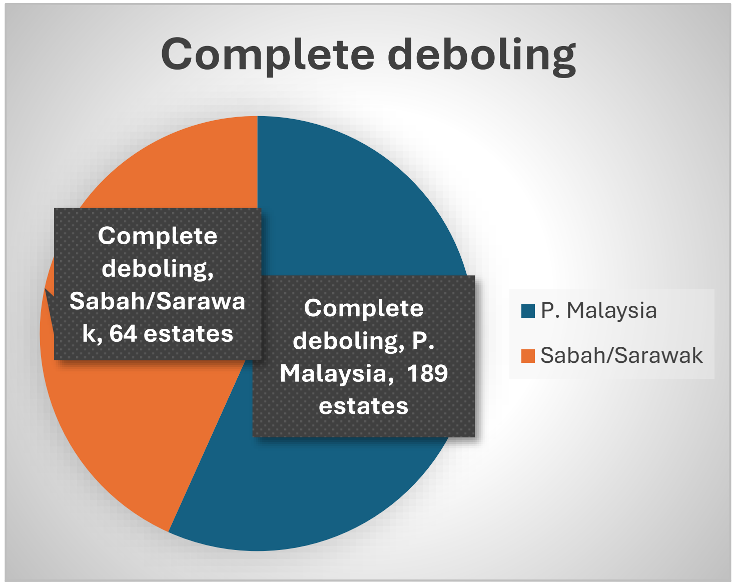


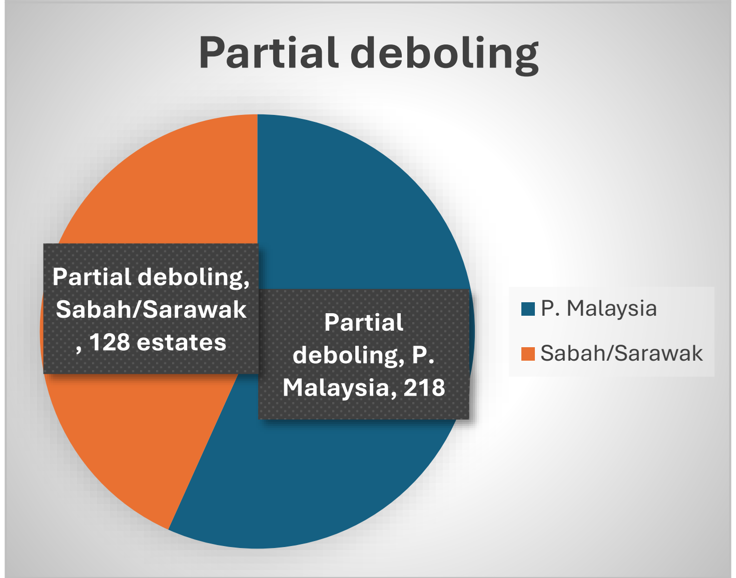



Supramani et al., 2022

# BASAL STEM ROT DISEASE





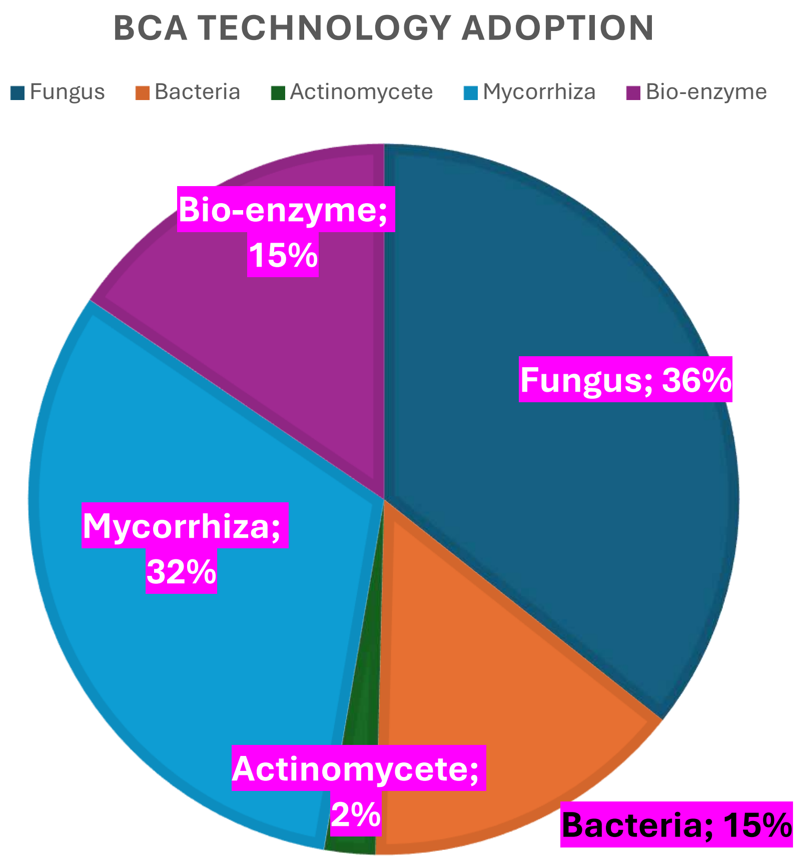

Complete deboling

| Region | Estates with BSR disease | | Treated area involved | |
|---|---|---|---|---|
| | No. of estates | Area (ha) | No. of estates | Area (ha) |
| P. Malaysia | 325 | 114,733.27 | 189 | 5,738.13 |
| Sabah/Sarawak | 435 | 84,899.74 | 64 | 4,377.87 |
| Total | 760 | 199,633.01 | 253 | 10,116.00 |
| Percentage (%) | 54.7 | 13.7 | | 5.07 |

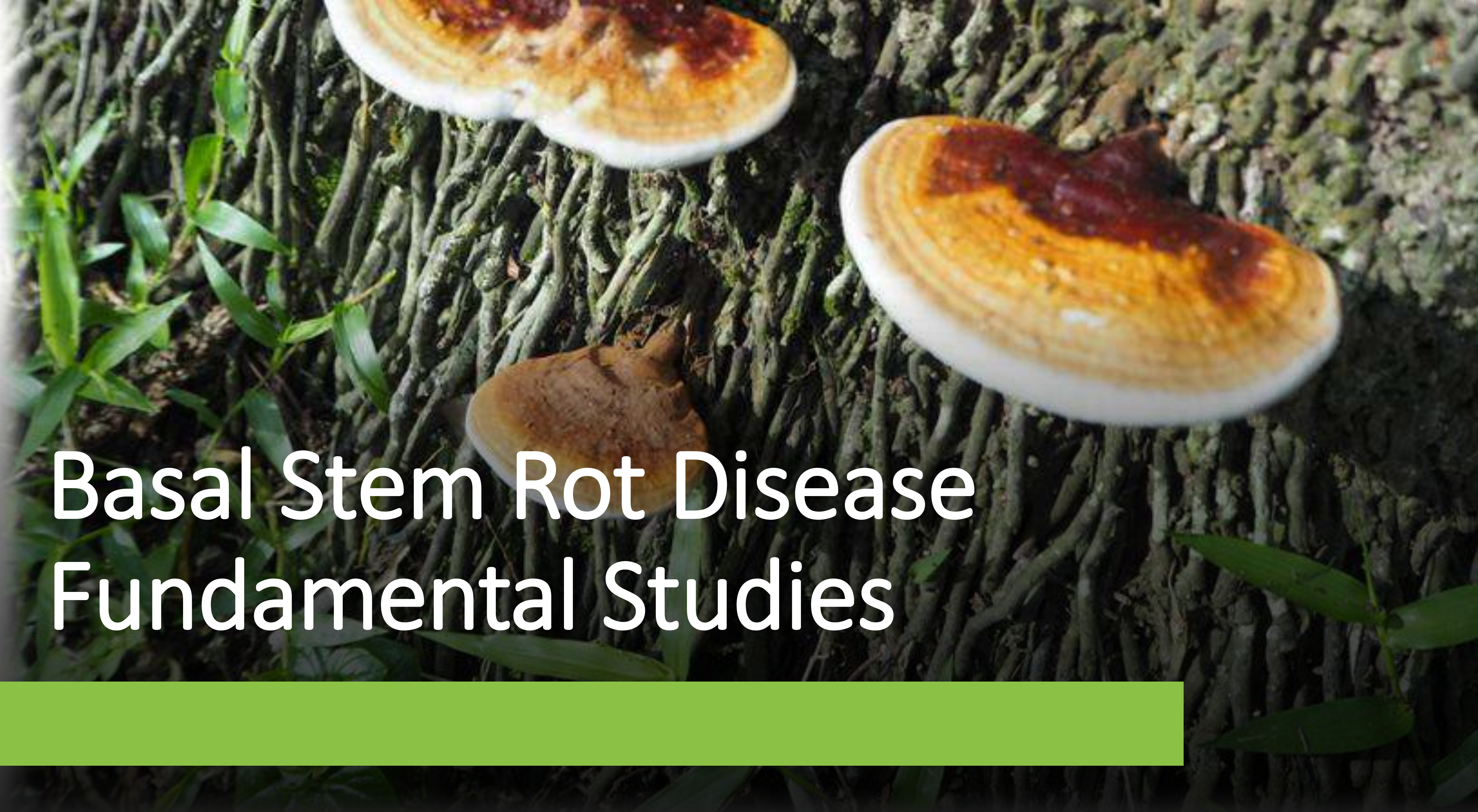
Partial deboling

| Region | Estates with BSR disease | | Treated area involved | |
|---|---|---|---|---|
| | No. of estates | Area (ha) | No. of estates | Area (ha) |
| P. Malaysia | 325 | 114,733.27 | 218 | 1,442.30 |
| Sabah/Sarawak | 435 | 84,899.74 | 128 | 1,100.40 |
| Total | 760 | 199,633.01 | 332 | 2,542.70 |
| Percentage (%) | 54.7 | 13.7 | | 1.27 |

# BASAL STEM ROT DISEASE




| Region | Estates with BSR disease | | Treated area involved | |
|---|---|---|---|---|
| | No. of estates | Area (ha) | No. of estates | Area (ha) |
| P. Malaysia | 325 | 114,733.27 | 95 | 4,303.7 |
| Sabah/Sarawak | 435 | 84,899.74 | 34 | 1,396.0 |
| Total | 760 | 199,633.01 | 129 | 5,699.8 |



# Basal Stem Rot Disease Fundamental Studies

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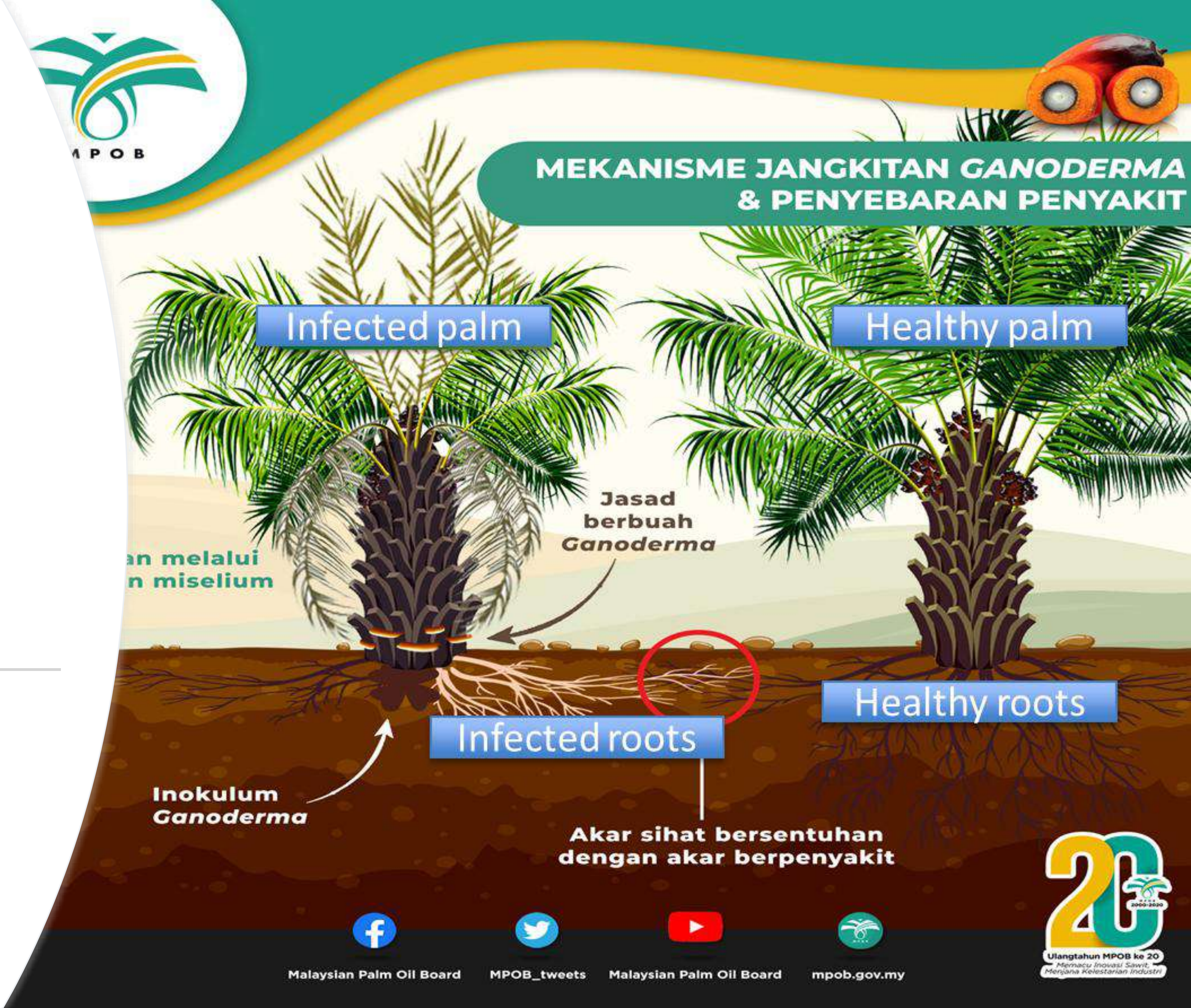
# BASAL STEM ROT DISEASE

Mechanism of infection

(Root To Root)



# BASAL STEM ROT DISEASE

## Mechanism of infection (Basidiospore)

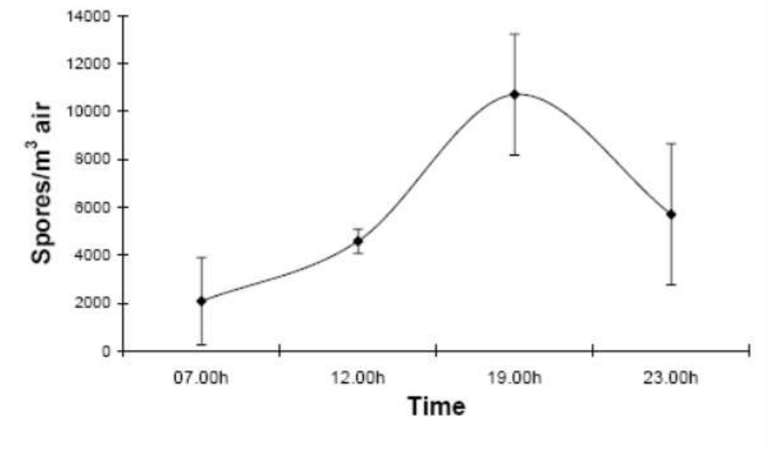
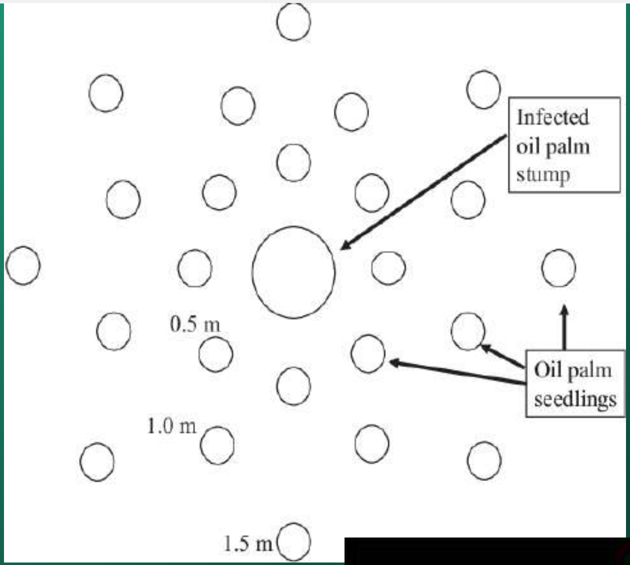
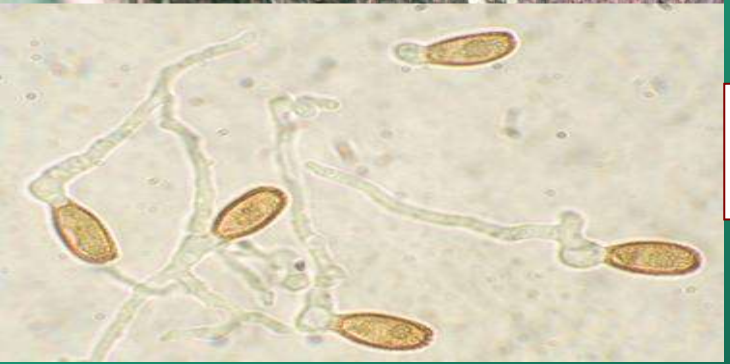
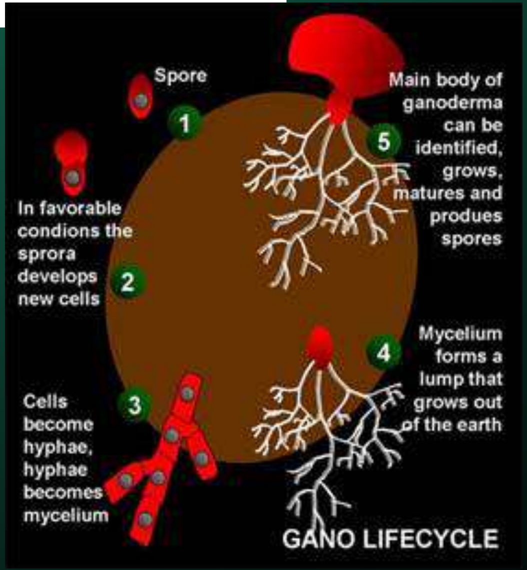


FIG. 26. Dimensional fluctuation of aerial basidiospore numbers in a 17-year old plot. Error bars represent standard deviation of the mean of four samples at each time point.



**c. $10^8$ spores *per bracket* per day** (Paul Bridge CABI)




- Infection through basidiospores (wind, insect vector etc.).
- Basidiospore stay active for 10 days.

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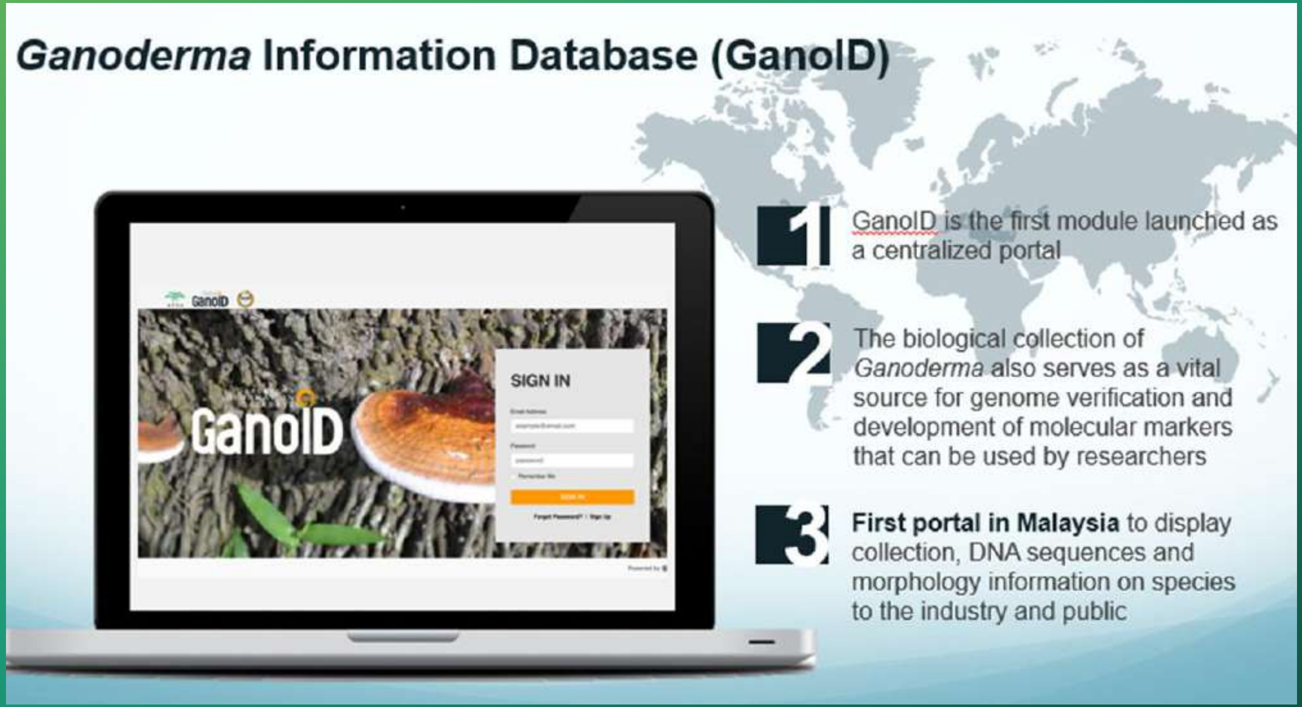
## Updataing on Ganoderma systematics: Diversity based on morpho-taxonomy, ultrastructural, biochemical and molecular techniques






*Ganoderma boninense* is now the dominant species in Malaysia

Unique basidiocarps in different colours; sizes; Basidiospores ellipsoid

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## Effect of pH on *Ganoderma* boninense


- Grow over a wide range of pH ranging pH 3.0 to 9.0.
- pH 5 is the optimum pH for the growth of mycelium for all *Ganoderma* isolates.

**❑ Impact in the field**

❑ Low pH equals to low microbial population

❑ Low beneficial microbes to compete with *G. boninense*

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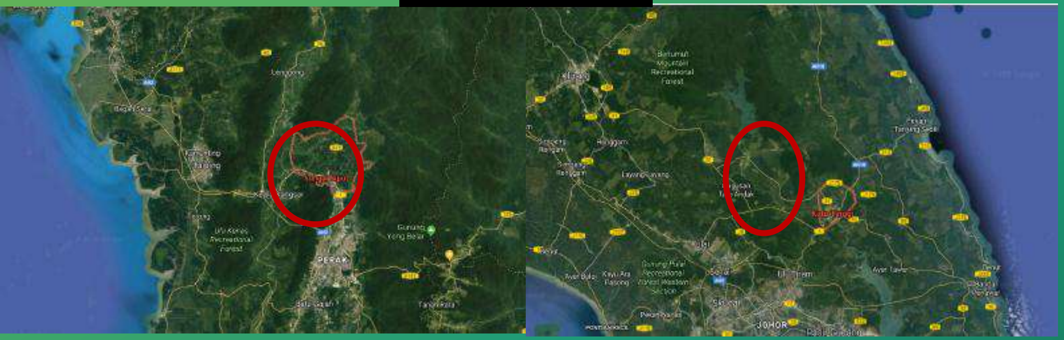
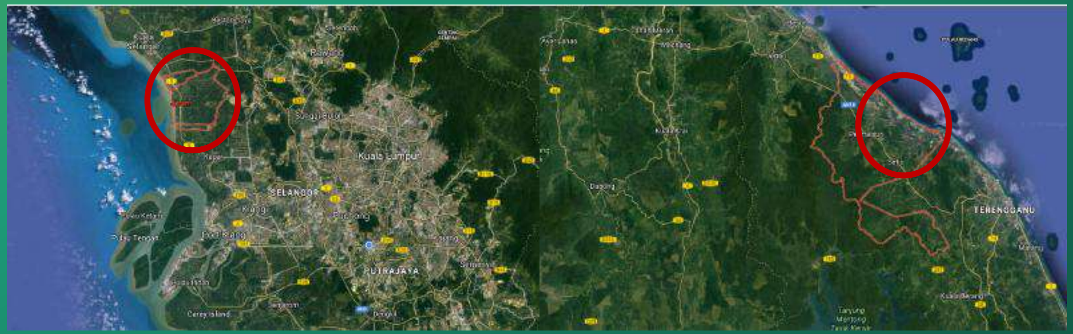
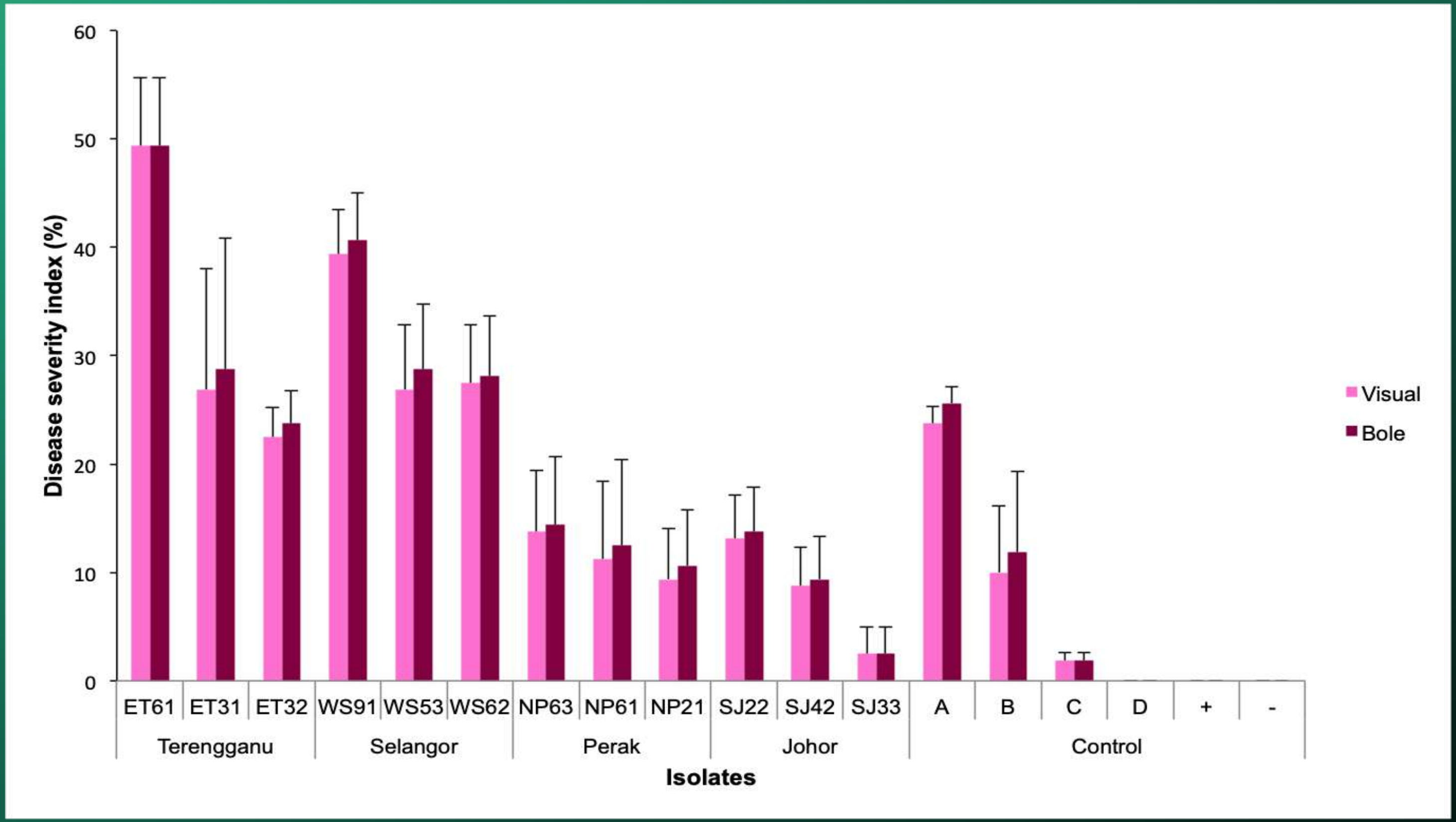
## Differential Responses In *Ganoderma* Isolate Aggressiveness

INLAND



COASTAL LAND






- **Most aggressive : ET61 (Terengganu)**
- **Least aggressive : SJ 33 (Johor)**
- **Standard culture PER 71 recorded DSI of 23.8 %**

# BASAL STEM ROT DISEASE

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## Differential Responses In *Ganoderma* Isolate Aggressiveness

| Disease Incidences (%) | Location | Soil Type | Palm symptom & Infection (%) | Palm (age) | Nursery DSI (%) |
|---|---|---|---|---|---|
| 0 – 10 | Johor (SJ33) | Inland | < 25 %; Skirting | 27 | 3.10 |
| | Perak (NP61) | Inland | < 25 % | 27 | 13.80 |
| | Perak (NP21) | Inland | > 50 % | 27 | 13.80 |
| 10 – 20 | Johor (SJ22) | Inland | < 25 % infected; Skirting | 27 | 16.30 |
| | Perak (NP63) | Inland | < 30 %; Skirting, multiple spears & hollow base | 27 | 18.80 |
| | Terengganu (ET32) | Coastal | < 10 %; Asymptomatic | 22 | 28.80 |
| | Selangor (WS53) | Coastal | < 25 %; Hollow base | 19 | 35.60 |
| 20 – 30 | Terengganu (ET31) | Coastal | < 10 %; Asymptomatic | 20 | 33.10 |
| 30 – 40 | Selangor (WS62) | Coastal | > 75 %; Skirting | 19 | 38.00 |
| | Selangor (WS91) | Coastal | > 75 % | 19 | 43.80 |
| | **Terengganu (ET61)** | **Coastal** | **> 75 %; Skirting, multiple spears** | **19** | **58.80** |

Increase in age

Increased aggressiveness

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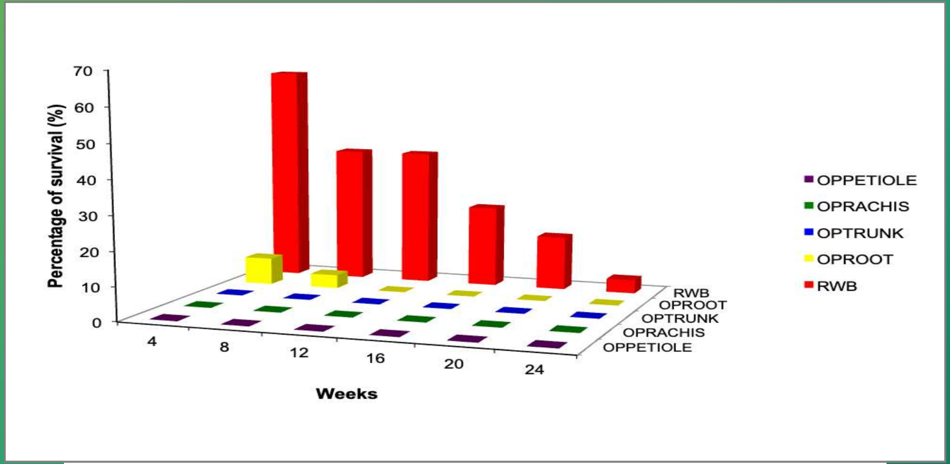
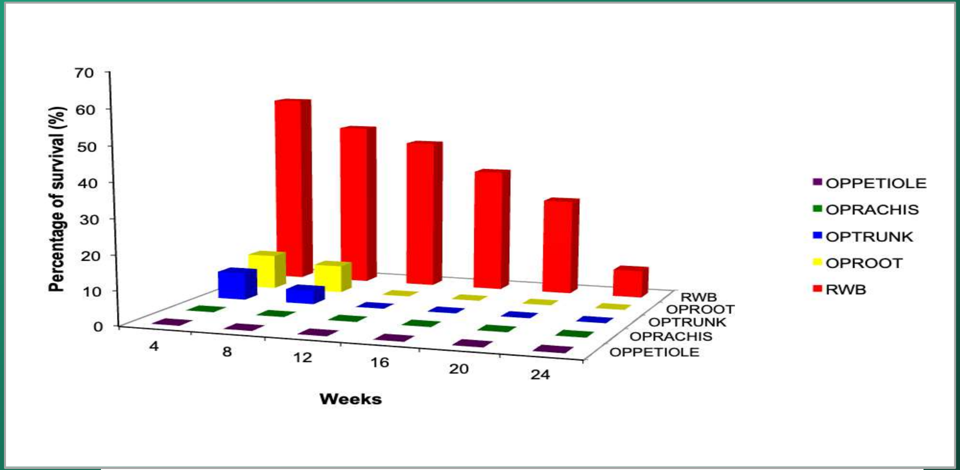
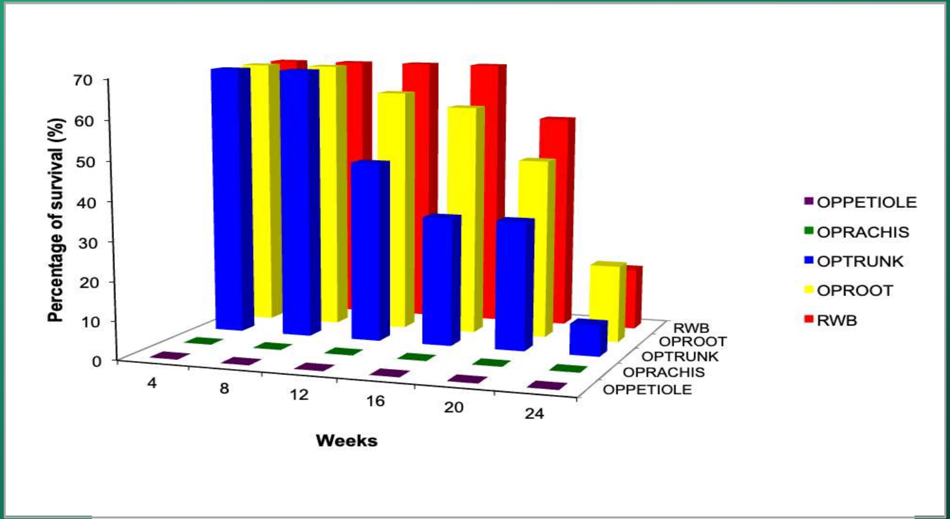
## Survival of Ganoderma *boninense* In The Soil



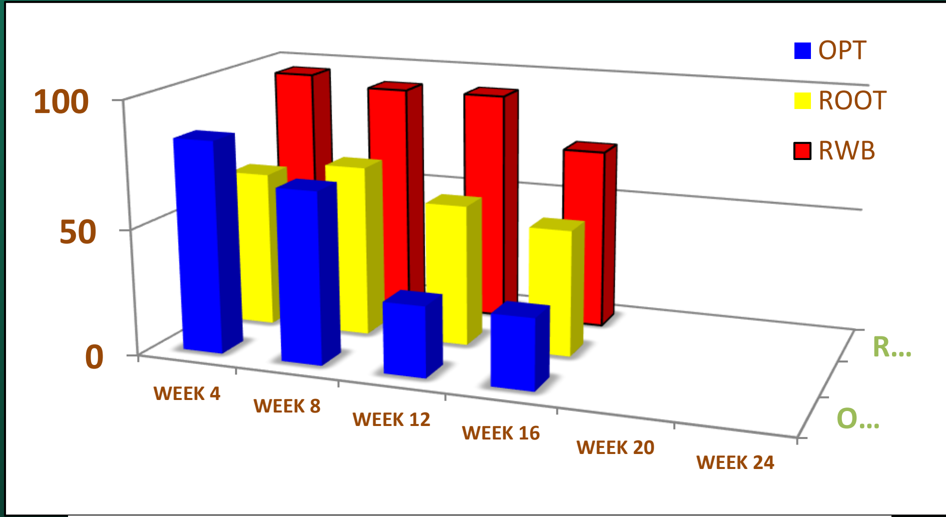

Recovery of *G. boninense* at 10 cm




Recovery of *G. boninense* at 20 cm




Recovery of *G. boninense* at 30 cm




Recovery of *G. boninense* at 60 cm

# BASAL STEM ROT DISEASE

## Survival of Ganoderma *boninense* In The Soil

- Rubber wood block (RWB)
- Oil palm roots
- Oil palm trunk
- Oil palm petiole rachis

✓ Depth significantly influences the survival of *G. boninense*.

✓ Rubber wood block inoculum found to be the highest surviving followed by root and oil palm trunk

✓ Oil palm petiole and rachis were not able to sustain the survival of *G. boninense* in soil

# BASAL STEM ROT DISEASE



## EFFECTS OF PLANTING DENSITY ON *GANODERMA* DISEASE INCIDENCE

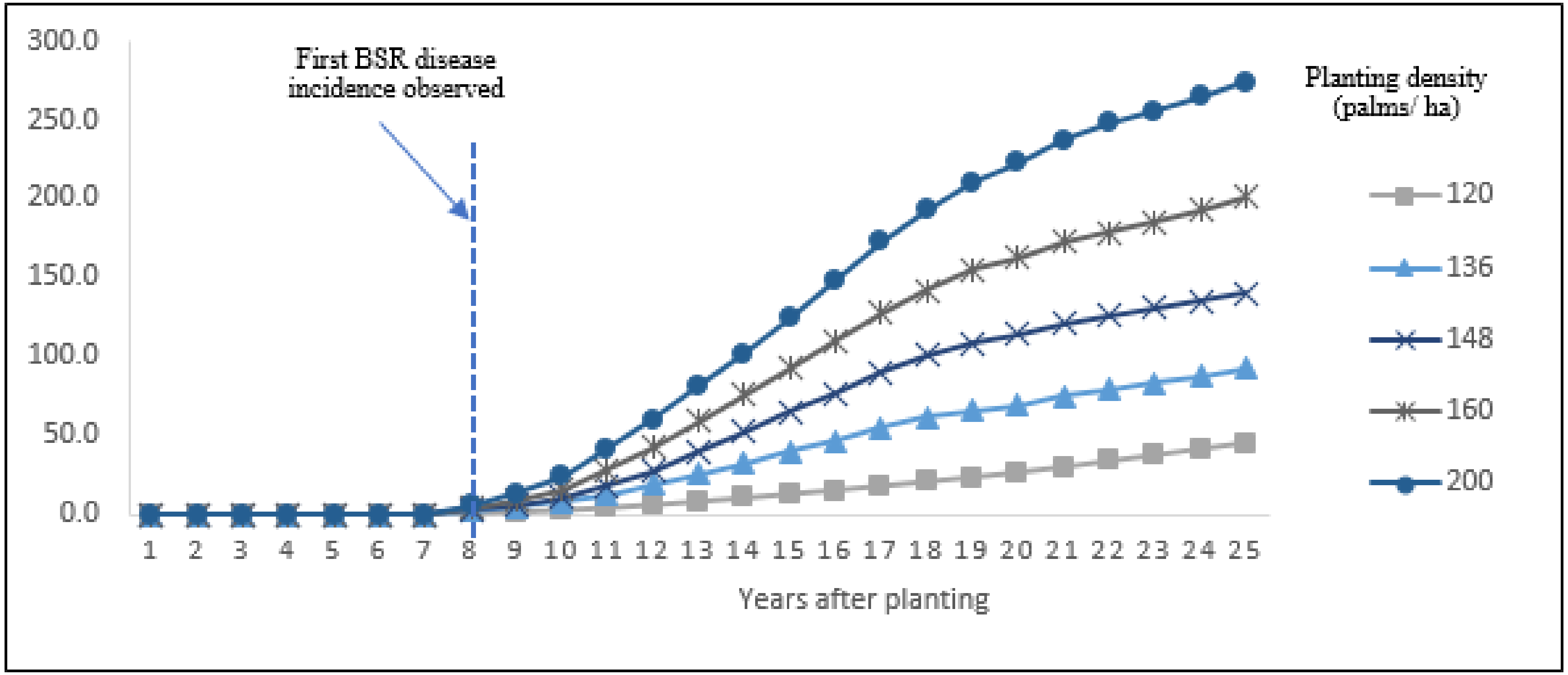



*Figure 2. The BSR disease progress in different oil palm planting densities over the years after planting in the plantations.*

Root to Root Contact?

# BASAL STEM ROT DISEASE

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## Exploring the Effects of Herbicides on Bacterial Diversity and Functionality in Oil Palm Plantation Soils

### 1 Soil bacterial diversity were unaffected by herbicides

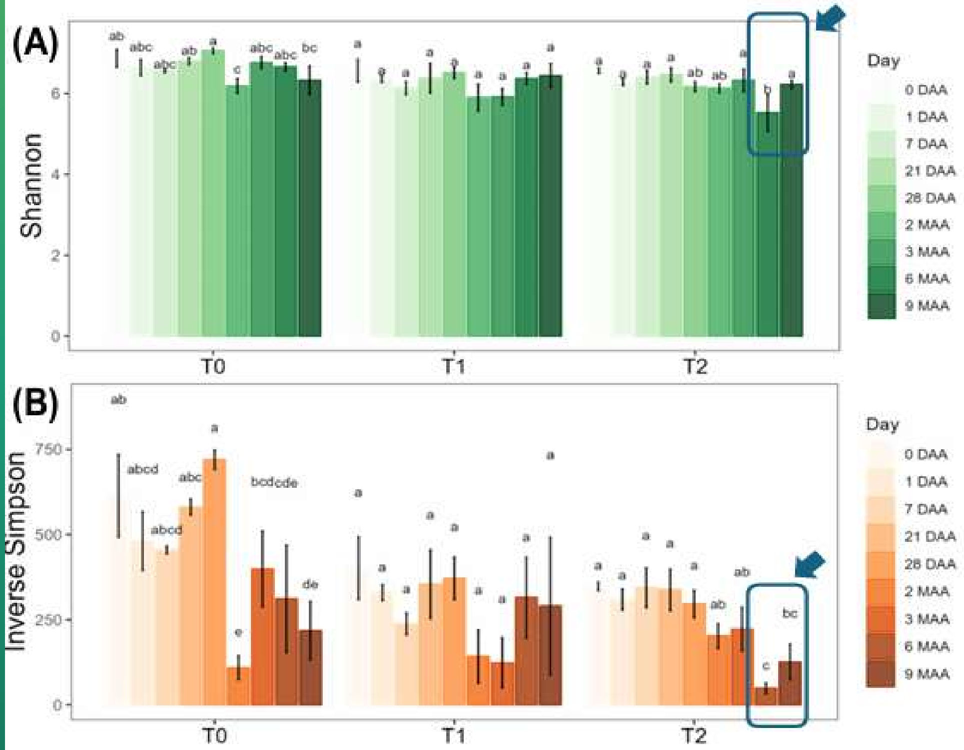


Fig. 1. Effects of herbicide application on Shannon (A) and inverse Simpson (B) diversity indices in control (T0), glufosinate-ammonium (T1), and metsulfuron-methyl (T2).

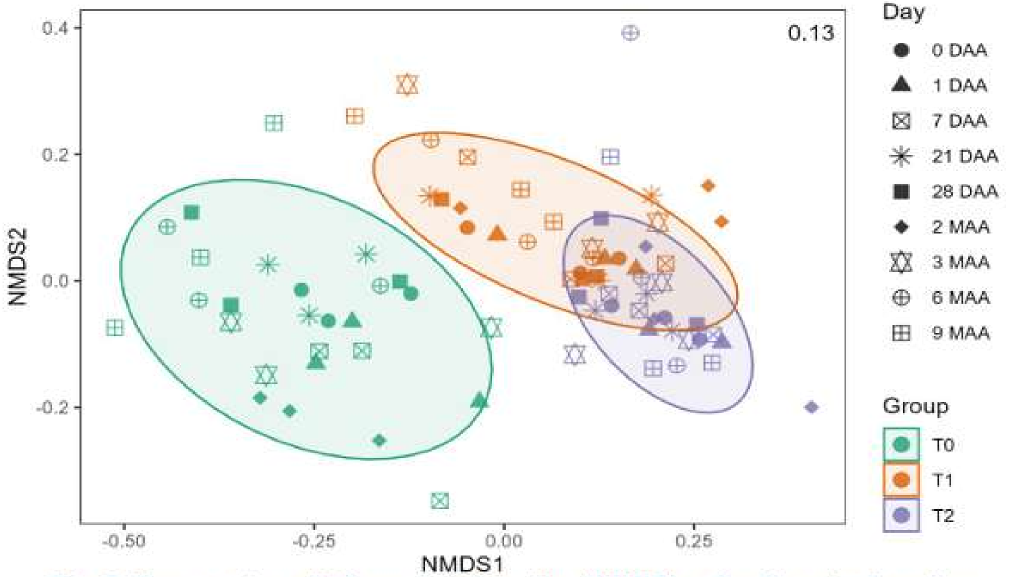


Fig. 2. Non-metric multidimensional scaling (NMDS) ordination plot based on Bray-Curtis distance.

- No significant changes may be due to the **herbicides' low toxicity at the standard recommended rate**[5].
- **Vegetation loss** from herbicide use affects soil microbes more than the chemicals themselves[6]. Metsulfuron-methyl spray drift can also **alter plant species by reducing seed viability or plant vigour**[7,8].

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## Exploring the Effects of Herbicides on Bacterial Diversity and Functionality in Oil Palm Plantation Soils

### 2 Beneficial soil rhizobacteria remained stable after application

- The **acetolactate synthase (ALS) enzymes** of beneficial bacteria **differ in structure or regulatory mechanisms** from those in plants[9].
- Sulfonylurea herbicides like metsulfuron-methyl **inhibit only type II and III acetohydroxyacid synthase (AHAS) isozymes** in bacteria[10].
- The abundance of beneficial bacteria did not change after spraying, probably due to **genes coding for alternative AHAS isozymes**[11].

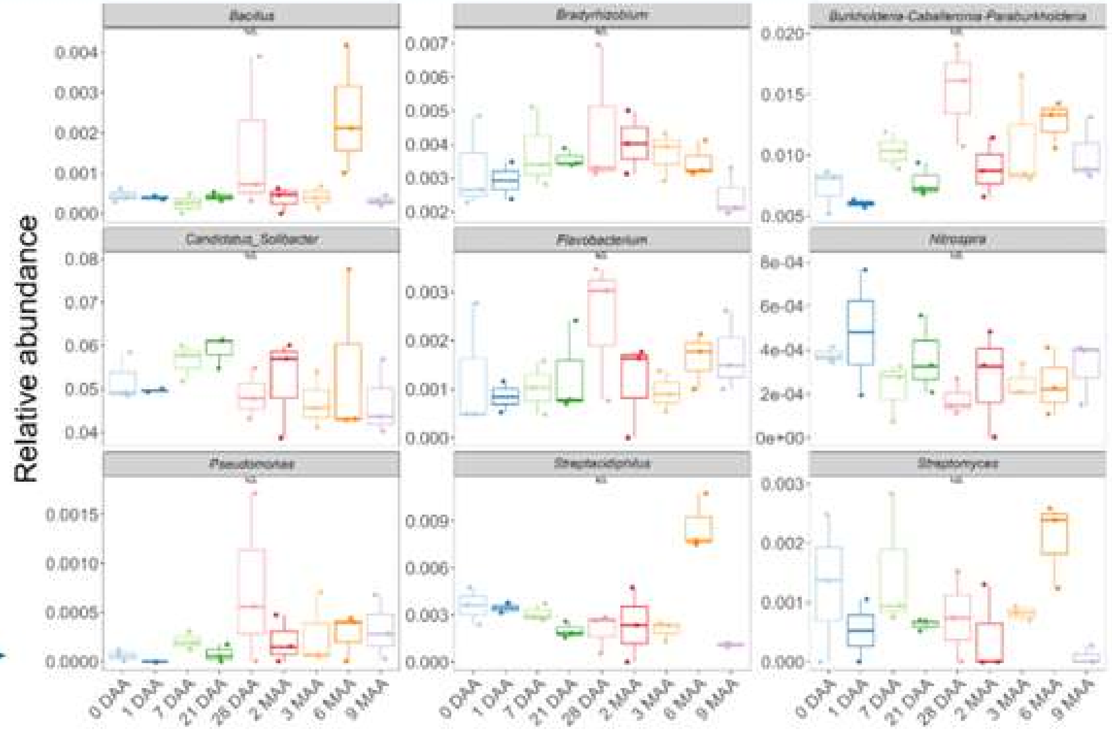



Fig. 3. Relative abundance of key bacterial genera involved in soil health and plant growth in T2.

# BASAL STEM ROT DISEASE

## Exploring the Effects of Herbicides on Bacterial Diversity and Functionality in Oil Palm Plantation Soils

### 3 No significant impact on key soil functions and activities

- Cellulolytic bacteria that break down cellulose into oligosaccharides **increased at 2 MAA**. These bacterial groups prevent soil pollution and enhance fertility by maintaining organic carbon levels[12]. Herbicides may **suppress glucose-utilizing microorganisms**, slowing cellulose conversion to glucose[13].
- Bacterial groups related to ureolysis **increased at 28 DAA**. Ureolytic bacteria **utilise nitrogen for their urease activity**, and since herbicides contain nitrogen, they may contribute to enhanced ureolysis in the soil[14].
- Nitrification and nitrate reduction **varied over the nine-month study** but showed no significant changes, likely due to **functional gene redundancy** in microbial communities[15].

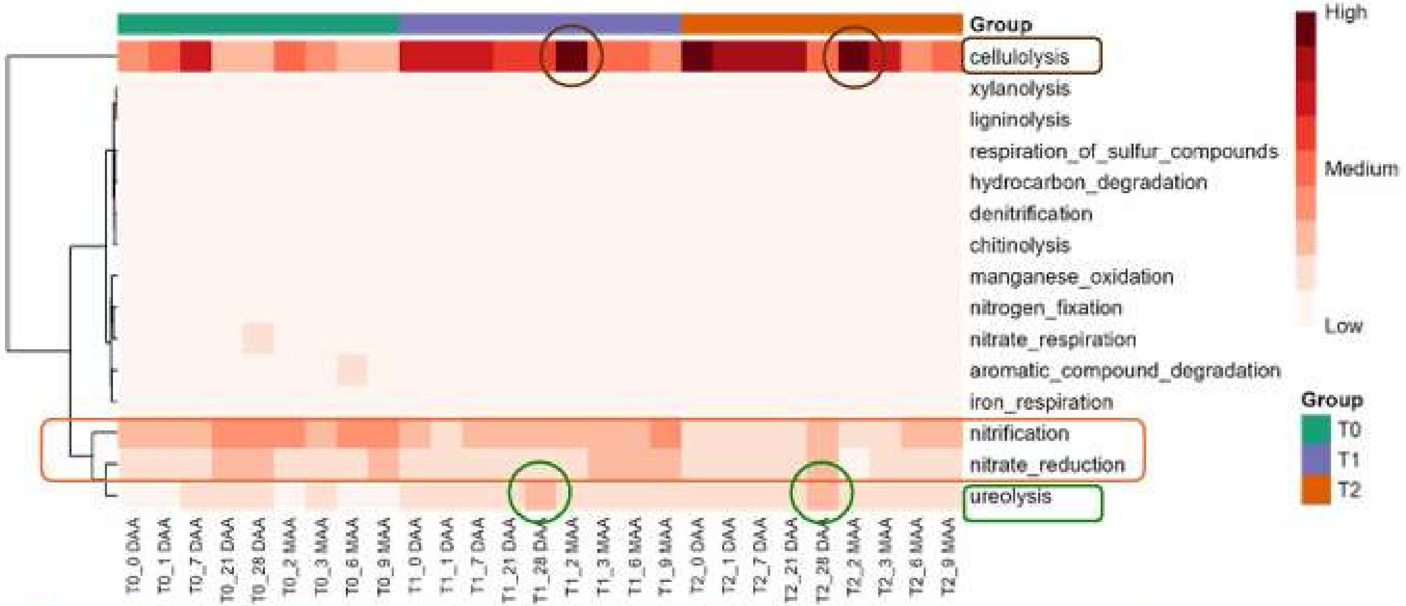



Fig. 4. Heatmap of functional groups involved in organic matter decomposition, nutrient cycling, and chemical degradation in soils applied with herbicides at various times.

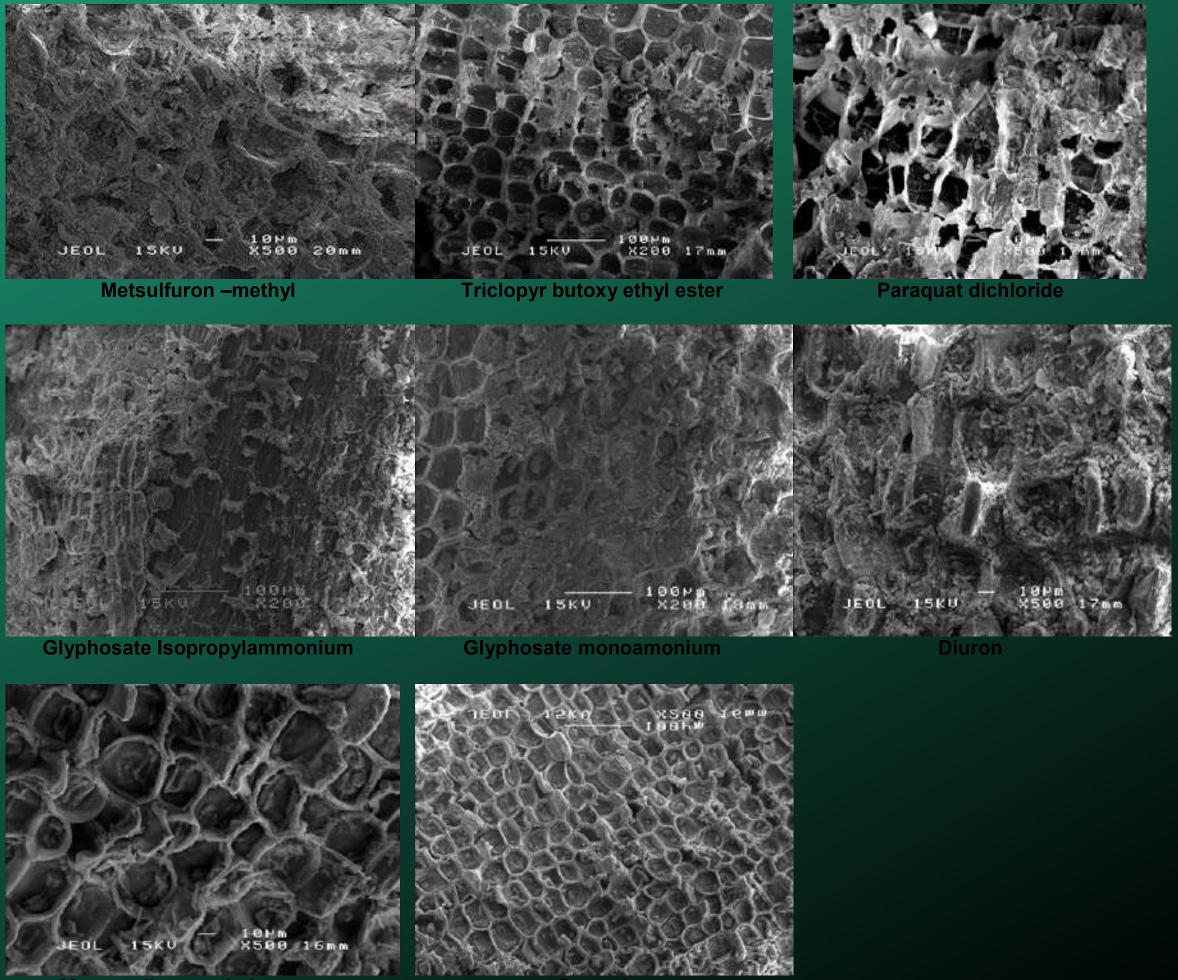
# BASAL STEM ROT DISEASE

## Influence Of Herbicides On BSR Disease Incidence

- Any physical root injuries or any physiological disorders when the root samples were treated with the seven selected herbicides were observed.

- Plant roots treated with most of the herbicides showed large numbers of cell ruptures near the meristem of axes particularly plants treated with diuron (92.73% DI) followed by metsulfuron-methyl (83.27% DI) and glyphosate isopropylammonium (73.81% DI)

Herbicide treatment at 90 days



Metsulfuron –methyl; Triclopyr butoxy ethyl ester; Paraquat dichloride; Glyphosate Isopropylammonium; Glyphosate monoamonium; Diuron; Monosodium methylarsenate; Control

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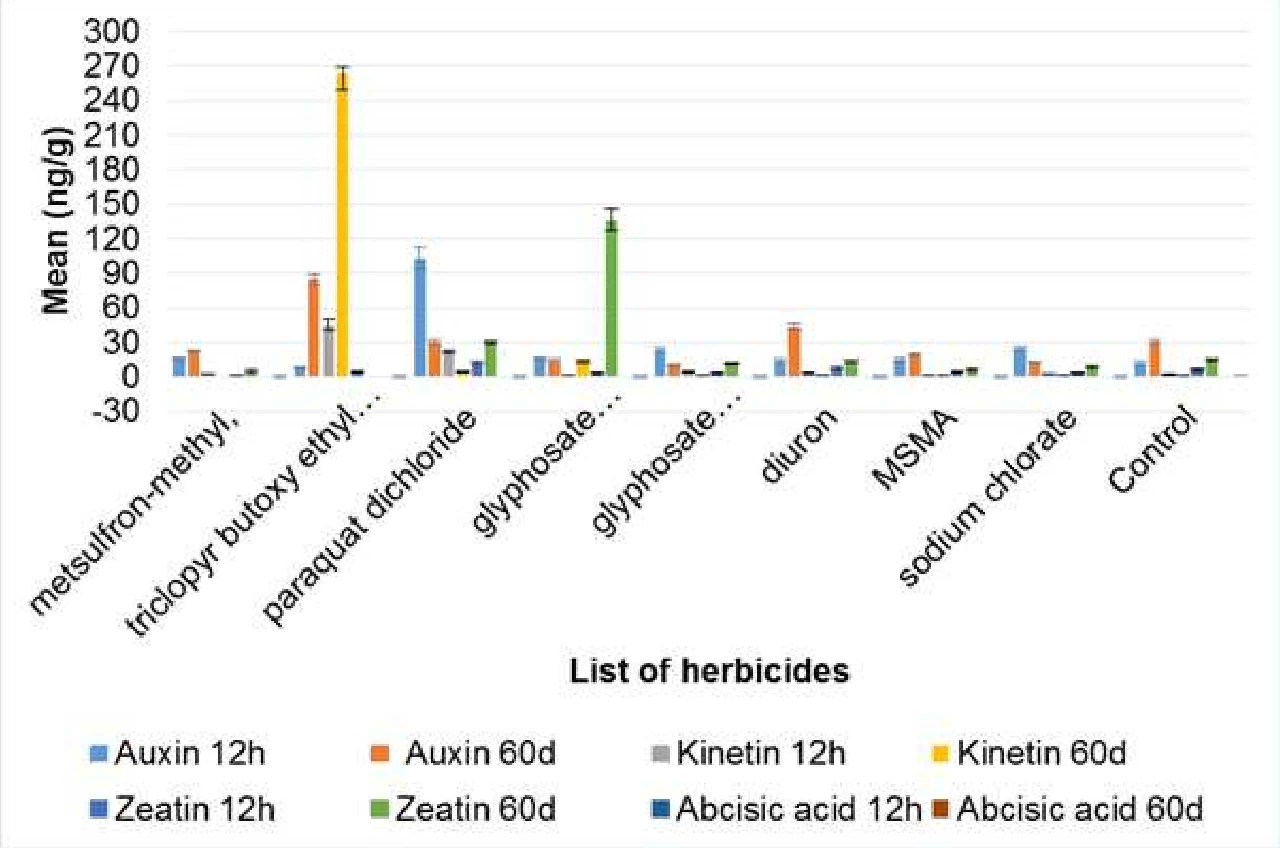
## Influence Of Herbicides On BSR Disease Incidence

The root damages coincided with the reduction and imbalance of targeted phytohormomes (involved in plant growth regulation and plant defense system)

Plants treated with paraquat dichoride, results showed that the expression of auxin was reduced from 103.3 ng/g to 30.1 ng/g, kinetin (21.81 ng/g to 4 ng/g), zeatin (29.88 ng/g to 11.92 ng/g) and AA (0.14 ng/g to 0.081 ng/g)



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# Management of Basal Stem Rot Disease

# Basal Stem Rot Disease of Oil Palm

## Standard Operating Procedure (SOP)

Over the years, MPOB continuously conducted research and advisory services related to Ganoderma disease with some of the technologies being eventually commercialised.

This standard operating procedure (SOP) for managing of Ganoderma disease in oil palm is based on the agreed standard practices as a guide for plantations to manage Ganoderma disease in oil palm more effectively.


**Integrated *Ganoderma* Management (IGM)**

# Basal Stem Rot Disease of Oil Palm

**Standard Operating Procedure (SOP)**

Disease Census

↓

Disease Symptoms Identification

↓ ↓

Immature Palm | Mature Palm

**Early Disease Detection**

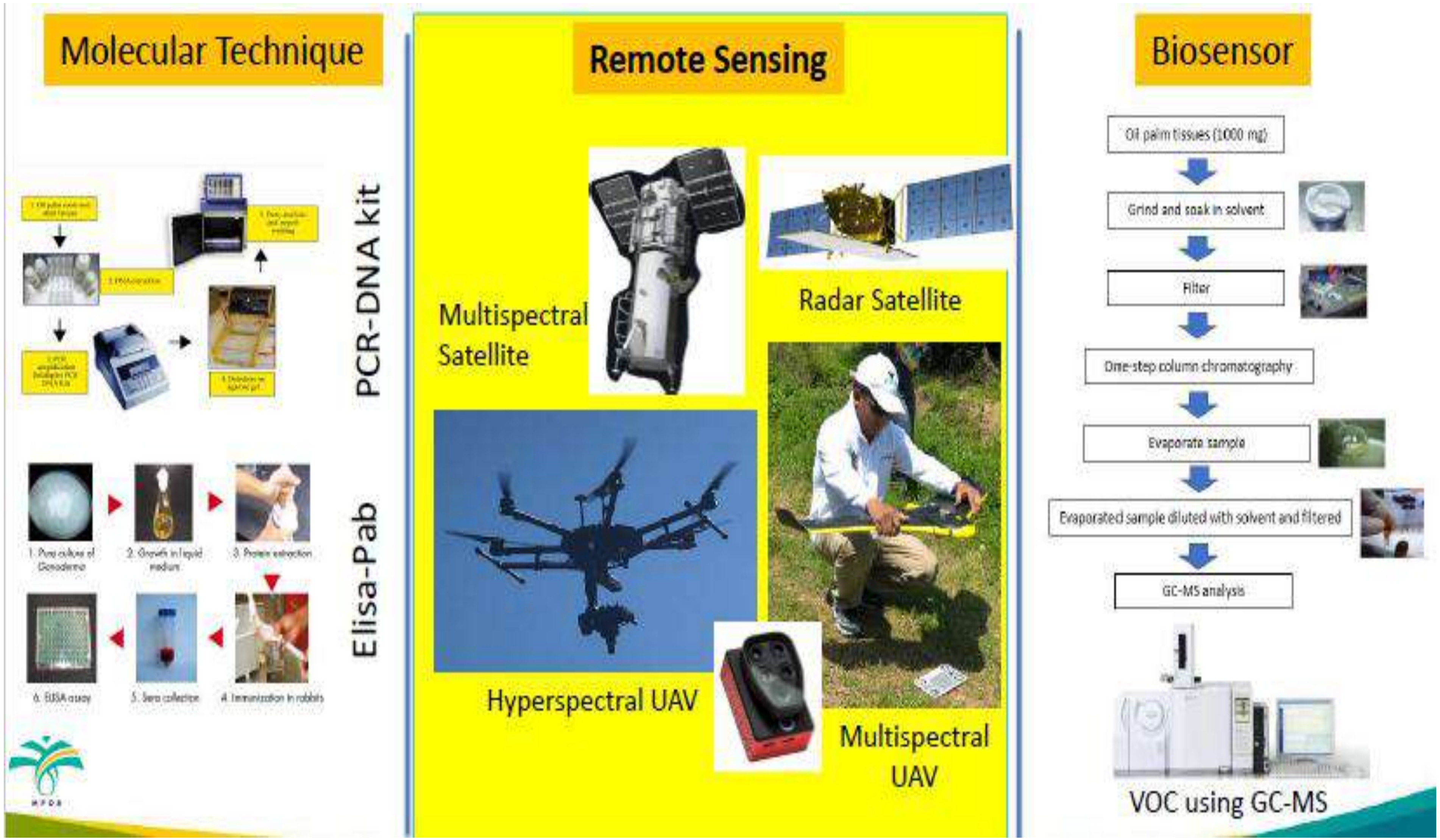
NOTE:

A. BSR is a slow disease. Census can be conducted annually.

B. Disease symptoms reference available on **SawitSecure** website

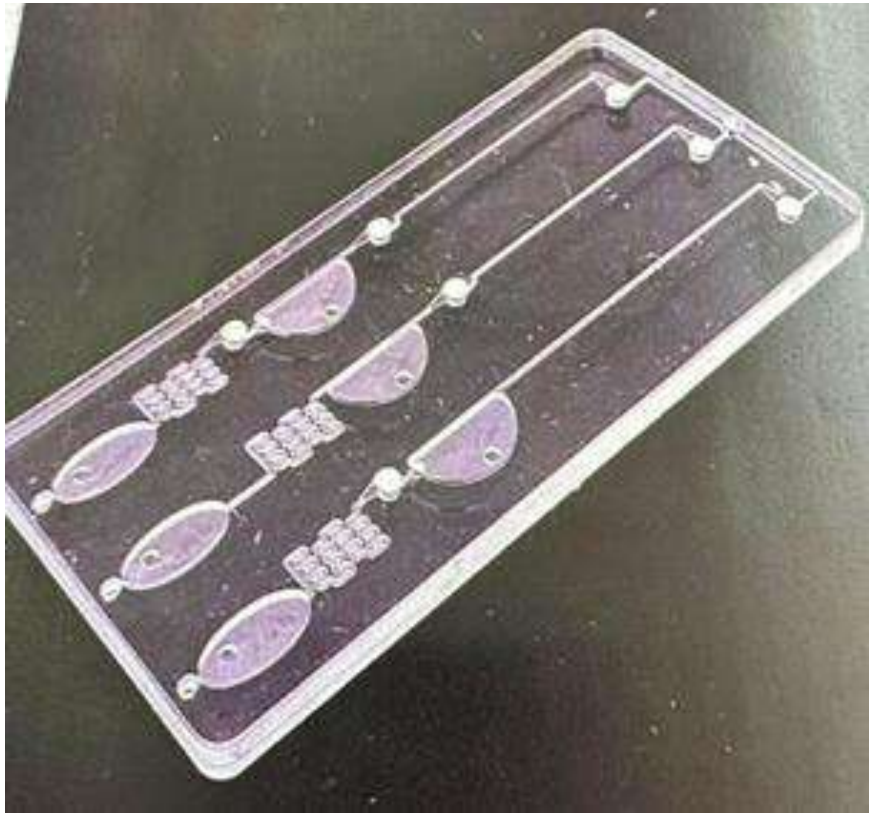
# Basal Stem Rot Disease of Oil Palm

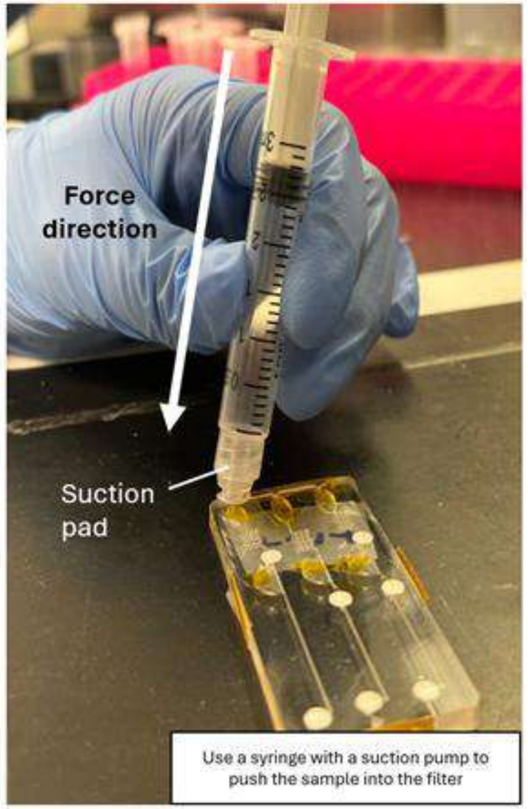
## Standard Operating Procedure (SOP): Early Disease Detection

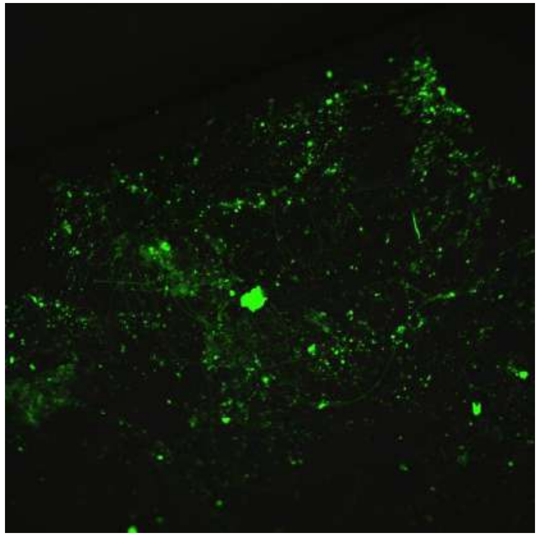


# Basal Stem Rot Disease of Oil Palm

**Standard Operating Procedure (SOP): Early Disease Detection**





A diagnostic tool for *Ganoderma* detection (microfluidic nanotechnology)

# Basal Stem Rot Disease of Oil Palm



## Standard Operating Procedure (SOP): Existing Planting

**Young/Immature palms**

(< 10 years old)

| Disease severity index (DSI) | Palm condition |
|---|---|
| DSI 0 | Healthy palm |
| DSI 1 | Mild, moderate, severely infected palm |

**SOP: Excavate and Replace**

**Mature palms**

(> 10 years old)

| Disease severity index (DSI) | Palm condition |
|---|---|
| DSI 0 | Healthy palm |
| DSI 1 | Early infection |
| DSI 2 | Moderate infection |
| DSI 3 | Severe infection |
| DSI 4 | Dead |

**SOP: Manage Based on DSI**

# Basal Stem Rot Disease of Oil Palm

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## Standard Operating Procedure (SOP): Existing Planting

### Focus on DSI 1 and DSI 2 only

**Treatment with fungicide hexaconazole**

- Prolong the economic life of an infected palm (fruiting).
- 66.6% – 83.3% (average 74.4%, 3 trials) of treated infected palms with hexaconazole still alive and producing fruit bunches at 5 years and none from untreated palms.
- Cost: USD 14 per palm (2 treatments).
- In return: Average USD 125 in 5 years (Min).

Practice in MPOB Plantations

GANO
Survey & Services

# Basal Stem Rot Disease of Oil Palm

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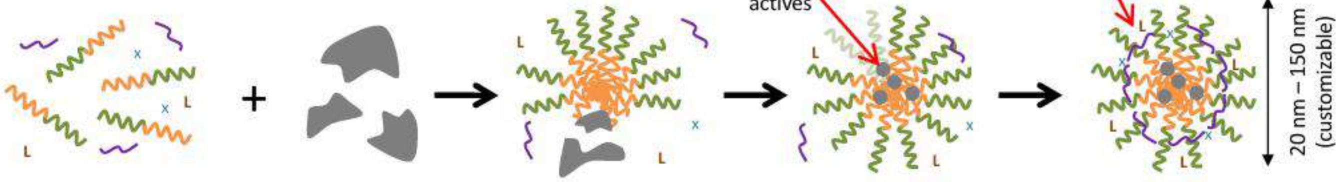
## Standard Operating Procedure (SOP): Existing Planting

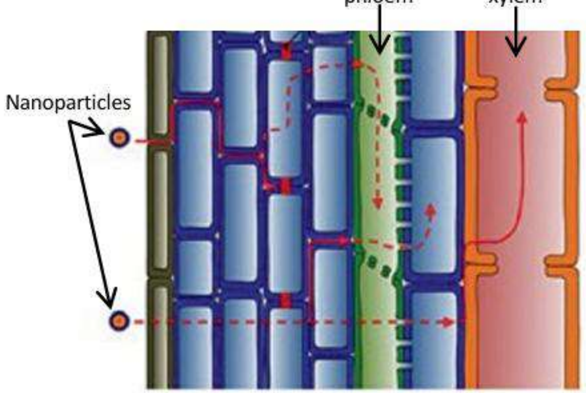
## Focus on DSI 1 and DSI 2 only

MPOB HYDROEMISSION BEHN MEYER Since 1840

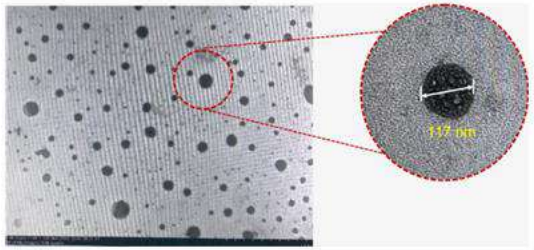
Hydroemission Nanotechnology for the Treatment of Ganoderma Basal Stem Rot in Oil Palms

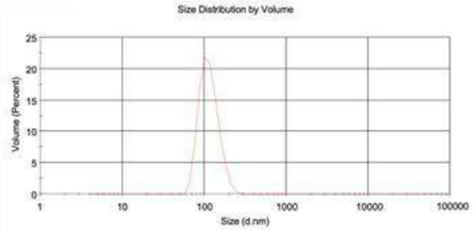
The technology allows a simultaneous nanonisation and encapsulation of hydrophobic crop protection inputs with a simple one step mixing process. This technology enables the inputs to acquire ***phloem mobility***, enhanced ***bioavailability*** and ***controlled release*** properties.




Reference: Effect of Nanomaterials on Water and Solutes Translocation in Plants





# Basal Stem Rot Disease of Oil Palm

21º CONFERENCIA INTERNACIONAL SOBRE PALMA DE ACEITE
21st International Oil Palm Conference

**Standard Operating Procedure (SOP): Existing Planting**

**Focus on DSI 3 and DSI 4 only**

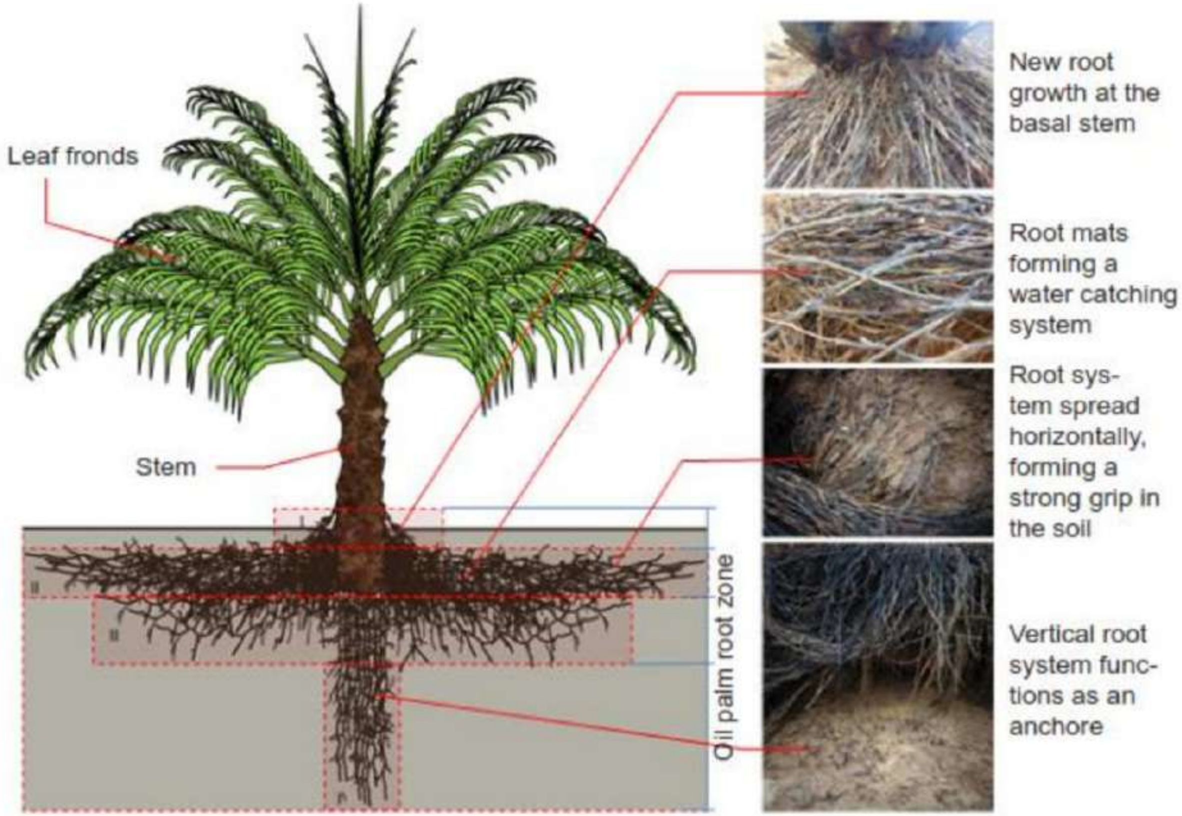



Figure 5 Oil palm roots architecture at the roots zone and its parts which is shown by the image resulted from the destructive measurement method.

*Ganoderma boninense* infects primary root

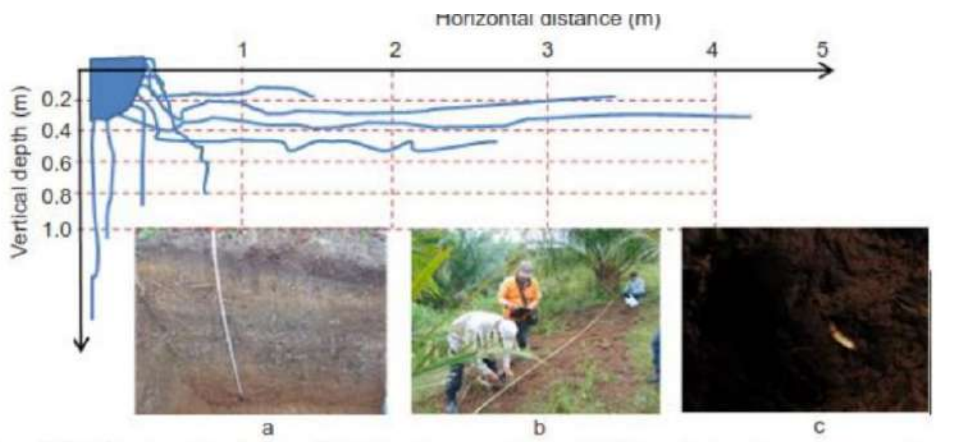



Figure 3 Architecture description of oil palm primary roots resulted from destructive measurement: a Excavation of soil around the palm roots; b Activity of measuring the root length of the palm at ground level; c The primary root tip that grows actively in the soil.

Intara *et al*., 2022

# Basal Stem Rot Disease of Oil Palm

21º CONFERENCIA INTERNACIONAL SOBRE PALMA DE ACEITE
21st International Oil Palm Conference

## Standard Operating Procedure (SOP): Existing Planting

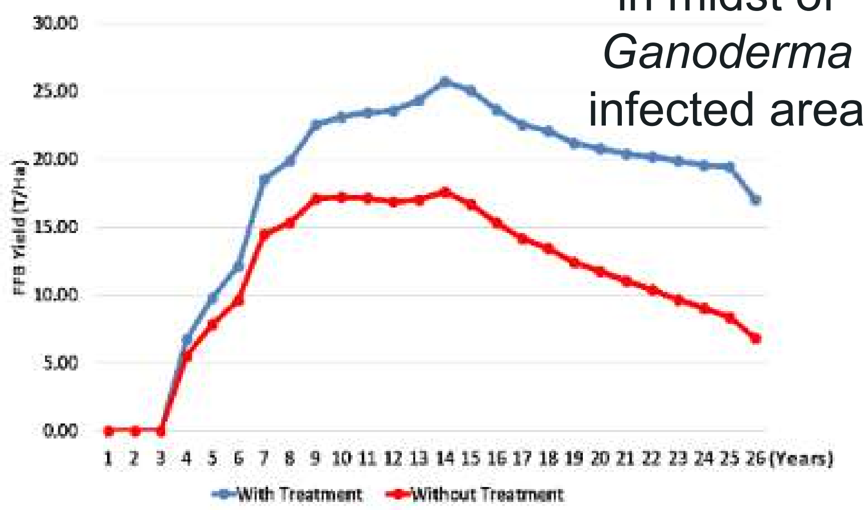
### Focus on DSI 3 and DSI 4 only

Removing the inocula pressure

- Sanitation / excavation (1.5m x 1.5m x 1.5m) to minimize the inoculum size.
- The excavated hole can be closed immediately with the nearby **top soil.**


1.5m x 1.5m x 1.5m

Maximum yield in midst of *Ganoderma* infected area

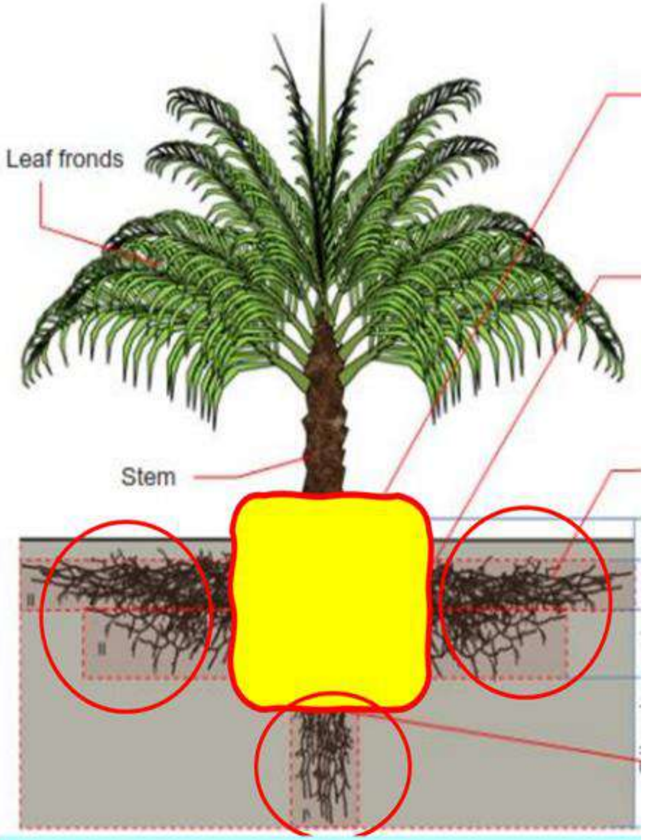


# Basal Stem Rot Disease of Oil Palm



## Standard Operating Procedure (SOP): Existing Planting

### Focus on DSI 3 and DSI 4 only




Root debris can be the source of Ganoderma inoculum

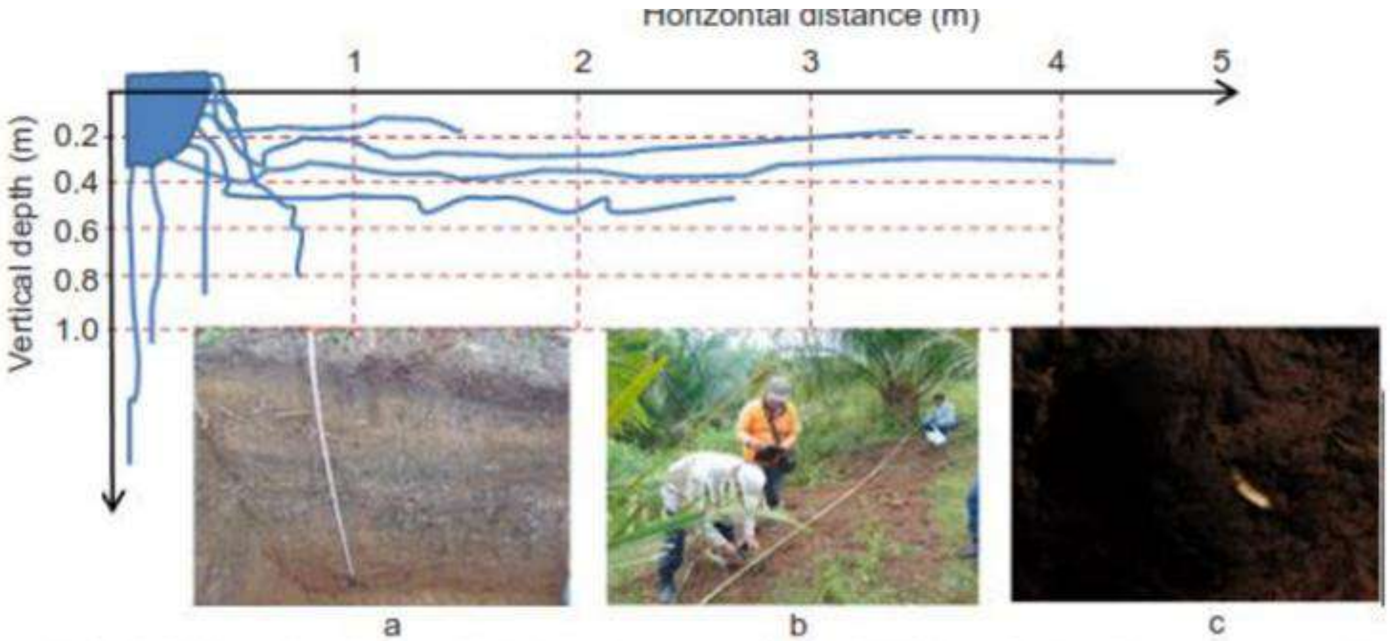



Figure 3 Architecture description of oil palm primary roots resulted from destructive measurement: a Excavation of soil around the palm roots; b Activity of measuring the root length of the palm at ground level; c The primary root tip that grows actively in the soil.

**Sanitation will buy you time!**

# Basal Stem Rot Disease of Oil Palm

**Standard Operating Procedure (SOP): Replanting**

Sanitation (removal or debolling) of diseased palm and old palm stump

Preventive treatment ( Biological control product)



# Basal Stem Rot Disease of Oil Palm

**Standard Operating Procedure (SOP): Replanting**

## Sanitation (removal or debolling) of diseased palm and old palm stump

Removing the inocula pressure

- Selected sanitation if disease incidences less than 10%.
- Full sanitation if disease incidence more than 10%.
- **How about deep ploughing and pulverising??**

# Basal Stem Rot Disease of Oil Palm

**Standard Operating Procedure (SOP): Replanting**

Removing the inocula pressure

Fabricated ripper on D6 bulldozer ploughing through the field, exposing primary roots and old root bole onto soil surface

- **1 metre deep ploughing**
- **5 – 8% of disease incidence after 15 years.**


Harrow implement modified for combing the surface roots


Planting hole after 100% deep ploughing field sanitation

# Basal Stem Rot Disease of Oil Palm

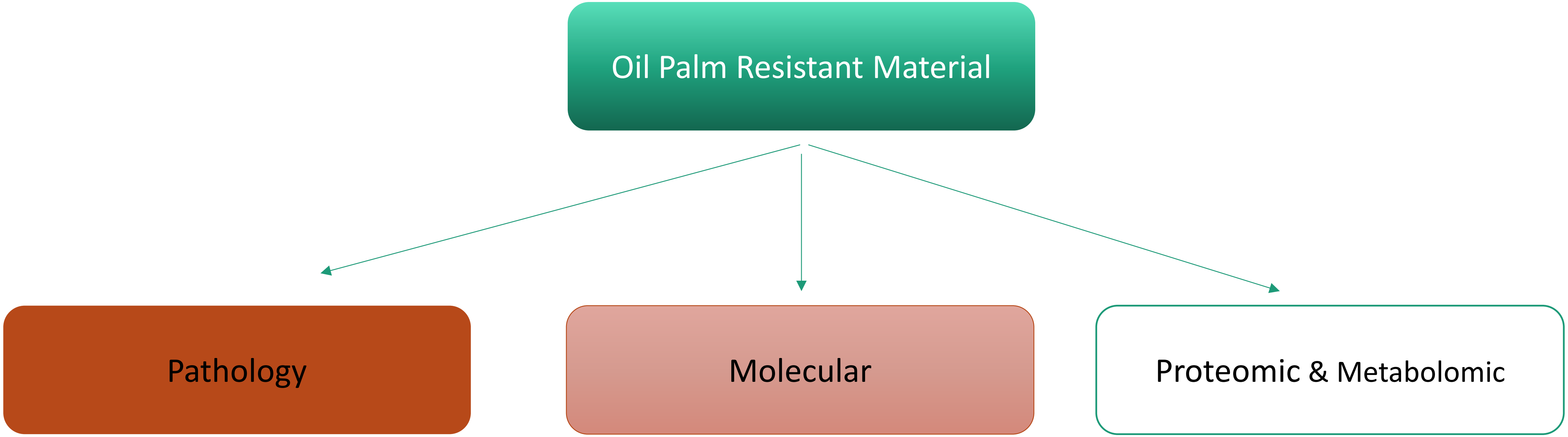
## Standard Operating Procedure (SOP): Replanting

### Preventive treatment ( Biological control product)


Sebanyak RM 5 juta telah diperuntukkan di dalam Skim Tanam Semula Pekebun Kecil Sawit 2.0 bagi mengaplikasi baja Embio ActinoPLUS dan GanoEF di kawasan berpenyakit.

| **Syarikat** | Pascal Biotech | All Cosmos | IBG Manufacturing | True Trichoderma |
|---|---|---|---|---|
| **Nama Produk** | *Embio ActinoPLUS* | *GanoEF* | *IM-Bioguard* | *Trichoshield* |
| **Durasi** | 10 tahun | 10 tahun | 2 tahun | 3 tahun |
| **Kejadian Penyakit (10 ha)** | 0.19% | 1.32% | 6.25% | < 10% |

# *Ganoderma* resistant material screening programme




MPOB have started the screening programme since 2016

# *Ganoderma* resistant material screening programme

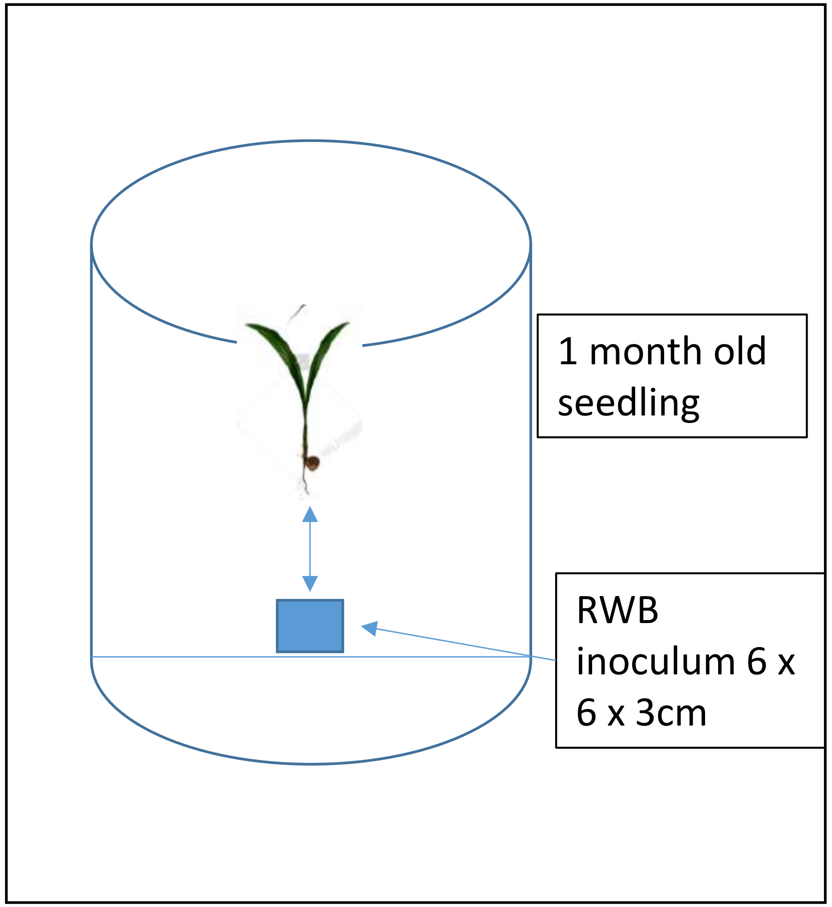
| Num. | Progeny Background |
|---|---|
| 1. | ZRE-Zaire |
| 2. | CMR-Cameroon |
| 3. | NGA-Nigeria |
| 4. | YG-Yangambi |
| 5. | AV-AVROS |
| 6. | E-Elmina Dura |
| 7. | JL-Johor Labis Dura |
| 8. | BD-Banting Dura |
| 9. | UR-Ulu Remis Dura |
| 10. | SD-Serdang Dura |
| 11. | CD-Chemara Dura |


- Only screen commercial progenies.
- Male x Female backgrounds
- Multiple testing on potential progenies e.g. partial –resistance and susceptible

# *Ganoderma* resistant material screening programme

## RESULTS ($2^{ND}$ GENERATION)

| 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 | |




Artifical inoculation used was sitting technique using 1 month old seedling (harmonize with Asian Agri, Indonesia). *Ganoderma* isolate – PER 71

# *Ganoderma* resistant material screening programme

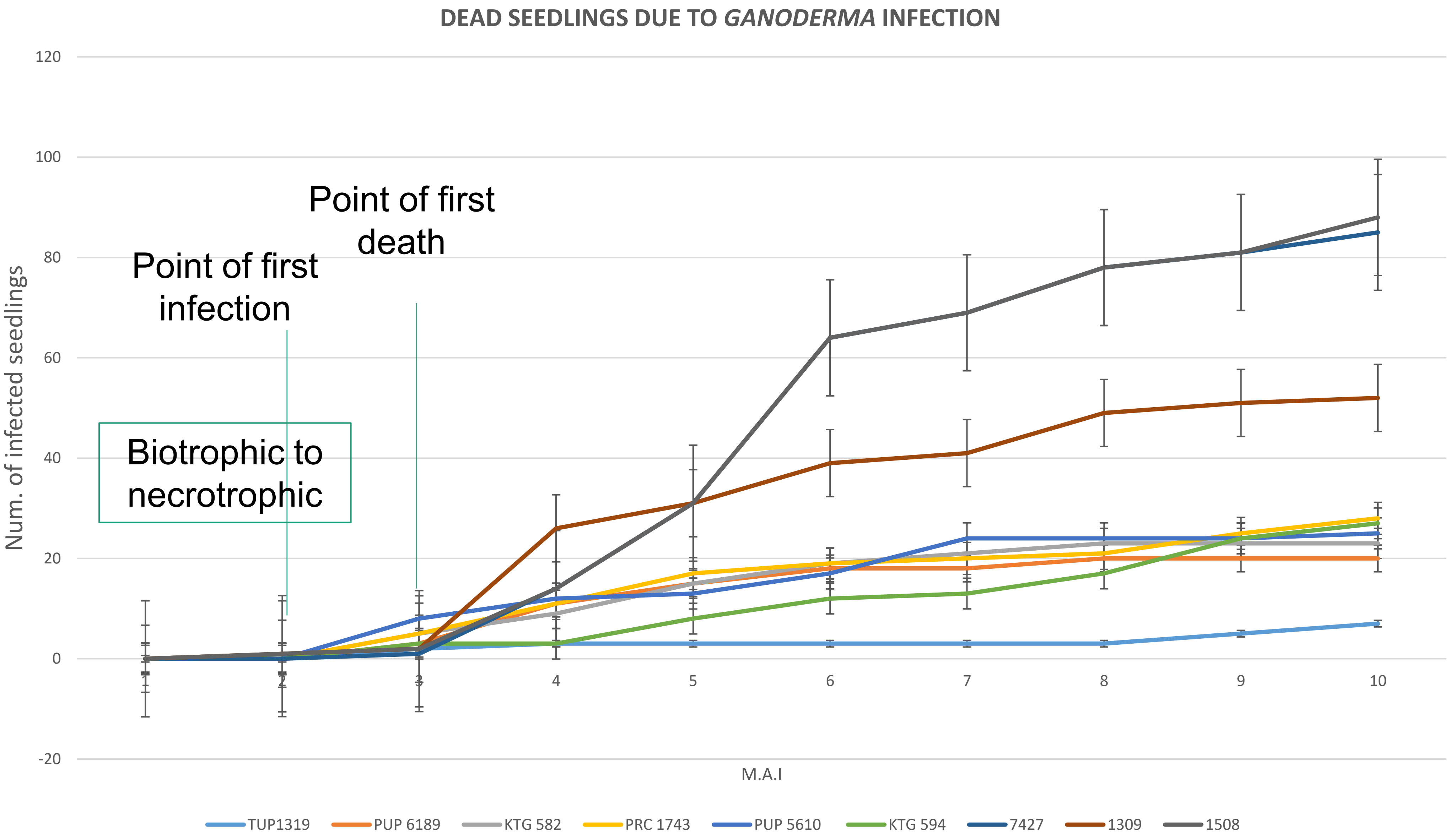
A few interesting pedigree were observed as partial resistance materials. The potential progenies are now undergoing further testing in the nursery and have been planted in *Ganoderma* hot spot areas.

| Cross Code | Batch | Cross Type | Background | Number of Samples Screened | % of dead seedlings | Total N Sample | N Repeat | Average Mortality % |
|---|---|---|---|---|---|---|---|---|
| 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 | CDx(ZRExAV) | 100 | 29.0 | | | |
| | | | | | | | | |
| KTG 576 | 7 | DxP | CD x (CMRxAV) | 100 | 47.0 | 200 | 2 | **35.5** |
| KTG 718 | 11 | DxP | CDx(CMRxAV) | 100 | 24.0 | | | |
| | | | | | | | | |
| 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 | CDx(ZRExAV) | 100 | 29.0 | | | |
| | | | | | | | | |
| 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 | CDx(CMRxAV) | 100 | 25.0 | | | |
| | | | | | | | | |
| KTG 574 | 6 | DxP | CD x (ZRExAV) | 100 | 29.0 | 200 | 2 | |
| KTG 726 | 11 | DxP | CDx(ZRExAV) | 100 | 24.0 | | | |

# *Ganoderma* resistant material screening programme

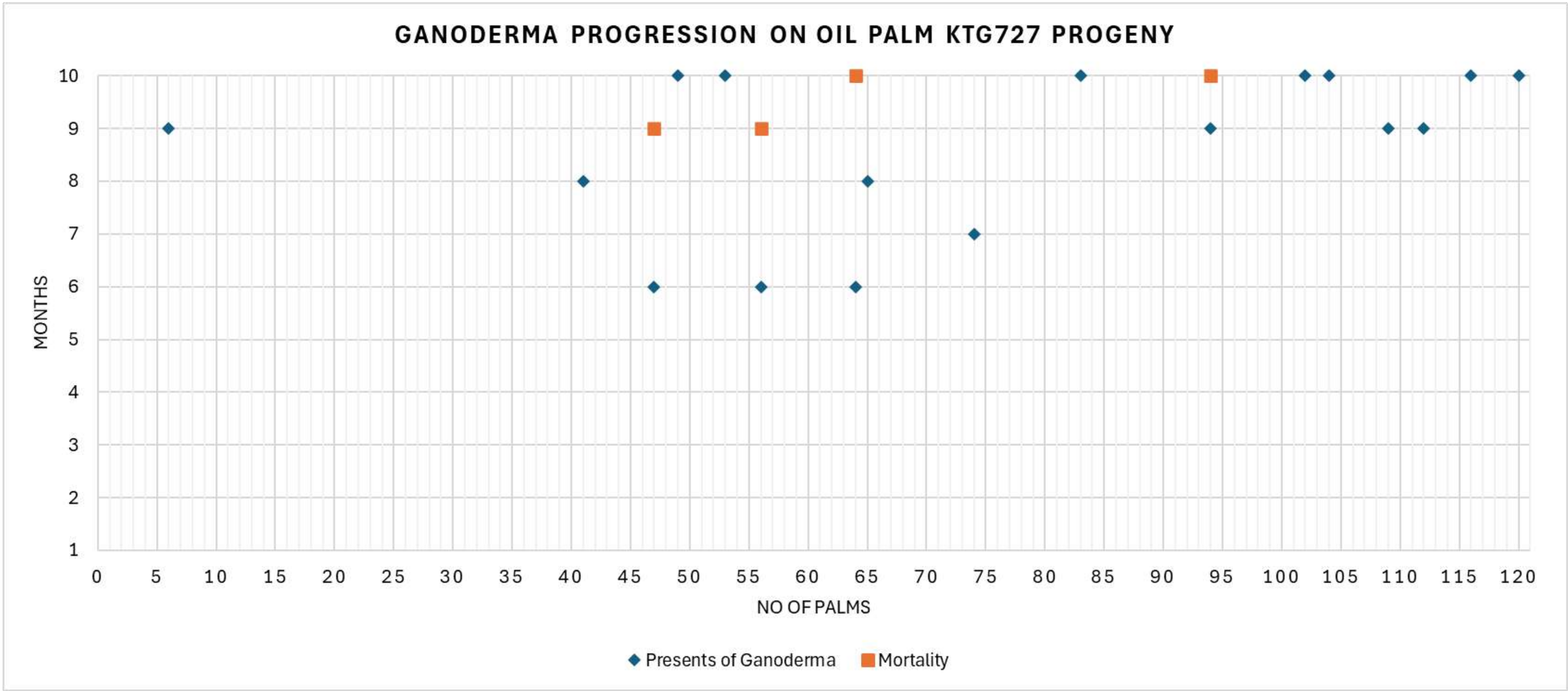
| No. | Cross Code | Batch | Cross Type | Background | Number of Samples Screened | % of dead seedlings | Total N Sample | N Repeat | Average Mortality % |
|---|---|---|---|---|---|---|---|---|---|
| 6 | KTG 594 | 6 | DxP | CD x (ZRExAV) | 100 | 27.0 | 300 | 3 | 34.7 |
| | KTG 594 | 7 | DxP | CD x (ZRExAV)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

# *Ganoderma* resistant material screening programme



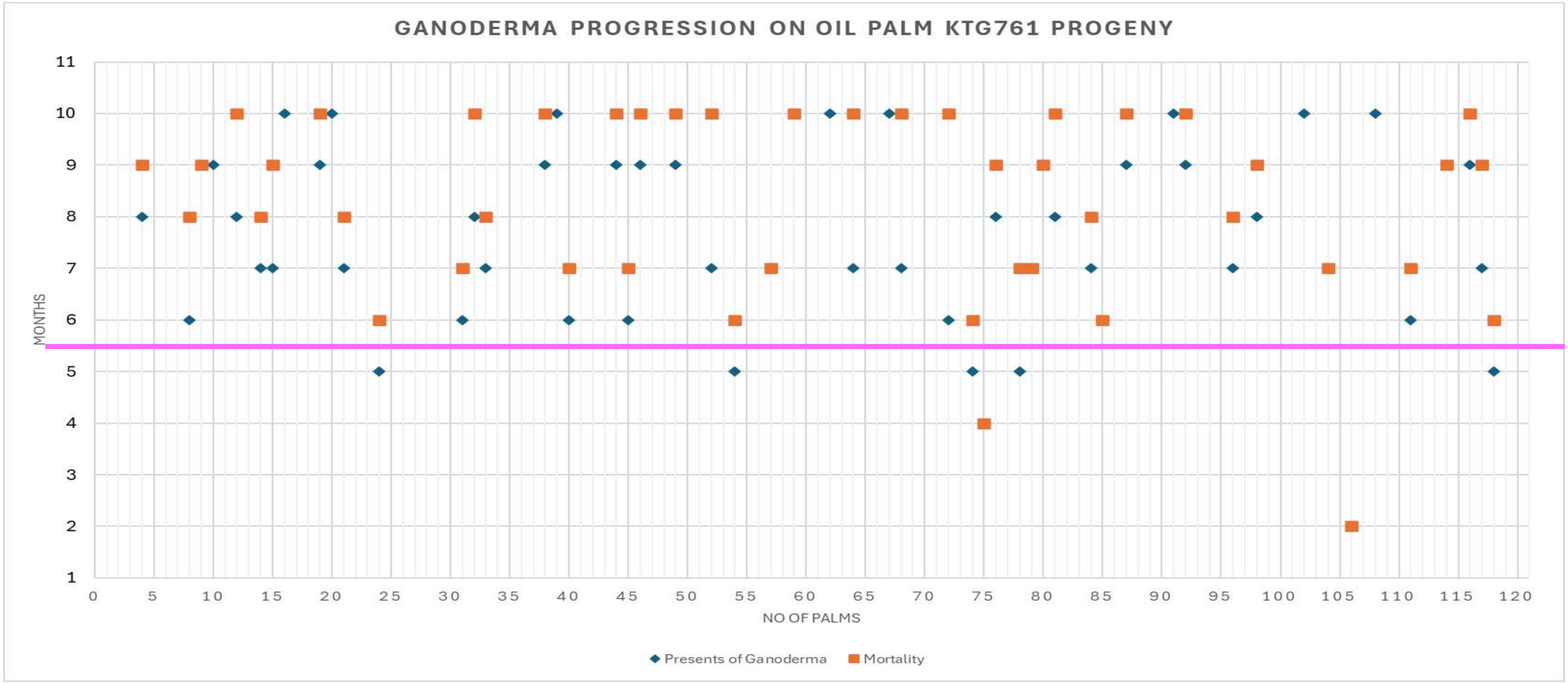
# *Ganoderma* resistant material screening programme

## POTENTIAL PARTIAL – RESISTANT PROGENY



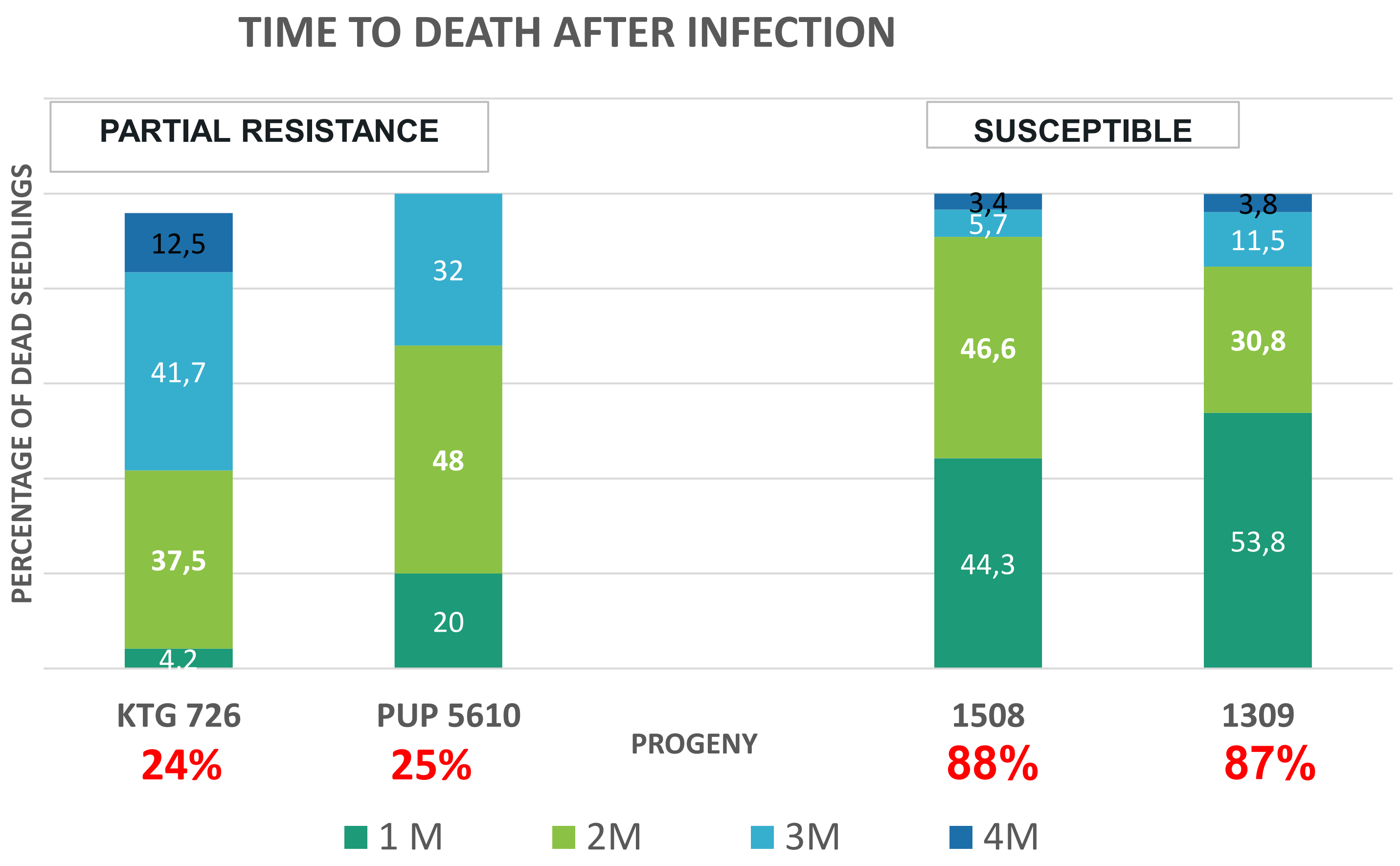
# *Ganoderma* resistant material screening programme

## POTENTIAL SUSCEPTIBLE PROGENY



# *Ganoderma* resistant material screening programme

## PARTIAL RESISTANCE / SUSCEPTIBLE INFECTION PATTERN




NOTE:

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

# *Ganoderma* resistant material screening programme

- MPOB collaborates with commercial partner in Indonesia whereby potential partial resistance and susceptible progenies were sent for testing with their *Ganoderma* most aggressive isolate.

- The results  patterns was similar albeit higher infections were observed with Indonesia aggressive isolate.

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

# *Ganoderma* resistant material screening programme

| 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 | 8 | | | | |
| | pLARmEB | | | | | | | |
| 3.5 | mrMLM | Affx-1291292135 | 129,211,442 | | | | | |
| | pLARmEB | | | | | | | |
| | | | | 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 |
| | | | | 16 | 23,662,154 | Affx-1289711753 | mrMLM | 5.2 |
| | | | | | | | pLARmEB | |

## Resistance related genes

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)

# *Ganoderma* resistant material screening programme

## YP3-12/2022 : RESISTANCE-ASSOCIATED PROTEIN AND METABOLITE PROFILING OF *Ganoderma boninense* INFECTION IN OIL PALM

**Sub-project A : Protein profiling of resistant and susceptible oil palms during *G. boninense* infection**

**Sub-project B : Metabolite profiling of resistant and susceptible oil palms against *G. boninense* infection**

### Significant Achievements

- Three potential partial resistant and susceptible oil palm seedlings were successfully inoculated with *G. boninense* PER71 and ET61.
- Leaf and root tissues were sampling at 5 time points (Week 0, 1, 2, 4 and 12) after inoculation.
- Preliminary observation: *G. boninense* mycelia were observed at roots of Week 4 and Week 12 (Figs. 1 and 2) with no foliar symptom.
- Protein and RNA were co-extracted from leaf and root tissues (Status 30% completion).
- Preliminary analysis: Differentiation of root and leaf proteome using principal component analysis (PCA).

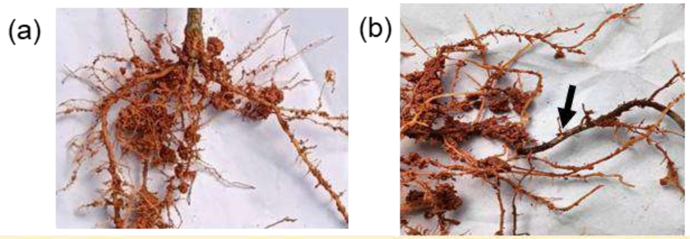



**Fig. 1: Representative images of (a) *G. boninense* PER71 and (b) ET61 mycelia at root of Week 4 after inoculation**

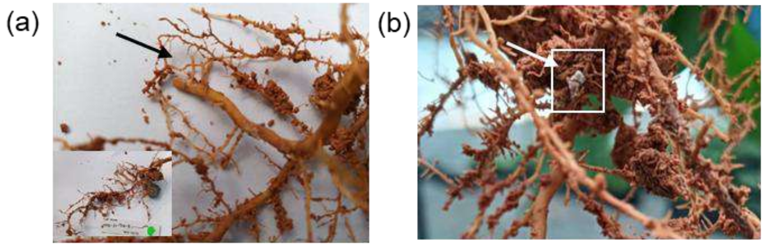
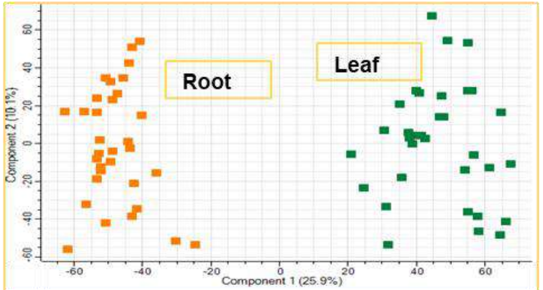


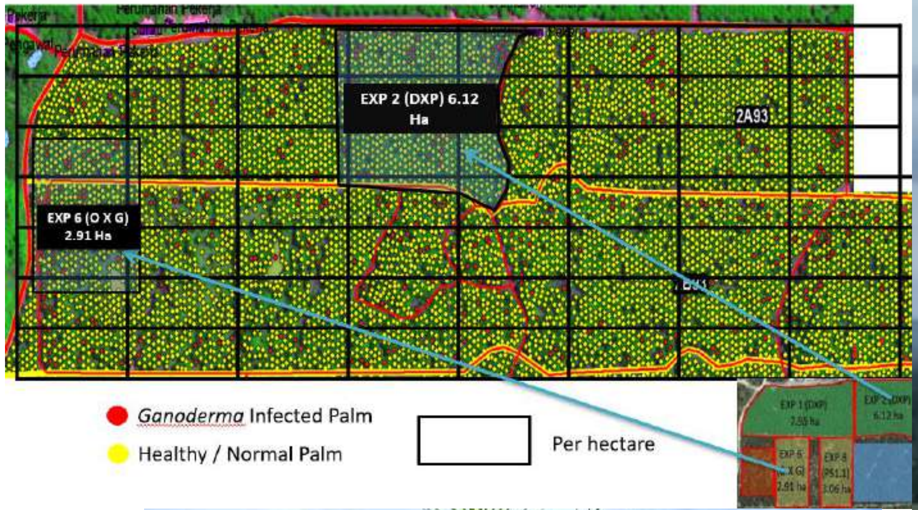

**Fig. 2: Representative images of (a) *G. boninense* PER71 and (b) ET61 mycelia at root of Week 12 after inoculation**

**Fig. 3: Good protein resolution and increased protein identification were observed using the principal component analysis.**



# *Ganoderma* resistant material screening programme

Field evaluation is on going – No infection yet after 20 months




# CONCLUSION



- Efforts to control must be done continuously – control and preventive treaments. Integrated management is essential:

  I. Early disease detection (diagnostic tools, census).
  II. Proper sanitation & replanting strategies.
  III. Fungicide and biological control application.
  IV. Resistant/tolerant planting materials.

- Fundamental studies improved understanding of infection mechanisms, pathogen diversity, and environmental factors.

# CONCLUSION



- SOPs provide practical field guidance for plantations and smallholders.
- Resistant material screening and molecular studies show promise for long-term solutions.
- Continuous R&D, stakeholder collaboration, and adaptive strategies are key to sustaining yield and industry resilience.

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