



# Fungal Diseases of Malaysian Taro (*Colocasia esculenta*) Accessions and Their Field Control

**Nurul Ammar Illani, Jaafar<sup>\*1</sup>, Aminah, Mahmud<sup>1</sup>, Razean Haireen, Mohd. Razali<sup>2</sup>, Siti Nur Hayati, Mohd Sufian<sup>1</sup>, Nurul Afiqah, Shamsolanwar<sup>1</sup>, Umikalsom, Mohamed Bahari<sup>2</sup> & Faziah, Umar<sup>1</sup>**

<sup>1</sup>Agrobiodiversiti and Environment Research Centre, Malaysian Agricultural Research and Development Institute (MARDI), MARDI Headquarters, Persiaran MARDI-UPM, 43400 Serdang, Selangor, MALAYSIA.

<sup>2</sup>Industrial Crop Research Centre, MARDI Headquarters, Malaysian Agricultural Research and Development Institute (MARDI), Persiaran MARDI-UPM, 43400 Serdang, Selangor, MALAYSIA.

\*Corresponding author: [ammarj@mardi.gov.my](mailto:ammarj@mardi.gov.my)

Received 25 May 2026; Accepted 05 July 2026; Available online 21 July 2026

**Abstract:** Taro (*Colocasia esculenta*) is an important root crop with significant nutritional and economic value. However, fungal diseases, particularly taro leaf blight, remain a major constraint to sustainable production. This study aimed to evaluate fungal disease incidence among Malaysian taro accessions and explore potential disease management strategies under field conditions. A field survey was conducted on fourteen Malaysian taro accessions to assess leaf blight incidence and symptom development. Symptomatic leaf samples from *Putih* and *Wangi* accessions were collected for fungal isolation, morphological characterization, and molecular identification using internal transcribed spacer (ITS) gene sequencing. A field trial was further conducted on *Wangi* accession to evaluate the effectiveness of selected treatments, including garlic oil + neem oil, Tricho Care, and Amistar® under natural infection conditions. Results showed considerable variation in disease incidence among accessions, with *Sarawak*, *Ulam*, and *Kumbul* recording the highest disease incidence (100%), while *Belang* exhibited the lowest incidence (10%), indicating potential disease tolerance. Morphological observation revealed variation in fungal colony characteristics. Nevertheless, ITS sequencing confirmed *Phytophthora colocasiae* as the primary pathogen associated with taro leaf blight, showing 99–100% sequence similarity with GenBank references. Field assessment indicated that treatment T1 (garlic oil + neem oil) was the most effective treatment in reducing disease development in *Wangi* accession. The outcomes of this study contribute valuable insights into disease susceptibility among Malaysian taro accessions and provide a foundation for the development of effective and sustainable disease control approaches.

**Keywords:** *Colocasia esculenta*, taro leaf blight, *Phytophthora colocasiae*, taro accessions, leaf blight disease management

## 1. Introduction

Taro (*Colocasia esculenta*) is an important tropical root crop cultivated extensively for its edible corms and leaves and serves as a staple food in many parts of Asia, Africa, and the Pacific. The crop is recognized for its high nutritional value, as both corms and leaves are rich in carbohydrates, dietary fiber, vitamins, and essential minerals including calcium, phosphorus, potassium, and iron, contributing substantially to food security and nutritional sustainability (Otieno, 2020; Quenum et al., 2023). In addition to its nutritional importance, taro possesses broad adaptability to diverse agroecological environments and can be cultivated under both upland and wetland systems, making it a valuable crop for smallholder farming systems and climate resilience (Lebot et al., 2017). Despite its economic and nutritional potential, taro cultivation in Malaysia remains relatively underutilized, although the country possesses diverse local accessions with considerable morphological and agronomic variation that may represent valuable genetic resources for crop improvement and sustainable agricultural development.

Nevertheless, taro production is increasingly threatened by several biotic constraints, particularly fungal diseases that adversely affect plant growth, corm quality, and yield performance. Most fungal diseases affecting taro are characterized by foliar necrosis, chlorosis, tissue decay, and corm deterioration, ultimately reducing plant growth and productivity. Among these diseases, taro leaf blight (TLB), caused by *Phytophthora colocasiae*, is widely recognized as the most destructive disease affecting taro cultivation worldwide because of its rapid spread and severe damage to foliage under humid tropical conditions (Takor et al., 2020; Donkor et al., 2023). The disease generally initiates as small water-soaked lesions on the leaf surface, which progressively enlarge into dark necrotic spots that coalesce and destroy large portions of the leaf lamina, thereby disrupting photosynthetic activity and weakening plant performance (Sahoo et al., 2010; Nirmala et al., 2024). Under favourable environmental conditions, particularly high humidity and prolonged rainfall, disease outbreaks may develop rapidly and result in severe yield losses exceeding 50% in susceptible accessions (Mbi et al., 2021).

Apart from taro leaf blight, several other fungal pathogens have been reported to infect taro foliage and underground tissues. Recent studies identified *Cladosporium colocasiae*, *Phoma* spp., *Pseudocercospora colocasiae*, and root rot-associated pathogens as important contributors to disease incidence and productivity decline in taro-growing regions (Yulia et al., 2024). Disease severity and progression are strongly influenced by environmental conditions, pathogen virulence, accession susceptibility, and crop management practices. High humidity, prolonged leaf wetness, and dense canopy conditions are particularly favourable for pathogen colonization and disease dissemination (Takor et al., 2020). Previous studies have also reported substantial variation in disease incidence and severity among taro germplasm, indicating that host genetic background may significantly influence resistance or susceptibility to fungal infection (Donkor et al., 2023; Otieno, 2020).

Although fungal diseases of taro have been extensively investigated in Africa, India, and Pacific countries, limited information exists regarding fungal disease occurrence and symptom development among Malaysian taro accessions. Malaysia possesses diverse taro germplasm, including *Belang*, *Bentan*, *Cina*, *Hitam*, *Kumbul*, *Manik*, *Mawar*, *Merah*, *Minyak*, *Putih*, *Sarawak*, *Udang*, *Ulam*, and *Wangi* accessions, which may differ in susceptibility or tolerance to fungal diseases under local environmental conditions. Evaluating fungal disease incidence among these accessions is therefore essential to identify disease-tolerant germplasm and support future breeding and sustainable disease management programs.

Field based disease surveys are valuable for understanding disease progression, symptom development, and accession performance under natural infection pressure. Such assessments provide practical insight into host-pathogen interactions and may facilitate the identification of accessions with superior tolerance or resistance characteristics. In this study, *Wangi* accession was selected for detailed field observations of fungal symptom progression and disease characteristics. This selection was based on its short cultivation period, reaching maturity just 6 months after planting. Additionally, its tubers serve as an excellent energy source due to a high carbohydrate content of 85–87% (Umikalsum et al., 2021).

Therefore, this study aims to assess fungal disease incidence among selected Malaysian taro accessions and examine fungal symptom progression under field conditions, with particular emphasis on the *Wangi* accessions. The findings of this study are expected to contribute toward the identification of disease-tolerant taro germplasm and provide baseline information for sustainable disease management and crop improvement strategies in Malaysia.

## 2. Methodology

### 2.1 Observation of fungal disease symptoms and incidence on taro accessions in the field

Field surveys were conducted in symptomatic taro (*Colocasia esculenta*) cultivation areas in study plots at Serdang, Selangor, with particular focus on major fungal diseases. Disease observations were carried out during the peak vegetative stages of the crop. Visual assessments were conducted on all plants within each plot to identify and record symptoms of common taro diseases. Disease incidence of each symptom was estimated based on the percentage of visibly affected plant tissue or fruits. For each variety, mean disease incidence percentages were calculated from all observed replicates to allow for comparative analysis across cultivars. Infected leaves showing lesions and fungal were collected in sterile paper bags and transported to the laboratory for pathogen isolation.

### 2.2 Isolation of fungal pathogen

Fungal isolation was carried out on Potato Dextrose Agar (PDA) media. Small sections of infected tissue were surface sterilized using 1% sodium hypochlorite, rinsed with sterile distilled water, and plated on PDA under aseptic conditions. Plates were incubated at 25 ± 2°C for 7-15 days. Emerging fungal colonies were sub-cultured on new plate. Morphological identification was conducted based on colony characteristics following descriptions by George et al. (2017) and Misra et al. (2009).



### 2.3 Pathogen identification using internal transcribed spacer (ITS) region gene sequencing

Molecular identification was performed using polymerase chain reaction (PCR) with universal primers targeting the internal transcribed spacer (ITS) region, following protocols as describe George et al. (2017) and modified using universal ITS primer. The fungal isolates were grown on PDA medium for 7 to 15 days. Fungal mycelia from full grown PDA were harvested and genomic DNA was extracted following the protocol provided by company for DNA extraction kit (PrimeWay Genomic II DNA Extraction Kit, 1<sup>st</sup> BASE) and subsequently used for PCR amplification. The internal transcribed spacer (ITS) region of ribosomal DNA was amplified using the primer pair ITS1 (5'-CGGATCTCTTGGTTCTGGCA-3') and ITS4 (5'-GACGCTCGAACAGGCATGCC-3'). PCR reactions were carried out in a total volume of 25 µl, consisting of 1 µl genomic DNA, 2.5 µl of 10× PCR buffer, 2.5 µl of 2.5 mM MgCl<sub>2</sub>, 2.0 µl of 2 mM dNTPs, 1.0 µl each of forward and reverse primers (20 pM), 0.2 µl of Taq DNA Polymerase (Vivantis, USA), and 14.8 µl of nuclease-free water. The thermal cycling conditions included an initial denaturation at 95°C for 3 minutes, followed by 35 cycles of denaturation at 94°C for 30 seconds, annealing at 55°C for 30 seconds, and extension at 72°C for 1 minute, with a final extension step at 72°C for 10 minutes. Amplification was performed using a thermal cycler (MJ Research PTC-200 Peltier Thermal Cycler, Bio-Rad). PCR products were resolved on a 1.5% agarose gel alongside a 1 kb DNA marker, and successfully amplified fragments were sequenced directly. The DNA sequencing results obtained from isolates in this study were compared with available sequences in GenBank using BLASTN tools through the National Centre for Biotechnology Information (NCBI).

### 2.4 Field trial assessment of potential fungicides for fungal disease control

The study was conducted in an open field at Malaysian Agricultural Research and Development Institute (MARDI) (Figure 1). Malaysia taro *Wangi* accession was used for this study. Field trials were conducted under natural infection conditions to evaluate the effectiveness of selected fungicides and biocontrol agents as similar to farmers taro plot.



**Fig. 1: Taro field study plot in MARDI.**

The experiment was laid out in a Randomized Complete Block Design (RCBD) with four treatments (T1–T4), each replicated three times for taro *Wangi*. Each replicate consisted of 10 plants, totalling 30 plants per treatment. Each plot consisted of ten plants with a spacing of 50 cm × 75 cm. The treatments included various combinations of commercial plant based (garlic oil and neem oil), commercial biofungicide (microbe based, Tricho Care) and commercial chemical fungicide (Amistar®) and untreated controls. Table 1 details out the treatments involved on taro *Wangi*. Agronomic practices, including the removal of petioles from taro leaves infected with fungal diseases, were also carried out for all treatments as part of conventional field disease management practices commonly adopted by farmers.

Seedlings were transplanted into prepared field plots and treated at 7-day intervals, beginning 30 days after planting. Treatments were applied in accordance with manufacturer recommended dosages. Standard agronomic practices, including fertilization and weeding, were followed throughout the trial period. Disease severity were recorded weekly for 18 weeks.

**Table 1: Description of fungicide treatments applied on taro *Wangi* in the field trial**

| No. of treatments | Types of fungicide used | Remarks (Main / active ingredient) | Description of field application |
|-------------------|-------------------------|------------------------------------|----------------------------------|
| T1                | Garlic oil + neem oil   | Garlic / neem                      | Apply alternate week for each    |
| T2                | Tricho Care             | <i>Trichoderma</i> spp.            | Apply every week                 |
| T3                | Amistar®                | azoxystrobin                       | Apply every week                 |
| T4                | Negative control        | plant without treatment            | No control measure involved      |

Assessment on disease incidence, and severity were calculated based of below formula.

Disease incidence (%) was calculated as:

$$\text{Disease Incidence (\%)} = (\text{Number of infected plants} / \text{Total number of plants}) \times 100$$

Disease severity was assessed using a 0–5 rating scale:

- 0 = No symptoms,
- 1 = 1 – 20 % leaf area infected,
- 2 = 21 – 40 %,
- 3 = 41 – 60 %,
- 4 = 61 – 80 %,
- 5 = > 81 % leaf area infected.

The Disease Severity Index (DSI) was calculated using the formula:

$$\text{DSI (\%)} = [\Sigma (\text{class rating} \times \text{number of leaves in that rating}) / (\text{total number of leaves} \times \text{maximum rating})] \times 100$$

Distribution of disease severity was analyzed based on the frequency of each severity rating class. Tukey's HSD test at  $p < 0.05$  was used to determine significant differences between treatments. Data on disease incidence, severity, AUDPC, and treatment efficacy were statistically analyzed using ANOVA. Mean separation was performed using Tukey's HSD test at 5% significance level.

### 3.0 Results and Discussions

#### 3.1 Observation of fungal disease symptoms on taro in the field

The disease symptoms observed in the present study followed the characteristic progression of taro leaf blight disease, beginning with early localized lesions and subsequently developing into severe tissue necrosis (Figures 2–5). In the initial stage of infection (Figure 2), symptoms appeared as small dark necrotic lesions on the upper leaf surface. These lesions initially developed as water-soaked spots before gradually enlarging and turning dark brown to black, indicating the early colonization of host tissues by the pathogen. Similar early stage symptoms of leaf blight disease have been reported in previous studies, where small circular lesions progressively increased in size under moist conditions (Nirmala et al., 2024; Otieno, 2020).



**Fig. 2: Early symptoms of leaf blight showing small black (necrotic) spots on the upper surface of the leaf.**

As disease severity increased, infected leaves exhibited the presence of bright orange to brown exudates oozing from necrotic tissues (Figure 3). This symptom is commonly associated with active pathogen growth and extensive cellular degradation and is particularly prominent under humid environmental conditions favorable for pathogen sporulation. Similar symptom expression has been documented as a diagnostic feature of taro leaf blight in field-grown taro (Takor et al., 2020; Yulia et al., 2024).



**Fig. 3: The presence of bright orange to brown exudates oozing from infected leaf tissues is a characteristic symptom associated with taro leaf blight disease.**

Further disease progression resulted in enlargement and coalescence of necrotic lesions, leading to extensive tissue decay and deterioration of leaf structure (Figure 4). At this stage, infected areas expanded rapidly and reduced the photosynthetically active leaf surface, impairing plant physiological performance. Previous reports have similarly shown that severe leaf blight infection causes destruction of the leaf lamina and petiole tissues, contributing to major yield losses in taro cultivation (Mbi et al., 2021; Sarkar et al., 2017).



**Fig. 4: Progressive development of taro leaf blight symptoms showing necrotic lesions and tissue decay on infected leaves of *C. esculenta*.**

At the advanced stage of infection (Figure 5-7), severe necrosis covered a large proportion of the leaf surface, ultimately disrupting photosynthetic activity and promoting premature senescence. Under severe disease pressure, extensive tissue collapse weakened overall plant growth and significantly reduced productivity. Similar findings have been reported where leaf blight incidence reached nearly 100% in highly susceptible taro accessions under conducive environmental conditions (Takor et al., 2020; Donkor et al., 2023).



**Fig. 5: Leaf blight symptoms show extensive necrotic lesions on the leaves, which interfere with the photosynthetic process.**





Fig. 6: Symptoms of leaf blight disease on taro accession *Putih*

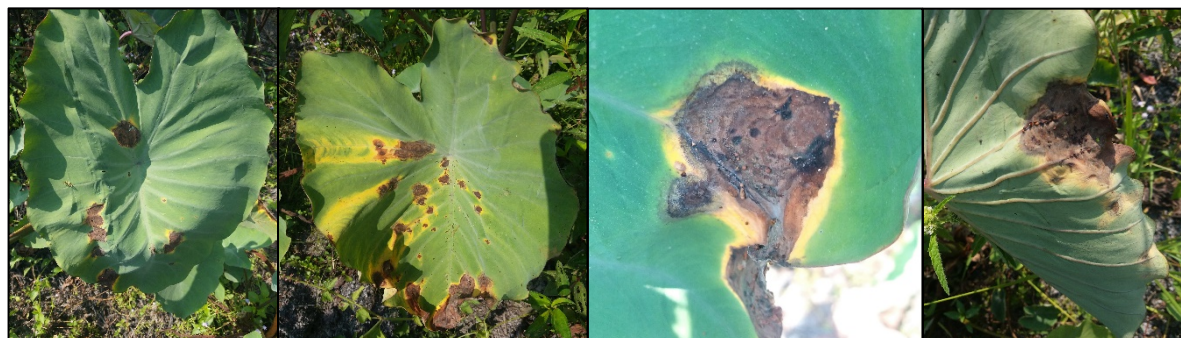


Fig. 7: Symptoms of leaf blight disease on taro accession *Wangi*

### 3.2 Incidence of fungal leaf blight disease on Malaysia taro accessions

Fourteen taro accession namely *Minyak*, *Putih*, *Bentan*, *Udang*, *Sarawak*, *Belang*, *Ulam*, *Mawar*, *Cina*, *Kumbul*, *Merah*, *Manik* were observed on fungal disease incidence (Figure 9). The survey revealed considerable variation in leaf blight incidence among the different accessions evaluated (Figure 8). Among the highly susceptible accessions, *Sarawak*, *Ulam*, and *Kimbul* recorded the highest disease incidence (100%), suggesting that these accessions are extremely vulnerable to taro leaf blight under the surveyed field conditions. Similarly, *Minyak* (95%) and *Merah* (90%) also showed very high incidence levels, followed by *Cina* (about 88%) and *Bentan* (85%). These results indicate that leaf blight is widespread in most of the surveyed Malaysian taro germplasm.

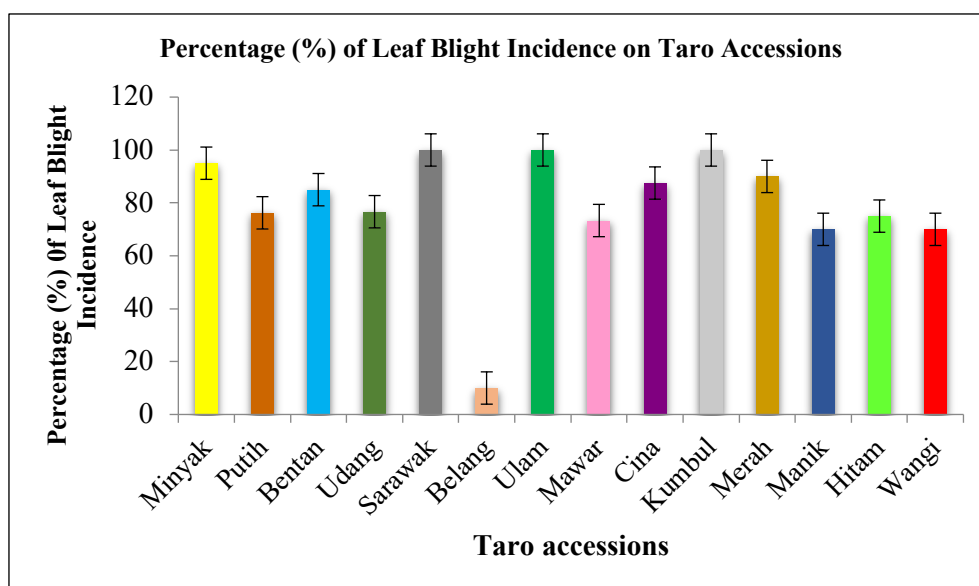
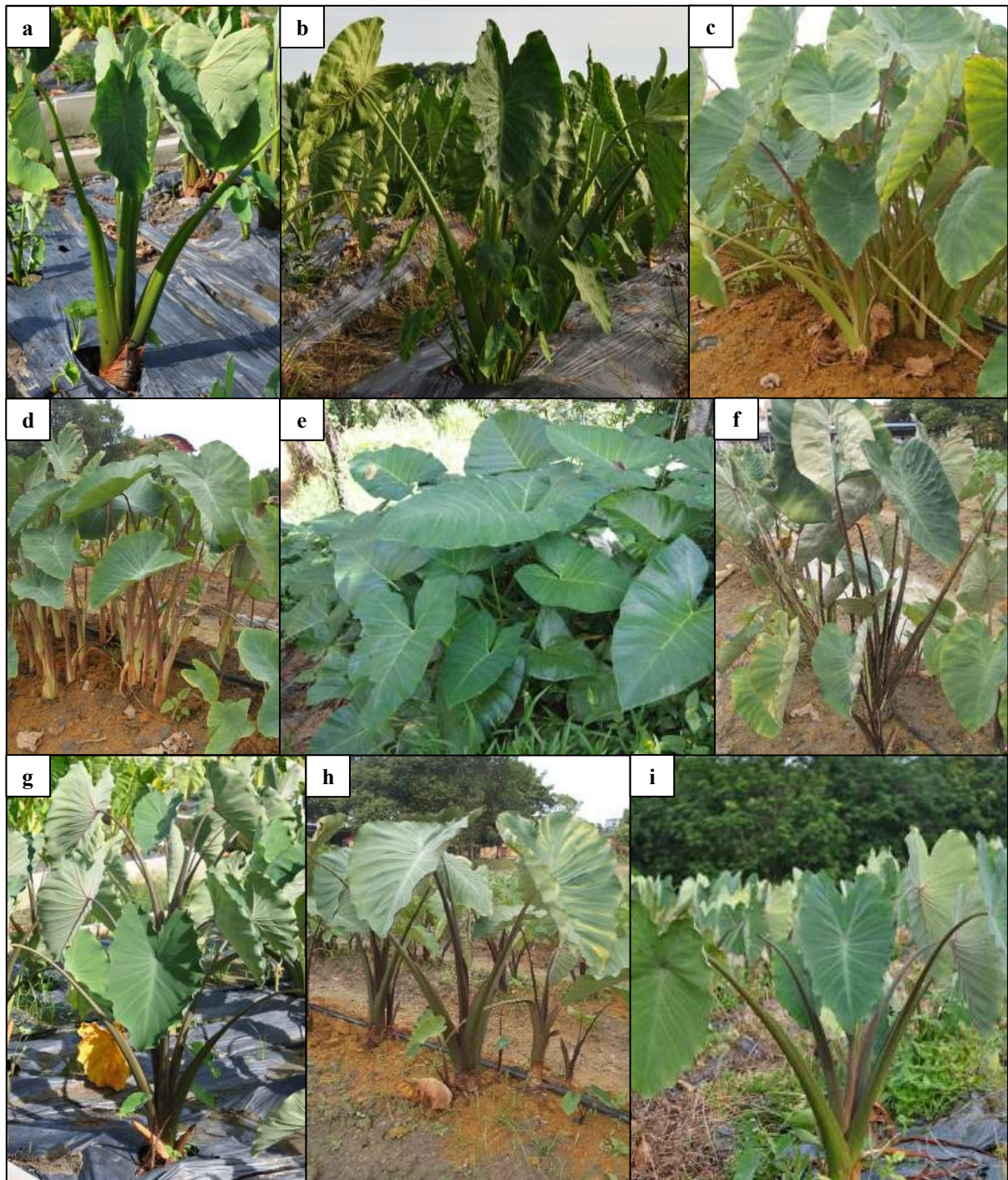


Fig. 8: Incidence of taro leaf blight among Malaysian taro (*C. esculenta*) accessions





**Fig. 9: Malaysian taro accessions. (a) Minyak, (b) Putih, (c) Bentan, (d) Udang, (e) Sarawak, (f) Belang, (g) Mawar, (h) Hitam and (i) Wangi.**

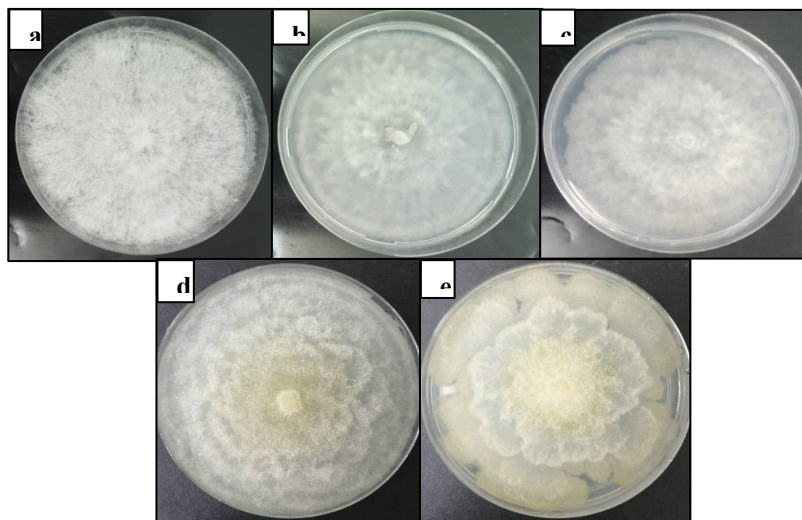
Moderate disease incidence was observed in *Putih* and *Udang* (about 76%), while *Mawar*, *Hitam*, and *Wangi* showed incidence values ranging between 70–75%. *Manik* also exhibited relatively lower disease incidence (70%), suggesting partial tolerance compared with the highly susceptible accessions. In contrast, *Belang* showed the lowest disease incidence (10%), which clearly distinguished it from all other accessions. This exceptionally low level of infection suggests that *Belang* may possess useful genetic resistance or field tolerance to leaf blight disease, making it a promising candidate for future breeding, resistance screening, and integrated disease management programs.

The error bars indicate some variation in disease incidence among sampled plants or survey sites, but the overall trend consistently shows *Belang* as the most resistant accession and *Sarawak*, *Ulam*, and *Kumbul* as the most susceptible.

The wide variation observed among Malaysian taro accessions highlights the importance of field disease surveys in identifying resistant germplasm for sustainable taro production.

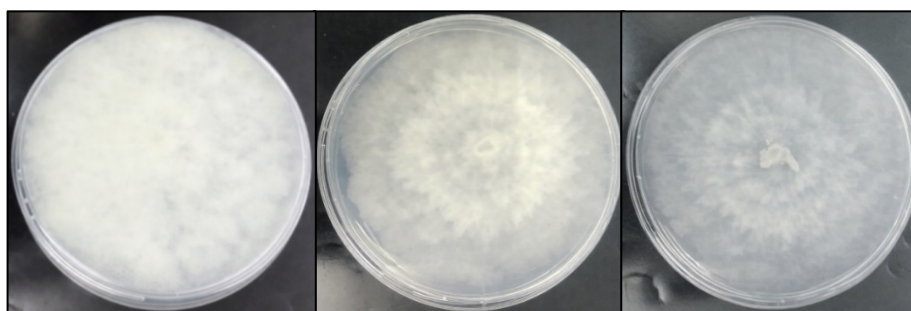
### 3.3 Leaf blight fungal isolates morphological observation

Fungal isolates obtained from symptomatic leaves of taro accessions *Putih* and *Wangi* demonstrated distinct morphological characteristics when cultured on Potato Dextrose Agar (PDA) after 15 days of incubation (Figures 10 and 11). A total of five fungal different morphological isolates were successfully recovered, consisting of three isolates from accession *Putih* (KP1, KP2, and KP3) and two isolates from accession *Wangi* (KW1 and KW2). Observable differences in colony morphology, including colony texture, pigmentation, growth pattern, and mycelial density, were recorded among isolates, indicating morphological diversity among fungal associated with diseased taro tissues.



**Fig. 10: Top view of full grow fungal isolates on PDA agar plate after 15 days. (a-c) Fungal isolates of KP1, KP2, KP3 from infected leaf taro *Putih*. (d-e) Fungal isolates of KW1 AND KW2 from infected leaf of taro *Wangi*.**

The top-view morphology of fungal colonies (Figure 9) revealed visible differences in colony appearance between isolates recovered from *Putih* and *Wangi* accessions. Isolates from *Putih* accession generally exhibited dense mycelial growth with variable colony margins and textures, whereas isolates from *Wangi* accession displayed differences in radial expansion and surface morphology. Most colonies developed cottony to fluffy aerial mycelia with whitish to greyish pigmentation, characteristics commonly associated with fungal pathogens isolated from foliar lesions in tropical crops. Colony morphology is an important preliminary criterion in fungal characterization, as variations in texture, pigmentation, and growth habit may reflect differences in fungal identity and physiological adaptation to host tissues. Observations of the reverse colony morphology (Figure 10) further demonstrated differences in pigmentation intensity and colony structure among isolates. Variability in reverse pigmentation is frequently used as an initial taxonomic characteristic in fungal identification and may indicate differences in fungal metabolism, substrate utilization, and sporulation potential.



**Fig. 11: Reverse view of full grow fungal isolates on PDA agar plate after 15 days isolated from both taro *Putih* and *Wangi*.**



Variation in fungal colony morphology between *Putih* and *Wangi* accessions may also reflect differences in accession response to pathogen colonization. During field assessment, *Putih* and *Wangi* exhibited moderate disease incidence, although differences in symptom severity and fungal recovery were observed. Previous studies demonstrated that host genotype influences fungal establishment, disease progression, and resistance mechanisms in taro, emphasizing the importance of accession screening in identifying disease-tolerant germplasm (Donkor et al., 2023). Therefore, morphological differences among fungal isolates may partly reflect host-pathogen interactions occurring under natural field conditions.

### 3.4 Molecular Identification of Fungal Isolates Based on ITS Gene Sequencing

Molecular identification of fungal isolates obtained from symptomatic taro leaves was conducted using ITS (internal transcribed spacer) gene sequencing to confirm the identity of pathogens associated with leaf blight symptoms in *Putih* and *Wangi* accessions. Sequence analysis revealed that all isolates recovered from both accessions were identified as *P. colocasiae*, with sequence similarity ranging from 99% to 100% compared with reference sequences deposited in the GenBank database (Table 2).

**Table 2: Molecular identification of fungal isolates based on ITS (internal transcribed spacer) gene sequencing.**

| Sample            | Fungal isolates | Identified Species Name        | Similarity % | Accession numbers |
|-------------------|-----------------|--------------------------------|--------------|-------------------|
| Taro <i>Putih</i> | KP1             | <i>Phytophthora colocasiae</i> | 99%          | KY432681.1        |
|                   | KP2             | <i>Phytophthora colocasiae</i> | 99%          | KY432681.1        |
|                   | KP3             | <i>Phytophthora colocasiae</i> | 99%          | KY432681.1        |
| Taro <i>Wangi</i> | KW1             | <i>Phytophthora colocasiae</i> | 99%          | KY432682          |
|                   | KW2             | <i>Phytophthora colocasiae</i> | 100%         | KY432682          |

Among the isolates obtained from accession *Putih*, KP1, KP2, and KP3 demonstrated 99% sequence similarity to *P. colocasiae* (accession number KY432681.1), confirming the presence of the pathogen in infected leaf tissues. Similarly, isolates from accession *Wangi* (KW1 and KW2) were identified as *P. colocasiae*, with KW1 showing 99% similarity and KW2 exhibiting 100% sequence similarity to reference accession KY432682, further validating the association between the pathogen and taro leaf blight symptoms observed during field assessment.

The molecular identification results supported the morphological observations described in the previous section, where fungal colonies isolated from *Putih* and *Wangi* accessions exhibited variations in colony pigmentation, texture, and mycelial growth patterns. Despite differences in colony morphology among isolates, ITS sequencing confirmed that all isolates belonged to the same pathogen species, *P. colocasiae*. Similar findings were reported by Misra et al. (2011), who observed considerable morphological variation among *P. colocasiae* isolates associated with taro leaf blight in India despite high species consistency. Likewise, George et al. (2017) reported that *P. colocasiae* isolates collected from different geographical locations exhibited variation in colony morphology and cultural characteristics, while molecular characterization confirmed their identity as the same pathogen species. These findings suggest that differences in fungal morphology may be influenced by environmental conditions, isolate adaptation, and growth responses during culturing rather than species-level variation.

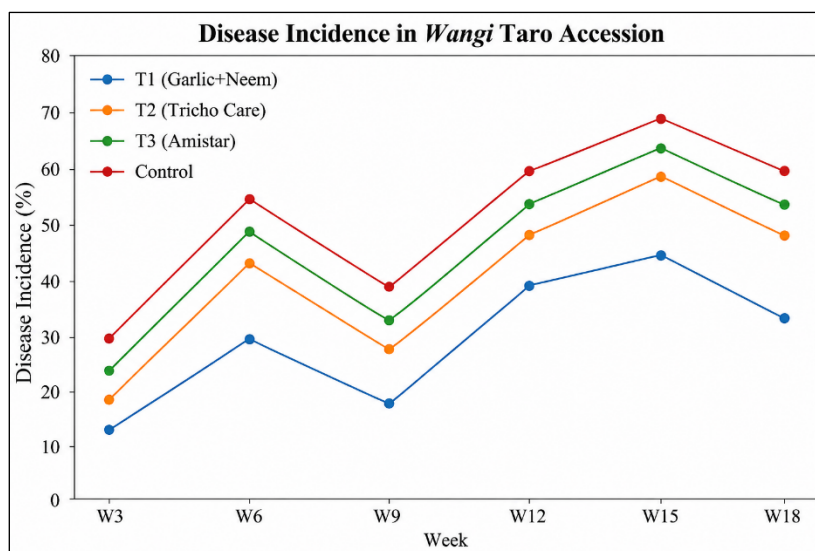
The identification of *P. colocasiae* in all isolates confirms its role as the principal pathogen associated with taro leaf blight symptoms in Malaysian taro accessions. *Phytophthora colocasiae* is recognized as one of the most destructive oomycete pathogens affecting taro cultivation because of its rapid infection cycle and aggressive disease development under humid tropical conditions. Severe infections may result in extensive leaf necrosis, disruption of photosynthetic activity, and substantial reductions in corm yield and crop productivity (Misra et al., 2011).

### 3.5 Effect of treatments on leaf blight incidence and severity on *Wangi* taro accession

#### 3.5.1 Leaf blight disease incidence on *Wangi* taro accession

Estimated disease incidence on *Wangi* taro accession varied throughout the assessment period and among treatment applications (Figure 12). Disease incidence increased progressively from week 3 (W3) to week 15 (W15), followed by a slight decline at week 18 (W18). The highest disease incidence was consistently observed at W15, indicating that this stage represented the peak period of disease development in *Wangi* accession under field conditions.

Among the treatments evaluated, T1 (garlic oil + neem oil) exhibited the lowest disease incidence throughout the observation period compared with T2, T3, and the untreated control. Disease incidence under T1 increased gradually from approximately 14% at W3 to 45% at W15, before decreasing to approximately 35% at W18. The lower disease incidence observed under T1 suggests that the combination of garlic oil and neem oil effectively reduced pathogen establishment and disease spread in the field. The antifungal properties of garlic oil are primarily associated with sulfur-containing compounds such as allicin, which possess inhibitory activity against fungal and oomycete pathogens, whereas neem oil contains bioactive compounds such as azadirachtin that suppress pathogen growth and spore germination (Tripathi & Dubey, 2004). Botanical based treatments have increasingly gained attention as sustainable disease management alternatives due to their lower environmental impact, biodegradability and lower cost of disease management.



**Fig. 12: Estimated leaf blight disease incidence on *Wangi* taro accession during field assessment. (Notes: T1 = Garlic oil + Neem oil, T2 = Tricho Care, T3 = Amistar® & C = Negative control)**

In comparison, T2 (Tricho Care) and T3 (Amistar®) demonstrated moderate disease suppression, although disease incidence remained relatively high during the later growth stages. Disease incidence under T2 increased from approximately 20% at W3 to 60% at W15, whereas T3 recorded disease incidence ranging from approximately 25% at W3 to 65% at W15. Tricho Care, which is generally associated with *Trichoderma* based biological control, may suppress pathogen development through competition for nutrients, mycoparasitism, and induction of host resistance responses (Harman et al., 2004). Meanwhile, the moderate effectiveness of T3 (Amistar®) may be attributed to fungicide performance under field conditions, where environmental factors such as rainfall, humidity, and disease pressure may influence treatment efficacy.

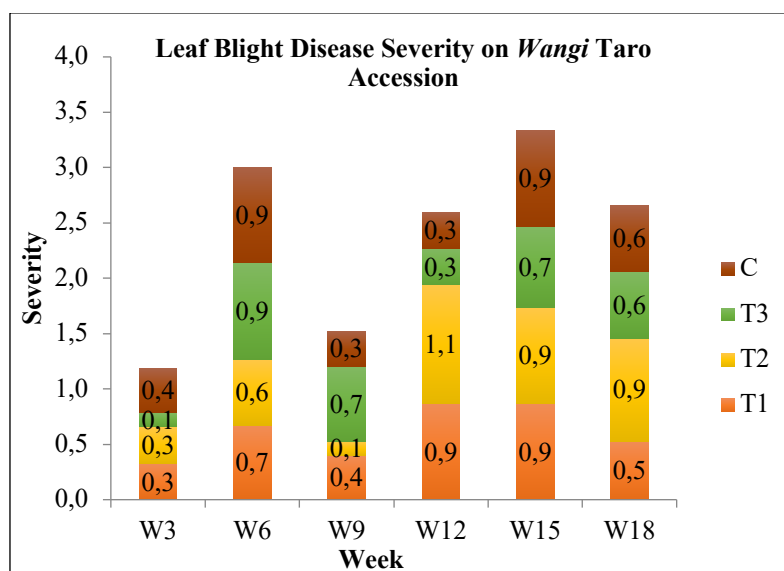
The untreated control consistently recorded the highest disease incidence throughout the observation period, increasing from approximately 30% at W3 to 70% at W15, before declining slightly at W18. The elevated disease incidence in untreated plants suggests that the absence of disease intervention allowed rapid pathogen colonization and disease spread. Similar findings were reported by Misra et al. (2011), who observed that taro leaf blight caused by *P. colocasiae* developed rapidly under humid conditions, particularly during advanced crop growth stages characterized by dense canopy formation and prolonged leaf wetness.

The sharp increase in disease incidence observed between W9 and W15 may be associated with favourable environmental conditions for pathogen sporulation and dissemination. Under humid tropical conditions, *P. colocasiae* spreads rapidly through water splashed sporangia and infected plant tissues, leading to extensive infection and rapid lesion development (George et al., 2017).

The results indicate that T1 (garlic oil + neem oil) was the most effective treatment in reducing disease incidence in the *Wangi* taro accession, whereas untreated plants exhibited the highest disease incidence throughout the assessment period. Disease incidence peaked around week 15, emphasizing the importance of timely disease intervention during critical stages of taro growth to minimize disease spread and crop damage.

### 3.5.2 Leaf blight disease severity on *Wangi* taro accession

The severity of taro leaf blight disease in the *Wangi* accession varied throughout the observation period and among treatment applications (Figure 13). Disease severity generally increased with crop age, with the highest severity recorded around week 15 (W15), indicating that disease development intensified during the later stages of plant growth. The increase in disease severity observed over time suggests that prolonged exposure to favorable environmental conditions, including high humidity and leaf wetness, may have enhanced pathogen infection and disease progression. Similar observations have been reported in taro cultivation systems, where leaf blight severity increased substantially during later growth stages due to dense canopy formation and prolonged moisture retention that favored *P. colocasiae* infection (Misra et al., 2011; Mbi et al., 2021).



**Fig. 13: Effect of different treatments on leaf blight severity in *Wangi* taro accession during field assessment.**  
(Notes: T1 = Garlic oil + Neem oil, T2 = Tricho Care, T3 = Amistar® & C = Negative control)

Among the treatments evaluated, T1 (garlic oil + neem oil) exhibited the greatest effectiveness in reducing leaf blight severity in the *Wangi* accession compared with T2, T3, and the untreated control. Disease severity under T1 remained comparatively lower throughout the assessment period, particularly during peak disease development at W15 and W18, indicating that the treatment may have suppressed pathogen establishment and disease progression. The effectiveness of garlic oil and neem oil may be attributed to their natural antifungal compounds. Garlic (*Allium sativum*) contains sulfur-containing compounds such as allicin, which exhibit strong antimicrobial and antifungal properties, while neem (*Azadirachta indica*) oil contains azadirachtin and other bioactive metabolites that inhibit fungal growth and spore germination (Tripathi & Dubey, 2004; Isman, 2020). Botanical extracts have increasingly been recognized as sustainable alternatives to synthetic fungicides because of their biodegradability, low environmental impact, and broad-spectrum antimicrobial activity.

In comparison, T2 (Tricho Care) and T3 (Amistar) demonstrated moderate effects in reducing disease severity, although disease progression remained evident during later weeks of observation. Tricho Care, which contains beneficial *Trichoderma* spp., may suppress disease through antagonistic interactions, competition for nutrients, mycoparasitism, and induction of plant defence responses (Harman et al., 2004). Meanwhile, Amistar (azoxystrobin), a systemic fungicide commonly used for fungal disease control, showed moderate disease suppression but was less effective than T1 under field conditions. Similar studies have shown that fungicidal effectiveness may vary depending on pathogen pressure, environmental conditions, and timing of application, particularly under humid tropical environments favourable for *P. colocasiae* sporulation (Sarkar et al., 2017).

The untreated control (C) consistently recorded higher disease severity than treated plants, indicating that the absence of disease intervention facilitated disease establishment and symptom progression. Disease severity increased markedly after week 12, reaching peak levels around week 15, suggesting that this stage represents a critical period for disease development in *Wangi* taro accession. Similar trends were reported by George et al. (2017), who observed increased aggressiveness of *P. colocasiae* under favorable environmental conditions, resulting in rapid lesion expansion and severe leaf damage.

The high disease severity observed at week 15 may also be associated with increased canopy density, which creates a favourable microclimate for pathogen infection through prolonged humidity and reduced air circulation. Under



such conditions, *P. colocasiae* can rapidly infect leaf tissues, causing necrosis and reducing photosynthetic efficiency, thereby affecting crop performance and yield (Misra et al., 2011). Agronomic practices such as the removal of infected petioles were also implemented throughout the field assessment as part of routine disease management commonly practiced by farmers. The removal of infected tissues may help reduce inoculum sources and slow disease spread within the planting area.

These findings indicate that T1 (garlic oil + neem oil) was the most effective treatment in reducing taro leaf blight severity in the Wangi accession, while disease severity was highest around week 15 after planting, emphasizing the importance of timely disease intervention during critical crop developmental stages. The results further suggest that plant-based treatments may provide an environmentally sustainable alternative for managing taro leaf blight under field conditions.

#### 4.0 Conclusion

This study demonstrated considerable variation in fungal leaf blight incidence among Malaysian taro (*C. esculenta*) accessions, indicating differences in susceptibility to disease. Among the accessions evaluated, *Belang* showed the lowest disease incidence, while *Sarawak*, *Ulam*, and *Kumbul* were the most susceptible. Morphological and molecular characterization confirmed *P. colocasiae* as the principal pathogen associated with taro leaf blight in *Putih* and *Wangi* accessions. Field evaluation further revealed that combination of garlic oil and neem oil was the most effective treatment in reducing disease development in *Wangi* accession. The findings provide valuable baseline information for identifying disease-tolerant taro germplasm and support the development of sustainable disease management strategies for taro cultivation in Malaysia.

#### Acknowledgement

The authors would like to express their sincere gratitude to Malaysian Agricultural Research & Development Institute (MARDI), Ministry of Agriculture and Food Industry (MAFI) for providing research facilities, field trial support, and technical assistance throughout the study. Special thanks are extended to the staff of the Agrobiodiversity and Environment Research Centre and the Industrial Crop Research Centre for their valuable contributions to data collection and laboratory analysis.

#### Conflict of Interest

The authors declare no conflicts of interest.

#### References

- Donkor, E. F., Nyadanu, D., Akromah, R., & Osei, K. (2023). Genotype by *Phytophthora colocasiae* isolate interaction in breeding for resistance to taro [*Colocasia esculenta* var. *esculenta* (L.) Schott] leaf blight disease in Ghana. *Heliyon*, 9, e16350. <https://doi.org/10.1016/j.heliyon.2023.e16350>
- George, A., Jeeva, M. L., Nath, V. S., Sreelatha, G. L., Sujina, M. G., & Makesh Kumar, T. (2017). Morphological and molecular characterization of *Phytophthora colocasiae* obtained from fine spatial scale. *Journal of Root Crops*, 43(2), 33–40.
- Harman, G. E., Howell, C. R., Viterbo, A., Chet, I., & Lorito, M. (2004). *Trichoderma* species—Opportunistic, avirulent plant symbionts. *Nature Reviews Microbiology*, 2(1), 43–56. <https://doi.org/10.1038/nrmicro797>
- Isman, M. B. (2020). Botanical insecticides in the twenty-first century—Fulfilling their promise? *Annual Review of Entomology*, 65, 233–249. <https://doi.org/10.1146/annurev-ento-011019-025010>
- Lebot, V., Tuia, V., Ivančič, A., Jackson, G. V. H., Saborío, F., Reyes, G., Rodriguez, S., Robin, G., Traoré, R., Aboagye, L., Onyeka, J., van Rensburg, W., Andrianavalona, A., Mukherjee, A., Prana, M. S., Ferraren, D., Komolong, B., Lawac, F., Winter, S., & Iosefa, T. (2017). Adapting clonally propagated crops to climatic changes: A global approach for taro (*Colocasia esculenta* (L.) Schott). *Genetic Resources and Crop Evolution*, 65(2), 591–606. <https://doi.org/10.1007/s10722-017-0557-6>
- Mbi, T. K., Ntsomboh-Ntsefong, G., Tonfack, L. B., & Youmbi, E. (2021). Field management of taro (*Colocasia esculenta* (L.) Schott) leaf blight via fungicidal spray of foliage. *Journal of the Cameroon Academy of Sciences*, 16(3), 197–208. <https://doi.org/10.4314/jcas.v16i3.2>

- Misra, R. S., Mishra, A. K., Sharma, K., Jeeva, M. L., & Hegde, V. (2011). Characterisation of *Phytophthora colocasiae* isolates associated with leaf blight of taro in India. *Archives of Phytopathology and Plant Protection*, 44(6), 581–591. <https://doi.org/10.1080/03235400903266339>
- Nirmala, D. N., Lal, A. A., & Simon, S. (2024). Report on *Phytophthora* sp. causing corm rot of colocasia (*Colocasia esculenta* L.) from Prayagraj, Uttar Pradesh, India. *Journal of Scientific Research and Reports*, 30(6), 955-960. <https://doi.org/10.9734/jsrr/2024/v30i62114>
- Otieno, C. A. (2020). Taro leaf blight (*Phytophthora colocasiae*) disease pathogenicity on selected taro (*Colocasia esculenta*) accessions in Maseno, Kenya. *Open Access Library Journal*, 7(6), 1–15. <https://doi.org/10.4236/oalib.1106393>
- Quenum, Z. N. J., Kumar, P. L., Akoroda, M. O., Dansi, A., Vetukuri, R. R., & Bhattacharjee, R. (2023). Ethnobotany and perceptions on the value of taro (*Colocasia esculenta*) among farmers in Benin Republic. *African Journal of Agricultural Research*, 19(5), 466–481. <https://doi.org/10.5897/AJAR2022.16240>
- Sahoo, M. R., Dasgupta, M., Kole, P. C., & Mukherjee, A. (2010). Biochemical changes in leaf tissues of taro [*Colocasia esculenta* L. (Schott)] infected with *Phytophthora colocasiae*. *Journal of Phytopathology*, 158(3), 154–159. <https://doi.org/10.1111/j.1439-0434.2009.01599.x>
- Sarkar, D., Adhikary, N. K., & Tarafdar, J. (2017). Field management of taro leaf blight using promising germplasm of taro. *International Journal of Current Microbiology and Applied Sciences*, 6(12), 1399–1407. <https://doi.org/10.20546/ijcmas.2017.612.157>
- Takor, M. C., Monono, E. Y., Ntane, O. A., Ngale, J. E., & Fontem, L. A. (2020). Assessing taro (*Colocasia esculenta* (L.) Schott) leaf blight incidence, severity, and farmers' knowledge of the disease in Fako Division of Cameroon. *International Journal of Plant & Soil Research*, 5(2), 17–29. <https://doi.org/10.9734/IJPR/2020/v5i230128>
- Tripathi, P., & Dubey, N. K. (2004). Exploitation of natural products as an alternative strategy to control postharvest fungal rotting of fruit and vegetables. *Postharvest Biology and Technology*, 32(3), 235–245. <https://doi.org/10.1016/j.postharvbio.2003.11.005>
- Umikalsum, M.B., Mohd Zulkhairi, A., Nurul Ammar, I. J., Siti Noor Aishikin, A.H., Aminah, M., Razean Haireen, M. R., Nurin Izzati, M. Z., Nor Asiah, I., Maya Izar, K., Rasmuna, M.M., Noor Camellia, N. A., Roslee, P., Mohd Norfaizal, G., Erny Sabrina, M.N., Rosliza, J. and Rozlaili, Z. (2021). Taro Production Mapping: Next Cash Crop For Nation Food Security. Proceeding book of MARDI Science and Technology Exhibition (MSTE), 12-14 Oktober 2021, Serdang, Selangor.
- Yulia, E., Yunira, A., Hidayat, S., Djaya, L., Widiyanti, F., Suganda, T., & Karuniawan, A. (2024). Inventory and disease incidence in 38 accessions of taro plants (*Colocasia esculenta* L.) in Jatinangor, Sumedang Regency, West Java. *CROPSAVER – Journal of Plant Protection*, 7(2), 89-102. <https://doi.org/10.24198/cropsaver.v7i2.58942>