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Inventory and Disease Incidence in 38 Accessions of Taro Plants (*Colocasia esculenta* L.) in Jatinangor, Sumedang Regency, West Java

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ABSTRACT

Taro is an important agricultural commodity with considerable prospects for international market competition. However, its cultivation faces several challenges, particularly pathogen infections that can lead to substantial yield losses. Conducting a disease inventory in taro plants is essential for effective disease management and serves as a preliminary step in developing resistant taro varieties. This study aimed to document diseases affecting 38 accessions of taro plants. The research was conducted from August to October 2021 at the Ciparanje Jatinangor Experimental Field and the Phytopathology Laboratory within the Department of Plant Pests and Diseases at the Faculty of Agriculture, Universitas Padjadjaran, located in Sumedang Regency. The methodology employed both qualitative and quantitative descriptive approaches. Data collection involved observing the incidence and severity of diseases, as well as identifying the pathogens responsible for the diseases. A total of 292 taro plants were examined during this study. The diseases identified included brown leaf spot (*Cladosporium colocasiae*), shot hole (*Phoma* sp.), orange leaf spot (*Neojohnstonia colocasiae*), white leaf spot (putative *Pseudocercospora colocasiae*), and leaf blight (*Phytophthora colocasiae*), along with other symptoms suspected to be caused by root pathogens and viruses.The most prevalent disease observed at the experimental site was brown spot disease, while leaf blight was identified as the most damaging. The incidence of leaf spot and leaf blight reached 100% across nearly all accessions of taro planted at the research site, with the highest severity of disease recorded at 49.65%.

Keywords: *Cladosporium colocasiae, Neojohnstonia colocasiae, Phoma sp., Phytophthora colocasiae,* Severity

Inventarisasi dan Kejadian Penyakit pada 38 Aksesi Tanaman Talas (*Colocasia esculenta* L.) di Jatinangor, Kabupaten Sumedang, Jawa Barat

ABSTRAK

Talas merupakan komoditas pertanian unggulan yang dapat bersaing di pasar internasional serta memiliki prospek yang tinggi. Namun, terdapat beberapa kendala di dalam budidaya tanaman talas, salah satunya adalah infeksi patogen yang dapat mengakibatkan gagal panen. Inventarisasi penyakit pada tanaman talas diperlukan untuk manajemen penyakit yang tepat serta proses skrining awal untuk pengembangan varietas tahan tanaman talas. Penelitian ini bertujuan untuk menginventarisasi penyakit-penyakit di 38 aksesi tanaman talas. Pengujian dilaksanakan dari bulan Agustus 2021 sampai dengan Oktober 2021 di Kebun Percobaan Ciparanje Jatinangor dan Laboratorium Fitopatologi, Departemen Hama dan Penyakit Tumbuhan, Fakultas Pertanian, Universitas Padjadjaran, Kabupaten Sumedang. Metode penelitian yang digunakan adalah metode deskriptif kualitatif dan kuantitatif. Pengumpulan data dilakukan dengan mengobservasi kejadian dan keparahan penyakit serta mengidentifikasi patogen penyebabnya. Sebanyak 292 tanaman talas diamati pada penelitian ini. Penyakit yang ditemukan adalah bercak daun cokelat (*Cladosporium colocasiae*), bercak daun berlubang (*Phoma* sp.), bercak daun oranye (*Neojohnstonia colocasiae*), bercak daun putih (putatif *Pseudocercospora colocasiae*), hawar daun (*Phytophthora colocasiae*), serta gejala lain yang diduga disebabkan oleh patogen akar dan virus. Penyakit yang umum ditemukan pada tanaman talas di tempat percobaan adalah penyakit bercak cokelat, sementara penyakit yang cukup besar menimbulkan kerusakan adalah penyakit hawar daun. Kejadian penyakit bercak daun dan hawar daun mencapai 100% pada hampir semua aksesi tanaman talas yang ditanam di lokasi penelitian dengan keparahan penyakit tertinggi mencapai 49,65%.

Kata Kunci: *Cladosporium colocasiae,* Keparahan, *Neojohnstonia colocasiae, Phoma sp., Phytophthora colocasiae*

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INTRODUCTION

The taro plant (*Colocasia esculenta* L.) is a tuber crop that can be found throughout most islands of Indonesia and has long been cultivated as a food crop, grown as either an annual or perennial plant (Setyowati *et al*., 2007). Taro tubers can serve as an alternative staple food to rice, while the leaves can be used as a plant-based food source (Wenda & Nangoi, 2020). In certain areas of Papua Province, taro is even considered a primary staple food (Rauf & Lestari, 2009).

Taro is a native tropical plant and a significant food source, as it provides carbohydrates, protein, fats, various minerals, vitamins, and medicinal ingredients (Sulistyowati *et al*., 2014; Patel & Singh, 2023). In Indonesia, there are various types of taro, including Bogor taro, Belitung taro, Bentul taro, Padang taro, Japanese taro, Butter taro, Sticky taro, Silk taro, and Lampung taro (Istiyawan & Wibisono, 2019; Latifah & Prahardini, 2020).

Taro is one of Indonesia's prime agricultural commodities with significant international market potential, particularly with increasing demand from Japan (Amelia & Yumiati, 2016). According to BPS data in 2020, Indonesia exported taro valued at USD 3.07 million, with a volume of 2,909 tons, to countries such as Thailand, Japan, China, Singapore, Malaysia, Vietnam, Australia, and the Netherlands (BPS, 2020). Currently, there is also a trend of exporting Beneng taro leaves from several Indonesian provinces to countries such as Australia and the United States (Humas Propinsi Jateng, 2022; Penghubung Provinsi Banten, 2023).

Taro production in Indonesia is relatively high, especially on the island of Java, in areas like Bogor, Malang, and Sumedang, which are key production centres with considerable genetic diversity (Andarini & Risliawati, 2018). The most commonly cultivated taro genera in Indonesia are *Colocasia*, *Xanthosoma*, and *Crytosperma* (Sulistyowati *et al*., 2014). Farmers typically use seeds passed down through generations, which generally produce moderate yields but have drawbacks, such as susceptibility to diseases, drought, and waterlogging (Arifin, 2015).

Plant diseases remain a major factor that reduces taro productivity. Key diseases affecting taro in Indonesia and other countries include tuber or root rot (*Pythium* spp., *Athelia rolfsii*), leaf blight (*Phytophthora colocasiae*), leaf spot (*Cladosporium colocasiae*, *Neojohnstonia colocasiae*, *Pseudocercospora colocasiae*), soft rot (*Erwinia chrysanthemi*), and post-harvest tuber rot (*Lasiodiplodia theobromae*) (Carmichael *et al*., 2008; Arifin, 2015; Rusbana *et al*., 2016; Sundar, 2016; Vásquez-López *et al*., 2018; Omane *et al*., 2020; Sulistiyono & Haryani, 2020).

Leaf blight is reported as the most damaging disease for the *Colocasia* group (Misra *et al*., 2008). This disease can lead to a 50% loss in taro tuber yield and up to a 95% loss in taro leaf yield, as well as degrade tuber quality by causing tuber rot (Singh et al., 2012; Omane *et al*., 2020). Meanwhile, leaf spot disease is the most common disease in taro plants, with some strains causing significant damage and others classified as minor diseases (Ooka, 1983; Carmichael *et al*., 2008).

The types of diseases affecting taro plants can vary depending on the resistance traits of the varieties cultivated and the environmental conditions of the growing area. Research on taro plant diseases is still very limited, so the results of this study will be useful for managing and enhancing taro productivity, particularly in terms of disease management and initial screening of taro varietal resistance. This research aimed to inventory diseases and assess their severity on 38 taro accessions collected by the Plant Breeding Laboratory at the Faculty of Agriculture, Universitas Padjadjaran, from various regions in Indonesia at the faculty's experimental field in Jatinangor.

MATERIALS AND METHODS

Taro Planting Location

The experiment was conducted at the Ciparanje Experimental Garden, Faculty of Agriculture, Universitas Padjadjaran, located in Jatinangor, Sumedang Regency, West Java, at an altitude of 753 meters above sea level. The soil is classified as Inceptisol, and the area has a type C rainfall pattern based on the Smith and Fergusson classification. Laboratory activities were carried out at the Phytopathology Laboratory, Department of Plant Pests and Diseases, Faculty of Agriculture, Universitas Padjadjaran. The experiment took place from August to October 2021.

The research method used was a descriptive method with both qualitative and quantitative approaches (Muhson, 2006; Rusbana *et al*., 2016). The objective was to identify and inventory diseases associated with taro plants and to calculate their incidence and severity. Data collection was carried out through field observations by examining the types of diseases present in the taro plants. Disease symptoms were directly observed on various parts of the taro plants. Some specimens or symptomatic plant parts were taken to the laboratory, stored in paper bags at 4 °C, and later isolated. The taro tuber accessions used in this research were collected by Prof. Agung Karuniawan, Plant Breeding Laboratory, Faculty of Agriculture, Universitas Padjadjaran, as presented in Table 1. A total of 292 taro plants from 38 accessions planted in five different blocks were observed in this study.

Table 1. Taro plant accessions used in the research

No.	Accession codes	Accession origin	Island
1.	CE1	Semir (Sumedang)	Java
2.	CE2	Pratama 1 (Sumedang)	Java
3.	CE3	Pratama 2 (Sumedang)	Java
4.	CE4	Bogor	Java
5.	CE5	Talas Hitam Halmahera Maluku Utara	Halmahera
6.	CE6	Talas Putih Halmahera Maluku Utara	Halmahera
7.	CE7	Pamulihan Sumedang	Java
8.	CE8	Manokwari Papua Barat	Papua
9.	CE9	Talas Satoimo (Jepang)	Japan
10.	CE10	Red Japanese Taro (Jepang)	Japan
11.	CE11	Magetan, Jawa Timur	Java
12.	CE12	Gorontalo 1	Sulawesi
13.	CE13	Palu 1	Sulawesi
14.	CE14	Gorontalo 2	Sulawesi
15.	CE15	Palu 2	Sulawesi
16.	CE16	Bentoel (Malang)	Java
17.	CE17	Beneng Pelepah Merah Gunung Halu (Bandung Barat)	Java
18.	CE18	Beneng Pelepah Hijau (Bandung Barat)	Java
19.	CE19	Talas Jahe (Bandung Barat)	Java
20.	CE20	Sorong	Papua
21.	CE21	Singkawang (Kalimantan Barat)	Kalimantan
22.	CE22	Talas Lipi	Java
23.	CE23	Banjarbaru Kalimantan Selatan	Kalimantan
24.	CE24	Talas Maluku Utara Putih	Halmahera
25.	CE25	Talas Maluku Utara Hitam	Halmahera
26.	CE26	Talas Maluku Utara Merah	Halmahera
27.	CE27	Maluku Barat Daya (MBD)	Ambon
28.	CE28	Pontianak (Kalimantan Barat)	Kalimantan
29.	CE29	Samarinda (Kalimantan Timur)	Kalimantan
30.	CE30	Aceh 5 (Kuta Fajar, Aceh)	Sumatera
31.	CE31	Aceh 1 (Kluet Tengah, Aceh Selatan)	Sumatera
32.	CE32	Aceh 2 (Kluet Tengah, Aceh Selatan)	Sumatera
33.	CE33	Aceh 3 (Kluet Tengah, Aceh Selatan)	Sumatera
34.	CE34	Aceh 4 (Kluet Tengah, Aceh Selatan)	Sumatera
35.	CE35	Beneng Pandeglang	Java
36.	CE36	Manado (Sulawesi Utara)	Sulawesi
37.	CE37	Maybat (Sorong)	Papua
38.	CE38	Mataram (Nusa Tenggara Barat)	Lombok

Land Preparation and Taro Planting

Land preparation began with weeding, followed by soil tilling and leveling, and then applying a base fertilizer of chicken manure. Before planting, the prepared land was formed into raised beds, with a spacing of 1 meter between them and lengths adjusted to the plot size. Taro plants were spaced 1x1 meter apart, with a planting depth of 30 cm (Maxiselly *et al*., 2009). Planting was done by placing the taro seedlings upright in the center of each hole, then covering them with 5 cm of soil to ensure they stood firmly. The number of plants for each accession varied from 2 to 15, depending on the availability of taro seedlings. Maintenance included weeding and mounding. Weeding was done to keep the plants free from weeds that could compete for nutrients while mounding involved covering the base of the stem to make the plants more stable and resistant to wind. These activities were carried out together once a week. Further fertilization involved applying NPK fertilizer at a rate of 100-200 kg Urea/ha, 50 kg TSP/ha, and 100 kg KCl/ha for all taro plants. Planting of the accessions was done in stages, based on the availability and readiness of each accession. Generally, two rounds of planting were conducted about one month apart. The first accessions planted (about one month old) typically had one or two leaves.

Observation of Disease Incidence and Severity

Disease incidence was calculated by directly assessing the presence or absence of disease symptoms on the taro plants. The incidence of symptomatic plants (P) in each accession was determined by the following equation: $P = D/T$, where D = total number of diseased plants, and T = total number of plants. Meanwhile, disease severity was observed by scoring, adjusted according to the characteristics of each disease found. Damage to leaves or the entire plant was measured using a scale from 0 to 5 (Table 2). Disease severity was determined using the following formula (Chaube & Pundhir, 2005):

$$I = \Sigma \frac{(nxv)}{(NxV)} x100\% \quad \dots (1)$$

Description:

I = disease severity (%)

n = number of plants in each symptom severity category

v = scale value for each symptom severity category

V = highest scale value of the symptom severity category

N = total number of plants observed

Table 2. Scoring of disease severity on taro plants

Scale	Severity score	Interpretation
0	< 1% area of taro leaf infected	No infection
1	1% - 25% area of taro leaf infected	Low infection
2	26% - 50% area of taro leaf infected	Moderate infection
3	51% - 75% area of taro leaf infected	High infection
4	> 75% area of taro leaf infected	Very high infection

Source**:** Abdulai *et al*. (2020), with modifications

Collection of Diseased Plant Samples

Samples were collected from symptomatic plant parts, including roots, leaves, or stems, depending on the characteristics of the symptoms observed. Plant samples were placed in brown envelopes and ziplock bags, labelled with relevant information, and stored in a refrigerator at 4 °C until the isolation and identification process was conducted.

Isolation and Identification of Pathogens

Pathogenic fungal isolation was performed on symptomatic plant parts by cutting the margin of the infected lesion to contain both diseased and healthy-looking tissue sections of about 0.5 cm in size (Agrios, 2005). The samples were then sterilized using 70% alcohol for 10 seconds and 2% clorox for 5 seconds, rinsed with sterile distilled water, and air-dried on sterile filter paper. Four pieces of each sample were then placed on 3-5 Petri dishes containing potato dextrose agar (PDA) medium. Pathogen colonies that grew after several days were transferred to new PDA to obtain pure fungal cultures. Isolation from smaller roots or fibrous roots was conducted by directly placing root sections on PDA after cleaning and surface disinfecting with 5% clorox for 2 minutes, followed by air drying on filter paper (Dervis *et al*., 2014).

Pathogen identification involved both macroscopic and microscopic observation of symptoms on plant samples. Macroscopic observation focused on visible disease symptoms or signs on the plant samples and the pathogen's macroscopic characteristics. Both macroscopic and microscopic morphological observations of the pathogen included the colony, mycelium, conidia, and other reproductive structures. Identification was aided by using the identification guidebooks by Barnett and Hunter (1987) and *Taro Pests: An Illustrated Guide to Pests and Diseases of Taro in the South Pacific* (Carmichael et al., 2008).

RESULT AND DISCUSSIONS

Taro Planting and Growth Condition

During the experiment, soil conditions were sufficiently moist, and some experimental blocks were adjacent to areas with dense trees, creating a humid environment (Figure 1). The average rainfall during the experiment was 41.5 mm per month, and the temperature ranged between 23.0-23.6 °C. Some disease symptoms were already observed on one-month-old taro plants, although the disease severity was generally low.

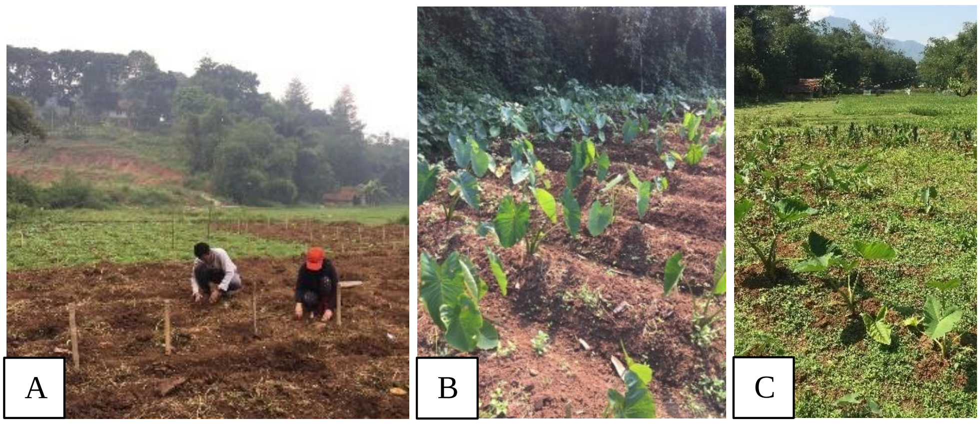

Figure 1. Taro planting time and planting blocks, (A) planting time with adequately moist soil conditions, (B) planting blocks adjacent to trees, (C) planting blocks in an open area

According to data from the Central Statistics Agency of Sumedang Regency in 2019, the annual rainfall in Jatinangor was about 1,230 mm, increasing to over 2,000 mm in 2020 (BPS Kabupaten Sumedang 2021; Susanto *et al*. 2023). However, climate data obtained from the Faculty of Agriculture, Universitas Padjadjaran weather station, showed relatively low monthly rainfall during the study period from August to October, with 10 mm, 24 mm, and 90.5 mm, respectively. Air temperatures during this period were 29.3 °C, 29.6 °C, and 28.6 °C, with an average humidity of over 80%. The optimal rainfall for taro growth is 1,750 mm per year, with a temperature range of 25-30 °C and high humidity. Taro also prefers open spaces with full sunlight during its growth (Bargumono & Wongsowijaya, 2013).

The planting period in this study was considered not optimal for taro growth, as it coincided with the dry season, and August is the month with the lowest rainfall in Sumedang Regency. However, observing and inventorying diseases during the first three months of the vegetative phase provided a useful overview of disease incidence. The presence of trees around the taro planting blocks also created a humid microclimate, which fostered a favorable environment for disease development.

According to the Schmidt-Ferguson climate classification, Jatinangor District falls into climate category C (moderately wet), while the Sumedang Regency as a whole is generally classified as Type B (wet climate) (LPPD Kabupaten Sumedang, 2022; Suryadi *et al*., 2022). This indicates that Sumedang Regency has relatively high rainfall, generally suitable for developing agricultural systems for almost all types of cultivated crops. Around the experimental area, there were taro plants (unidentified varieties) owned by residents, as well as previously planted taro collections from the Faculty of Agriculture's Experimental Garden, providing a sample source of inoculum. These conditions are ideal for testing the response of various taro accessions to different diseases.

Disease Incidence and Severity in Taro Accessions

Symptoms observed often included multiple types on a single plant, so scoring was done at the plant level, whether the plant showed one type of symptom or mixed symptoms. Out of the 292 taro plants, 132 generally exhibited one dominant symptom. These symptoms included brown leaf spots, orange leaf spots, white leaf spots, perforated leaf spots, leaf blight, and symptoms suspected to be caused by viruses. The proportion of dominant disease symptoms on the 132 taro plants is shown in Figure 2.

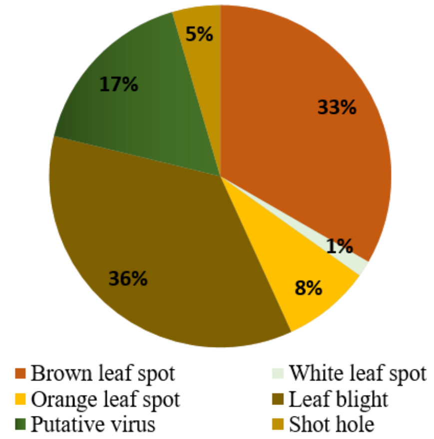

Figure 2. Proportion of dominant disease symptoms on 132 taro plants

Table 3. Disease incidence and severity in taro accessions

No.	Accession code	Disease severity (%)	Disease incidence (%)	No.	Accession code	Disease severity (%)	Disease incidence (%)
1.	CE1	41.32	93.33 (14/15)	20.	CE20	30.00	100 (2/2)
2.	CE2	39.72	93.33 (14/15)	21.	CE21	34.33	100 (14/14)
3.	CE3	38.54	100 (15/15)	22.	CE22	38.38	100 (15/15)
4.	CE4	29.94	100 (14/14)	23.	CE23	30.72	100 (13/13)
5.	CE5	35.56	100 (3/3)	24.	CE24	41.63	100 (6/6)
6.	CE6	37.33	100 (7/7)	25.	CE25	39.08	100 (8/8)
7.	CE7	35.29	100 (10/10)	26.	CE26	35.09	100 (13/13)
8.	CE8	39.79	100 (15/15)	27.	CE27	33.40	100 (7/7)
9.	CE9	32.33	100 (9/9)	28.	CE28	28.88	100 (2/2)
10.	CE10	43.11	100 (15/15)	29.	CE29	20.00	100 (2/2)
11.	CE11	40.95	100 (13/13)	30.	CE30	25.00	100 (3/3)
12.	CE12	40.91	100 (4/4)	31.	CE31	40.00	100 (2/2)
13.	CE13	45.45	100 (3/3)	32.	CE32	n.a.	n.a.
14.	CE14	47.22	100 (10/10)	33.	CE33	21.66	100 (2/2)
15.	CE15	49.01	100 (9/9)	34.	CE34	45.00	100 (2/2)
16.	CE16	39.40	100 (11/11)	35.	CE35	33.33	100 (7/7)
17.	CE17	38.18	100 (4/4)	36.	CE36	33.33	100 (3/3)
18.	CE18	41.55	100 (15/15)	37.	CE37	42.21	100 (2/2)
19.	CE19	**49.65***	100 (5/5)	38.	CE38	n.a.	n.a.

Note: *Indicates the highest disease severity. n.a.: no data available due to plant failure or death. The number in parentheses indicates the number of symptomatic plants per total number of plants for each accession.

The disease incidence rate was nearly 100% across all accessions, while disease severity ranged from 20-50%. The highest disease severity was observed in accession CE19 (Table 3). The disease severity was particularly high when leaf blight symptoms were present. The high incidence rate indicates that disease symptoms were found on nearly all planted taro accessions. In addition to dominant symptoms with high disease severity, some plants displayed only small spots with low frequency. Mixed symptoms on single plants made it challenging to separate and quantify disease severity for different symptoms. Carmichael *et al*. (2008) mentioned that brown spots closely resembled orange spot symptoms, while white spot disease often coincided with brown spots, making it difficult to differentiate between them.

The data in Table 3 indicated that the highest disease severity was found in accession CE19, with a rate of 49.65%. Accession CE19 is a variety known as *Ginger taro*, which is commonly referred to as S*afira* taro in Gunungkidul, Yogyakarta, and originates from Japan (known as S*atoimo taro*). The only disease symptom observed in CE19 was leaf blight. Kallo *et al*. (2019) reported that leaf blight was a major disease affecting S*atoimo taro* with potential yield losses reaching up to 50%.

Symptoms and Pathogens in Taro Plant Accessions

Several fungal isolates were obtained from symptomatic plants in the field. The frequent mixing of symptoms in the field made the isolation process more challenging. Nevertheless, the morphological characteristics of the obtained isolates were identified as *Cladosporium colocasiae*, *Neojohnstonia colocasiae*, *Phoma* sp., putative *Pseudocercospora colocasiae*, and *Phytophthora colocasiae*, along with other minor pathogens as described below.

Brown leaf spot (*Cladosporium colocasiae*). Brown leaf spot, also known as cladosporium leaf spot or ghost leaf spot, is caused by *Cladosporium colocasiae*. Initial symptoms appeared as round, light-yellow spots that eventually turned brown, taking on either round or irregular shapes. Some spots did not penetrate the upper or lower leaf surfaces, giving them an indistinct appearance, commonly referred to as ghost spots (Figure 3). Symptoms of brown leaf spot disease were found in almost all taro accessions (CE1-4, CE7-9, CE11, CE14-16, CE18, and CE21-26). This disease symptom was the most commonly observed and was often found on older leaves, though it can also affect younger leaves. The colony of *C. colocasiae* had a grey-green colour with a velvety texture. Colony growth was relatively slow. The colony appeared greenish-brown with short-septate hyphae, while the detected conidia were tubular with 0–1 septa (Figure 3C). The macroscopic and microscopic characteristics of the fungal isolates are consistent with descriptions by Bensch *et al*. (2010), Phengsintham *et al*. (2013), and NARO (2024).

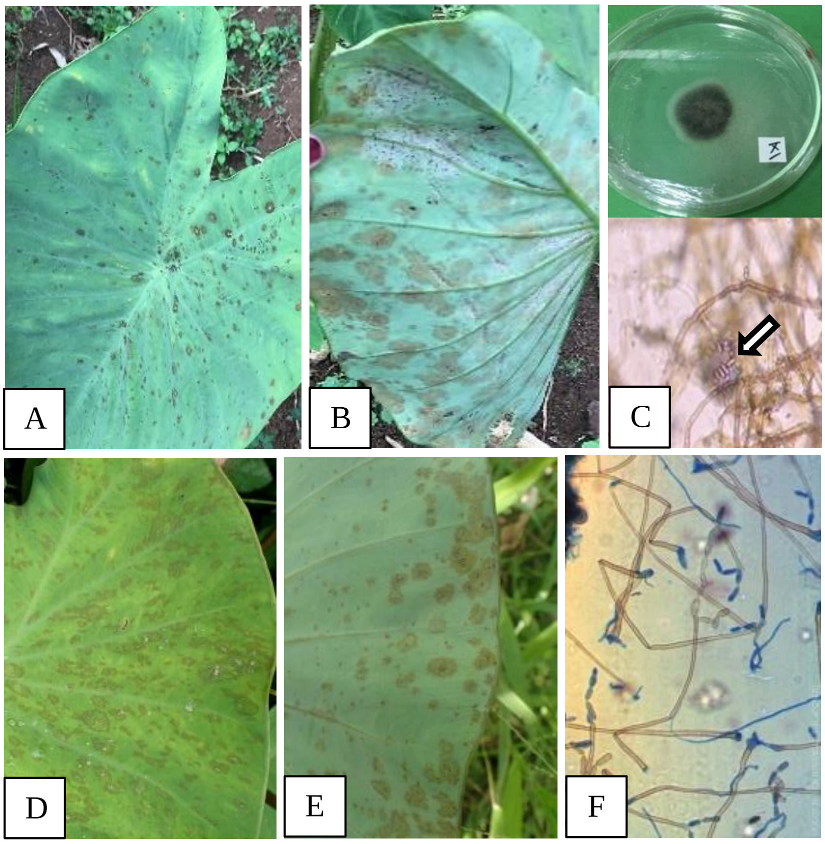

Figure 3. Brown leaf spot symptoms in taro accessions with (A) yellow spots that turn brown, appearing round or irregularly shaped, (B) ghost spots showed lesions that do not penetrate the upper or lower surface of the leaf, (C) fungal colony and conidia, (D-F) symptoms and conidia of *C. colocasiae* according to Ephytia (2022).

Carmichael *et al*. (2008) mentioned that early symptoms of the disease include yellow spots that become reddish-brown blotches with a light brown centre, round or irregular, reaching up to 15 mm in diameter. Some spots remain on the underside of the leaf, not fully penetrating the leaf surface, which gives rise to the term "ghost spots". As the spots age, they may turn black, and merging spots can lead to dried edges around the leaf. Brown leaf spot disease is widespread in Asia, Southeast Asia, and Oceania and is now present in nearly all taro-growing regions in tropical areas (Ephytia, 2022). Infections typically occur on older leaves, but severe infections can affect younger leaves as well. This pathogen infects only leaves, primarily within the *Colocasia* genus (water taro). It is assumed that *C. colocasiae* is the most widely distributed fungus affecting taro and is likely present wherever taro is cultivated (Tsatsia & Jackson, 2021a)

Orange leaf spot (*Neojohnstonia colocasiae*). The orange leaf spot disease, caused by *Neojohnstonia colocasiae*, presented symptoms of irregular, large yellow-orange spots (Figure 4). As the disease progressed, the spots merged to form blight symptoms. When these spots extend along secondary leaf veins, the affected areas exhibit chlorosis and elongated blight symptoms, ultimately leading to tissue desiccation in those parts. The disease was found in CE-1, CE20-22 and CE-25 taro accessions. The colony of *N. colocasiae* was green with some black areas and had a cottony texture, with round-shaped fungal conidia (Figure 4C).

Carmichael *et al*. (2008) mentioned that orange leaf spot is a disease affecting older leaves that manifests as irregular or circular yellow-brown spots on both leaf surfaces, often with yellow margins. The spots on the underside of the leaf tend to be darker due to spore production. Morphological data on *N. colocasiae* are still limited, but Carmichael *et al*. (2008) described its conidia as large, spherical, with or without septa, and produced singly at the tips of conidiophores while the symptoms are similar to those of brown leaf spot (*C. colocasiae*), thus requiring microscopic examination for accurate differentiation. This is the only known species in the genus *Neojohnstonia* (McKenzie et al., 2002). Orange leaf spots generally does not result in significant economic losses with the highest reported disease intensity was 12.30% (Sundari, 2017).

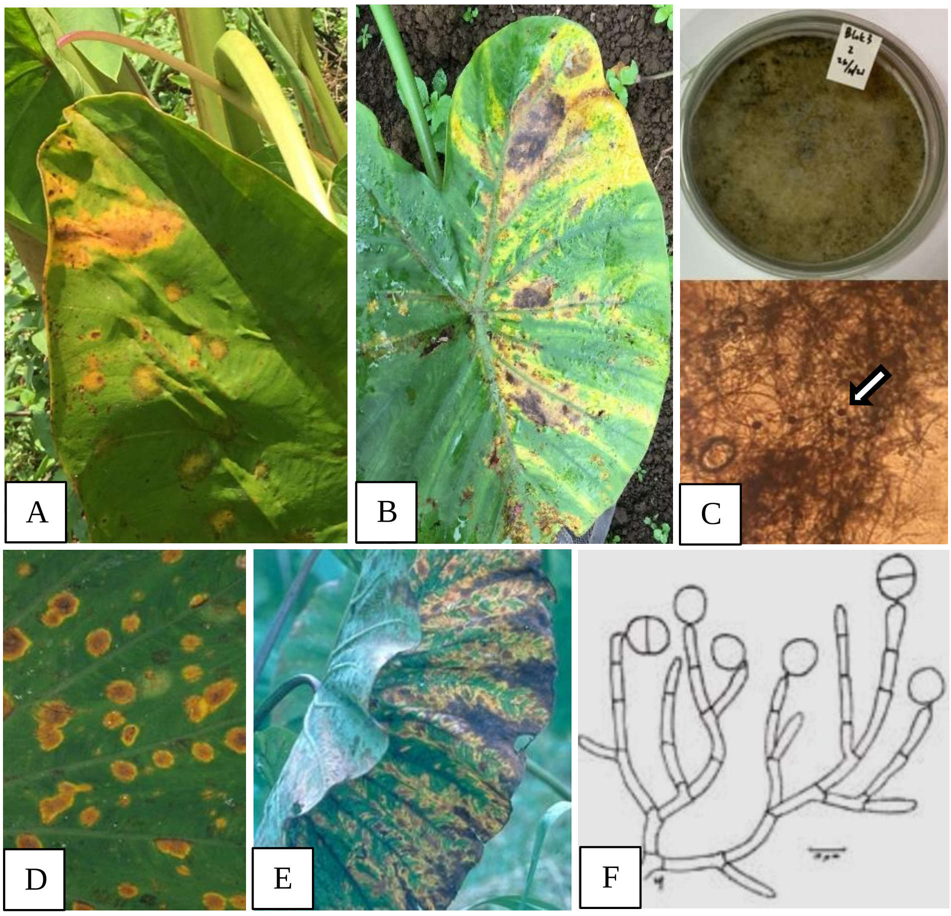

Figure 4. Orange leaf spot symptoms in taro accessions included (A) irregularly shaped orange spots that can merge into larger patches, (B) these combined spots create a distinctive pattern on the leaf surface in advanced stages, (C) fungal colony and conidia, (D-F) symptoms and conidia of *N. colocasiae* according to Carmichael *et al*. (2008) and Tsatsia & Jackson (2021a).

Shot hole (*Phoma* sp.). The shot hole disease symptom was light brown spots with yellow margins. Typically, these spots were irregularly shaped or oval or elongated (Figure 5). Early symptoms appeared as circular yellow spots with a brown center. As the disease progressed, the spots enlarged, and holes formed as the centres of the spots dried out and fall off. Shot hole disease symptoms were found in CE-1, CE3-4, CE-8, CE-23 and CE-25 taro accessions. The colony of *Phoma* sp. initially appeared white, then transitioned to a dark gray-green with small white clumps of mycelium. Its texture was flat, velvety, and powdery. The conidia of *Phoma* sp. were slightly oval and were produced in large quantities (Figure 5C).

The shot hole symptom is a distinctive feature of this disease (Carmichael *et al.*, 2008). The holes may coalesce, leading to extensive leaf damage and eventual leaf death. This disease is caused by fungi from the *Phoma* genus (Sundar, 2016). Symptoms manifest as large brown lesions on leaves that dry out and eventually fall out, creating holes reminiscent of bullet holes. This damage is restricted to the leaf area, presenting as brown spots with yellow margins, which is key to identifying this disease (Carmichael *et al.*, 2008). Observing the fungal fruiting bodies (pycnidia) on the spots is essential to distinguish this disease from leaf blight caused by *Phytophthora colocasiae.*

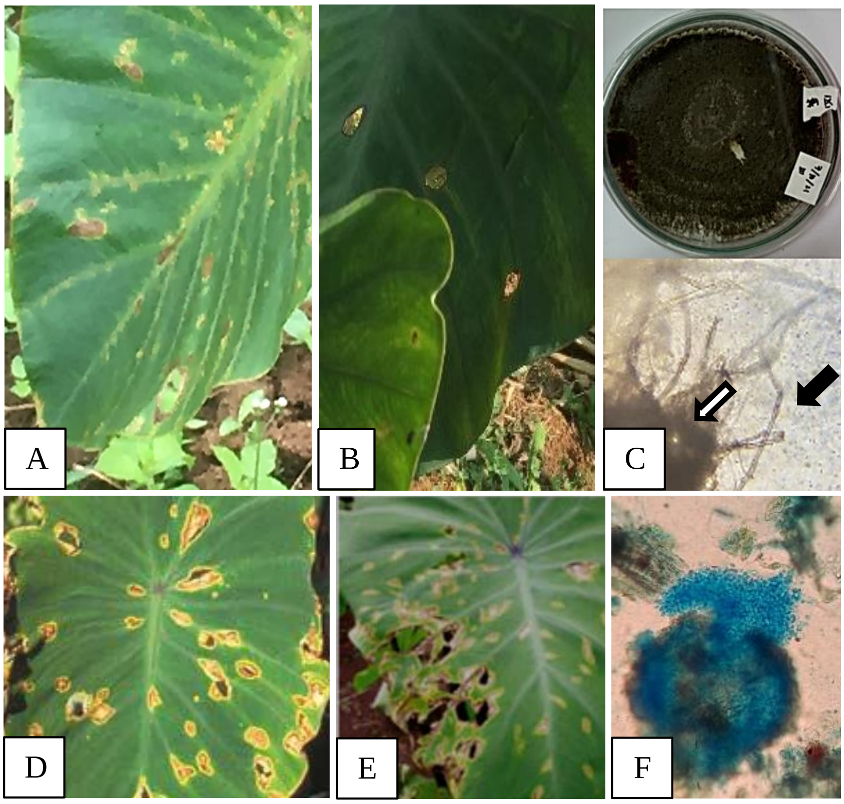

Figure 5. Shot hole disease symptoms in taro accessions with (A) elongated brown spots, (B) perforated spots, (C) fungal colony, pycnidia (white arrow) and conidia (black arrow), (D-F) symptoms, pycnidia and conidia of *Phoma* spp. according to Carmichael *et al*. (2008) and Ephytia (2022).

White leaf spot (putative *Pseudocercospora colocasiae*). The suspected symptoms of white leaf spot disease appeared as whitish-green spots on the upper leaf surface (Figure 6). This symptom was quite rare and difficult to distinguish from the early stages of brown leaf spot. White leaf spot disease is caused by *Pseudocercospora colocasiae* (*Ps. colocasiae*) and is also known as "leaf blotch" due to the blotchy or discolored appearance of the spots (Carmichael *et al*., 2008). The colony of suspected *Ps. colocasiae* initially appeared white, later turning dark gray to black with a cotton-like texture. Although challenging to identify, short, septate, club-shaped conidia were observed, consistent with descriptions by Carmichael *et al*. (2008) and Braun *et al*. (2014). *Pseudocercospora colocasiae* has been reported on taro plants in Indonesia, particularly in Papua Province (Braun *et al*., 2014). The white leaf spot symptoms in this study were observed in only two accessions – CE1 and CE15 – without the characteristic sporulation on the lower leaf surface. This may be due to the young or undeveloped spots or unfavorable environmental conditions for disease development.

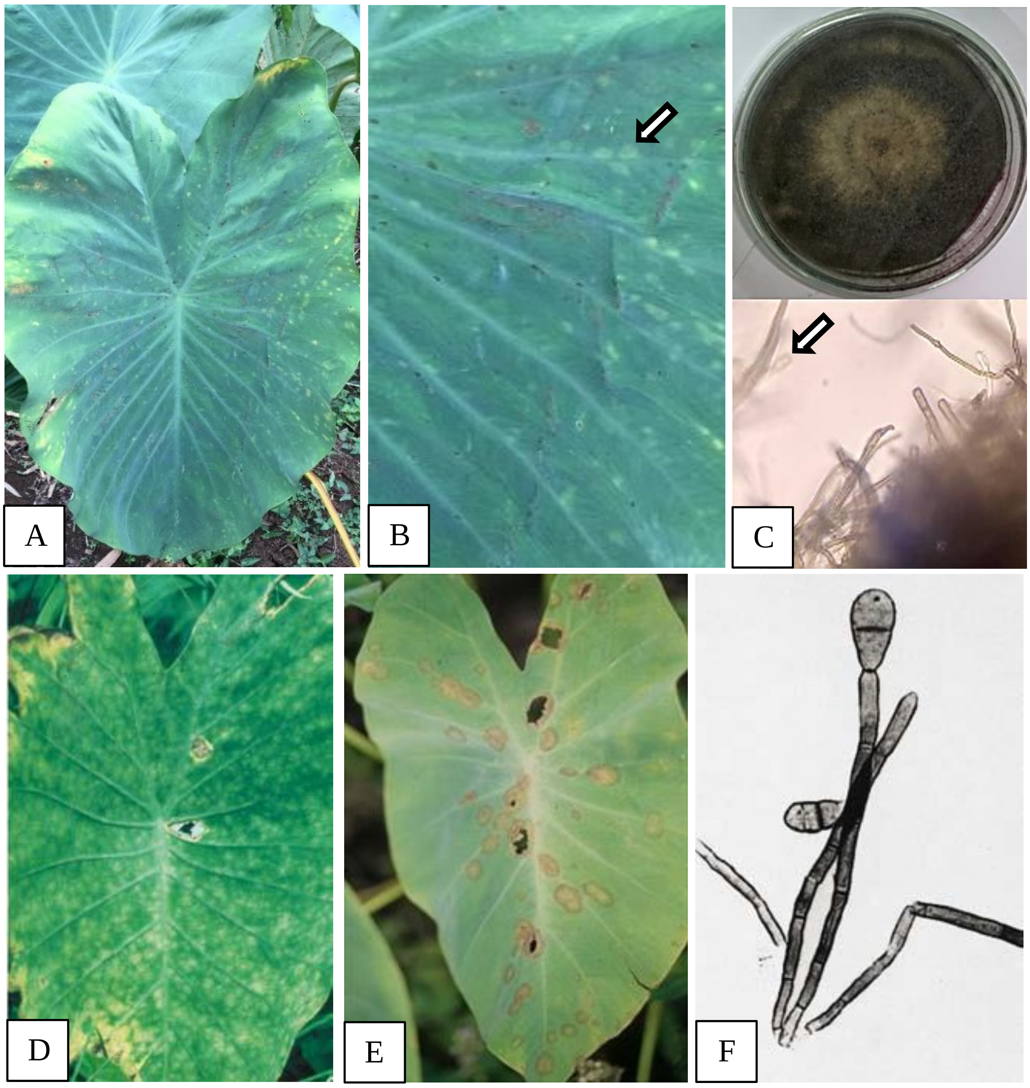

Figure 6. Putative white leaf spot symptoms in taro accessions showed (A) spots with a greenish-white color, (B) spots that resemble blotches or discolorations, (C) fungal colony and conidia, (D-F) symptoms and conidia of *Ps. colocasiae* according to Carmichael *et al*. (2008) and Tsatsia & Jackson (2021a).

Leaf blight (*Phytophthora colocasiae*). The initial symptoms of leaf blight disease appeared as small, round, and dark brown specks (Figure 7). These specks or spots then expanded, forming a dark brown blight with a yellow edge. As the disease progressed, the spots enlarged and merged, resulting in extensive blight that eventually caused the leaf blade to collapse or die while still hanging from the stalk. Exudate was also found on the underside of the leaf. Blight spots were commonly observed along the leaf edges, tips, or in the center of the leaf. The Symptoms were found in the taro accessions of CE2-4, CE6, CE8-12, CE14-23, CE26-31, CE34-35 and CE37. The *P. colocasiae* colony was white with a cotton-like texture and exhibited the distinctive pattern typical of the *Phytophthora* group of an irregular pattern. Microscopic observations of *P. colocasiae* reveal hyphal swelling or chlamydospores characteristic of this pathogen, while sporangia were not observed. Nath *et al*. (2014) categorized *P. colocasiae* isolates into nine groups based on colony texture on PDA media, including irregular patterns. Misra *et al*. (2011) described four *P. colocasiae* colony growth patterns: cottony, petaloid, rosaceous, and stellate. On PDA media, *P. colocasiae* colonies grow slowly, producing very few sporangia (Tsopmbeng *et al*., 2012; Mbong *et al*., 2015). Padmaja *et al*. (2017) reported two types of *P. colocasiae* sporangia, i.e., globose semi-papillate and ovoid papillate. However, sporangia were not clearly observed in this study.

Leaf blight disease is a significant threat to taro crops and, in some countries, a major limiting factor for taro cultivation (Carmichael *et al*., 2008). Infection by *Phytophthora colocasiae* can cause leaves to rot and petioles to collapse. Although petioles are rarely affected, in certain susceptible varieties, symptoms may also appear on the petiole. The initial symptoms appear as small, brown, water-soaked lesions that rapidly expand into large, dark brown lesions that merge into blight spots, sometimes accompanied by orange host exudate (Bandyopadhyay & Sharma, 2014). These spots are often found on parts of the leaf that retain water, such as the center, edges, and tips, and under wet environmental conditions, white sporulation can occur on the lesion surfaces (Abdulai *et al.*, 2020). Sporangia and zoospores are dispersed by rain and wind, allowing the pathogen to spread easily. While *P. colocasiae* primarily infects leaves, it can also affect petioles and taro corms, resulting in corm rot (Carmichael *et al*., 2008).

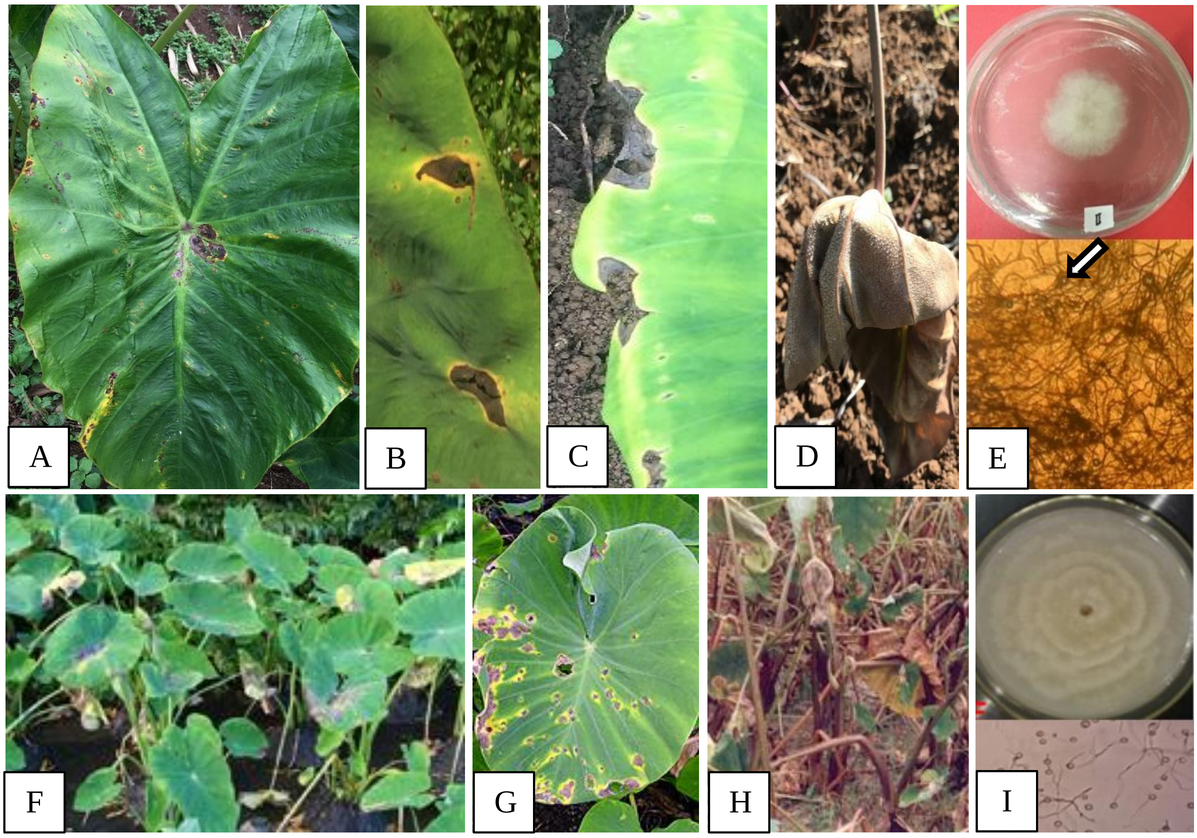

Figure 7. Leaf blight symptoms in taro accessions included (A) initial symptoms of dark brown spots, typically appearing in the centre and along leaf edges, (B) enlarged spots with a yellow halo, (C) advanced symptoms showing dark brown blight, (D) leaves hanging, dead, with exudation observed on the underside, (E) fungal colony and hyphae structure, (F-I) symptoms, colony and zoospores of *P. colocasiae* according to Misra *et al*. (2008) and Kalhoro *et al.* (2022).

Root diseases. Several symptoms observed were suspected to be caused by root pathogen infections. These symptoms included yellowing, wilting, and death of older leaves accompanied by the death of the shoot (Figure 8). One root disease reported in taro plants is caused by *Pythium* spp. Symptoms resulting from *Pythium* spp. infection include yellowing and drying of older leaves, while younger leaves or shoots may experience dieback. Overall, plant growth will be hindered (Tsatsia & Jackson, 2021b).

Virus diseases. Field observations revealed several disease symptoms suspected to be caused by viruses. These symptoms included mosaic patterns, darkening of the main leaf veins (vein banding), or feather-like chlorosis along smaller veins, leaf distortion or curling, and stunted plant growth (Figure 9). Several viruses reported to infect taro plants include *Dasheen mosaic virus* (DsMV), which causes mosaic symptoms, *Taro bacilliform virus* (TaBV) and *Taro bacilliform CH virus* (TaBCHV) which lead to leaf malformation, *Colocasia bobone disease virus* (CBDV) which results in spotting and stunting, and *Taro vein chlorosis virus* (TaVCV) causing vein thickening and chlorosis (Yusop *et al*., 2019). DsMV is considered the main virus affecting taro (Sundar, 2016). Although viral diseases in taro plants are generally minor, certain infections have been reported to reduce taro yields or even result in plant death (Yusop *et al*., 2019).

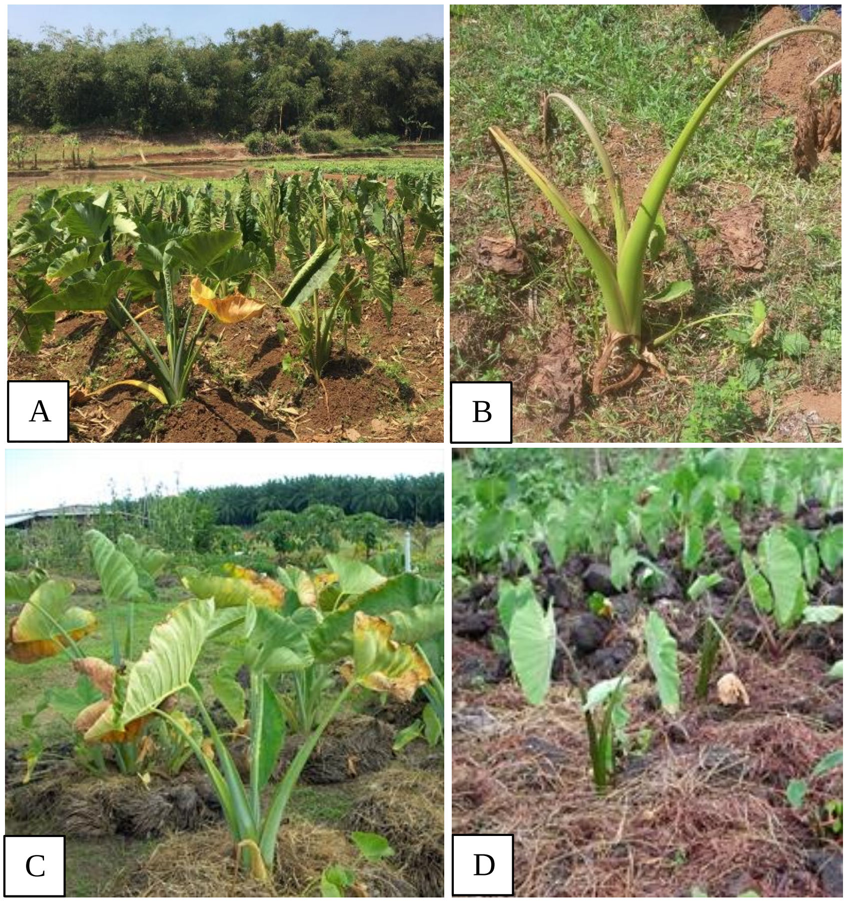

Figure 8. Root disease symptoms showed (A) older leaves that are yellowing and dying, (B) leaves and shoots of the plant wilting, drying, and dying or dieback, (C, D) symptoms of root diseases according to Tsatsia and Jackson (2021b).

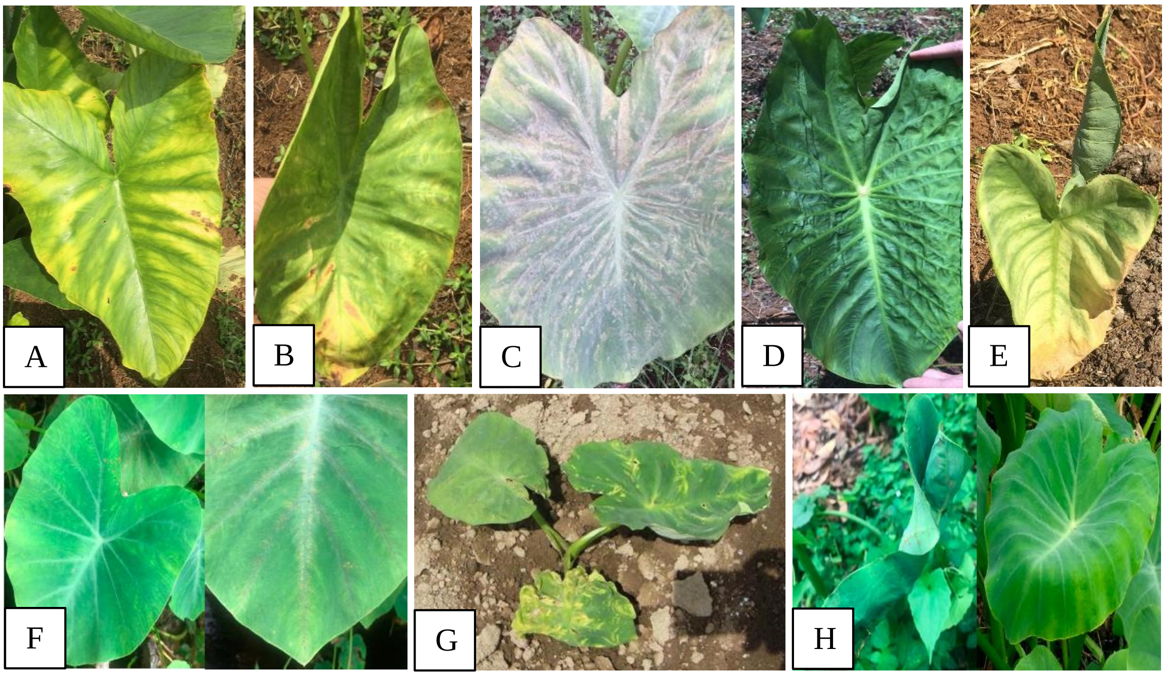

Figure 9. Suspected virus infection symptoms showed (A, B) mosaic patterns, (C) leaf vein chlorosis, (D) vein thickening, (E) stunted growth, (F-H) Symptoms of virus infections according to Kallo (2019) and Yusop *et al*. (2019).

Leaf spot diseases caused by *C. colocasiae*, *N. colocasiae*, *Ps. colocasiae*, and *Phoma* sp. are categorized as minor taro leaf spot diseases (Tsatsia & Jackson, 2021a). This classification is due to the fact that these diseases typically affect older leaves, which only accelerates leaf senescence without impacting yield. Although these diseases are commonly observed, they are not considered a threat to taro production as they do not affect the crop yield. Studies have reported differences in the susceptibility of taro varieties to these four diseases, especially for the shot hole leaf spot caused by *Phoma* sp.

Minor diseases are reported as non-economically damaging and therefore do not require chemical control (Carmichael *et al*., 2008). This is because these diseases generally affect older leaves, and there have been no reports indicating that these four diseases reduce taro yields. Mechanical control, such as removing or cutting off infected leaves and burning them, can help reduce the inoculum sources for these minor pathogens. Meanwhile, for leaf blight, effective control methods remain limited. Current control options for leaf blight include chemical and cultural practices. Cultural practices involve planting new crops away from infected plants, maintaining sanitation by removing symptomatic plant parts, and ensuring adequate spacing between plants. Chemical control using fungicides in the field and post-harvest treatments, such as dipping taro corms, has shown positive results in managing leaf blight.

In general, plant diseases remain a primary challenge in taro cultivation. The warm and humid tropical climate allows for year-round taro cultivation, ensuring a continuous supply of host plants. Taro is also typically propagated vegetatively, which facilitates the long-distance spread of pathogens through infected planting material. Additionally, residual corms left in the field after harvest can serve as an inoculum source for subsequent taro crops, especially for leaf blight disease.

CONCLUSIONS

Several types of diseases were found across all taro accessions planted in Jatinangor, with the most common being brown leaf spot (*Cladosporium colocasiae*) and the least common being white leaf spot (putative *Pseudocercospora colocasiae*). Leaf spot and leaf blight were dominant diseases, appearing in nearly all taro accessions with an incidence rate reaching 100%. The highest recorded disease severity was 49.65%. Leaf spot diseases caused by *C. colocasiae*, *Neojohnstonia colocasiae*, *Ps. colocasiae*, and *Phoma* sp. are classified as minor diseases. They generally do not significantly impact production since they primarily affect older leaves.

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