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IDENTIFICATION AND MORPHOLOGICAL CHARACTERIZATION OF PERONOSCLEROSPORA MAYDIS CAUSING DOWNY MILDEW ON MAIZE IN LANGKAT AND SIMALUNGUN REGENCIES

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Abstract

Downy mildew, caused by oomycetes of the genus Peronosclerospora, is the most destructive biotic threat to maize cultivation in Indonesia, with the potential to cause up to 100% yield loss. Accurate species identification is crucial for determining effective control strategies. This study aimed to identify and characterize the Peronosclerospora spp. responsible for downy mildew in eight survey locations across Langkat and Simalungun Regencies, North Sumatra. The research involved field surveys and laboratory microscopic observations to analyze qualitative (morphological) and quantitative (morphometric) parameters. Identification results indicated that all pathogen isolates from the eight locations were Peronosclerospora maydis. Morphologically, the pathogen featured hyaline conidiophores that were clustered, with 2–4 dichotomous branches. Morphometrically, structural variations were observed, with conidiophore lengths ranging from 150–550 µm and conidial diameters between 17–23 x 27–39 µm. Conidia were predominantly spherical to subspherical with thin cell walls. These dimensional variations are suggested to be influenced by external factors such as local agroclimatic conditions and host genotypes. This study confirms that P. maydis remains the primary pathogen causing downy mildew in North Sumatra.

Keywords: Maize, Peronosclerospora maydis, Downy Mildew, Morphometrics, North Sumatra.

INTRODUCTION

Maize (Zea mays L.) is a strategic food commodity in Indonesia, playing a vital role in fulfilling carbohydrate needs and livestock feed raw materials. The national demand for maize continues to rise annually, aligned with the rapid growth of the livestock industry (Ministry of Agriculture, 2023). Pathogen attacks often hinder efforts to increase national maize productivity. Downy mildew ranks as the most damaging biotic constraint in global maize cultivation (Oren et al., 2020). This systemic infection has the potential to cause 100% yield loss if it attacks plants during the early growth phase (Kalqutny et al., 2022). In Indonesia, downy mildew is caused by oomycete fungi from the genus Peronosclerospora. Three main species have been identified infecting maize in the archipelago: Peronosclerospora maydis, P. philippinensis, and P. sorghi (Muis et al., 2021). These species exhibit varying geographical distributions and epidemiological characteristics. P. maydis is reported as the dominant species widely spread across various maize production centers in Indonesia (Widiantini et al., 2021). P. sorghi has an alternative host in sorghum and can survive in the soil through soil-borne oospore structures (Septian et al., 2020). Determining effective control strategies relies heavily on the accuracy of identifying the infecting species. Morphological and morphometric characterization of reproductive structures remains the most practical conventional method for distinguishing pathogen species (Nurtjahyani et al., 2022). Morphological observations focus on conidiophore color, branching number, and conidial dimensions. However, morphology-based identification faces significant challenges as structural dimensions are often influenced by environmental fluctuations, temperature, and host plant genotypes (Junaid et al., 2024). North Sumatra Province, specifically Langkat and Simalungun Regencies, are maize production centers frequently threatened by downy mildew epidemics. Detailed information regarding the morphological profiles and morphometric variations of the species

infecting various villages in these regions remains limited (Sitanggang, 2024). Environmental diversity among these planting locations has the potential to influence the phenotype and size variations of the pathogens found in the field (Putri et al., 2023). This study aimed to identify and characterize the Peronosclerospora spp. causing downy mildew in eight survey locations in North Sumatra through morphological and morphometric approaches. Accurate data regarding species dominance and dimensional variations are essential as a scientific basis. This information is expected to contribute to the development of more specific, effective, and targeted plant protection strategies tailored to local conditions.

LITERATURE REVIEW

Maize (Zea mays L.) Maize (Zea mays L.) is a determinate annual crop with a life cycle ranging from 80 to 150 days, divided into a vegetative phase in the first half and a generative phase in the second (Iriany et al., 2007). Taxonomically, maize belongs to the Poaceae family and the Poales order. This plant possesses high adaptability to various soil types; however, optimal growth is achieved in fertile, loose, and humus-rich Andosol soils with efficient aeration and drainage systems (Rizki & Irdaningsih, 2020). In cultivation, the use of superior varieties (both hybrid and composite) is a key factor due to advantages such as robust rooting, upright stalks, faster harvest duration (±95 days), and resistance to diseases such as rust (Yovita, 2022). Downy Mildew Disease Downy mildew is a serious global threat to maize and sorghum crops, significantly reducing production through both local and systemic infections (Khoiri et al., 2021). The disease is caused by fungi from the genus Peronosclerospora, which is classified under the Kingdom Chromista and Class Oomycetes (Ginting & Prasetyo, 2016). In Indonesia, there are three main species: P. maydis, P. philippinensis, and P. sorghi, the latter two of which are categorized as A2 Quarantine Pests (OPTK A2) under Ministry of Agriculture Decree No. 25 of 2020. Morphologically, these three species are distinguished by the shape of their conidia: P. maydis is spherical, P. sorghi is oval, while P. philippinensis ranges from elongated ovoid to cylindrical (Hikmahwati et al., 2011). Peronosclerospora spp. are obligate parasites spread via seeds, wind (air-borne), or soil (soil-borne), particularly in the case of P. sorghi, which produces oospores (Bonde, 1982; Muis et al., 2018; Wardani et al., 2023). The disease incubation phase lasts for 11–14 days, with the critical infection period occurring from early growth until the plant reaches 45 days of age (Kalqutny et al., 2020).

Infection Process and Environmental Factors The infection process is heavily influenced by environmental factors. Conidia are formed in the early hours of the morning (01:00–02:00 AM) when humidity exceeds 90% and temperatures are below 24°C, accompanied by the presence of dew on the leaf surface (Budiarti et al., 2012; Sukorini & Roeswitawati, 2023). The release of conidia occurs due to mechanical movement in the conidiophores, which are then carried by the wind to enter the leaf mesophyll cells through the stomata. In addition to conidia, oospores in the soil can also infect seedling roots systemically, causing white-striped chlorosis that eventually turns necrotic and shredded (Sukorini & Roeswitawati, 2023). Symptoms and Yield Loss Typical symptoms of downy mildew include the appearance of chlorotic spots that develop into parallel stripes along the leaf veins. This is caused by a decrease in chlorophyll levels due to fungal colonization of the stomata (Adhi et al., 2019). In advanced infections, the plant will become stunted, leaves will appear stiff and dry, and ear formation will fail. In the morning, a mass of conidia resembling white powder is often visible on the leaf surface. If environmental conditions highly favor the pathogen, epidemics can occur with yield losses reaching up to 90% (Purwanto et al., 2016).

Figure 1. Symptoms of downy mildew disease
Source: Sitanggang (2024)

Maize plants infected by the downy mildew pathogen during the early growth phase (less than one month old) generally experience mortality. The characteristic symptoms that appear are chlorosis and the presence of a white powdery layer on the lower surface of the leaves, consisting of clusters of conidia and conidiophores, which are most clearly visible in the morning (Rustiani et al., 2015). Infection by P. maydis causes significant growth inhibition and has the potential to trigger total crop failure (80%–100%), as systemically infected plants are unable to produce seeds (Ridwan et al., 2015; Ulhaq & Masnilah, 2019).

METHOD

Research Location and Time

This research was conducted at eight maize cultivation sites spread across North Sumatra, including:

a) **Langkat Regency:** Hinai Kiri Village (Secanggang District), Karang Anyar Village (Secanggang District), Pasar VIII Namu Terasi Village (Sei Bingai District), and Purwobinangun Village (Sei Bingai District).
b) **Simalungun Regency:** Merek Raya Village (Raya District), Siporkas Village (Raya District), Marjandi Village (Panombeian Panei District), and Simpang Panei Village (Panombeian Panei District).

Procedures

Morphological Identification

The pathogen identification process was carried out through microscopic observations in the laboratory using a light microscope. The identification stages included:

1. Sampling: Maize leaves showing typical symptoms of downy mildew (elongated chlorosis/striping) were collected from the eight survey locations.
2. Preparation: Fungal structures (conidia and conidiophores) were taken from the surface of the infected leaves, placed on a glass slide with a drop of water or staining solution, and then covered with a cover slip.
3. Microscopic Observation: Observations were performed at 40x magnification to examine the overall fungal structure and 100x magnification for detailed observation of cellular components.

Observation Parameters (Morphometrics)

Characteristics observed to determine the pathogen species included qualitative and quantitative (morphometric) parameters, namely:

1. Color and presence of hyaline in the conidiophores.
2. Number of conidiophore branches.
3. Conidial shape (spherical or subspherical).
4. Morphometrics: Measurement of conidiophore length (µm), conidial diameter (length x width in µm), and conidial wall thickness (µm).

Data Analysis

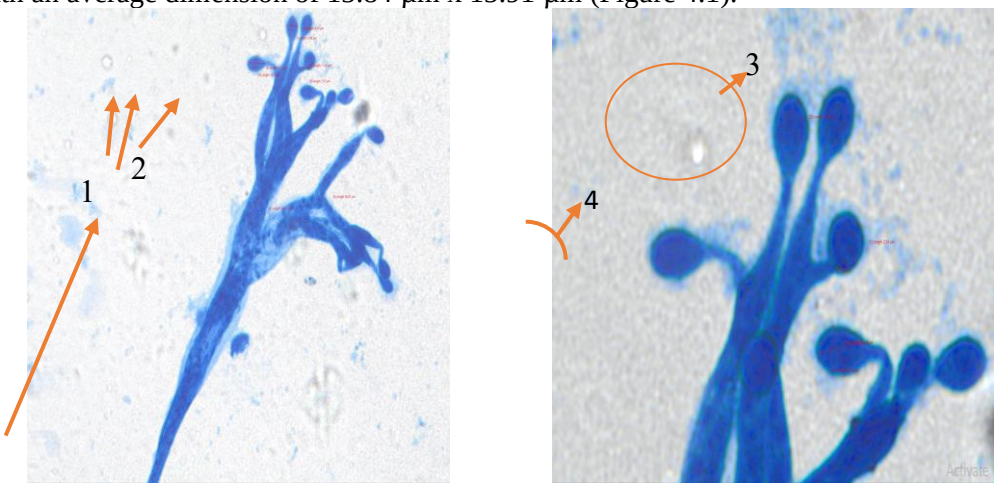
The morphological and morphometric data obtained were compared with literature descriptions and identification keys for Peronosclerospora spp. (e.g., Kuswinanti, 2018). The data are presented descriptively, through inter-location comparison tables, and microscopic photographic documentation to draw conclusions regarding the species causing downy mildew at the research sites.

RESULTS AND DISCUSSION

Morphological Identification Results of Peronosclerospora spp. Causing Downy Mildew on Maize (Zea mays L.)

Morphological characterization using a light microscope was conducted based on parameters including the number of conidiophore branches, the shape and dimensions of the conidia, and the cell wall thickness. Identification results across the eight research locations revealed pathogen characteristics consisting of hyaline conidiophores structured in clusters with 2–4 levels of branching. These structures measured between 150–550 µm in length and were equipped with sterigmata as supports for the conidia. The conidia found possessed thin cell walls and were spherical to subspherical in shape, with diameters ranging from 17–23 x 27–39 µm. Referring to previous literature, this morphological and morphometric profile confirms that all isolates from the eight survey locations are Peronosclerospora maydis. For instance, the isolate from Hinai Kiri Village exhibited specific

characteristics of hyaline conidiophores with three branches and a length of 168.61 µm, as well as spherical or ovoid conidia with an average dimension of 15.84 µm x 15.91 µm (Figure 4.1).



A B

Figure 4.1. Morphological characteristics of P. maydis in Hinai Kiri Village, Secanggang District, Langkat Regency. (A) P. maydis at 40x magnification, (B) P. maydis conidia at 100x magnification.
Legend: 1. Conidiophore; 2. Conidiophore branching; 3. Conidia; 4. Conidial wall
Source: Sitanggang (2024)

Based on morphological analysis, the downy mildew pathogen infecting maize crops in Karang Anyar Village was identified as Peronosclerospora maydis. Specimens from this location exhibited characteristics of hyaline conidiophores with three levels of branching. Morphometric measurements at 100x magnification showed a conidiophore length of 254.07 µm and a conidial wall thickness of 3.73 µm. The conidia found were predominantly spherical, with average dimensions of 28.79 µm x 25.59 µm, as documented in Figure 4.2.

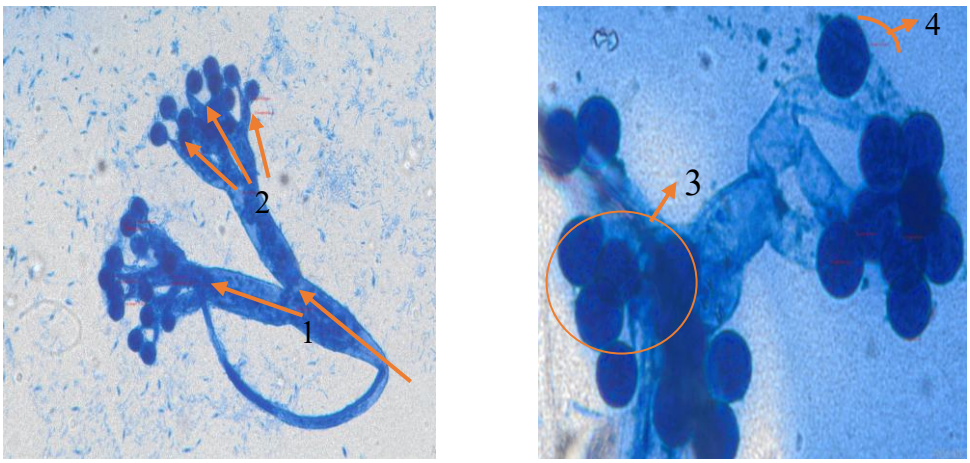


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Figure 4.2. Morphological characteristics of P. maydis in Karang Anyar Village, Secanggang District, Langkat Regency. (A) P. maydis at 40x magnification, (B) P. maydis conidia at 100x magnification.
Legend: 1. Conidiophore; 2. Conidiophore branching; 3. Conidia; 4. Conidial wall.
Source: Sitanggang (2024)

Microscopic analysis of samples from Pasar VIII Namu Terasi Village confirms that the cause of downy mildew at this location is Peronosclerospora maydis. This isolate is characterized by hyaline conidiophores with two levels of branching and a structural length of 157.79 µm. Measurement results at 100x magnification show that the conidia are spherical in shape, with average dimensions of 18.58 µm x 13.05 µm and a cell wall thickness of 4.41 µm. The visual documentation of these pathogen characteristics is presented in Figure 4.3.

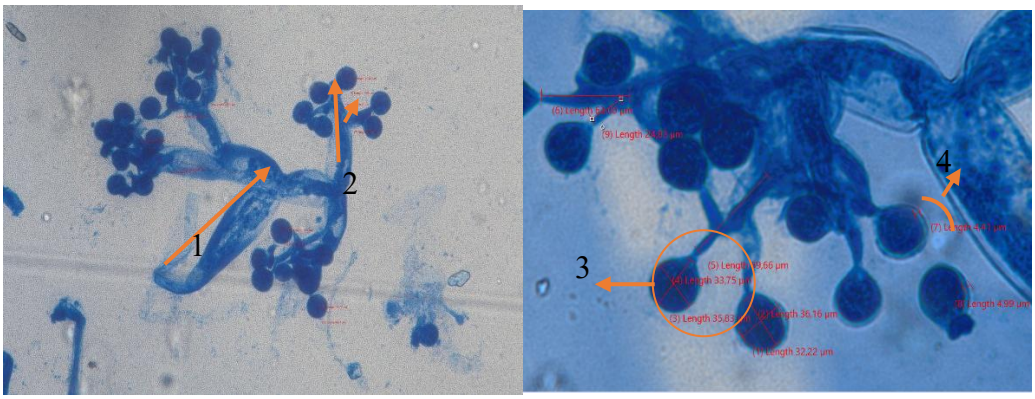

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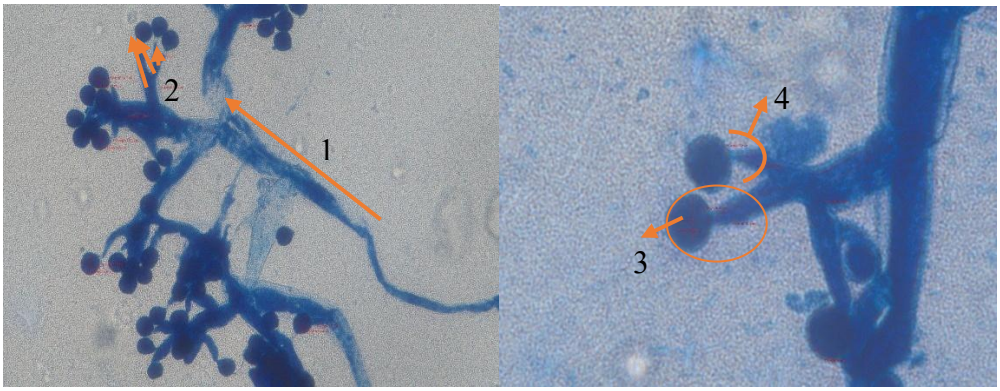
Figure 4.3. Morphological characteristics of P. maydis in Pasar VIII Namu Terasi Village, Sei Bingai District, Langkat Regency. (A) P. maydis at 40x magnification, (B) P. maydis conidia at 100x magnification. Legend:1. Conidiophore; 2. Conidiophore branching; 3. Conidia; 4. Conidial wall
Source: Sitanggang (2024)

Morphological identification of the pathogen from Purwobinangun Village also indicates the presence of the species Peronosclerospora maydis. The primary characteristics observed include hyaline conidiophores with three levels of branching and a structural length reaching 274.81 µm. Observations at 100x magnification describe spherical conidia with average dimensions of 34.13 µm x 29.57 µm and a cell wall thickness of 2.04 µm. Microscopic documentation of this isolate is shown in Figure 4.4.



A B

Figure 4.4. Morphological characteristics of P. maydis in Purwobinangun Village, Sei Bingai District, Langkat Regency. (A) P. maydis at 40x magnification, (B) P. maydis conidia at 100x magnification. Legend: 1. Conidiophore; 2. Conidiophore branching; 3. Conidia; 4. Conidial wall.
Source: Sitanggang (2024)

Morphological identification of the downy mildew pathogen in Merek Raya Village confirms the presence of the species Peronosclerospora maydis. Isolates from this region are characterized by hyaline conidiophores with three levels of branching and a length reaching 235.61 µm. Measurement results at 100x magnification show spherical conidia with average dimensions of 32.41 µm x 29.28 µm and relatively thick conidial walls of 6.13 µm. The microscopic characteristics of this pathogen are presented in Figure 4.5.

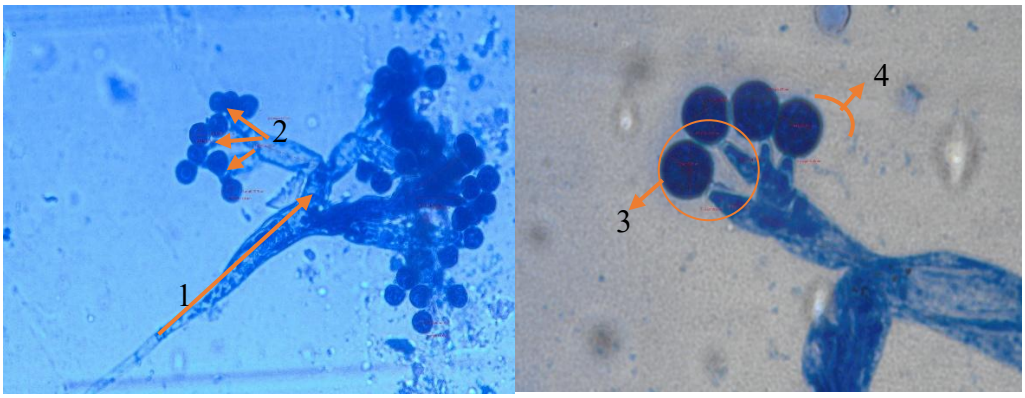


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Figure 4.5. Morphological characteristics of P. maydis in Merek Raya Village, Raya District, Simalungun Regency. (A) P. maydis at 40x magnification, (B) P. maydis conidia at 100x magnification.
Legend: 1. Conidiophore; 2. Conidiophore branching; 3. Conidia; 4. Conidial wall
Source: Sitanggang (2024)

Microscopic analysis of samples from Siporkas Village confirms that the species causing downy mildew in the region is Peronosclerospora maydis. This pathogen exhibits characteristics of hyaline conidiophores with three levels of branching and a considerable length reaching 468.18 µm. Morphometric measurements of the conidia at 100x magnification show a spherical shape with average dimensions of 25.56 µm x 26.11 µm and a cell wall thickness of 3.76 µm. Visual documentation of this isolate can be observed in Figure 4.6.

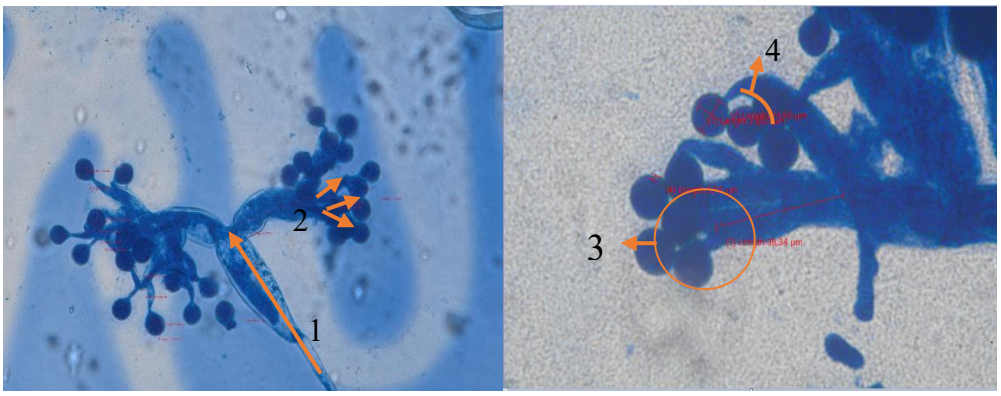

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Figure 4.6. Morphological characteristics of P. maydis in Siporkas Village, Raya District, Simalungun Regency. (A) P. maydis at 40x magnification, (B) P. maydis conidia at 100x magnification.
Legend: 1. Conidiophore; 2. Conidiophore branching; 3. Conidia; 4. Conidial wall
Source: Sitanggang (2024)

Morphological identification conducted on the pathogen from Marjandi Village confirms the presence of the species Peronosclerospora maydis as the cause of downy mildew. The characteristics of the isolate at this location include hyaline conidiophores with three levels of branching and a structural length reaching 359.80 µm. Observations at 100x magnification describe spherical conidia with average dimensions of 33.98 µm x 32.28 µm and a cell wall thickness of 2.18 µm. Microscopic documentation of the Marjandi Village isolate is available in Figure 4.7.

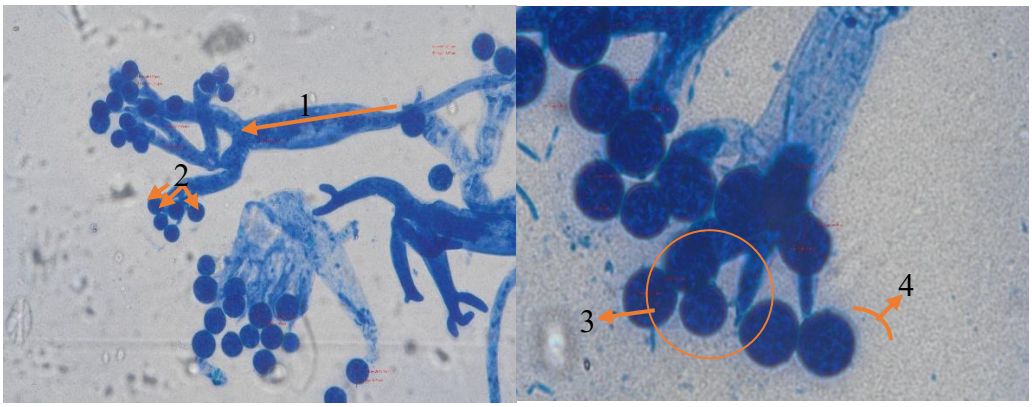

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Figure 4.7. Morphological characteristics of P. maydis in Marjandi Village, Panombeian Panei District, Simalungun Regency. (A) P. maydis at 40x magnification, (B) P. maydis conidia at 100x magnification.
Legend: 1. Conidiophore; 2. Conidiophore branching3. Conidia; 4. Conidial wall
Source: Sitanggang (2024)

Morphological identification of the isolate from Simpang Panei Village confirms that the downy mildew at this location is caused by Peronosclerospora maydis. This pathogen is characterized by hyaline conidiophores with a dichotomous branching structure and a branching frequency of three times. Based on morphometric measurements, the conidiophores have a length of 254.07 µm, while the conidia are spherical with average dimensions of 28.79 µm x 25.59 µm and a wall thickness of 3.35 µm at 100x magnification. The visual characteristics of this isolate are documented in Figure 4.8.

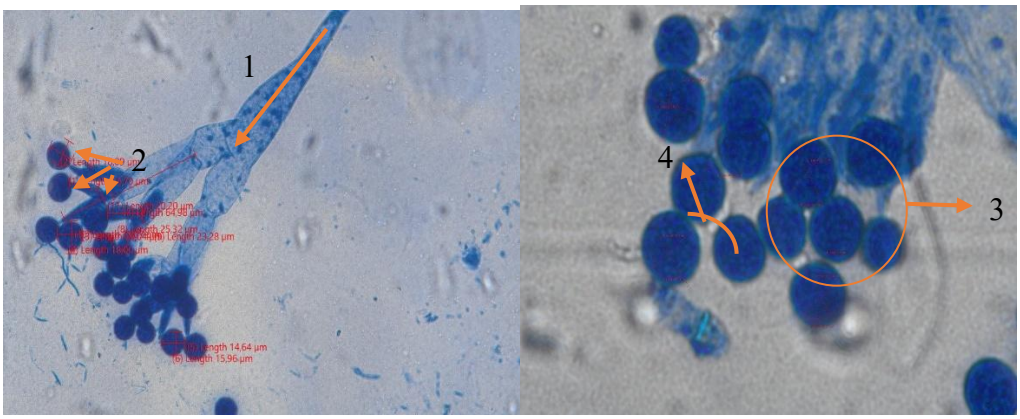

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Figure 4.8. Morphological characteristics of P. maydis in Simpang Panei Village, Panombeian Panei District, Simalungun Regency. (A) P. maydis at 40x magnification, (B) P. maydis conidia at 100x magnification.
Legend: 1. Conidiophore; 2. Conidiophore branching; 3. Conidia; 4. Conidial wall
Source: Sitanggang (2024)

According to Kuswinanti (2018), Peronosclerospora maydis is the causal agent of downy mildew with a distribution specific to the Indonesian region. This differs from P. philippinensis, whose distribution is restricted to the Minahasa area of North Sulawesi, and P. sorghi, which has a broader host range including both maize and sorghum. However, Septian et al. (2020) emphasize the limitations of species identification based on morphological characters. These limitations arise from the lack of unique distinguishing parameters between species. Furthermore, morphometric variables such as conidial dimensions, which have long been used as primary diagnostic characters, are highly fluctuating due to external factors, including climatic conditions and host plant genotypes.

CONCLUSION

Based on the morphological and morphometric identification of the pathogen causing downy mildew on maize (Zea mays L.) across eight observation sites in Langkat and Simalungun Regencies, it can be concluded that:

1. Species Identity: All pathogen isolates found in the eight research locations were identified as Peronosclerospora maydis.
2. Morphological Characteristics: This species is characterized by hyaline conidiophores in clustered structures with 2–4 dichotomous branches. The conidia are spherical to subspherical with thin cell walls.
3. Morphometric Variation: Variations in measurement parameters were observed across locations, with conidiophore lengths ranging from 150–550 µm and conidial diameters ranging from 17–23 x 27–39 µm. These differences are likely influenced by external factors such as local weather and host plant varieties.
4. Distribution: These findings confirm that P. maydis remains the primary pathogen of downy mildew in North Sumatra, consistent with literature identifying this species as the dominant cause of the disease in Indonesia.

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