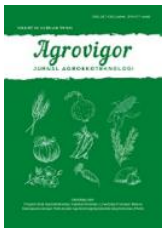
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Article

Evaluation of Downy Mildew Resistance in Several Corn Varieties

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ABSTRACT

Peronosclerospora spp. are pathogens causing powdery mildew disease in corn. The increasing number of corn varieties available in the market leads to fluctuations in powdery mildew levels in corn production centres. This study aims to improve the resistance of several corn varieties to powdery mildew by examining stomatal and trichome function and identifying the pathogens involved. This study was conducted in Morosunggingan Village, Peterongan District, Jombang Regency, in October-November 2025, and involved the observation of 0.5 ha of corn plants. Sampling was carried out every 4 days for each variety, starting 4-26 days after planting. The observed parameters analysed included disease incidence, disease severity, AUDPC value, stomatal and trichome density, and the pathogen causing powdery mildew. The conclusions that can be put forward are: 1) Andalan NK007 and Pioneer P40 varieties are more resistant to powdery mildew disease attacks than Berlian 415 varieties. 2) Lower stomatal density and higher trichomes contribute positively to the level of resistance to powdery mildew disease attacks. 3) The powdery mildew disease attack in Morosunggingan Village, Peterongan District, Jombang Regency, was caused by the fungal pathogen Peronosclerospora

INTRODUCTION

Corn (Zea mays L.) is a cereal crop that serves as a primary source of carbohydrates, protein, fibre, and several vitamins and minerals. It also contains various bioactive compounds and has a relatively low fat content, both of which are beneficial for health. Globally, corn ranks third among food crops, behind rice and wheat. In Indonesia, corn ranks second after rice as a primary food commodity.

One of the main obstacles to corn production is downy mildew, caused by the fungus Peronosclerospora spp. As explained by Muis et al. (2018) and Pakki et al. (2019), the three species of Peronosclerospora that cause downy mildew in Indonesia are P. maydis, which is spread in Java and Kalimantan; P. philipinensis in Sulawesi; and P. sorghi in Sumatra, Yogyakarta, West Java, and Southeast Sulawesi. Downy mildew infections can cause significant losses of up to 90% (Purwanto et al., 2017) and, in certain varieties, yield losses of up to 100%. Downy mildew infection generally occurs during the early phase of plant growth; the initial symptoms appear within 7-25 days after planting, although it can also attack plants up to 45 days after planting without causing significant damage (Kalqutny et al., 2020). If the plant survives, it fails to form cobs, resulting in total crop failure (Ginting et al., 2020). Visible symptoms include yellowing of the leaves and a white coating of fungal spores on the underside of the leaves (Muis et al., 2018; Rosyadi et al., 2023).

Leaf symptoms are characterised by the appearance of chlorotic lines running parallel to the leaf veins, extending to the base of the leaf. In the morning, a velvety coating containing conidiophores and fungal conidia appears on the underside of the leaf, developing over a period of about three days. Affected leaves become stiffer and more upright than healthy leaves (Utomo et al., 2020).

This disease produces a secondary inoculum at humidity levels around 90% and at low temperatures of 23-24°C, when conidia are released from the conidiophores. Conidial germination requires appropriate temperature and humidity, and the presence of a water film on the leaf surface for extended periods is significant for the pathogen mycelia to enter plant tissue cells via stomata. If the humidity is only short-lived, the pathogen will dry out and die, thus preventing infection (Sukorini & Roeswitawati, 2023).

Constitutive resistance structures, particularly leaf anatomy such as stomatal density and trichomes, act as physical barriers against infection. Higher stomatal density increases the severity of powdery mildew attacks. Meanwhile, leaves with dense, long trichomes tend to trap more pathogen conidia than those with sparse, short trichomes (Pudjiwati et al., 2013; Muis et al., 2018). Stomatal and trichome density, as well as trichome length, are genetically inherited physical characteristics of each corn variety.

Morosunggingan Village is one of the corn centres in Peterongan District, Jombang Regency; however, production levels fluctuate with the severity of downy mildew attacks. This relates to the presence of various cultivated varieties, the cultivation methods employed, and the environmental conditions that facilitate disease outbreaks. Therefore, the purpose of this study is to assess resistance to downy mildew in several corn varieties planted in Morosunggingan Village, Peterongan District, Jombang Regency, and to identify the causative fungus and the physical condition of leaf anatomy, especially the density of stomata and trichomes.

MATERIALS AND METHODS

This study was conducted from October to November 2025. The method used in this study was to observe corn planting areas when the plants were 7-25 days old. Sampling was conducted randomly using the systematic diagonal method, as shown in Figure 1. The total area observed for each variety was 0.5 ha, divided into five observation plots, with a sample size of 10% of the plant population per plot. Observation parameters, including disease incidence and severity, were recorded every four days. To assess disease progression, the area under the disease progression curve (AUDPC) was calculated from disease severity over time.

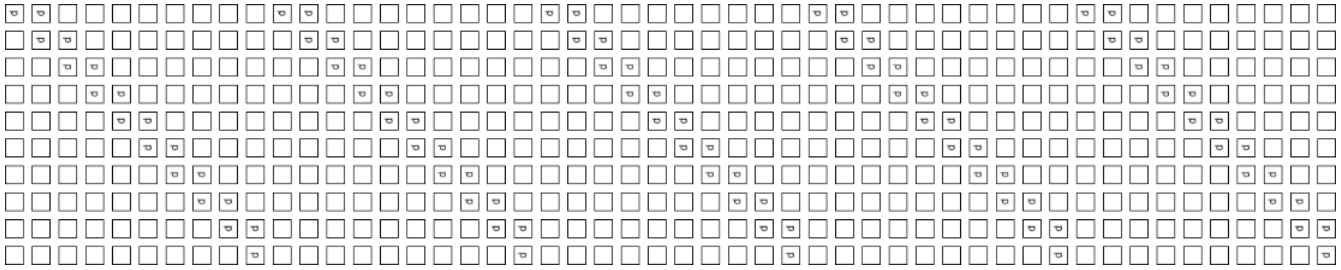


Figure 1. Sampling plan

Description :

p : Observation sample

Plant samples were collected from three different varieties in Morosunggingan Village, Peterongan District, Jombang Regency. The varieties obtained were Pioneer P40 (4,400 m2), Andalan NK007 (4,900 m2), and Berlian 415 (4,700 m2).

Disease incidence was calculated using the following formula:

I = n/N x 100%

Where:

I: Disease incidence (%)

n: Number of corn plants showing downy mildew symptoms

N: Number of corn plants observed

Disease severity is calculated using the formula:

S = ∑ (ni.vi)/(N.V) x 100%

Where:

S: Disease severity

ni: Number of leaves for each attack category

vi: Score for each attack category

N: Number of leaves observed per plant

V: Highest score

The AUDPC value is calculated using the formula:

$$AUDPC = \sum_{i=1}^{n-1}\left[\left(X_{i+1} + X_i\right)/2\right]\times\left[t_{i+1} - t_i\right]$$

Where:

Xi: disease severity at time i

Xi+1: disease severity at time i+1

ti : ith observation

ti+1: next observation

Microscopic Observation

1. Identification of Peronosclerospora

A collection of conidiophores is placed on a glass slide, then two drops of dye (lactophenol cotton blue) are applied to the conidiophores. A coverslip is placed over the conidiophores, left for several minutes, and then examined under a microscope to visualise the structure of Peronosclerospora (Koroch et al., 2024). Identification of Peronosclerospora species is based on morphological and morphometric features, including conidiophore length, branching, and conidia dimensions and shape (Rustiani et al., 2015).

2. Stomata Observation

Samples were taken from the third leaf from the top of the plant. The underside of the leaf was cleaned of dirt, including sand and soil. Nail polish was applied to an area of 1 cm² at the tip, middle, and base of the underside of the leaf. After the nail polish dried, the layer was covered with clear tape. The tape was then slowly removed, lifting the nail polish layer. The piece of tape, which had been covered with nail polish, was placed on a compound microscope slide (Agustamia et al., 2016).

3. Trichome Observation

The number of trichomes was observed using a stereomicroscope. Trichome density was calculated based on the field of view. Observations were made by examining three leaf sections: the base, middle, and tip (Andika et al., 2024).

RESULTS AND DISCUSSION

Based on the observation results on the Andalan NK007 variety, the disease incidence rate was lower than that of the Pioneer P40 variety and the Berlian 415 variety; however, the disease incidence rate in each variety did not always increase, as seen in the observation period 5-6, there was a decrease in incidence (Table 2). Based on the constitutive resistance system, particularly the presence of stomata and trichomes, the Andalan NK007 variety tended to have lower stomatal density than other varieties, and the

number of trichomes was also higher and longer (Figures 3, 4, and Table 4). Pudjiwati et al. (2013) reported a positive correlation between disease incidence and stomatal and trichome densities. This condition results in the Andalan NK007 variety experiencing lower disease incidence. This is consistent with the findings of Astari et al. (2024): mycelial growth from conidial germination is more difficult or takes longer to reach stomata as sites of infection. However, the opposite is true when based on trichome density.

Table 1. Scores/values for each damage category

Score/grade	Damage category
0:	No infection
1:	If <10% of the leaf surface shows symptoms
2:	If 10-25% of the leaf surface shows symptoms
3:	If 25-50% of the leaf surface shows symptoms
4:	If>50% of the leaf surface shows symptoms

The Andalan NK007 and Pioneer P40 varieties have higher trichome densities than Berlian 415 but also exhibit lower disease incidence. Under this condition, trichome density tends to be negatively correlated with disease incidence. Dense trichome conditions will make it more difficult for mycelial growth to reach stomata because the trichomes obstruct stomatal access. Furthermore, Cahyono et al. (2022) explained that variations in trichome size and high trichome density can enhance leaf defence mechanisms against pathogen or disease attacks.

On the other hand, a decrease in disease incidence can be caused by environmental conditions that can induce systemic resistance, such as induced systemic resistance (ISR) due to hypersensitivity reactions or SAR (systemic acquired resistance) caused by avirulent microbes (Ulhaq & Masnilah, 2019; Prasetyo et al., 2021). Meanwhile, Amara et al. (2020) explained that abiotic environmental factors, such as temperature and humidity, strongly influence disease occurrence. Temperatures around 30°C, high humidity, and the presence of dew strongly favour the development of downy mildew in corn plants. In addition, wind gusts significantly reduce leaf-surface humidity, thereby drying out conidia and mycelia.

Table 2. Disease occurrence (%) in each observation period and each variety

Observation period	Variety		
	Andalan NK007	Pioneer P40	Berlian 415
1.	11,42	20,75	26,79
2.	22,85	38,99	52,94
3.	39,28	52,20	66,01
4.	37,85	74,84	95,42
5.	35,71	69,18	81,04
6.	35	30,18	54,24

Based on disease severity, the Andalan NK007 variety exhibited lower severity than the other varieties, and Pioneer P40 exhibited lower severity than Berlian 415. (Table. 3) This condition shows that of the three varieties, Andalan NK007 is a variety that tends to be more resistant than the other two varieties. Likewise, based on the AUDPC value (Figure 2), downy mildew severity was low and development was delayed in the Andalan NK007 variety, as reported by Purwanto et al. (2017).

Based on the AUDPC value (Figure 2), there appears to be a significant difference between the Berlian 415 variety and the Andalan NK007 and Pioneer P40 varieties, but not between the Andalan NK007 and Pioneer P40 varieties. This condition indicates that the downy mildew infection on this variety is more severe and develops faster. Furthermore, based on the constitutive resistance system, particularly the length of the trichomes, the Pioneer P40 variety has shorter trichomes than Berlian 415, yet its AUDPC value is much lower. This indicates that the contribution of trichome length to resistance to downy mildew is lower than that of trichome density.

Table 3. Disease severity (%) at each observation period and for each variety

Observation period	Variety		
	Andalan NK007	Pioneer P40	Berlian 415
1.	1,03	1,77	2,68
2.	1,91	2,73	4,83
3.	2,37	3,22	5,92
4.	2,52	6,33	22,32
5.	3,56	6,57	35,74
6.	2,58	6,82	36,39

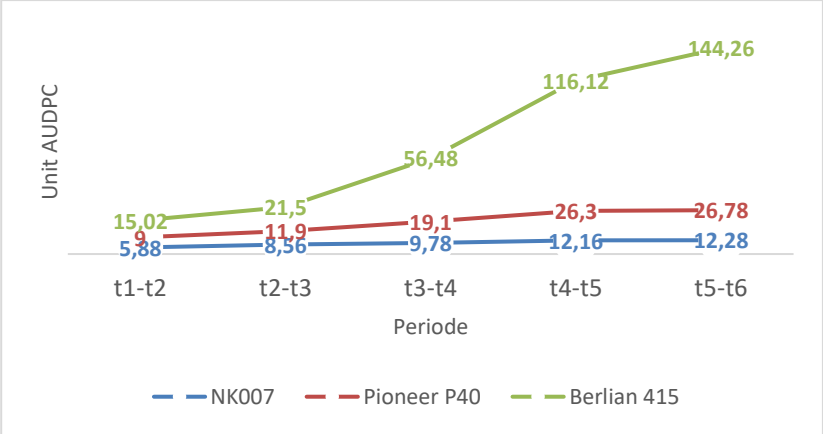


Figure 2. AUDPC values of each variety for 24 days

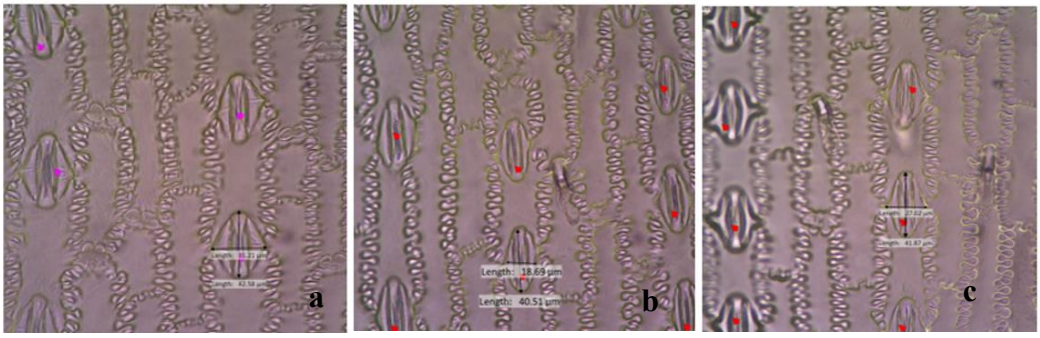


Figure 3. Number of stomata of each variety in the field of view. a: Andalan NK004, b: Pionir P40, c: Berlian 415.

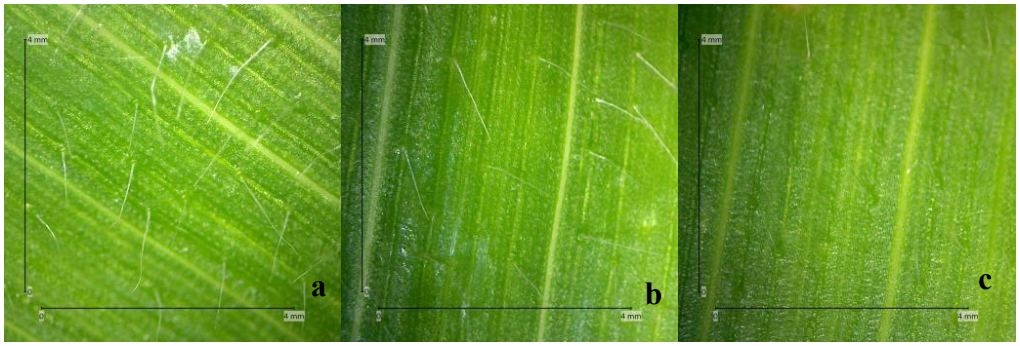


Figure 4. Number of trichomes on each variety in 4x4 cm. a: Andalan NK007, b: Pioneer P40, c: Berlian 415.

Table 4. Average number and length of trichomes for each variety in 4x4 mm

Variety	Number of trichomes	Length of trichomes
Andalan NK007	19	1,214 mm
Pioneer P40	17	0,890 mm
Berlian 415	10	1,096 mm

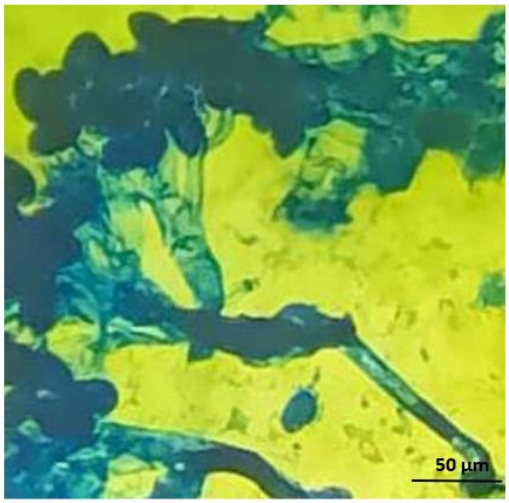


Figure 5. Peronosclerospora Identification Results

Based on microscopic observations of twenty samples from each variety attacked by downy mildew, only one pathogen type was observed. In the samples obtained, there were variations/differences; however, these variations were within the morphometric guideline range, namely conidiophore length 278-318 µm, conidiophore branching 2-3, conidia width 17-20 µm, conidia length 19-22 µm, and conidia shape subspherical to spherical (slightly round to round), which furthermore suggests that the pathogen is suspected to be Peronosclerospora maydis (Adhi et al., 2021; Rustiani et al., 2015; Widiantini et al., 2015).

Adhi *et al*. (2021) menjelasakan bahwa berdasarkan data morfometrik pada strain-strain Peronosclerospora spp. di pulau Jawa dari sentra-sentra penghasil jagung dibedakan atas 2 klaster utama, yaitu klaster A dan klaster B. Klaster A merupakan strain dari Kediri yang mirip dengan *P. Philippinensis,* klaster B terdiri strain dari daerah lain dan Kediri yang mirip dengan *P. maydis*. Strain yang tergabung dalam klaster B memiliki bentuk morfologi konidium yang bulat (spherical) hingga agak bulat (subspherical) yang mengarah pada spesies *P. maydis*, meskipun di dalamnya juga menunjukkan variasi satu sama lain, yang dapat dibedakan dalam dua subklaster, yaitu B1 dan B2. Dijelaskan oleh Shivas *et al*. (2012), bahwa variasi tersebut akibat dari variabilitas intraspesifik morfologi aseksual seperti konidium dan konidiofor dari spesies-spesies Peronosclerospora, sedangkan Telle *et al*. (2011) dan Yao *et al*. (1991) menjelaskan bahwa variasi morfologi dan morfometri dipengaruhi oleh kondisi iklim, jenis tanaman inang atau varietas jagung dan Bock *et al*. (2000) mengemukakan bahwa variasi tersebut dipengaruhi oleh kondisi geografis. Di sisi lain Ginting *et al*., (2020) mengemukakan bahwa morfometrik tidak hanya dilakukan pada konidia (struktur aseksual) namun juga dilakukan pada struktur seksual seperti oogonia atau oospora juga metode molekuler.

Adhi et al. (2021) reported that, based on morphometric data for Peronosclerospora spp. Strains in Java from corn-producing centres are divided into two main clusters: cluster A and cluster B. Cluster A comprises strains from Kediri that are similar to P. philippinensis. Cluster B consists of strains from other regions and Kediri, which are identical to P. maydis. Strains in cluster B have spherical, subspherical, or round-to-slightly-round conidial morphology, which is characteristic of P. maydis. However, within cluster B, there is also variation, which can be divided into two subclusters: B1 and B2. Shivas et al. (2012) explained that this variation is caused by intraspecific variability in asexual morphologies, such as conidia and conidiophores, of Peronosclerospora species. In

contrast, Telle et al. (2011) and Yao et al. (1991) explained that climatic conditions, host plant type, or maize variety influence morphological and morphometric variation. Bock et al. (2000) stated that geographical conditions influence these variations. On the other hand, Ginting et al. (2020) showed that morphometry is applied not only to conidia (asexual structures) but also to sexual structures such as oogonia and oospores, and that molecular methods are also used.

CONCLUSION

1. The Andalan NK007 and Pioneer P40 varieties are more resistant to downy mildew than the Berlian 415 variety.
2. Lower stomatal density and higher trichomes contribute positively to resistance to downy mildew.
3. Downy mildew in Morosunggingan Village, Peterongan District, Jombang Regency, is caused by the fungal pathogen Peronosclerospora maydis.

SUGGESTION

Further studies are needed on the density and length of trichomes in relation to downy mildew infection across additional varieties.

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