



Digital Identification of Mango Leaf Diseases (*Mangifera indica* L.) through the Integrated Use of ImageJ, Plantix, and Agri AI Software for Accurate and Efficient Diagnosis

*Identifikasi Digital Penyakit pada Daun Mangga (*Mangifera indica* L.) melalui Penggunaan Terpadu Perangkat Lunak ImageJ, Plantix, dan Agri AI untuk Diagnosis yang Akurat dan Efisien*

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ABSTRAK

Tanaman pangan memiliki peran penting dalam mendukung ketahanan pangan dan perkembangan peradaban manusia, termasuk tanaman mangga (*Mangifera indica* L.) yang bernilai ekonomi tinggi namun rentan terhadap berbagai penyakit daun. Penelitian ini bertujuan untuk mengidentifikasi jenis penyakit yang menyerang daun mangga serta membandingkan hasil analisis menggunakan perangkat lunak ImageJ, Plantix, dan Agri AI. Metode yang digunakan adalah *purposive sampling* dengan pengambilan sampel daun yang menunjukkan gejala penyakit. Alat yang digunakan meliputi kertas HVS, penggaris, aplikasi Plantix, Agri AI, perangkat lunak ImageJ, dan telepon genggam, sedangkan bahan penelitian berupa sampel daun mangga dan tisu. Prosedur penelitian diawali dengan survei lapangan untuk memilih daun bergejala, kemudian dilakukan identifikasi penyakit menggunakan Agri AI dan Plantix, serta analisis tingkat keparahan penyakit menggunakan ImageJ. Hasil penelitian menunjukkan bahwa sampel A teridentifikasi terserang penyakit antraknosa yang disebabkan oleh jamur *Colletotrichum* sp. dan *Pezizomycotina* sp., sedangkan sampel B terserang bercak daun cercospora oleh jamur *Cercospora* sp. serta bercak daun ganggang yang disebabkan oleh alga parasit *Cephaleuros virescens*. Analisis kuantitatif menggunakan ImageJ menunjukkan tingkat keparahan penyakit pada sampel A sebesar 19,93% dan sampel B sebesar 16,65%. Dapat disimpulkan bahwa kombinasi penggunaan ketiga perangkat lunak mampu mendukung identifikasi jenis penyakit dan tingkat keparahan secara lebih objektif dan akurat.

Kata Kunci:

Analisis citra;
Kecerdasan buatan;
Keparahan;
Mangga;
Penyakit daun

ABSTRACT

Keywords:

Artificial intelligence;
image analysis;
leaf disease;
mango;
severity

Food crops play an important role in supporting food security and the development of human civilization, including mango (*Mangifera indica* L.), which has high economic value but is susceptible to various leaf diseases. This study aimed to identify the types of diseases affecting mango leaves and to compare the analytical results obtained using ImageJ, Plantix, and Agri AI software. The method applied was *purposive sampling* by selecting leaf samples that exhibited disease symptoms. The tools used included HVS paper, a ruler, the Plantix and Agri AI applications, ImageJ software, and a smartphone, while the materials consisted of mango leaf samples and tissue paper. The research procedure began with a field survey to select symptomatic leaves, followed by disease identification using Agri AI and Plantix, and severity level analysis using ImageJ. The results showed that sample A was infected with anthracnose caused by *Colletotrichum* sp. and *Pezizomycotina* sp., whereas sample B was affected by cercospora leaf spot caused by *Cercospora* sp. and algal leaf spot caused by the parasitic alga *Cephaleuros virescens*. Quantitative analysis using ImageJ indicated that disease severity in sample A was 19.93%, while in sample B it was 16.65%. It can be concluded that the combined use of the three software applications supports more objective and accurate identification of disease types and severity levels.

INTRODUCTION

Food crops have played an important role in the development of human culture and civilization for thousands of years. As a basic human need, sufficient food availability is essential to create quality human resources. Food crops provide essential nutrients such as protein, carbohydrates, vitamins, and minerals that support human growth and development. Crop diversity also helps communities obtain balanced nutrition for maintaining good health (Tilman et al., 2017). In Indonesia, food crops are very important because they are the main source of carbohydrates and protein for most of the population. Therefore, strengthening agricultural productivity is necessary to achieve food security and independence (Springmann et al., 2018).

Plant diseases are one of the main problems that reduce agricultural productivity. Diseases can decrease both the quantity and quality of crop yields (Savary et al., 2019; Ristaino et al., 2021). A plant disease is an abnormal condition that disturbs the normal physiological function of plants and reduces their ability to grow and produce optimally. The causes of plant diseases can be divided into two main groups, sum biotic and abiotic factors. Biotic factors include fungi, bacteria, viruses, mycoplasma, nematodes, and parasitic plants, while abiotic factors include environmental conditions such as temperature, humidity, mineral deficiency, and toxic substances (Velásquez et al., 2018). Understanding these factors is important to develop effective disease management strategies (Ristaino et al., 2021; Savary et al., 2019).

Mango (*Mangifera indica* L.) is one of the most popular fruit crops in Southeast Asia, including Indonesia. It belongs to the Anacardiaceae family and has high genetic diversity, which allows it to grow in various environmental conditions. Mango originated from India and later spread to many tropical and subtropical regions, including Southeast Asia. In Indonesia, mango is widely consumed because of its sweet taste and high nutritional value. Morphologically, mango is a large perennial tree with a strong trunk and dense green canopy. The plant consists of roots, stems, leaves, flowers, and fruits. Among these parts, leaves play an important role in photosynthesis and plant growth. Healthy leaves are essential for maintaining optimal fruit production (Rymbai et al., 2014; Lebaka et al., 2021).

However, mango leaves are highly susceptible to various diseases that can significantly reduce plant growth and yield. Early and accurate identification of these diseases is essential to prevent further spread and economic losses. To address this challenge, digital technology has increasingly been applied in agriculture to support rapid and accurate disease diagnosis. Smartphone-based applications such as Plantix and Agrio (Agri AI) enable farmers to identify plant diseases, pests, and nutrient deficiencies by capturing images of affected leaves (Ferentinos, 2018; Picon et al., 2019). These applications provide diagnostic results and treatment recommendations, making disease management more practical and accessible.

In addition, ImageJ software is widely used for digital image analysis due to its efficiency and ability to process large numbers of samples (Schindelin et al., 2012). ImageJ can measure leaf area using a pixel-based threshold method to estimate disease severity quantitatively (Lobet et al., 2013). By integrating image-based identification and quantitative analysis, disease assessment can become more objective and measurable compared to manual observation.

Based on this background, this study aims to identify common diseases that attack mango leaves (*Mangifera indica* L.) through image analysis using ImageJ, Plantix, and Agri AI software. This research is expected to provide a simple and practical method for detecting leaf diseases and measuring disease severity in mango plants.

METHODOLOGY

Time and Place

This research was conducted on Saturday, 22 November 2025, at Jalan Gunung Lingai, Gang Bina Baru 33, Sungai Pinang District, Samarinda City, East Kalimantan 75242, Indonesia.

Sampling Technique

The study used purposive sampling to select mango leaves (*Mangifera indica* L.) that showed visible disease symptoms. Leaves were chosen based on clear signs such as yellow spots, brown or black lesions, and fungal growth on the leaf surface. Healthy leaves were also observed as comparison samples. This method was used to compare different types of diseases found on mango leaves.

Tools and Materials

The tools used were HVS paper, a ruler, a smartphone, the Plantix application, the Agri AI application, and ImageJ software. The materials used were mango leaf samples and tissue paper.

Image Collection and Identification Process

The selected leaves were cleaned carefully using tissue paper to remove dust. Each leaf was placed on white HVS paper to create a clear background. A ruler was placed beside the leaf to provide measurement scale. The leaves were photographed using a smartphone camera under natural lighting conditions. The images were first analyzed using the Plantix application to identify the type of disease. After uploading the image, the diagnosis result was recorded. The same images were then analyzed using the Agri AI application by selecting the mango leaf category. The disease name and severity information provided by the application were recorded.

Disease Severity Measurement

The images were further analyzed using ImageJ software to measure the level of disease severity. Image contrast was adjusted to improve clarity. The threshold feature was used to separate healthy and infected areas based on color differences. The software then calculated the total leaf area and the infected area. Disease severity was calculated by comparing the infected area to the total leaf area and expressing the result as a percentage (Rosadi et al., 2022).

Observation Parameters

The parameters observed in this study were the type of disease identified by Plantix and Agri AI, and the percentage of disease severity measured using ImageJ. The results from all methods were compared to determine the final identification and severity level.

RESULTS AND DISCUSSION

The identification results of mango leaf diseases were obtained using two artificial intelligence applications, Agri AI and Plantix, and further analyzed quantitatively using ImageJ software. The combination of qualitative identification and quantitative measurement provides a clearer understanding of the disease type and its severity level.

Disease Identification Using Agri AI

Based on the analysis using Agri AI, mango leaf sample A was identified as anthracnose. The symptoms observed included dark irregular spots and necrotic lesions on the leaf surface. These characteristics can be clearly seen in Figure 1(a). Anthracnose in mango plants is commonly caused by fungi from the genus *Colletotrichum*. This pathogen attacks young leaves first and may spread to branches, flowers, and fruits if not controlled. The infection usually begins as small brown to black spots that expand and merge, reducing the photosynthetic area of the leaf. Severe infection may cause leaf wilting and premature leaf drop.

Rattanakreetakul et al. (2023) identified and characterized two newly described *Colletotrichum* species associated with symptomatic mango tissues, highlighting the important role of this fungal genus in the etiology and progression of mango anthracnose. Similarly, Asmita et al. 2022 explained that anthracnose is one of the most destructive fungal diseases affecting mango, particularly in warm and humid regions, and it can cause significant losses in both pre-harvest and post-harvest stages.

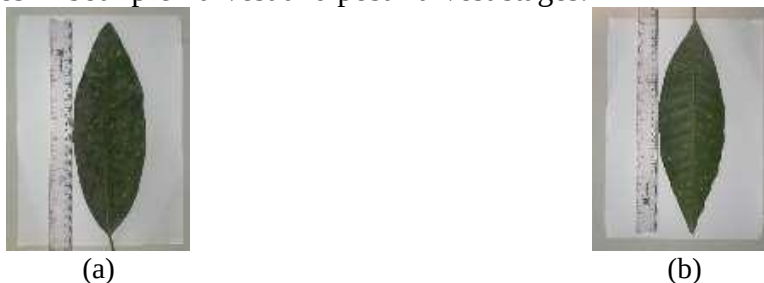


Figure 1. Identification Results of Mango Leaf Diseases Using Agri AI Application. (a) Sample A diagnosed with anthracnose caused by *Colletotrichum* sp.; (b) Sample B diagnosed with Cercospora leaf spot caused by *Cercospora* sp. using Agri AI application.

Meanwhile, sample B was identified by Agri AI as Cercospora leaf spot, as shown in Figure 1(b). The symptoms included small brown circular spots scattered across the leaf surface. These spots may enlarge over time and lead to leaf damage. Cercospora infection is known to reduce chlorophyll content and photosynthetic efficiency. According to Berutu et al. (2023), Cercospora leaf spot spreads through airborne spores and develops rapidly under warm and wet conditions. The disease may also survive in plant residues, increasing the risk of repeated infection.

Disease Identification Using Plantix

Further analysis using Plantix showed different but related results. Sample A was identified as sooty mold caused by fungi belonging to Pezizomycotina. The infection is characterized by dark gray to black fungal growth covering the leaf surface, as presented in Figure 2(a). Unlike anthracnose, sooty mold does not directly infect plant tissue but grows on honeydew secreted by insects. However, it can still interfere with photosynthesis by blocking sunlight and gas exchange.

Fiani, A., & Hadiyan, (2017) explained that sooty mold forms a thin black layer on leaves and fruits, especially in plants previously attacked by insects. Although it is considered non-parasitic, heavy colonization can reduce plant vigor and growth.



Figure 2. Identification Results of Mango Leaf Diseases Using Plantix Application. (a) Sample A identified with sooty mold caused by *Pezizomycotina* sp.; (b) Sample B identified with algal leaf spot caused by *Cephaleuros virescens* using Plantix application.

In contrast, sample B was identified by Plantix as algal leaf spot caused by *Cephaleuros virescens*, as shown in Figure 2(b). The symptoms included orange to brown slightly raised spots on the leaf surface. These spots are formed by algal colonies growing within plant tissue. Rizky et al. (2023) stated that *Cephaleuros virescens* is a parasitic alga that commonly infects mango leaves in tropical regions with high rainfall and humidity. The infection can cause defoliation and reduce plant productivity if severe.

The differences in disease identification results obtained from the two artificial intelligence applications may be explained by the similarity of visual symptoms between Anthracnose and Sooty mold observed on mango leaves. Anthracnose, which is commonly caused by species of *Colletotrichum*, typically produces necrotic lesions that appear as brown to black spots on the leaf surface. As the infection progresses, these lesions may enlarge and merge into irregular dark patches. Such dark necrotic areas may visually resemble superficial fungal growth when captured in digital images, especially when the disease reaches advanced stages. In addition, the appearance of anthracnose symptoms can vary depending on the stage of infection, which may complicate accurate visual identification (Dofuor et al., 2023).

On the other hand, sooty mold is a superficial fungal growth that develops on honeydew secreted by sap-sucking insects such as aphids, scale insects, or whiteflies. The fungi form a black soot-like layer on the surface of leaves, which may cover a large portion of the leaf area and reduce photosynthetic efficiency by blocking light penetration. Because this fungal layer also appears as dark or black patches on the leaf surface, its visual characteristics may overlap with necrotic lesions caused by other plant diseases when observed through photographic images (Liu et al., (2024). This overlap in visual symptoms can make it difficult to distinguish between anthracnose lesions and sooty mold growth based solely on digital images.

The similarity of visual characteristics between different diseases may influence the performance of artificial intelligence–based plant disease detection systems. Most AI-based plant disease identification tools rely on image pattern recognition, including features such as color distribution, lesion morphology, and surface texture. When different diseases share similar visual features, classification models may produce inconsistent or overlapping predictions. Previous studies have shown that factors such as lighting conditions, image quality, and variations in symptom development stages can significantly affect the accuracy of image-based disease classification systems (Nyawose et al., 2025); (Upadhyay et al., 2025; Shafay et al., 2025).

In this study, the use of two artificial intelligence–based plant disease identification applications was not intended to determine which application was absolutely more reliable, but rather to compare the diagnostic outputs generated by both systems and evaluate whether they could provide mutually supportive information. Comparing the results from multiple digital diagnostic tools can serve as a form of cross-validation, helping researchers assess the consistency of disease identification results.

Furthermore, to reduce potential bias from visual interpretation alone, quantitative image analysis using ImageJ was conducted to measure the symptomatic leaf area objectively. The integration of qualitative identification from AI applications and quantitative image analysis provides a more comprehensive approach for evaluating disease symptoms and estimating their severity. This combined approach can improve the reliability of disease assessment based on digital image analysis.

Disease Severity Analysis Using ImageJ

Quantitative analysis using ImageJ software provided objective measurement of disease severity. The results are presented in Table 1.

Based on Table 1, sample A had a total leaf area of 1358.66 cm², while sample B had a slightly larger total area of 1397.25 cm². However, the diseased area in sample A was 23.165 cm², which was significantly higher than sample B with only 2.701 cm². The number of lesions was also higher in sample A (47 lesions) compared to sample B (28 lesions).

The calculated disease severity percentage showed that sample A had a severity of 19.93%, while sample B had 16.65%. Although sample B had a larger leaf size, the proportion of infected area was higher in sample A. This indicates that anthracnose and associated fungal infection caused more extensive tissue damage compared to Cercospora and algal leaf spot in sample B.

Table 1. Disease Severity Analysis on Mango Leaves (*Mangifera indica*)

No.	Sample	Total Leaf Area (cm ²)	Healthy Area (cm ²)	Diseased Area (cm ²)	Lesions	Severity (%)
1	Mango Leaf Sample A	1358.66	1087.95	23.165	47	19.93%
2	Mango Leaf Sample B	1397.25	1165.60	2.701	28	16.65%

Rosadi et al. (2023) reported that digital image analysis using ImageJ can effectively measure infected leaf area and provide accurate severity estimation compared to visual scoring methods. Similarly, Dhawan et al. (2024) explained that combining image segmentation with disease classification improves reliability in plant disease evaluation.

The higher severity value in sample A suggests that anthracnose infection may have progressed further compared to the diseases found in sample B. Environmental factors such as humidity, temperature, and plant health condition may influence the difference in severity between the two samples. Zakaria (2021) explained that *Colletotrichum* species, which cause anthracnose in many tropical fruit crops, develop well in warm and humid environments. These conditions support infection and lesion formation on plant tissues, especially leaves and fruits.

Implications of the Study

The results of this study show that combining AI-based applications (Agri AI and Plantix) with image analysis software (ImageJ) provides both qualitative and quantitative understanding of plant diseases. AI applications help identify disease types quickly, while ImageJ measures severity more objectively. This integrated approach can support farmers and researchers in making better decisions regarding disease management and control strategies.

Generally, sample A showed higher disease severity and more extensive tissue damage compared to sample B. The findings confirm that digital analysis methods are useful tools for early detection and evaluation of mango leaf diseases.

CONCLUSION

Based on the results of this study, mango leaves (*Mangifera indica* L.) exhibited different diseases. Agri AI identified sample A as infected with anthracnose caused by *Colletotrichum* sp., while sample B was infected with Cercospora leaf spot caused by *Cercospora* sp. and algal leaf spot caused by *Cephaleuros virescens*. Plantix identified sample A as affected by sooty mold caused by *Pezizomycotina* sp. and sample B by algal leaf spot caused by *C. virescens*. ImageJ analysis showed greater disease severity in sample A (19.93%) than in sample B (16.65%).

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