Anthracnose Disease Attack on Chili Plants in West Sumatra

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***Abstract*—This study aims to determine *Colletotrichum spp*'s attack level. causing anthracnose disease in chili in West Sumatra. The location of plant samples is determined based on the chili plant production centers in the high and lowlands. Sampling is done by randomized multi-stage sampling. The first stage determines two districts in the highlands, namely Tanah Flat and Agam, and two districts in the lowlands, namely Padang Pariaman and Padang City. The second stage determines two sub-districts in each district, namely X koto and Batipuh districts (Tanah Datar regency), Ampek Angkek and Sungai Pua districts (Agam regency), 2 x 11 Enam Lingkung and Patamuan districts (Padang Pariaman regency) and Pauh and Kuranji districts (Padang city). The third stage determines the Nagari, and each Nagari selects two chili planting fields with the criteria of having a land area of ± 400 m2; on that land, the chili plants have borne fruit. In each field, 40 sample plants were taken systematically randomly. The parameters observed included the infested plants, the infested fruit, and the intensity of the attack. The results showed that the attack of Colletotrichum spp. causing anthracnose disease on chili plants in West Sumatra was relatively high, with the infested plants ranging from 36.32% to 62.85% (average 45.13%), the number of infested fruits 23.50%-48.00% (average 36.39%) and the intensity of attack 37.8%-73.33% (average 52.85%). There was no visible difference in attack between highlands and lowlands.**

***Keywords*—*Colletotrichum spp*; disease incidence; multi-stage sampling**.

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I. INTRODUCTION

Chili pepper, scientifically known as *Capsicum annuum L.*, is a popular spice used worldwide [1], [2], [3], [4]Chili peppers are a staple in many cuisines and have numerous health benefits, including boosting metabolism and providing a good source of vitamins A and C. They are known for their vibrant colors and varying heat levels from capsaicin. Chili peppers are fruits from plants in the Capsicum genus, known for their fiery flavor, which ranges from mild to extremely hot. They originated in the Americas and are now popular globally [5], bringing spice and flavor to countless dishes. Capsaicin, the active compound in chili peppers, gives them heat. Capsaicin concentration is measured in Scoville Heat Units (SHU), which indicates the pepper's spiciness level—higher SHU means hotter peppers [6].

Chili pepper (*Capsicum annum L.*) is one of the essential horticultural commodities in Indonesia [7], [8]. It has a relatively high economic value due to its significant role in meeting domestic needs and being an export commodity and raw material for the food industry. The productivity of chili peppers in Indonesia from 2020-2022 was 8.8 tons/ha, 10.4 tons/ha, and 10.6 tons/ha, respectively. Meanwhile, the productivity of chili peppers in West Sumatra during the same period was 11.16 tons/ha, 10.4 tons/ha, and 9.6 tons/ha [9]. This productivity still needs to improve compared to the optimal chili productivity of 20-22 tons/ha [10]. Various factors can cause chili peppers' low productivity, including attacks by the fungus *Colletotrichum spp.*, which causes anthracnose disease.

Anthracnose is one of the most critical diseases in chili plants, seed-borne, and can reduce both the quantity and quality of chili fruits, resulting in significant economic losses [11], [12], [13]. This disease can reduce yields by 45-60%. Yield losses in the field due to anthracnose during the rainy season can reach 80%, while during the dry season, it can cause losses of 20-35%. If no proper control measures are taken, the yield loss can reach 100% [13]. This fungus can also cause significant economic losses in tropical and subtropical regions, with yield losses reaching 65% and post-harvest losses reaching 100% [14].

Symptoms of anthracnose disease on fruits are characterized by yellow-brown rot, resembling sunscald, followed by wet rot, sometimes accompanied by black lesions. Infected seeds may fail to germinate, or if they do, they can lead to seedling collapse. Attacks on mature plants can cause the death of the shoots, followed by the drying and death of other parts of the plant, such as branches, which turn brown to black. The *fungal aservulus* appears on chili stems as a protrusion [13].

The pathogen causing anthracnose disease is *Colletotrichum spp.*, a seed-borne facultative parasite from the order *Melanconiales*, characterized by conidia arranged in an *aservulus* (asexual structure in parasitic fungi). Species of *Colletotrichum spp.* that attack chili plants in Indonesia include *C. gloeosporioides*, *C. acutatum*, and *C. capsici* [15]. The most common causes of anthracnose in chili plants in Indonesia are *C. capsici* and *C. gloeosporioides* [16].

Colletotrichum spp. is a facultative parasitic fungus from the order Melanconiales, with conidia arranged in an aservulus. Fungi of the genus *Colletotrichum* belong to the class *Sordariomycetes* [17]. *Colletotrichum spp.* has various species, including *C. capsici*, *C. acutatum*, *C. gloeosporioides*, *C. coccodes*, and *C. dematium* [18]. In Indonesia, *C. gloeosporioides*, *C. acutatum*, and *C. capsici* are commonly found to attack chili plants [15]. The most common species causing anthracnose in chili plants in Indonesia are *C. capsici* and *C. gloeosporioides* [16]. It has been reported that *C. gloeosporioides* infects both immature and mature chili fruits, while *C. capsici* only infects mature fruits [19]. *Colletotrichum spp.* can infect chili peppers at all growth stages, from seedling to fruiting. The development of this disease is supported by humid conditions and relatively high temperatures [20]. *C. acutatum* is frequently found in Indonesia and can infect young and mature fruits [21]. *C. truncatum* can infect various plant species with varying pathogenicity [22].

Black lesions on infected fruits characterize the disease. The main species causing anthracnose include *Colletotrichum capsici*, which is often found on chili plants and causes significant damage to chili fruits [11]. *Colletotrichum gloeosporioides* is an important pathogen in various plants, including shallots and tea, which can significantly reduce production [23] Additionally, *Colletotrichum acutatum* is known to cause anthracnose in tomatoes, leading to reduced yields [24]. Control of this disease is generally carried out using disease-resistant cultivars and good agronomic practices to prevent the spread of the fungus [25]. This study aims to determine the anthracnose disease attack on chili plants in West Sumatra and the difference in attack levels between the low and highlands.

II. MATERIALS AND METHODS

A. Research Setting

The research was conducted in several chili production centers with different geographical conditions in West Sumatra, highlands, and lowlands in four districts, including Tanah Datar Regency, Agam Regency, Padang Pariaman Regency, and Padang City. The primary reference for determining the sample plant locations was the central chili production areas in West Sumatra's lowland and highland regions. The sample was collected using a stratified random sampling method (Multi-Stage Sampling). The first stage involved selecting two regencies in the highland areas, namely Tanah Datar and Agam, and two in the lowland areas, namely Padang Pariaman Regency and Padang City. In the second stage, two districts from each regency were selected: X Koto and Batipuh (Tanah Datar Regency), Ampek Angkek and Sungai Pua (Agam Regency), 2x11 Enam Lingkung and Patamuan (Padang Pariaman Regency), and Pauh and Kuranji (Padang City). The third stage involved selecting villages, and in each village, two chili farms were chosen, with the criteria being a plot size of approximately 400 m² and the chili plants already bearing fruit. On each plot, 40 sample plants were selected using a systematic random sampling technique.

B. Affected Plants

In all sample plants, anthracnose symptoms were observed, and the number of plants showing symptoms of anthracnose disease was counted. Then, the percentage of affected plants was determined using the formula:

$$P = \frac{a}{b}\ x\ 100\% \quad (1)$$

Descriptions:
I = Disease incidence
a = number of affected plants
b = number of observed plants

C. Number of Affected Fruit

Early fruits and ripe fruits showing symptoms of anthracnose disease were observed, and the percentage of infected fruits was calculated using the formula:

$$P = \frac{a}{b}\ x\ 100\% \quad (2)$$

Description:
P = Affected fruit percentage
a = Number of affected fruits
b = Number of observed fruits

D. Disease Severity

The severity of the disease attack was determined by observing chili fruits with anthracnose symptoms. The percentage of disease severity can be calculated using the formula:

$$\text{KP} = \sum \frac{nxv}{NxZ}\ \text{x}\ 100\% \quad (3)$$

Descriptions:
KP = Disease severity
n = Number of plants in each score
v = Scale value of disease attack for each plant
Z = The score value of the disease attack
N = Number of observed plant

The attack category value (score) for anthracnose disease is based on the scale of damage to affected plants modified [26]. Table 1 shows the value of the attack category (score). This scoring system helps assess the severity of anthracnose disease in chili plants, which is crucial for monitoring crop health and implementing appropriate management practices.

Table 1 shows that score 0 is no damage to the plant. Score 1 is the portion of the area impacted by the disease ranges from 1% to 20%, indicating minimal infection. Score 2 is the portion of the area impacted by the disease that spans from 21% to 40%, suggesting a moderate level of infection. Score

3 is the portion of the area affected by the disease that falls between 41% and 60%, indicating a significant level of infection. Score 4 is the portion of the area impacted by the disease that exceeds 60%, reflecting a severe level of infection.

TABLE I
SCORE OF THE ANTHRACNOSE DISEASE IN CHILI PLANT

Score	Level of damage
0	No damage
1	Spot area 1 – 20%
2	Spot area 21 – 40%
3	Spot area 41 – 60%
4	Spot area > 60%

III. RESULTS AND DISCUSSIONS

A. *The Symptom of Anthracnose Disease in Chili Plant*

Figure 1 shows the symptoms of anthracnose disease in chili plants, and Figure 1A illustrates the symptoms present in harvested chili fruits. These symptoms often manifest as dark, sunken lesions that may appear to have concentric rings surrounding them, which can ultimately result in the fruit's decay. Meanwhile, Figure 2A depicts the symptoms observed in the field, showcasing the broader impact on the plants before harvesting.

Fig. 1 Symptoms of anthracnose disease on chili plants and fruits A. Symptoms on harvested chili fruits. B. symptoms in the field

From Figure 1, the symptoms of anthracnose disease on chili fruit are characterized by the presence of blackish-brown spots on the surface of the fruit; the spots will grow larger, cause a wrinkled indentation, and dry out over time. The symptoms of anthracnose on the surface of chilies are characterized by blackish-brown spots, after which it expands, causing soft rot to dry rot [27]. The attack of *Colletotrichum capsici* is latent, occurs at several stages of development on the fruit, and the decay will be delayed until the fruit ripens [28]. The disease spreads very quickly in warm and humid temperatures [29].

B. *Plants Affected by Colletotricum spp.*

Plants infested with *Colletotricum spp*. in upland and lowland areas can be seen in Table 2. Table 2 shows that the percentage of plants infected with *Colletotrichum spp.* in all locations of the sample plants (highland and lowland) showed results that were not significantly different from each other except for the percentage of infected plants in District of 2 x 11 Enam Lingkung, which was only significantly different from the percentage of infected plants in X Koto and Batipuh.

TABLE II
PLANTS INFESTED WITH *COLLETOTRICUM SPP*. IN UPLAND AND LOWLAND AREAS

Sample location	Plants infested with *Colletotricum spp* (%)
2 x 11 Enam Lingkung **	62.50a
Patamuan **	51.00ab
Kuranji **	48.50abc
Pauh **	41.00bc
Ampek Angkek*	40.50bc
Sungai Pua *	40.50bc
Batipuh *	37.50bc
X Koto *	35.50c
Mean	44.62

Numbers in the same column and followed by the same lowercase letter are not significantly different according to LSD at the 5% significant level. Notes: * highland ** lowland

The district of 2 x 11 Enam Lingkung had the highest percentage of anthracnose-infested plants, 62.50%, and the lowest, 35.50%, in X Koto. In general, the percentage of infested plants is relatively high, and there is no significant difference between the percentages of infested plants in the lowlands and highlands.

C. *Infected Fruit with Colletotricum spp.*

Table 3 shows anthracnose-infected fruits in highland and lowland areas. It shows that the percentage of fruit infected with *Colletotrichum spp.* in all locations of sample plants (highland and lowland) showed significantly different results between each other, namely District of Ampek Angkek, Batipuh, and 2 x 11 Six Lingkung showed significantly different results with Pauh and X Koto.

TABLE III
ANTHRACNOSE-INFECTED FRUITS IN HIGHLAND AND LOWLAND AREAS.

Sample Location	Infected fruit with *Colletortrichum* spp (%)
Ampek Angkek *	48.00a
Batipuh *	47.00a
2 x 11 Enam Lingkung **	47.00a
Kuranji **	37.50ab
Patamuan **	32.00ab
Sungai Pua *	29.00ab
Pauh **	26.50b
X Koto *	23.50b
Mean	36.31

Numbers in the same column and followed by the same lowercase letter are not significantly different according to LSD at the 5% significant level. Notes: * highland ** lowland

The highest percentage of infected fruit was found in the sample of observation land in Ampek Angkek District, namely 48.00%. In contrast, the lowest rate of anthracnose-infected fruit was found in the sample of observation land in X Koto District, namely 23.5%. Symptoms of anthracnose disease begin with blackish-brown and dry spots on the surface of red chili fruit [30]. Symptoms of blackish-brown spots can grow and develop into symptoms of soft rot on red chili fruit. This disease causes lesions or wounds on the fruit, which can reduce its selling value [31]. In chili peppers, these spots will develop into brown depressions on the fruit [32].

D. Disease Incidence of Colletotricum spp.

The incidence of *Colletotricum spp.* attack in upland and lowland areas can be seen in Table 4. From Table 4, it can be seen that the intensity of *Colletotrichum spp.* attack in all locations of the sample plants (highland and lowland) showed significantly different results, namely Ampek Angkek, which showed significantly different results from Kuranji, Sungai Pua, and X Koto. The intensity of attack ranged from 37.00 to 73.33%, with an average of 52.18%. The highest attack was found on chili plants in Ampek Angkek District, 73.33%, while the lowest intensity in X Koto District was 37.00%. The high attack of *Colletotrichum spp.* in all chili planting locations in West Sumatra, as shown in Tables 2, 3, and 4, is caused by various factors.

TABLE IV
DISEASE INCIDENCE OF ANTHRACNOSE IN HIGHLANDS AND LOWLANDS

Sample location	**Infected plant *Colletotrichum spp* (%)**
Ampek Angkek *	73.00a
Pauh **	63.00ab
2 x 11 Enam Lingkung **	58.50ab
Patamuan **	51.00ab
Batipuh *	50.00ab
Kuranji **	43.50b
Sungai Pua *	41.50b
X Koto *	37.00b
Mean	52.18

Numbers in the same column and followed by the same lowercase letter are not significantly different according to LSD at the 5% significant level. Notes: * highland ** lowland

Farmers usually use seeds from their fields that have been attacked by *Colletotrichum spp.,* which is seed-borne, so this pathogen has likely been transmitted through seeds. In addition, farmers in this research location plant chilies continuously so that the source of inoculum is always available. Land sanitation is also lacking, where infected chili fruit is scattered on the land, and diseased fruit is not picked up or discarded. Environmental factors such as high humidity and rain are also favorable. It was stated by [33] that wet conditions and rainwater play a role in spreading spores from one plant to another. The development of anthracnose disease is greatly assisted by air humidity and rain [34]. Environmental factors and plant age influence the intensity of disease attacks [35]. The disease occurrence is determined by three components: susceptible plants, virulent pathogens, and a favorable environment, also known as the disease triangle [36]. In this study, altitude did not affect the attack of *Colletotrichum spp.* This fungus is known to attack plants anywhere in the tropics and subtropics.

IV. Conclusion

The findings revealed that Colletotrichum spp., a fungal pathogen, was the primary cause of anthracnose disease affecting chili plants in West Sumatra. The extent of infection among the plants varied significantly, with infection rates ranging from 36.32% to 62.85%, and an average infection rate of 45.13%. A closer examination of the fruits showed that between 23.50% and 48.00% were infected, yielding an average of 36.39%. The severity of the disease, measured by the intensity of the attack, ranged from 37.8% to a concerning 73.33%, with an average of 52.85%. Notably, there were no significant differences in the rate of infection between the highland and lowland regions, suggesting that the disease is uniformly affecting chili cultivation regardless of elevation.

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