

Diversity of Pathogenic Fungi and Disease on Vegetable Crops at Polyculture Systems

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Abstract. Vegetables polyculture system is potentially increasing pathogenic fungi diversity because various plant hosts are available. There is no data about pathogenic fungi diversity at polyculture vegetable farming in Serang village, District of Karangreja, Purbalingga Regency. This study aimed to determine pathogenic fungal diversity and disease percentage caused by the fungi at polyculture vegetable farming in Serang village, District of Karangreja, Purbalingga Regency. This research used purposive random sampling. Infected plants were collected at ten polyculture farming locations and fungal identification was performed at the laboratory. Fungi were identified morphologically based on the signs, symptoms, as well as macroscopic and microscopic characters. The fungi's pathogenity was determined by applying Koch's postulate test. The data were analyzed descriptively through literature comparison. The results showed that seven fungal species were found at polyculture farms in Serang Village. The obtained fungi were *Colletotrichum* sp., *Fusarium* sp., *Alternaria* sp., *Septoria* sp., *Cercospora* sp., *Botryodiplodia* sp., and *Nigrospora* sp. The lowest damage was 18.24% on tomato fruit infected by *Fusarium* sp. and the highest was on chili plants which were caused by *Colletotrichum* sp. The data is the first report for polyculture system. The obtained data has important implication for the management of vegetables farming in Serang Village.

Key words: disease percentage; fungal diversity; polyculture; vegetable

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INTRODUCTION

Serang Village, Karangreja District, Purbalingga Regency, has a suitable climate for horticultural farms. The village has an area of 3,052.44 ha with approximately of 1,245.07 ha (43.26%) is utilized for monoculture and polyculture farms. Horticulture commodities planted in Serang Village include potato, cabbage, spring onion, yardlong bean, chili, cayenne pepper, tomato, green bean, eggplant, and carrot (Central Bureau of Statistics, 2020).

The production of most vegetable crops commodities in the Karangreja sub-district has decreased from 2018 to 2019, especially for chili, potato, cabbage, spring onion, cayenne pepper, tomato, yardlong bean, green bean, and eggplant (Central Bureau of Statistics, 2020). Production loss of horticulture crops in Serang Village is suggested because of pathogenic fungal infection. It has been reported by Soesanto et al. (2019) that pathogenic fungi caused horticulture production loss.

Several pathogenic fungi had been reported from horticulture farms (Liu et al., 2011; Masoodi et al., 2013; Matruti et al., 2013; Meilin 2014; Chadar et al., 2016). Fungal diversity is closely related to plant variety (Chen et al., 2017; Yang et al., 2017). In vegetable farming, a monoculture system might increase the pathogen's ability to suppress the host plant for an extended period. In contrast, the

polyculture system increases pathogenic fungal diversity because various host plants are available (Peralta et al., 2018). In Serang Village, *Colletotrichum* spp. is among the pathogenic fungi that infect vegetable crops (Suciato et al., 2020).

There is no report about pathogenic fungal diversity and disease percentage caused by each fungal species on the vegetable crop at the polyculture system in Serang Village, District of Karangreja, Purbalingga Regency. Therefore, it was essential to study pathogenic fungal diversity and disease percentage in that area. This study aimed to determine pathogenic fungal diversity and disease percentage caused by the fungi at polyculture vegetable farming in Serang village, District of Karangreja, Purbalingga Regency. The data on pathogenic fungal diversity and disease percentage are vital for disease control.

METHODS

Research time and location

The research was conducted on vegetables polyculture farming areas in the Serang Village, Karangreja District, Purbalingga Regency. Samples were collected using purposive random sampling at ten sites of polyculture vegetable farms (Figure 1). Sample collection was carried out in two sampling periods, the first sampling was from the 7th to the 20th

of March, 2020, and the second sampling was from the 9th to the 23rd of May, 2020. Fungal identification was conducted at the Laboratory of Mycology and Phytopathology, Faculty of Biology, Jenderal Soedirman University, Purwokerto. Laboratory observations and examinations were carried out from March 15, 2020 to June 20, 2020.



Figure 1. Sampling sites in Serang Village (modified from Suciato et al., 2020)

Research variable and parameter

Research variables consisted of fungal diversity, infection level, and ecological variables. The parameters were the number of species, fungal diseases percentages, temperature, humidity, and soil pH.

Fungal isolation and identification

Pathogenic fungi were isolated from infected horticulture vegetables. The obtained fungal colonies were then subjected to a Koch's postulate test on the same plants. The result of Koch's postulate test was then compared with the fungal characteristics available in the references. The observed fungal characteristics consisted of macroscopic and microscopic characters. The macroscopic characters were the colony top and bottom surface color, texture, edge, spread pattern, and growth pattern. Microscopic characters observed were septa in the hyphae,

conidiophores and conidial shapes, presence of septa in the conidia, and conidial length, width, and color. The observed characteristics were compared to the fungal characteristics as reported by Srideepthi et al. (2017), Thangamami et al. (2011), and Suwardani et al. (2014) for *Colletotrichum* sp. and from Meilin (2014) and Flori et al. (2020) for *Fusarium*. Additional references were used for the comparison to other fungal species, such as Marthin et al. (2015), Nagrale et al. (2013), Hutabarat et al. (2014), Raut et al. (2014), and Wang et al. (2017).

Data collection

Species diversity was measured as species number (S). S is the total number of species obtained during the study. The disease percentage was calculated using the formula from Palupi et al. (2015) as follows:

$$Kp = \frac{n}{N} \times 100\%$$

Note:

Kp: Percentage of disease

n : The number of infected plants

N : Total number of observed plants

Temperature and humidity measurements were carried out in the morning (07.00 WIB) and evening (17.00 WIB) using a thermohygrometer. Soil pH measurements were carried out at each location using a soil tester.

Data analysis

The data of species diversity was analyzed descriptively as a total number of species. Data about disease percentage and environmental factors were also analyzed descriptively through reference comparison.

RESULTS AND DISCUSSION

Fungal diversity

Isolation and identification of fungal diseases from vegetable plants at polyculture farms obtained seven species of pathogenic fungi. The fungal species and their vegetable hosts are presented in Table 1.

Table 1. List of fungal species, organs, and infected vegetables at polyculture farming system in Serang Village, District of Karangreja, Purbalingga Regency

Fungal Species	Plant Organs	Vegetable species
<i>Colletotrichum</i> sp.	Fruit	Green bean (<i>Phaseolus vulgaris</i> L.)
		Chili (<i>Capsicum annuum</i> L.)
		Cayenne pepper (<i>Capsicum frutescens</i> L.)
		Spring onion (<i>Allium fistulosum</i> L.)
<i>Fusarium</i> sp.	Fruit	Tomato (<i>Lycopersicum esculentum</i> Mill.)
	Leaf	Chinese cabbage (<i>Brassica rapa</i> L.)
<i>Alternaria</i> sp.	Leaf	Brown mustard (<i>Brassica juncea</i> L.)
		Tomato (<i>Lycopersicum esculentum</i> Mill.)
<i>Septoria</i> sp.	Leaf	Celery (<i>Apium graveolens</i> L.)
<i>Cercospora</i> sp.	Leaf	Celery (<i>Apium graveolens</i> L.)
<i>Botryodiplodia</i> sp.	Leaf	Chinese cabbage (<i>Brassica rapa</i> L.)
<i>Nigrospora</i> sp.	Leaf	Lettuce (<i>Lactuca sativa</i> L.)

The fungal species was determined based on the macroscopic and microscopic characters of each species. The characteristics of fungal species are as follow.

1. *Colletotrichum* sp.

Colletotrichum sp. was found in four vegetable species, i.e., green bean (*Phaseolus vulgaris* L.), chili (*Capsicum annuum* L.), cayenne pepper (*Capsicum frutescens* L.), and spring onion (*Allium fistulosum* L.). The symptoms of *Colletotrichum* sp. infection could be seen in Figure 2.

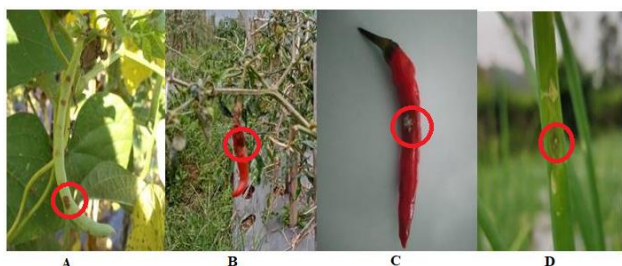


Figure 2. Disease symptoms caused by *Colletotrichum* sp. on vegetables fruit and leaf (red circle): (A) green bean; (B) chili; (C) cayenne pepper; (D) spring onion

The observed disease symptoms on all vegetables were circular dark brown spots with approximately 8 mm in diameter. In the case of fruit, the spots were causing grooves on the fruits' surface. Those symptoms are similar to the characteristic of *Colletotrichum* sp. infection as reported by Srideepthi et al. (2017), which causes anthracnose on the plant host. In spring onion (*Allium fistulosum* L.), the spots formed brown hollow to inward direction with irregular shapes measuring 3 mm to 10 mm and surrounded by a yellowish halo. In adverse conditions, the leaves became fall out. The observed symptoms were similar to a report by Grahovac et al. (2012) that *Colletotrichum* could cause the leaves to fall out and wilt in young spring onion.

The general macroscopic observation indicated that the fungi isolated from four vegetables have a yellowish-white colony color of upper and bottom surfaces. The upper surface is cotton-like with serrated edges and concentric distribution patterns (Figures 3A, 3B). These characters are similar to *Colletotrichum* characteristics reported by Masoodi et al. (2013) that have white to the blackish gray upper surface and yellowish-white bottom surface. Moreover, Thangamami et al. (2011) had noted that *Colletotrichum* has a concentric colony distribution pattern and a smooth surface. Ningsih et al. (2012) stated that *Colletotrichum* colonies are round with jagged edges.

Microscopic observation of the fungus showed that it has insulated hyphae, insulated conidiophores, and cylindrical conidia. The conidia are rounded tips, hyaline, and non-insulated with the dimension of 7-13 μm long and 2-5 μm wide (Figure 3C). The observed characteristics were matched to *Colletotrichum* sp. as reported by Santos et al. (2013) that it has grayish-white colonies consisted of elongated and rounded tip conidia with the dimension of 14.5 μm in length and 4.4 μm in width. Moreover, it was also explained by Suwardani et al. (2014) that *Colletotrichum* sp. has insulated hyphae and is hyaline in color.

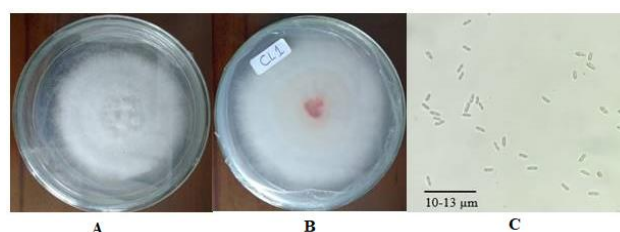


Figure 3. The colony and conidial characteristics of *Colletotrichum* sp.: (A) upper surface; (B) bottom surface; (C) conidial morphology on 40 x 10 magnification

2. *Fusarium* sp.

The infected Chinese cabbage (*Brassica rapa* L.) showed yellowing or pale green leaves and wilting petiole (Figure 4A). The symptoms indicated that the plants were infected by *Fusarium*. That decision was made because the observed symptoms were similar symptoms of plant infected by *Fusarium* as reported by Zhang et al. (2015). Vegetable that infected by *Fusarium* showed pale green and withers leaves (Zhang et al., 2015). According to Meilin (2014), infected leaves will wilt, starting from the plant's bottom and then spread to the top of the plant leaves to become wilted and turn yellow. Symptoms of fruit rot disease in tomato (*Lycopersicon esculentum* Mill.) infected by *Fusarium* sp. were the appearance of brown spots on the fruit's tips that became watery, and rot. The spots expanded and the white fungal mycelium grew or spread over that part of the spot (Figure 4B).

According to Nilawati et al. (2017), fruit rot is a disease commonly found in tomato plants. Symptoms are visible in the form of a spot on the fruit's tip that spread and occur in young fruit. Contact between the *Fusarium* fungus and the fruit occurs through soil splashing when it rains. Humid and wet conditions can stimulate the development of the disease.

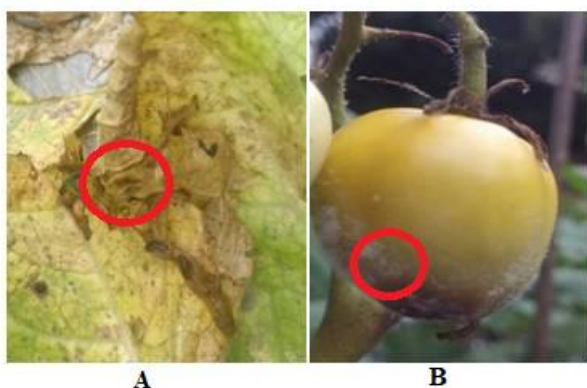


Figure 4. Disease symptoms caused by *Fusarium* sp.: (A) leaf spot in Chinese cabbage; (B) rotten fruit in tomato

Macroscopic or macromorphological observations of the fungus causing tomato wilt indicated that the disease was caused by *Fusarium* sp. The characteristics of the colony are yellowish-white reverse colony color, rough surface, serrated edges, cotton-like surface texture, and concentric distribution pattern (Figures 5A, 5B). Elfina et al. (2012) and Zhang et al. (2015) found that *Fusarium* fungus has a reddish-white colony color and fluffy mycelium structure. According to Samson et al. (2010), *Fusarium*, macroscopically have cotton-like

mycelium which proliferates with pink and yellowish coloration.

Microscopic identification showed that the fungus has septate hyphae. Its conidiophores are branched into a crescent shape of macroconidia. The macroconidia have a size of 10-24 x 2-4 μm , hyaline, and have septa. In contrast, the oval-shaped microconidia measuring 4-5 x 2 μm are hyaline without septa (Figure 5C). The results of these microscopic observations are similar to a study by Flori et al. (2020), that the *Fusarium* sp. has septate hyphae, as well as macro and microconidia. The microconidia are oval-shaped without septa, while the macroconidia are crescent-shaped with septa. According to Ningsih et al. (2012), *Fusarium* sp. has either hyaline or colored conidia consisted of crescent-shaped macroconidia with 3-5 septa and ovoid-shaped microconidia.

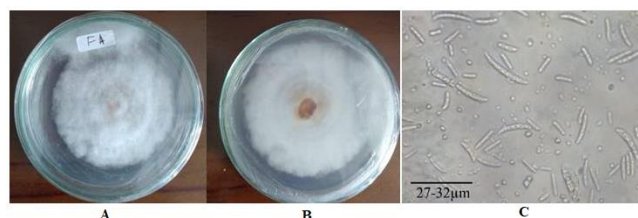


Figure 5. The colony and conidial characteristics of *Fusarium* sp.: (A) upper surface; (B) bottom surface; (C) conidial morphology on 40 x 10 magnification

3. *Alternaria* sp.

Based on morphological observations on brown mustard (*Brassica juncea* L.), leaf spot disease was found. Light brown spots with irregular shapes characterized the symptoms of leaf spot disease. The spots then expanded to form dark brown concentric circles with a diameter of 0.5-10 mm with yellowish color on the spots (Figure 6). According to Winarsih et al. (2012), the pathogenic fungus *Alternaria* sp. can decrease brown mustard quality. It can also cause yield losses ranging from 10-70% (Chadar et al., 2016). Leaf spot disease was also found in tomato plants (*Lycopersicon esculentum* Mill.). This leaf spot's symptoms was seen on the tomato leaf's upper surface, where there was a small brown spot that developed into rounded spots with a diameter of approximately 1 cm. The spots were brown with visible center circles. The sign of *Alternaria* disease was a black conidial mass on the blotches (Figure 6). According to Marthin et al. (2015), the spots would expand or widen at a severe level of attack, then the leaves will dry out.

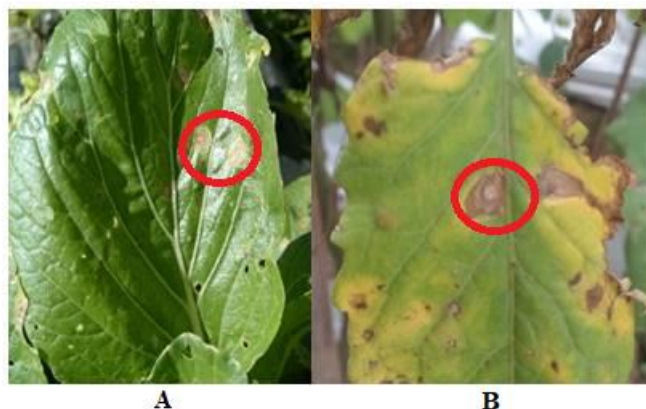


Figure 6. Leaf spot symptoms caused by *Alternaria* sp.; (A) leaf spot in brown mustard; (B) Leaf spot in tomato

Macroscopic observations showed that the isolate has grayish-brown colony with opposite surface is black. The colony has rough and cotton-like surface, serrated edges, and radial distribution pattern (Figures 7A, 7B). The result is similar to Kumar et al. (2014), that the fungus *Alternaria* sp. has macroscopic characteristics such as grayish black, cotton-like surface, wavy, and rough edges colony, and round (radial) conidia. According to Rahayu et al. (2019) *Alternaria* sp. has a blackish gray surface with the opposite color is black and cotton-like colony.

The fungal microscopic characteristics were septate hyphae, ovoid conidia, upright conidiophores, septate conidia, conidial length of 9-13 μm , conidial width of 3-4 μm , and dark color of conidia. Micromorphologically, the fungus has short, single, insulated, and pear-shaped conidia (Faridatul et al., 2019). Nagrale et al. (2013), stated that the fungus *Alternaria* sp. has a brownish septate mycelium (Figure 7C).

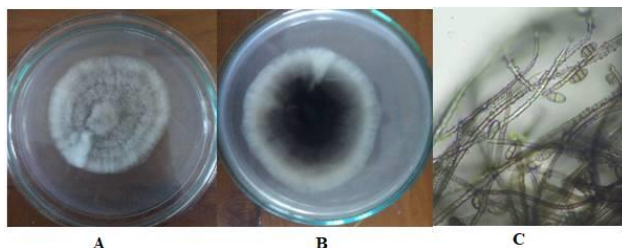


Figure 7. The colony and conidial characteristics of *Alternaria* sp.: (A) upper surface; (B) bottom surface; (C) conidia morphology on 40 x 10 magnification

4. *Septoria* sp.

Observation of signs and symptoms morphologically on celery (*Apium graveolens* L.) obtained two types of leaf spot disease: *Septoria* and *Cercospora* leaf spot diseases. Symptoms of leaf spot caused by the fungal pathogen *Septoria* sp. indicated by the presence of small spots on leaves with a

diameter of 0.5-3.5 mm, with irregular edges and brown to black color (Figure 8). Symptoms of leaf spot caused by the fungus *Septoria* sp. was a spot with 1.5-10 mm in diameter, the inner edge of the spot was brown to reddish-brown and surrounded by a reddish-brown line on the outer edge of the spot. Infection from this pathogenic fungi occurred when black dots, chlorosis, and brown spots were observed in plant tissue. If the spots develop and coalesce, the leaves will wither (Gul et al., 2016). According to Gul et al. (2016), the spread of conidia of the fungus *Septoria* sp. can through the splash of rain, wind, and agricultural tools. *Septoria* sp. is an airborne fungus and distributes its spores through the air (Wahyuno, 2010).



Figure 8. Leaf spot symptom on celery (*Apium graveolens* L.) infected by *Septoria*

Macroscopic observation showed that colony of *Septoria* sp. has white upper surface, gray-black bottom surface, cotton-like texture, serrated edges, and radial distribution pattern (Figures 9A, 9B). The observed characters, similar to Hutabarat et al. (2014), that the pure culture results of *Septoria* sp. isolate is white at the upper surface and brown to blackish at the bottom.

Microscopic characters of the obtained fungi showed that the conidia of the fungus are septate, hyaline, and needle-shaped with a length of 13.8-30 μm and a width of 2.3-3 μm (Figure 9C). It is in accordance with a study by Shagdarova et al. (2018) that the conidia of fungal pathogen *Septoria* sp. are hyaline-colored, elongated shape with a tapered tip, and have septa.

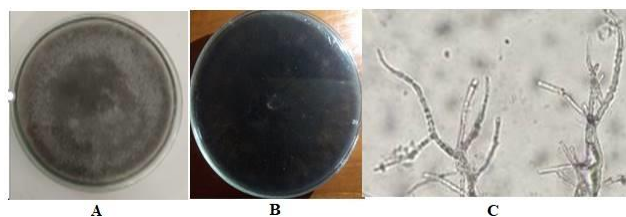


Figure 9. The colony and conidial characteristics of *Septoria* sp.: (A) upper surface; (B) bottom surface; (C) conidia morphology on 40 x 10 magnification

5. *Cercospora* sp.

Leaf spot disease caused by *Cercospora* sp. in celery was indicated by visible spots scattered on the upper leaf surface in a round shape (1-2 mm in diameter), with brownish color surrounded by a yellow halo (Figure 10). The symptom was matched with *Cercospora*'s disease symptoms, as reported by Islam et al. (2015). According to Islam et al. (2015), *Cercospora* leaf spot symptoms on celery leaves are in the form of visible, round, small, brownish spots surrounded by a yellow halo. Symptoms difference between *Septoria* and *Cercospora* infection is in the edge of spots. *Septoria* infection is characterized by having reddish-brown line in the outer of the spots, whereas *Cercospora* infection is characterized by the present of yellow halo in the outer area of the spots.



Figure 10. Leaf spot symptom on celery (*Apium graveolens* L.) infected by *Cercospora*

Macroscopic observations of the fungus *Cercospora* sp. showed that the fungi have a colony with a gray upper surface and blackish gray bottom surface with cotton-like texture, serrated edges, and radial spread pattern (Figures 11A, 11B). Microscopic observation of *Cercospora* sp. indicated that it has septic mycelium and hyaline conidia. Conidia are cylindrical with a length of 25-70 μm and a width of 4-6 μm , and have conidiophores (Figure 11C). These characteristics were similar to *Cercospora* characters reported by Islam et al. (2015) that it has a blackish colony, hyaline conidia, and cylindrical shape. According to Price et al. (2015), *Cercospora* have hyaline conidia, club or tube shape, 3-10 insulated hyphae with a size of 50-80 x 4 μm .

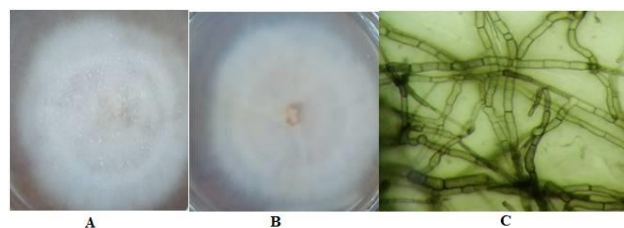


Figure 11. The colony and conidial characteristics of *Cercospora* sp.: (A) upper surface; (B) bottom surface; (C) conidial morphology on 40 x 10 magnification

6. *Botryodiplodia* sp.

The morphological observations on Chinese cabbage (*Brassica rapa* L.) obtained leaf spot disease caused by the fungus *Botryodiplodia* sp. Symptoms of leaf spot disease were indicated by signs on the upper surface of the leaf. There was a small circular spot, a whitish brown sphere, and necrosis areas on the leaves (Figure 12). At the initial symptoms, the spots will be light brown then develop and turn to dark brown then black. These spots will expand, starting from the top of the leaf and then spread to all parts of the leaf so that the leaves turn from dark brown to black (Raut et al., 2014).



Figure 12. Leaf spot symptoms on Chinese cabbage (*Brassica rapa* L.) caused by *Botryodiplodia* sp

The results of macroscopic observations of the pathogenic fungus *Botryodiplodia* sp. on the growth media showed that this fungus have a black colony surface color, a cotton-like texture, flat colony edges, concentric distribution patterns, and aerial colonies growth. Komalaningrat et al. (2018) reported that the mycelium of fungus *Botryodiplodia* sp. is initially white, then becomes blackish-gray, and the development is aerial (Figs. 13A, 13B).

Microscopic observation of the fungus *Botryodiplodia* sp. showed that it has insulated and branched hyphae, septate conidiophores, round conidial shape, hyaline conidial color, and conidial size of 7-20 μm in length and 2-5 μm in width (Figure 12C). According to Abdollahzadeh et al. (2010), the *Botryodiplodia* have conidia measuring 10-18 μm x 3-5 μm . The young conidia are elliptical with hyaline colored and are not insulated, while the mature conidia have a bulkhead. Conidia of *Botryodiplodia* sp. are hyaline at first then become colored and have one bulkhead.

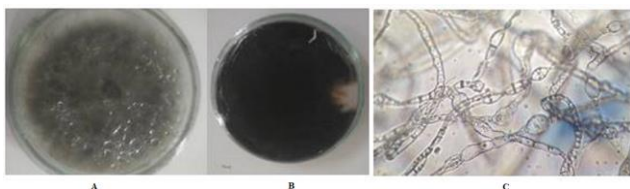


Figure 13. The colony and conidial characteristics of *Botryodiplodia* sp.: (A) upper surface; (B) bottom surface; (C) conidial morphology on 40 x 10 magnification

7. *Nigrospora* sp.

The results of observations showed the signs and symptoms of leaf spot disease caused by pathogenic fungi on the leaves upper surface indicated by blackish-brown spots and necrosis on the leaf surface area, the spots shape varied with varying size (Figure 14). Leaf spot disease was caused by the fungal pathogen *Nigrospora* sp. Symptoms of leaf spots on lettuce were necrotic sores, with brown or white color at the center or the edge of dark spots. If the number of spots on the leaf surface is large, these spots can coalesce and expand and cause leaf tissue to die. The spread of leaf spot disease is through wind and rainwater splashes (Sastrahidayat, 2017).



Figure 14. The symptoms of leaf spot on lettuce (*Lactuca sativa* L.) caused by *Nigrospora*

Macroscopic observations of fungi isolated from lettuce leaf spot showed that the fungus has a grayish-white upper surface and grayish-white bottom surface, cotton-like, flat colony edges, concentric colony distribution patterns, and aerial colony growth (Figures 15A, 15B). Wang et al. (2017) stated that the fungus *Nigrospora* sp. has a cosmopolitan distribution and a broad host range. This pathogenic fungus is also often found in many fruit and ornamental plants.

The results of microscopic observations on *Nigrospora* sp. proved that the fungus has insulated, cylindrical, and branched hyphae. It has short, non-insulated, and hyaline conidiophores. Conidia are round and black, ranging from 5 μm up to 6 μm (Figure 15C). Hao et al. (2020) stated that the fungus *Nigrospora* sp. conidiophores are short, with black and round conidia. Moreover, Wang et al. (2017), stated that the fungus *Nigrospora* sp. has fine, hyaline, branched, and septic hyphae with the diameter ranging between 3 μm and 8 μm .

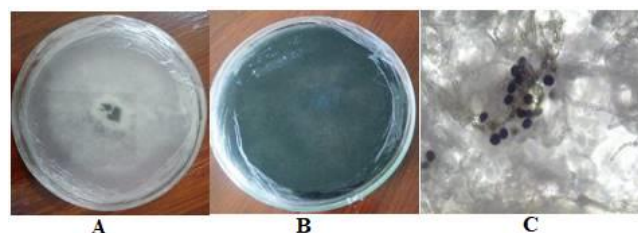


Figure 15. The colony and conidial characteristics of *Nigrospora* sp.: (A) upper surface; (B) bottom surface; (C) conidial morphology on 40 x 10 magnification

Disease percentage

The results of the observation on the disease percentage showed different levels of damage for each type of observation site. The percentage of

diseases caused by pathogenic fungi in several types of vegetable crops in polyculture areas can be seen in Table 2.

Table 2. List of sampling sites, infected vegetables, disease code, disease frequency, and disease percentage on polyculture system in Serang Village, District of Karangreja, Purbalingga Regency

Site	Vegetables	Disease Code	Frequency (times)	Disease Percentage
I	Bean	A	67	44.66
	Chili	A	81	54.00
II	Chili	A	54	31.76
	Tomato	B	31	18.24
III	Cayenne pepper	A	57	33.52
	Spring onion	A	49	28.82
IV	Brown mustard	C	122	55.46
	Spring onion	A	84	34.09
V	Brown mustard	C	92	34.71
	Celery	D	79	29.82
VI	Tomato	E	102	45.34
	Spring onion	A	88	34.12
VII	Chili	A	86	57.34
	Spring onion	A	60	40.00
VIII	Chili	A	74	35.24
	Celery	F	66	31.43
IX	Chinese cabbage	G	64	37.65
	Spring onion	A	49	28.83
X	Lettuce	H	117	48.75
	Spring onion	A	92	38.84

Remarks: (A) Anthracnose; (B) Rotten fruit on tomato; (C) Leaf spot on brown mustard; (D) *Cercospora* leaf spot; (E) Leaf spot on tomato; (F) *Septoria* leaf spot; (G) Leaf spot on Chinese cabbage; (H) Leaf spot on lettuce

The disease caused by *Colletotrichum* sp. was observed at almost all polyculture farms. The fungi infect green beans, chili, cayenne pepper, and spring onion. The highest percentage of *Colletotrichum* infection was found in chili plants, with a value of 57.34% at location VII and at location II chili with 54%. At site IV, on the brown mustard vegetable cropping percentage went 55.46% due to the attack of the pathogenic fungus *Alternaria* sp. causes leaf spot disease. Leonard (2001) stated that the disease percentage of less than 50% is not in the dangerous category. While the disease percentage exceeds 50%, the condition has exceeded the danger threshold, so it is necessary to make prevention or control efforts. The same thing was conveyed by Cooke et al. (2006) that if the disease percentage reaches 50-75%, it is categorized as dangerous so that disease control and prevention efforts are necessary. Environmental factors such as temperature, humidity, and soil pH significantly affect the development of disease-causing fungi and the process of spreading disease. The use of polyculture areas on site is beneficial in spreading pathogenic spores because plant spacing is

too tight. Environmental sanitation, those are not given enough attention, resulting in disease progression that could quickly distribute to other crops and several locations where different plants are planted.

Control efforts applied in the Serang area are by using fungicides, crop rotation, and mulch. The use of mulch by local farmers has been carried out in vegetable crops, but the environment's cleanliness around the polyculture areas has not been given attention indicated by the presence of some weeds growing. The negative effect of weeds is that they have a high competitive ability to absorb nutrients and water. According to Matruti et al. (2013), nutrients influence the host's growth rate and level of readiness to resist pathogens. Nutrients such as phosphorus influence disease progression. Phosphorus can increase resistance by increasing the nutrient balance in plants allowing the avoidance of pathogenic infections.

Air temperature in sampling sites ranged between 15°C and 22°C. Humidity during the study ranged from 81% to 92%, whereas soil temperature ranged

between 6.7 and 6.9. The temperature ~~dan~~ and soil pH ranges in the research location were in optimum condition for horticulture. The humidity values were above the optimum condition for vegetable crops. According to Edi and Bobihoe (2010), the optimum range temperature of vegetable crops are between 15 and 24, whereas for pH ranges from 5 to 7 depend on the species and for the humidity is less than 80%.

This research provide the first data about pathogenic fungal diversity and disease percentage caused by each fungi species at vegetable polyculture system in Serang Village, District of Karangreja, Purbalingga Regency. The data on pathogenic fungal diversity and disease percentage are vital for disease control in vegetables farming in Serang Village, District of Karangreja, Purbalingga Regency.

CONCLUSION

It can be concluded that fungal pathogens identified in vegetable polyculture crops in Serang Village are *Colletotrichum* sp., *Fusarium* sp., *Alternaria* sp., *Septoria* sp., *Cercospora* sp., *Botryodiplodia* sp., and *Nigrospora* sp. The lowest percentage of damage was 18.24% for tomato fruit rot (*Fusarium* sp.) and the highest was 57.34% for anthracnose in chili plants (*Colletotrichum* sp.).

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