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SHORT COMMUNICATION

Incidence of twisted disease and cultivation practice of shallot farmers in Bantul coastal area, Yogyakarta, Indonesia

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ABSTRACT

Shallot (*Allium cepa* var. *aggregatum* L.) is an important commodity in horticulture and Indonesian foods. In Bantul Regency, Yogyakarta, Indonesia, shallot twisted diseases caused by *Fusarium* spp. significantly reduced yield quality and quantity. Supportive condition for plant-pathogen interaction needed for twisted disease development. This research aimed to measure the twisted disease incidence and observe the cultivation practice applied by shallot farmers in the Bantul coastal area as environmental aspects of the twisted disease to be a pre-study for further research on metagenomic analysis. This research had conducted in three sub-villages with different agroecosystems in the coastal area: Sono, Samiran, and Depok. Data were collected in shallot cultivation period in dry and rainy seasons from three farmers of each area. The higher disease incidence in the rainy season occurred in the Samiran sub-village at 33.97%, while in the dry season, disease incidence occurred in the Depok sub-village at 20.14%. Sono sub-village had the lowest disease incidence in rainy and dry seasons at 12.44% and 0%. Farmer cultivation practice may drive disease incidence due to environmental factors such as shallot variety, spacing between plants, fertilizer, and fungicides. Hence, further study is needed to understand plant-pathogen interaction with metagenomics through samples from 2 and 6 WAP in rainy seasons.

Key words: agroecosystem, environment, fusarium, twisted shallot disease

INTRODUCTION

Shallot (*Allium cepa* var. *aggregatum* L.) is an important commodity in horticulture and Indonesian foods. It contains a beneficial substance for human health (Minh, 2019). Due to pathogen attacks, shallot production seems to fluctuate yearly (Yusidah and Istifadah, 2018). *Fusarium* spp. causes twisted disease reduced the quality and quantity of shallot yield (Lestiyani, 2015). Wiyatiningsih et al. (2009) also reported that *Fusarium oxysporum* f.sp. *cepae* causing twisted disease affected significant loss to the farmers in several main shallot fields, including Bantul, Brebes, and Nganjuk. Based on its agroecosystem, Bantul had two types of the agroecosystem, wetland and coastal sandy land.

This study is conducted mainly in the shallot cultivation center in Bantul coastal area. Based on the dominant cropping pattern, farmers in Bantul cultivated shallot twice a year. The difference between coastal sandy and wetland can be seen from the cropping pattern. The coastal sandy has horticulture non shallot -shallot-mix shallot & chili. A wetland with better irrigation can cultivate paddy-shallot-mix shallot & chili due to the irrigation (Hasan et al., 2012). Lestiyani et al. (2021) reported that *Fusarium* spp. isolates from Bantul and Nganjuk caused disease incidence of 77.7% to 100%. In 2007, Wiyatiningsih reported that twisted disease was more common in shallot cultivation areas in the Nganjuk, East Java, than in Bantul, Yogyakarta. The twisted disease is presumably due to differences in the environmental conditions in the two regions, which may lead to supportive conditions for plant-pathogen interaction causing the twisted disease. Following the infection process after interaction among disease triangle components, plant disease typically starts at a low level and gradually increases in incidence and severity over time (Semangun, 1996). Area Under Disease Progress Curve (AUDPC) can be applied to understand the disease development in different conditions, including agroecosystem (Siemko and Piepho, 2012). In a particular area, plant

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disease incidence and intensity were also influenced by microbial communities interacting with plants and pathogens in the ecosystem. The metagenomics approach by amplicon sequencing is used to understand the microbial community in certain agroecosystems (Knief, 2014). A pre-study is needed to decide which samples will be analyzed to understand the microbial community before and during the pathogen infection process.

Therefore, this research aimed to measure the twisted disease incidence and observe the cultivation practice in the Bantul regency applied by shallot farmers in the Bantul coastal area as environmental aspects of the twisted disease. The data will be pre-study for further research on metagenomic analysis.

MATERIALS AND METHODS

Research Site. The research was conducted in three sub-villages: Sono, Samiran, and Depok, in Bantul regency, Yogyakarta, Indonesia, from March to May 2021 for the rainy season period and June to September 2021 for the dry season. Soil dan landscape type and G-maps location are presented in Table 1.

Shallot cultivation and farmer practice. There were nine farmers, and a survey was conducted on nine farmers with a questionnaire scope including their cultivation practices, shallot varieties, crop rotation, organic and synthetic fertilizers, and pesticide application. Three farmers were selected in each sub-village as unit samples and observed plants ranged from 130 to 200 per unit sample.

Observation of shallot twisted disease incidence. The incubation period was measured as the observation week when the twisted symptom was first recorded. The data obtained were presented in tabular form and analyzed descriptively. Twisted disease incidence (DI) was observed at 7-day intervals until harvest during the planting period by measuring the percentage of infected plants per total observed plants. Data were collected during the shallot cultivation period in the dry and rainy seasons. The DI was statistically analyzed with ANOVA by IBM SPSS version 25 and further analyzed using DMRT (P = 0.05). The area under the disease progress curve (AUDPC) was calculated from the assessment of disease incidence using the formula below (Sutrisno et al., 2018). AUDPC were statistically analyzed with ANOVA by IBM SPSS version 25 and further analyzed using DMRT (P = 0.05).

$$\mathrm{AUDPC} = \frac{\sum_{i=1}^{n}\left[\frac{X_{i+1}+X_i}{2}\right] x \left[t_{i+1}-t_i\right]}{N-1}$$

Note: n= number of observations; x= disease incidence at the i-th observations; t= observation time.

RESULTS AND DISCUSSION

Soil characteristics and cropping pattern. There are two seasons for the shallot planting period, along with one year in Bantul. While from October to January is the off-season period. The growing season on wetland and coastal sandy is from March to May, and it continues for the second season from June to September. In the middle of the second season, the intercropping with chili was applied and continued to September. In this area, shallot planting is generally intercropped with chili during the dry season. Chili is planted on the sidelines at one-month-old shallots; therefore, the chili plants are protected from the sun's rays. When the shallot is harvested, chili plants are strong enough to grow to replace shallots in the field. Sono and Samiran sub-villages have the same agroecosystem and type of soil, wetland, and grumusol chromic. However, both locations have different types of landscapes as foothill plains and floodplains. In addition to that, they also have different soil colors. Sono sub-village has red browny soil color, while Samiran sub-village has dark brown soil color. Red soil presumably relates to the high percentage of iron content responsible for its color (Dwevedi et al., 2017). Depok sub-village has regosol eutric soil with a dunes landscape (Table 1 and Figure 1).

Observation of shallot twisted disease. Twisted disease on shallot showed typical symptoms with twisted or curved leaves due to disturbances at the roots or base, estimated to rot extensively and consequently hinder the function (Supyani et al., 2021). The twisted disease on shallot in Bantul coastal area showed in Figure 2. In the rainy season, the higher DI occurred in Samiran sub-village with 33.97%, which was insignificant compared to other locations. AUDPC data showed that the development of twisted disease in the Samiran sub-village has the highest score, which is not significantly different from Depok sub-village. The DI and AUDPC of twisted disease in the Depok sub villages was significantly differed from Sono and Samiran sub-villages in the dry season. Twisted

Table 1. Shallot fields in different locations and the characteristics

Sub-village	Type of	Type of soil	Type of landscape	Location Gmaps
Sono	Wetland	Grumusol chromic	Foothill plains	7°59'48.3"S 110°18'50.0"E 7°59'50.2"S 110°18'47.5"E 7°59'55.2"S 110°18'43.7"E
Samiran	Wetland	Grumusol chromic	Floodplains	8°00'05.3"S 110°18'27.3"E 8°00'04.1"S 110°18'25.4"E 8°00'07.2"S 110°18'22.5"E
Depok	Coastal sandy land	Regosol eutric	Sand dunes	8°00'40.7"S 110°17'51.1"E 8°00'41.3"S 110°18'23.5"E 8°00'41.7"S 110°18'25.5"E

Figure 1. Shallot fields in different locations, A. Sono sub-village, B. Samiran Sub-village, and C. Depok sub-village

Figure 2. Twisted disease on shallot in Bantul coastal area 2 WAP

disease was not found in Sono during the dry season (Table 2). Holilullah et al. (2015) explained that soils with granular/crumb structures have higher porosity than soils with massive/solid structures. Soil with a sand texture has macropores, making it difficult to hold water. Therefore, during the dry season, plants suffer from drought stress, making them susceptible to disease. Data showed that not all shallot fields and seasons in Bantul were conducive for twisted pathogens. Two weeks after planting (WAP), twisted symptoms have already been observed in Sono and Samiran sub-villages in the rainy season. The disease incidence increased every week until the harvest period (6 WAP for Depok sub-village and 7 WAP for Sono and

Table 2. The incubation period, disease Incidence, and AUDPC of shallot twisted disease in three observed sub-villages during the rainy and dry season in the 2021 planting year

Sub-village	The incubation period (WAP)		Disease incidence (%)		AUDPC (%-days)	
	Rainy	Dry	Rainy	Dry	Rainy	Dry
Sono	2	-	12.44 a	0.00 a	13.45 a	0.00 a
Samiran	2	5	33.97 a	0.39 a	51.44 b	0.77 a
Depok	4	3	21.00 a	20.14 b	27.72 ab	21.24 b

Same letters showed the non-significantly different values (P<0.05)

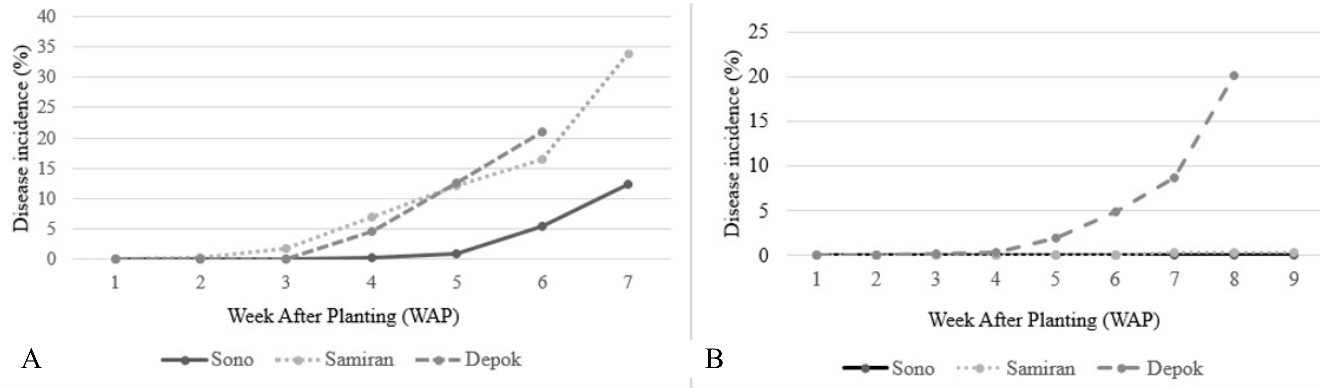

Figure 3. Disease incidence. A. Rainy season; B. Dry season

Samiran sub-village), as shown in Figure 3. During the dry season, the weekly increasing twisted disease was only found in the Sono sub-village. Two WAP described the early state of twisted disease infection, and 6 WAP depicted the late disease development. The relative abundance of microbes on 2 WAP and 6 WAP will be observed to understand the microbial interaction during twisted disease progress in each location. This data will be used as the decision for metagenomics analysis.

Sono sub-village, which showed the lowest disease incidence, can be used as an approach model in developing soil management health for twisted disease, which can be studied further to check the soil suppressiveness against the disease. It refers to Poromaroto et al. (2021), which reported that if the disease intensity is equal to or less than 5% is designated as a suppressive field, while a shallot field with disease intensity equal to or more than 50% is defined as a conducive field.

Cultivation practice in three observed locations. All farmers grow Thailand's variety in the rainy and dry seasons (Table 3). In Bantul, the general plant spacing for shallot in the dry season is 15 × 15 cm or 15 × 20 cm, while in the rainy season, it is 15 × 20 cm or 20 × 20 cm (Anonim, 2013). In Sono and Samiran sub-villages, ideal plant spacing of 15 × 20 cm is applied. Prakoso et al. (2016) reported that Biru and Thailand varieties showed the fastest incubation period for 14 days under screen house conditions. On the contrary, the twisted disease showed that Nganjuk and Bauji varieties had an extended incubation period of approximately 20 days. At the same time, the disease incidence and the incubation period of twisted in the rainy season were higher and faster compared to the dry season (Table 2). The twisted disease in the rainy season has occurred in 2 WAP in Sono and Samiran sub-villages.

The relatively high twisted disease in shallot fields is assumed to relate to soil chemical properties. Recently, farmers in Brebes rarely use organic fertilizers in shallot cultivation (Poromaroto et al., 2021). Dewayanti et al. (2020) showed that in Selopamioro village, Bantul farmers started using a semi-organic cultural practice to plant shallot for sustainable purposes. Organic fertilizer from manure is produced by farmers and is used during the first and second plantation seasons. However, farmers still used various synthetic fertilizers with pressed dosages, including NPK, Ponskha, ZA, and KCL.

Soil organic matter is one of the health indicators where healthy soils generally have a high organic matter content. Soil containing high organic matter provides a suitable environment for functional microbes, including antagonistic and other microbes involved in plant health (Supriyadi et al., 2021). In

Table 3. Cultivation practice applied by shallot farmers in Bantul Regency

Culture practices	Sono	Samiran	Depok	Explanation
CV. Thailand	+	+	+	All of the farmers used the same variety.
Own seed	-	-	-	
spacing between plants (cm)	15 × 20	15 × 20	15 × 17	
Apply organic fertilizer	+	-	+	Sono used goat Depok used goat, quail, cow
Ammonium Sulphate fertilizer (ZA)	+	-	+	Fertilizer dose: Sono sub-village: 250-900 kg/Ha Depok sub-village: 280-1400 kg/Ha
NPK fertilizer	+	+	+	Fertilizer dose: Sono sub-village: 250-900 kg/Ha Depok sub-village: 280-1400 kg/Ha
KCl fertilizer	+	-	-	Fertilizer dose 900 kg/ha
Synthetic chemical fungicides	+	+	+	Note: All of the Farmers sprayed their shallot ±10 days after planting with antracol. The plant disease symptoms appeared four weeks after planting, and farmers switched their fungicides to Rhemazol and other fungicides. Antracol [AI: propineb] Rhemazole [AI: imidazol and triazol]
Bio-pesticides	-	-	-	

this research, only farmers in Samiran did not use any organic fertilizer.

On the other hand, various kinds of organic fertilizer were applied in Depok. However, farmers need to give more attention to the decomposition process of organic materials. The imperfect decomposition process will support the growth of harmful organisms, such as fungi and weeds, which interferes with plant growth, causing disease or damage (Mustika, 2019).

Generally, the shallot farmers in Bantul used NPK and Phonska with various dosages/doses as the main fertilizer. It was applied with different doses in each sub-village (Table 3). The fertilizer dose was applied two times, at 14 and 29 days after planting. The additional synthetic fertilizer in Sono had more variants, such as KCl and ZA. Based on PT. Petrokimia Gresik's recommendation in 2011 for shallot, farmers need to apply 800 kg/ha Ponsksha and 400 kg/ha ZA. However, in Bantul, farmers apply the fertilizers in various dose ranges based on their preferences Table 3. According to Gunadi (2009), inorganic fertilizers such as potassium significantly improve the shallot bulb's quality. One of the main macronutrients besides N and P. Potassium has several functions, including increasing carbohydrate metabolism, stomatal behavior, and plant tolerance in drought conditions. Nevertheless, excessive fertilizer application will impact the plant's absorption of nutrient balance. Martinus et al. (2017) showed that the highest shallot production was showed by fertilizer treatment with 15 ton/ha buffalo manure,65 kg/ha NPK, 65 kg/ha ZA, and 15 kg/ha KCl.

Farmers in Bantul commonly used chemical fungicides with active ingredients such as Propineb, Imidazole, and Triazole to control fungal disease on shallot (Table 3). Propineb is a multi-site activity fungicide with a low risk for resistance development. At the same time, Imidazoles and Triazoles have sterol biosynthesis in fungal membranes. These active ingredients pose a medium resistance risk (FRAC, 2020). Syarifudin (2021) reported that Propineb fungicide could effectively control the DI of twisted disease in shallot 42 days after planting (DAP) for 16.66% compared to control (25.33%) by direct spraying application on farmer shallot fields in Ambon. While on the screen house, experiments showed that 0.1% Tebuconazole spraying on Brebes variety inhibited twisted DI up to 50% compared to control (Girsang, 2020). These fungicides were applied for

2-3 days/ spray, which was very intensive. Applying pesticides with multi-site effect mixed with single-site effect may reduce the risk and avoid pathogen resistance in the field. However, fungal resistance possibly happened due to the natural selection on the field and gene mutation (Sumardiyono, 2008).

CONCLUSIONS

The results show that disease incidence and AUDPC of twisted in rainy season in Bantul District were higher than in the dry season. A similar result was shown in the incubation period, faster in the rainy season than in the dry season. Cultivation practices are estimated to be a driving factor of twisted disease. Metagenomics research will be conducted based on the disease incidence data to comprehend the plant-pathogen interaction by using samples from the early and late symptoms, 2 and 6 WAP in rainy seasons.

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AUTHORS' CONTRIBUTIONS

AW is the first author for his contribution to this writing manuscript. IAS performed data collection and analysis for the rainy and dry seasons. LMS also collects data on the rainy season. As the corresponding author, AW* contributed as a proofreader and revised this manuscript. SS planned the design of the experiment. SH led and supervised the project. Then, all the authors have read and approved the final manuscript.

COMPETING INTEREST

The authors declared that there is no potential conflict of interest.

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