Agrotechnology Research Journal
Volume 8, No. 1, June 2025, pp. 58–65

ISSN 2655-7924 (Print)
ISSN 2614-7416 (Online)
https://jurnal.uns.ac.id/arj
doi: 10.20961/agrotechresj.v9i1.105240

Susceptibility of Shallot cv Tajuk Cultivated in Bantul and Kulon Progo Against *Fusarium* Disease

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Received; Accepted

ABSTRACT

Shallot cv. Tajuk is one of the most preferred shallot varieties to be cultivated, especially by farmers living in lowland areas with low water availability issues, such as Bantul and Kulon Progo. However, to date, the information about the resistance of this variety to Fusarium disease is poorly studied. Therefore, this study aims to investigate the prevalence of Fusarium disease in shallot cv. Tajuk is cultivated in Bantul and Kulon Progo. A survey of Fusarium disease occurrence was conducted in 8 shallot fields from 3 districts in Bantul (Imogiri, Sanden, and Kretek) and six shallot fields representing two districts of Kulon Progo (Lendah and Sentolo). Disease observation in Bantul was carried out during the dry season from June to August 2023, while the survey in Kulon Progo was performed during the rainy season from January to February 2024. The cropping system applied in each selected shallot field was also collected through the landowner interviews. Data obtained from disease monitoring were statistically analyzed using one-way analysis of variance (ANOVA), and significance among locations was subsequently analyzed using Duncan's New Multiple Range Test with a $p<0.05$. Findings of this study revealed that the susceptibility of shallot cv. Tajuk to Fusarium disease varied between Bantul and Kulon Progo. Shallot var. Tajuk conferred higher resistance against Fusarium disease when it was cultivated in Kulon Progo. Results of this study also confirmed that different farming practices applied in each location appear to have a minor impact on the severity of this disease in the shallot cv. Tajuk.

Keywords: *Allium cepa*; disease occurrence; leaf twisting disease; resistance; variety

***Cite this as (CSE Style)*:** Aisyah SN, Fajrin QV, Dewi IP, Hidayat T, et al. 2025. Susceptibility of Shallot cv Tajuk Cultivated in Bantul and Kulon Progo Against *Fusarium* Disease. Agrotechnology Res J. 9(1): 58-65. https://dx.doi.org/10.20961/agrotechresj.v9i1.105240

INTRODUCTION

Shallot is considered one of the strategic horticultural crops that contributes significantly to national economic growth. High demand and consumption of shallots in Indonesia are associated with its use as a basic ingredient for cooking (Anggrasari et al. 2025; Ridqi and Kusumaningsih 2025). Apart from its use as food flavoring, latest studies also reported the promising medicinal properties of shallot (Gusman et al. 2025; Neda et al. 2025). Moreover, Ridqi and Kusumaningsih (2025) mentioned that shallot has high export potential and high employment opportunities. Due to its economic value, shallots have become a commodity that could affect the inflation rate in Indonesia, suggesting their essential contribution to national food security (Anggrasari et al. 2025; Arifin et al. 2025).

The special Region of Yogyakarta is one of the shallot-producing provinces in Indonesia (Anggrasari et al. 2025) that contributed about 333,117 quintals the shallot production in 2024 (Statistics Indonesia 2025). Shallot production in this province is centralized in two regencies, namely Bantul and Kulon Progo. Considering the size of the harvested area, Bantul Regency is the largest shallot-producing area with the harvested area in 2024, reaching 1,806 ha and total production of about 198,286 quintals. Shallot production in Kulon Progo Regency was 128,345 quintals in 2024 with the harvested area reaching 983.2 ha (Statistics Indonesia 2025). According to these data, the shallot productivity in these two regions, is approximately 10.99 $t.ha^{-1}$ (Bantul) and 13.04 $t.ha^{-1}$ (Kulon Progo). This productivity is considered low compared to the world average productivity (21.4 $t.ha^{-1}$) (FAOSTAT 2023). This low productivity suggests that the shallot cultivation in these

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regions was challenging. Sutardi et al. (2022) highlighted low efficiency farming practices as one of main factors limiting the shallot productivity, particularly in Special Region of Yogyakarta. Moreover, Arifin et al. (2025) also explained the challenges faced by shallot farmers in Bantul Regency due to unstable weather and disease infection.

Regarding disease infection, soil-borne disease caused by *Fusarium* spp. has been reported as an important disease in the production of *Allium* species, including shallot (Poursakhi et al. 2024). The disease is known locally as *moler* disease and known internationally as basal plate rot or basal rot. When shallots are infected by this disease, various symptoms may appear, such as leaf twisting followed by withering, root rot, bulb rot, and basal plate rot (Le et al. 2021; Sholeh and Nurcahyanti 2023). The importance of *Fusarium* disease in the cultivation of *Allium* species has been extensively documented due to its challenging management, thus leading to significant crop loss (Dewi et al. 2025; Haapalainen et al. 2023; Sharma et al. 2024). Infection of *Fusarium* disease had caused yield loss in shallots up to 78% and severe damage to stored bulbs (Dinata et al. 2021; Mariani et al. 2022). Previous studies also reported significant crop loss up to 50% in onion caused by *Fusarium* infection (Mahanty et al. 2023; Sharma et al. 2024; Sogoba et al. 2022).

As one of the shallot-producing provinces in Indonesia, the Special Region of Yogyakarta cultivates several varieties of shallots, including *Tajuk* variety. This variety, also known as the Thailand variety, has been widely cultivated due to its suitability for lowlands and its high adaptability with minimal water input (Fauzia et al. 2020; Pasaribu 2017). Moreover, Pasaribu (2017) also highlighted other advantages of shallot cv. *Tajuk*, such as the ability to grow in acidic soil (pH 5.5), tiller production ranging from 5-15 per plant, and productivity of about 10 $t.ha^{-1}$ dried bulb. Despite its promising potential, the information regarding its susceptibility to *Fusarium* disease is not yet thoroughly studied to date. Concerning farmers' preferences regarding this variety, the investigation of *Fusarium* disease occurrence in shallot cv. *Tajuk* has been urgently needed. Therefore, this present study aimed to investigate the prevalence of *Fusarium* disease during the cultivation of shallot cv. *Tajuk* in Bantul and Kulon Progo areas. This study also collected information about cropping system applied in each area to determine its effect on the prevalence of *Fusarium* disease. The results of this study are expected to provide beneficial information regarding the resistance of *Tajuk* variety against *Fusarium* disease. This information would become a reference required to develop better recommendations for the cultivation of shallot cv. *Tajuk*, particularly in Bantul and Kulon Progo areas.

MATERIALS AND METHODS

This study was conducted in the selected shallot fields in Bantul and Kulon Progo Regency. Selection of shallot fields used in this study was based on the use of shallot cv. *Tajuk* for the cultivation. Eight shallot fields in Bantul Regency and six shallot fields in Kulon Progo Regency were carefully selected to be used (Table 1) in disease monitoring and survey of cropping system. For Bantul Regency, disease observation and cropping system survey at each selected field were carried out during dry season from June to August 2023. For Kulon Progo Regency, both surveys were performed during rainy season from January to February 2024. Cropping system applied in each selected shallot field was also collected through land owner interview. Several aspects in shallot cultivation were identified, such as cropping pattern, cropping frequency, use of crop rotation, plant spacing, and watering intensity.

Table 1. Details of shallot fields used in this study.

Regency	District	Sub-village	Location Coordinate	Elevation* (m asl)
Bantul	Imogiri	Kalidadap	7°57'51.2"S 110°22'48.9"E	113.64
		Srunggo	7°58'17.5"S 110°22'53.6"E	169.03
	Sanden	Srigading 1	7°59'57.7"S 110°15'53.4"E	5.38
		Gadingsari	8°00'02.5"S 110°15'33.3"E	7.89
		Srigading 3	7°59'18.2"S 110°16'32.1"E	7.27
	Kretek	Kretek 1	7°59'42.3"S 110°18'54.2"E	10.42
		Kretek 2	7°59'39.8"S 110°18'47.8"E	8.65
		Sono	7°59'54.5"S 110°18'41.6"E	7.36
Kulon Progo	Sentolo	Demangrejo	7°52'24.4"S 110°12'25.1"E	25.03
		Karasan	7°52'30.5"S 110°12'13.8"E	25.48
		Kalimenur	7°52'10.2"S 110°12'31.7"E	26.63
	Lendah	Ngentakrejo 1	7°53'45.7"S 110°14'58.3"E	22.79
		Ngentakrejo 2	7°53'31.0"S 110°15'07.8"E	25.35
		Ngentakrejo 3	7°53'49.7"S 110°15'12.2"E	24.69

*Elevation was identified using Google Earth.

Monitoring of *Fusarium* disease occurrence was performed using protocol adapted from Aisyah et al. (2022) with slight modification. Disease symptom was observed weekly starting from the plants aged 4 weeks until 7 weeks. About 20 plants collected from 5 different points in each field were collected to observe the disease based on the scoring of leaf symptoms (Table 2). Severity of *Fusarium* disease was further determined using the following formula [1]:

$$\textit{Disease Severity}\ (\%) = \frac{\sum_{i=0}^{n}(n_i \times v_i)}{N \times V} \times 100 \text{ ....[1]}$$

where n_i is the number of symptomatic plants representing each score, v_i is the score of severity, N is the number of plants observed, and V is the highest symptom score. Data obtained from disease monitoring was statistically analyzed using one-way analysis of variance. Statistical analysis was conducted using SPSS version 26.0. Significance recorded among location was subsequently analyzed using Duncan's New Multiple Range Test (DNMRT) with a $p<0.05$.

RESULTS AND DISCUSSION

Shallot cv. *Tajuk* grown in Bantul and Kulon Progo showed different responses towards the infection of *Fusarium* disease indicated by the difference of disease development dynamics (Fig. 1a and b). Development of *Fusarium* disease in Bantul fields was more progressive than those recorded in Kulon Progo. Exponential increase of disease severity at 5 WAP was shown in Imogiri, while Sanden revealed higher severity since 4 WAP (Fig. 1a). However, the severity of *Fusarium* disease in this area became stagnant at 6 and 7 WAP. Contrast pattern was shown in Kulon Progo fields where the disease was slowly developed from 4 to 7 WAP (Fig. 1b) resulting in less severe impact.

Table 2. Scoring used to measure leaf twisting symptom on infected shallot

Score	Symptom Description
1	No visible symptom
3	Chlorosis of the youngest leaves
5	Necrosis on the leaf tip
7	Elongated (excessive length increase) leaf followed with yellowing
9	Leaves dry out and twisted
12	Plant dead

Source: Herlina et al. 2021.

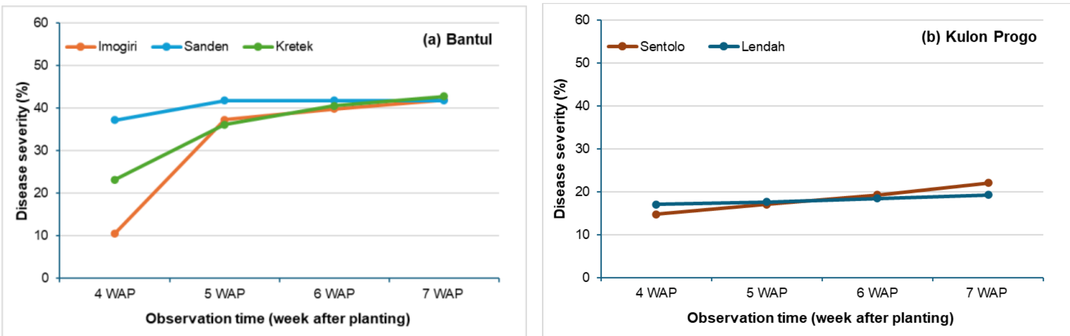

Figure 1. Comparison of Fusarium disease development between shallot cv. Tajuk fields in each district of Bantul (a) and Kulon Progo (b).

Severity of *Fusarium* disease at 7 WAP from each shallot field in Bantul and Kulon Progo was compared to determine the diversity in resistance of this variety within the same site. Of all fields observed in Bantul, the most severe infection was found in Kretek 2, exhibiting a significant difference compared to other villages, such as Kretek 1, Srigading 1, Srigading 3, and Srunggo (Figure 2a). Interestingly, disparity of disease severity among shallot fields in Kretek District was more remarkable than those recorded in Sanden and Imogiri. Such notable gap in disease severity within the same district was also found in Kulon Progo. Figure 2b demonstrated significant difference in severity between Kalimenur and Ngentakrejo 1 compared to other fields within the same district. Shallot cv. *Tajuk* cultivated in Ngentakrejo 1 showed the lowest disease severity (13.3%), while those cultivated in Kalimenur exhibited the highest severity of about 25% (Figure 2b).

Occurrence of plant disease is affected by various factors, including cultural practices applied. Table 3 and 4 demonstrated the difference of cultural practices applied during the cultivation of shallot cv. *Tajuk* in Bantul and Kulon Progo. Most shallot fields in both regencies applied intercropping with chili, while all observed fields in Bantul and Kulon Progo used rotation (Table 3 and 4). In terms of planting frequency, shallot cultivation in Bantul varied among districts. District in Bantul with the most frequent shallot planting was Sanden (particularly Srigading 1 and Gadingsari), where fields observed in Imogiri cultivated shallot once in a year only (Table 3). Unlike Bantul, all fields observed in Kulon Progo cultivated shallot twice a year (Table 4).

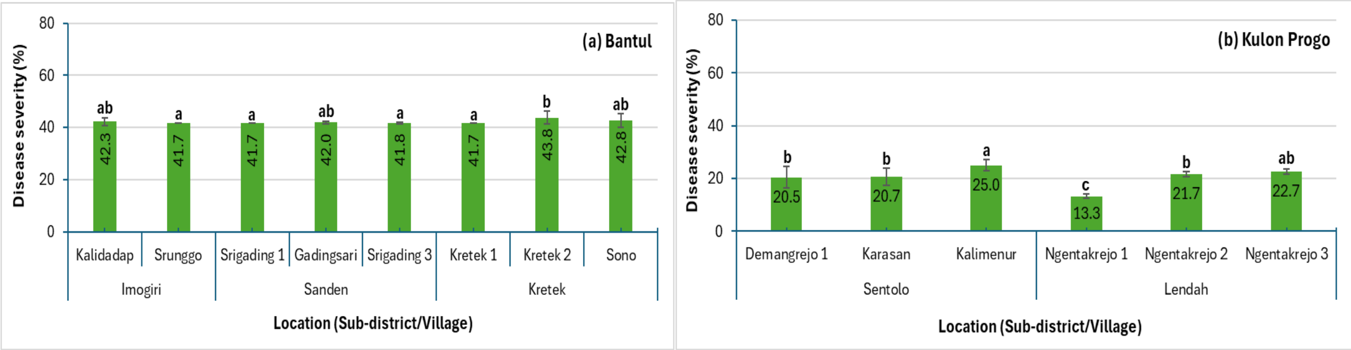

Figure 2. Severity of *Fusarium* disease at 7 WAP in each shallot field representing Bantul (a) and Kulon Progo (b). Bars with the same letters shows insignificant difference based on DNMRT with a p<0.05.

Table 3. Differences of shallot cv. *Tajuk* cultivation practices applied in several fields in Bantul Regency

District/Village	Aspects of farming practices					
	Cropping system	**Intercropped crops**	**Planting frequency (times.year^{-1})**	**Rotated crops**	**Plant spacing (cm x cm)**	**Watering frequency**
Imogiri District						
Kalidadap	Intercropping	Chili	1	Paddy, chili, tobacco	20 x 20	Once in 2 days
Srunggo	Monoculture	None		Paddy, tobacco		
Sanden District						
Srigading 1	Intercropping	Chili	3	Watercress, eggplant	20 x 20	Once in 2 days
Gadingsari					19 x 19	
Srigading 3			2	Chili, paddy	15 x 20	Daily
Kretek District						
Kretek 1	Intercropping	Chili, peanut	2	Chili, paddy	20 x 20	Once in 2 days
Kretek 2		Chili				
Sono						

Other aspects of farming practices observed in this study were plant spacing and watering intensity. Plant spacing used for shallot planting varies among districts in both areas. Several districts applied the same plant spacing in all observed fields, as shown in Imogiri and Kretek (Bantul) (Table 3), as well as Lendah (Kulon Progo) (Table 4). Distinct variation in plant spacing among shallot fields was found in Sanden (Table 3). In terms of watering frequency, most shallot fields in Bantul performed watering every two days, except in Srigading 3 (Table). In contrast, all shallot fields observed in Kulon Progo applied daily watering (Table 4). Referring to the observation period for each area, the watering frequency implemented in both areas appeared to contradict the weather conditions, particularly rainfall. Observation in Bantul was carried out during the dry season (June – August 2023), where the rain intensity within this period was extremely low (Table 5). On the other hand, the rainfall recorded in the Kulon Progo area during the observation period (January – February 2024) was high (Table 5).

Table 4. Differences of shallot cv. *Tajuk* cultivation practices applied in several fields in Kulon Progo Regency

District/Village	Aspects of farming practices					
	Cropping system	**Intercropped crops**	**Planting frequency (times/year)**	**Rotated crops**	**Plant spacing (cm x cm)**	**Watering frequency**
Sentolo District						
Demangrejo 1	Monoculture	None	2	Chili	18 x 18	Daily
Karasan	Intercropping	Chili			15 x 15	
Kalimenur				Paddy, chili		
Lendah District						
Ngentakrejo 1	Intercropping	Chili	2	Chili, peanut	20 x 18	Daily
Ngentakrejo 2				Chili		
Ngentakrejo 3						

Based on the disease severity at 7 WAP, the most severe *Fusarium* infection in Bantul was recorded from shallot field in Kretek 2 (Figure 2a). Shallot cv. Tajuk cultivated in this village applied intercropping with chili, quite wide plant spacing, and used less frequent watering (Table 3) during the observation period. The highest severity of *Fusarium* disease from shallot fields in Kulon Progo was found in Kalimenur, while the lowest severity was recorded in Ngentakrejo 1 (Figure 2b). Cultivation of shallot cv. Tajuk in Kalimenur utilized narrower plant spacing (15x15 cm) and implemented rotation with paddy and chili (Table 4). In contrast, the shallot field in Ngentakrejo 1 applied wider plant spacing (20x18 cm) and performed rotation with chili and peanut (Table 4).

Table 5. Monthly rainfall and number of rainy days in Bantul and Kulon Progo during the observation period

Regency	Observation Period	Average Rainfall (mm) per Month	Number of Rainy Days per Month
Bantul	June – August 2023	0.0 (June)	0.0 (June)
		24.0 (July)	5.0 (July)
		0.0 (August)	1.0 (August)
Kulon Progo	January – February 2024	405.0 (January)	22.0 (January)
		147.0 (February)	10.0 (February)

Source: Statistics of Yogyakarta Province (2024a).

DISCUSSION

Bantul and Kulon Progo are the main contributors to regional shallot production. Statistics of Yogyakarta Province (2024b) reported that shallot production in both regencies in 2023 reached 94% of total shallot production in the Special Region of Yogyakarta Province. However, shallot production in both Bantul and Kulon Progo has not reached its optimal productivity due to various issues during its cultivation, including disease infection. *Fusarium* disease is one of the important diseases infecting Allium species, including shallot (Le et al. 2021; Poursakhi et al. 2024). In Indonesia, disease caused by *Fusarium* spp. in shallot, garlic, and leeks is mainly known as *moler* or twisted disease since the symptom that appeared is leaf twisting.

Prevalence of *Fusarium* disease in shallots may vary depending on variety, environmental factors, and pathogen species/strain. This present study highlighted the *Fusarium* intensity recorded from the shallot cv. Tajuk cultivated in several areas in Bantul and Kulon Progo, where the disease observation was carried out at different times between Bantul and Kulon Progo. Shallot cv. Tajuk cultivated in Bantul conferred higher susceptibility to *Fusarium* disease than those cultivated in Kulon Progo (Figure 2). In addition, Figure 1 also emphasized the distinct differences in disease progression from 4 to 7 WAP between Kulon Progo and Bantul. These findings suggest that shallot fields in Bantul may experience higher exposure to this disease than those in Kulon Progo.

Regarding the disease severity, the highest severity (43.8%) in Bantul was recorded from shallot field in Kretek 2 (Figure 2a). This finding was higher than those reported by Wibowo et al. (2023), where the twisted disease infecting shallot cv. Tajuk cultivated in the coastal area of Bantul reached its highest incidence at 33.97% during the rainy season in 2021. Interestingly, this present study found that high disease severity in Bantul occurred during the dry season with extremely low rainfall (Table 5). Moreover, result of this study implies that the increase in disease severity recorded in Bantul compared to the previous study might be associated with the level of pathogen infestation in the specified field. The longer the pathogen is infested and survives in the field, the higher the chance of disease severity increasing in the next infection cycle. Despite the accumulation of pathogen residue, another factor that contributes to more severe infection is the possibility of complex *Fusarium* species. Infection by these complex species may result in stronger pathogenicity and higher virulence, leading to a more severe impact on plant growth (Sidharthan et al. 2023). Other studies also highlighted that the composition of *Fusarium* complex varied by location and host, hence resulting in different levels of virulence (Degani et al. 2024; Le et al. 2021).

Considering the shallot variety, resistance of Tajuk variety to *Fusarium* infection has been investigated previously under greenhouse conditions (Hadiwiyono et al. 2020; Herlina et al. 2021). This variety was considered to be in the moderate category for infection by *Fusarium oxysporum* f.sp. *cepae* resulting in 37.17% severity (Hadiwiyono et al. 2020). In contrast, Herlina et al. (2021) reported higher severity (68.54%) from this shallot variety after being inoculated with three isolates of FOC. Comparison of these previous studies underlines that the susceptibility of the shallot variety to *Fusarium* disease could fluctuate depending on *Fusarium* species. In that context, *Fusarium* has been known for its diverse host range due to the formation of *formae speciales* (f.sp.) with different virulence and host specificity (Edel-Hermann and Lecomte 2019; Gordon 2017). However, the response of Tajuk variety to specified *Fusarium* species/strains may differ depending on geographical location since various environmental aspects may affect disease development. Therefore, further research on the resistance of this variety across multiple locations in Indonesia would provide an in-depth knowledge regarding the characteristics of Tajuk variety.

Findings of this study conveyed the variation of cultural practices applied in the cultivation of Tajuk variety between Bantul and Kulon Progo (Table 3 and 4). Most of the representative shallot fields in each regency applied an intercropping system with chili as the intercropped plant. Our previous work in 2021 also found that the cultivation of this shallot variety in Kretek and Sanden (Bantul Regency) was performed with the same choice of intercropped crop (Aisyah et al. 2022). Despite the intercropping system applied in most shallot fields in this study, the occurrence of *Fusarium* disease showed higher severity in Bantul Regency than Kulon Progo (Figure 1 and 2). It implies that the use of intercropping and crop rotation in Bantul is unable to mitigate the disease prevalence significantly. Such high disease severity recorded from most shallot fields in Bantul indicates that the disease prevalence in this area has reached the state of endemic. Therefore, regardless of the variation of farming practices applied, the disease severity did not differ significantly. In addition, this endemic state was also marked with high severity developed during the dry season in Bantul (Table 5) and low watering intensity applied during the shallot cultivation (Tabel 3a).

Endemic of *Fusarium* disease in a specific geographical area could occur due to the establishment of the pathogen during several growing seasons. This establishment could result in higher virulence depending on the diversity of species or the presence of a species complex (Delgado-Ortiz et al. 2016; Haapalainen et al. 2016). Infection by these complex species has a higher chance to cause greater growth reduction and yield loss (Sidharthan et al. 2023). Interestingly, complex species of *Fusarium* may consist of both pathogenic and non-pathogenic species and the formation of this species complex can be triggered through crop rotation. Diabankana et al. (2024) reported the infection of *Fusarium* strains isolated from onion on other plant species used for crop rotation, suggesting the risk of *Fusarium* co-infection to non-host plants. Aligned with this previous study, all shallot fields in Bantul applied rotation with various non-*Allium* crops (Table 3) with no significant impact on the disease severity (Figure 2a). Nonetheless, the *Fusarium* species infecting each shallot field in Bantul and Kulon Progo has not been thoroughly explored in this present study. Further investigation is recommended to identify whether the *Fusarium* disease found in both locations is caused by a single or complex species.

Contrast disease prevalence recorded from shallot fields in Kulon Progo, highlighting the possibility of lower exposure of *Fusarium* in this area, thus resulting in less severe impact on shallot cv. Tajuk (Figure 1b and 2b). Considering the cultural practices applied, shallots cultivated using both monoculture and intercropping systems showed similar disease severity in this region (Figure 2b). Nevertheless, the lowest disease severity (13.3%) in Kulon Progo was obtained from Ngentakrejo 1 (Lendah District) (Figure 2b) where the cultivation applied intercropping with chili and used peanut as one of the rotated crops (Table 4). This finding is higher compared to those reported by Pustika et al. (2024), where Tajuk variety cultivated in Panjatan District (Kulon Progo) showed 7.60% severity (at 8 WAP) to *Fusarium* infection recorded in 2022. Not only the location difference, but also the difference in Tajuk variety resistance to *Fusarium* disease between this present study and the previous one could be attributed to the climatic conditions during the observation. Disease monitoring conducted by Pustika et al. (2024) was carried out during the dry season (August to October 2022), while the present study was observed during the rainy season (January to February 2024). However, to justify the prevalence of this *Fusarium* disease in a specified area more accurately, disease monitoring should be conducted in a specified field continously following the growing season of shallot in that area. Thus, the dynamic of the disease incidence in each growing season could be comprehensively quantified to determine the factors affecting its severity as well as the resistance of the shallot variety.

Overall, the findings of this study highlight the susceptibility of shallot cv. Tajuk to *Fusarium* disease varies depending on the location of its cultivation, instead of the cultural practices applied in both Bantul and Kulon Progo. The difference in disease severity recorded in each location suggests the different levels of disease exposure among locations that could be linked to the pathogen establishment and virulence. Further analysis should focus on the identification of *Fusarium* species infecting each shallot field in both locations to evaluate the spectrum of pathogen virulence. In addition, this present study also reveals that higher rainfall does not appear to be in line with the increased disease intensity, thus indicating a shift in the interaction of plant-pathogen-environment due to climate change effects. Nonetheless, deeper investigation is needed to complement the findings of this study through consecutive disease monitoring following the shallot cv. Tajuk growing season in both locations

CONCLUSIONS AND SUGGESTIONS

This study confirms that the susceptibility of the shallot cv. *Tajuk* to *Fusarium* disease varied between Bantul and Kulon Progo. Shallot cv. *Tajuk* reveals higher resistance against *Fusarium* disease when it was cultivated in Kulon Progo. The findings also indicate that farming practices applied and rainfall intensity in each location appear to have a negligible impact on the occurrence of this disease. However, since the detailed analysis on both environment and pathogen factors was limited in this study, further investigations should address how these aspects contribute to disease development. In addition, multi-year observations on climate and cropping records in both areas are also suggested to evaluate the disease progression over time. This information would provide a more comprehensive overview regarding the profile of *Fusarium* disease (particularly in shallots) as well as the resistance of certain shallot varieties.

ACKNOWLEDGMENTS

The authors acknowledge the funding support from the Research and Innovation Center of Universitas Muhammadiyah Yogyakarta through the International Collaborative Research Grant for the fiscal year 2022-2023.

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