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Effect of Shallot Biopesticide Extract and Liquid Organic Fertilizer on Plant Growth and Suppression of *Fusarium*-Induced Twisting Disease

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Abstract. Shallot (*Allium ascalonicum* L.) is a major agricultural commodity in Indonesia. This plant contributes significantly to the national economy and contains numerous bioactive compounds with various properties, such as antioxidant, antibacterial, and antifungal activity. However, the biggest production constraint is infection by the pathogen *Fusarium*, known as Twisting disease. Therefore, this study aimed to investigate the effect of combining biopesticides and liquid organic fertilizer (LOF) in shallot farming on *Fusarium* spp. The experiment was conducted using randomize block design with two main parameters. The first parameter was the interval of biopesticide extract applications, namely, no extract, once a week, and once every two weeks. The second parameter was the LOF dosage, including 0, 25, 50, and 75 mL/plant. Plant height, number of leaves, fresh biomass, and disease incidence were observed to evaluate the effect of biopesticides and LOF application. The results showed that a combination of biopesticide extract and LOF positively affected growth but suppressed disease incidence. The combination of once-a-week biopesticide extract and 75 mL/plant LOF applications was identified as the best treatment. In conclusion, biopesticide extract and LOF can be applied for sustainable, environmentally friendly disease management in shallot plants. The results support Sustainable Development Goals (SDGs) 2, 12, and 15 by controlling *Fusarium* fungal infections in shallots, maintaining production, reducing the use of chemical pesticides, and promoting sustainable agricultural management.

Keywords: *Allium ascalonicum*; biopesticide; *Fusarium* spp; liquid organic fertilizer

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INTRODUCTION

Brebes, Central Java, is one of the highly productive regions for shallot in Indonesia (Sahara et al., 2025). This region produced a total 608.351,2 tons of shallot in 2024 (BPS-Statistics, 2025), representing the highest contribution in Indonesia, followed by East Java, South Sulawesi, and West Sumatra, respectively. From a biological perspective, shallot contains various bioactive compounds, including pyruvic acid, sugar, flavonoid that act as antioxidants for living organisms (Major et al., 2021). Flavanoids are recognized as the major phenolic compounds responsible for the reddish, bluish, or violet coloration of leaves, flowers, or fruits (Arora et al., 2017).

The Tajuk variety, derived from a Thai cultivar, can thrive in both rainy and dry seasons. It has a potential yield of 12–16 tons/ha with a harvest age of 52–59 days after planting (DAP). The plant is typically characterized by a bulb diameter of 0.8–2.7 cm, 5–15 bulbs per clump, bright red color, and distinctive aroma (Rachmawati et al., 2023). Shallot production often fluctuates due to disease, including twisting caused by *Fusarium oxysporum* f.sp. *cepae* (Marianah et al., 2024). This type of disease can lead to significant yield reduction in crops (Wiyatiningsih et al., 2024).

Fusarium infection in shallot potentially induces wilting and chlorosis of leaves, stunted growth, and basal stem rot, commonly known as twisting. Plants infected by this disease usually show symptoms, including thinness and an easy collapse (Yudha et al., 2023; Widono et al., 2023).

Similar pathogenic infections may also cause er symptoms, including yellowish-brown discoloration at the leaf tips, curling leaves with brown lesions that gradually darken, and eventual plant death (Herlina L, 2020; Marianah et al., 2024; Jannah et al., 2024). Recently, various methods have been intensively developed to control plant disease, including infection by *Fusarium*. One alternative is the application of liquid organic fertilizer (LOF) for crops. LOF plays an important role in providing nutrients that are essential for growth and disease control (Ji et al., 2017; Siregar et al., 2017).

Waste from shallots can be processed into LOF that promotes a sustainable agriculture program. Previous studies have shown that this method effectively maintains and reduces chemical fertilizer residues in the plantation area (Sitorus et al., 2025). LOF contains various bioactive compounds with antipathogenic microorganisms and/or anti-inflammatory properties (Moldovan et al., 2024). Shallot is also rich in phenolic compounds, carbohydrates, and vitamins that provide substantial nutrition in the LOF (Sun et al., 2019). High nutrient availability stimulates the growth of beneficial soil microbes that induce plant defense against disease (Elshafie et al., 2023). Furthermore, LOF from shallot waste is effective for suppressing the development of fungi in the rhizosphere area of the roots. The phenolic and sulfur compounds in shallot disrupt fungal growth and prevent pathogenic infections (Degani et al., 2022; Marianah et al., 2024).

Shallot belongs to the Alliaceae family and is classified alongside common onions under the group name *Allium cepa Aggregatum*. This group has a lower dry matter content and pungency based on its pyruvic acid content. Shallot is more suitable for fresh consumption due to the richness in phenolic compounds, particularly the glycosides quercetin and isorhamnetin (Major et al., 2022; Al-Shammary et al., 2024). The plant also possesses strong antioxidant activity under *in vitro* conditions (Major et al., 2022).

Several studies have investigated strategies for controlling *Fusarium* fungal infections and improving shallot production. These include the induction of plant defense mechanisms through biopesticide induction (Wiyatiningsih et al., 2024) to test the effect of LOF on flowering, shallot yields, and the ability to improve soil quality (Triharyanto et al., 2022). Previous studies have also examined the correlation between disease severity and resistance of several shallot varieties with crop loss (Hadiwiyono et al., 2020), as well as the development of liquid biopesticide formulations and the effects on disease in shallot (Prihatiningsih et al., 2025).

Boyolali Regency has extensive agro-ecological characteristics consisting of lowlands and highlands. Various horticultural crops, including shallot, can grow optimally in this region, but farmers often face serious problems related to disease caused by fungi, bacteria, or virus infections. This study investigated the effect of LOF and biopesticides to control twisting disease caused by *Fusarium* in shallot plants from Bangsalan Village, Boyolali.

Based on the discussion above, this study aimed to investigate the effect of shallot biopesticide extract and LOF on plant growth and suppression of *Fusarium*-induced twisting disease. The results are expected to help farmers overcome the disease problem in shallot and finally increase crop productivity in this region. It may also suggest a significant reduction in chemical pesticide application for crop production. Overall, this study provides insights for the development of sustainable strategies in agricultural activities.

METHODS

Study Design

The experiment was performed on sandy Regosol soil in Bangsalan Village, Boyolali, from June 2025 to October 2025. A qualitative approach with an exploratory design was applied for data analysis (Resti et al., 2024). A Completely Randomized Block Design consisting of two factors was used. The first factor was the interval of shallot biopesticide extract (F) application, including the treatment without extract (F0), tuber extract once a week (F1), and once every two weeks (F2). The second factor was the dose of LOF (U), including 0 mL/plant (U0), 25 mL/plant (U1), 50 mL/plant (U2), and 75 mL/plant (U3). Each combination of F and U treatment was repeated five times (Haryuni et al., 2024).

Land preparation

The soil was tilled about 20–30 cm deep, then three beds with a size of 175 x 100 cm were prepared. A total of 12 plots were arranged for each block, cultivated with shallot plants. In total, five shallot plants were randomly selected as samples during the experiment period. Before mulching, each bed was administered 50 kg of dolomite. Base fertilizers in the form of organic fertilizer 17.5 tons/ha, urea (300 kg/ha, ZA 150 kg/ha, and KCl 300 kg/ha were applied evenly 1–3 days before planting (Hasanah et al., 2022; Haryuni et al., 2024).

Preparation and Planting of Seeds

The shallot seeds used in this study were 70-80 DAP. Fresh, healthy, and firm seeds with medium size (5–10 g) were selected for the experiment. The dry skin was removed before planting. The tips of the seeds were immediately trimmed and mixed evenly with 50% dimetomorph fungicide (Purba et al., 2020; Haryuni et al., 2024)

Observation

The symptoms of twisting disease were observed in all plants. The fungal isolation and microscopic observation were performed on diseased plants to identify the causative pathogen. Plant growth was evaluated by measuring plant height from the base of the leaf to the tallest leaf (Jamil et al., 2022), the number of leaves was counted from the first emergence until harvest, and fresh biomass was calculated in the form of fresh weight of tubers, leaves, and roots (Sutardi et al., 2022). Disease incidence was recorded eight weeks after transplanting using the following formula Haryuni et al. (2024).

$$P= \frac{v}{2n} x\ 100\%$$

P = Disease incidence (%); n = Number of affected plants; v = Number of observed plants each plot

Analysis of Results

Data were analyzed using analysis of variance (ANOVA). Furthermore, the Duncan Multiple Range Test (DMRT) at a 5% significance level was performed when the difference was identified among the treatments. Microscopic observation was performed descriptively using a qualitative method (Muscat et al., 2020; Haryuni et al., 2024).

RESULTS AND DISCUSSION

Initial symptoms of *Fusarium* infection were observed in plants at 10–14 DAP. In the infected plants, the leaves turned yellowish to brownish (Figure 1A) and eventually died within a few days. *Fusarium* was successfully isolated (Figure 1B) and microscopically identified (Figure 1C) in the infected plants. This indicates that twisting disease observed in plants was mainly caused by *Fusarium*.

Species of *Fusarium* are widely recognized as one of the most destructive fungal pathogens and are very difficult to control after infecting crops, including shallot varieties. Disease caused by *Fusarium* infection can reduce yield by more than 50% (Rahayu et al., 2021; Wahyuni et al., 2023; Haryuni et al., 2024; Resti et al., 2024). *Fusarium* is a well-known soil-borne pathogen that infects the roots of plants. It also spreads through the vascular system and inhibits the distribution of essential nutrients for the plants, resulting in the disruption of tuber formation. Infection is indicated by the appearance of brownish to yellow spots, followed by wilting or bending of the leaves and the base of the stem and root, finally leading to plant death (Wahyuni et al., 2023; Yudha et al., 2023; Jannah et al., 2024). *Fusarium* infection in shallot also weakens the root system due to impaired development, which potentially leads to decay, and in severe cases, penetration of the bulb's basal plate, causing plants to collapse and eventually die after a few days (Shin et al., 2023; Wesoly et al., 2024).

Isolated mycelium shows a white color that changes from cream to black and oval-shaped macroconidia (Haryuni et al., 2024). This study examined the effect of the LOF and biopesticide extract application for preventing Fusarium-induced disease in shallot plants. The results showed a positive effect on growth, including plant height, leaf number, and biomass, as well as disease control (Table 1).

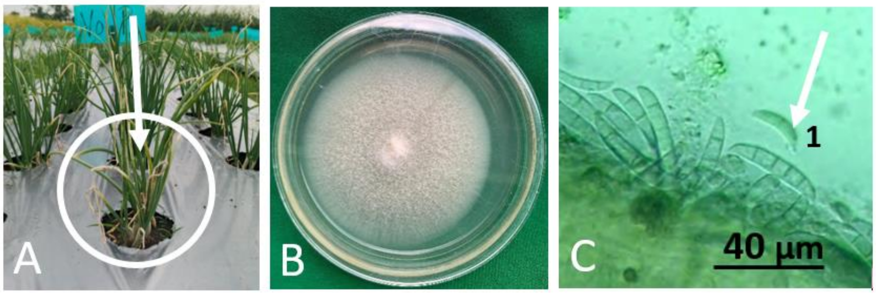

Figure 1. Symptoms of *Fusarium* spp. infection on plants (A), colony growth after 8 days of isolation on PDA medium (B), and microscopic observation of *Fusarium* spp. conidia under 40×magnification (C). codidinum of *Fusarium* spp (1)

Table 1. The Effect of Liquid Organic Fertilizer and shallot Biopesticide Extract on the Growth (plant height, number of leaves, fresh biomass, and disease incident) of shallot.

Treatment	Observation			
	Plant height (cm)	**Number of leaves**	**Biomass (g)**	**Disease incidence (%)**
Biopesticide extract				
F0	34.40[a]	29.97[a]	36.19[a]	42.67[c]
F1	37.17[b]	40.31[b]	52.40[b]	13.00[a]
F2	39.08[c]	47.27[c]	65.39[c]	24.32[b]
Liquid organic fertilizer				
U0	27.42[a]	28.63[a]	36.54[a]	23.67[c]
U1	27.48[ab]	28.81[a]	37.28[a]	21.33[bc]
U2	27.86[ab]	28.94[a]	37.56[a]	18.33[ab]
U3	27.89[b]	31.16[b]	42.60[b]	16.66[a]
Interaction of Biopesticide extract and Liquid organic fertilizer				
F0U0	34.00[a]	29.74[a]	37.72[a]	49.33[g]
F0U1	35.50[a]	29.51[a]	34.67[a]	45.33[fg]
F0U2	34.35[a]	30.14[a]	36.55[a]	40.00[ef]
F0U3	33.76[a]	30.46[a]	35.81[a]	36.00[e]
F1U0	38.8[e]	44.89[c]	61.08[d]	18.67[c]
F1U1	39.01[e]	45.05[c]	60.28[d]	16.00[c]
F1U2	38.34[de]	44.79[c]	60.25[d]	12.00[b]
F1U3	40.17[f]	54.35[d]	79.96[e]	5.33[a]
F2U0	36.89[c]	40.62[b]	50.32[b]	26.67[d]
F2U1	37.05[c]	41.18[b]	51.19[bc]	24.00[d]
F2U2	37.22[c]	39.59[b]	53.42[bc]	21.33[cd]
F2U3	37.53[c]	39.84[b]	54.65[c]	25.29[d]

Note: Numbers followed by the same letter show no significant difference in the Duncan multiple range test (DMRT) at the 5% level

The F2 treatment showed the best growth performance, indicated by greater plant height (39.08 cm), leaf number (47.27), fresh biomass (65.39 g), and differed significantly from the F0 treatment. This improvement is attributed to the presence of bioactive compounds, including flavonoids, phenolics, and sulfur-containing substances. The bioactive compounds can function as antifungal and antibacterial agents, thereby reducing pathogen pressure and allowing more efficient allocation of energy toward vegetative growth (Zhao et al., 2021). In addition, the compounds are known to impair pathogen cell integrity or inhibit key enzymatic processes essential for survival and multiplication (Hidayanti et al., 2025). Therefore, red shallot extract is considered an effective natural substance for controlling plant disease (Khan et al., 2025).

The once-a-week application interval (F1) was significantly different compared to the control (F0) and the once-every-two-weeks interval (F2). The results showed that the biopesticide extract was effective in controlling disease and improving plant physiological performance (Wiyatiningsih et al., 2024). It also maintains the stability of bioactive compounds in the rhizosphere, thereby promoting systematic pathogen suppression (Salamiah & Orbani, 2022). The LOF application significantly affected the number of leaves, fresh biomass, and disease incidence. The highest dose (U3) increased the number of leaves and fresh biomass. LOF plays an important role as a supporter of vegetative growth due to the micronutrients and organic acid content (Septian et al., 2025).

LOF dosage was also significantly associated with the incidence of twisting disease. The results showed a significant correlation between the reduction in disease incidence and the nutritional status of plants through LOF, followed by increased resistance. Appropriate nutrient availability plays important roles in strengthening cell wall formation, optimizing enzymatic function, and plant defense mechanisms through the production of secondary metabolites. Consequently, plants supplied with higher LOF doses showed increased tolerance to disease stress (Kumar et al., 2022).

A significant interaction was detected between the application of shallot biopesticide extract and LOF dosage, in which the F1U3 treatment combination produced the highest plant height, leaf numbers, and fresh biomass, accompanied by the lowest disease incidence. This indicates an optimal balance between biopesticide application frequency and nutrient availability from LOF (Sitorus, 2025). The interactions have an effect on increasing vegetative growth, followed by a decrease in the incidence of disease through the formation of bioactive compounds that act as antibiotics (Zhao et al., 2021). The application of biopesticides and LOF also stimulates resistance induction mechanisms and accelerates biomass accumulation (Wiyatiningsih et al., 2024).

This study demonstrates the interaction between shallot biopesticide extract and LOF, which contributes to increased growth and yield as well as the suppression of twisting disease in shallot caused by the fungus *Fusarium*. The results show the effectiveness of environmentally friendly plant pest management and support sustainable agriculture, while also contributing to SDGs, including SDG 2 related to zero hunger, SDG 12 about responsible consumption and production, as well as SDG 15 relevant to sustainable use of terrestrial ecosystems, which focus on food security, sustainable production, and environmental protection.

CONCLUSION

In conclusion, the combination of weekly LOF application with 75 mL/plant (F1U3) significantly increased plant height, leaf number, and fresh biomass, while reducing the incidence of twisting disease caused by *Fusarium* spp. This combination is a sustainable and environmentally friendly disease management strategy. Future studies are needed in various regions and seasons to comprehensively understand the mechanisms of secondary metabolite-based resistance induction. Furthermore, identifying bioactive compounds in biopesticide extracts could provide important information regarding the future development of sustainable and environmentally friendly pesticides for crops.

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AUTHOR CONTRIBUTION STATEMENT

In this study, all authors made substantial contributions, were involved in reviewing and approving the manuscript, and were responsible for the integrity and accuracy of all aspects.

CONFLICT OF INTEREST STATEMENT

All authors declare that there is no conflict of interest regarding the publication of this manuscript.

USE OF ARTIFICIAL INTELLIGENCE (AI)-ASSISTED TECHNOLOGY

All authors confirm that no artificial intelligence (AI) technology was used in conducting the study, analyzing the data, or preparing the manuscript, and that all stages of the study were completed by the authors without the assistance of AI.

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