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RESEARCH PAPER

Application of *Trichoderma* Isolate consortium in organic fertilizer for controlling shallot twisted disease

Lilies Supriati, Siti Zubaidah, Adrianson Agus Djaya, Oesin Oemar, & M. M. Ramadhan

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ABSTRACT

The aim of the research was to determine the effect of applying a consortium of *Trichoderma* spp. isolates to a type of organic fertilizer that is effective in controlling twisted disease and on the growth and yield of shallot plants. The study utilized a completely randomized design (CRD) consisting of eight treatments with four replications. The treatments examined werea= as follows: P_0 = control, P_1 = 5 tons per ha of chicken manure fertilizer, P_2 = 5 tons per ha of chicken manure fertilizer and consortium of two *Trichoderma* spp. isolates, P_3 = 5 tons per ha of chicken manure fertilizer and consortium of three *Trichoderma* spp. isolates, P_4 = 5 tons per ha of chicken manure fertilizer, 20 tons per ha trichocompost, and a consortium of two *Trichoderma* spp. isolates, P_5 = 5 tons per ha of chicken manure fertilizer, 20 tons per ha trichocompost, and consortium of three *Trichoderma* spp. isolates, P_6 = 20 tons per ha of trichocompost and a consortium of two *Trichoderma* spp. isolates, and P_7 = 20 tons per ha of trichocompost and a consortium of three *Trichoderma* spp. isolates. The results showed that the twisted disease incidence in treatment P_4 was the lowest (14.52%) at 8 weeks after planting. The plant height was of 39.10 cm, with 29.8 leaves per clump at 7 WAP, and the dried bulb weight was 112.4 g per clump. In conclusion, the application of chicken manure fertilizer at a dose of 5 ton per ha, combined with 20 tons per ha of trichocompost and a consortium of two *Trichoderma* spp. isolates, could control twisted disease in shallot.

Key words: organic fertilizer, shallot, *Trichoderma* isolates, twisted disease

INTRODUCTION

Shallot (*Allium ascalonicum*) is a vegetable crop with relatively high economic value due to its high demand as cooking spices. The demand for shallot is increasing in line with population growth and purchasing power. The per capita need for shallots increases every year, the average need for shallots in 2020 was 2699 kg per capita, increasing to 2926 kg per capita in 2021, and 3024 kg per capita in 2022 (Ministry of Agriculture, 2022). Considering the community's need for shallot, its production needs to be increased. Shallot production in 2020 was 1,815,445 tons, increasing to 2,004,590 tons in 2021 (Ministry of Agriculture, 2021), and in 2022 to 1,970,000 tons, experiencing a decrease in production of 1.51% (BPS, 2023). However, efforts to increase shallot production are often hindered by the incidence of twisted disease (Hikmahwati et al., 2020). Yield losses due to pathogen infection in shallot plants range between 20–100% (Syarifudin et al., 2021).

Corresponding author:
Lilies Supriati (lilies.supriati@gmail.com)

Faculty of Agriculture, Universitas of Palangka Raya, Jl. Yos Sudarso, Palangka Raya Indonesia

Twisted disease, caused by *Fusarium oxysporum* f.sp. *cepae*, has become a major disease in various shallot production areas in Indonesia (Susanti et al., 2016). The incidence of twisted disease in the field varies up to 80%, depending on the cultivated varieties (Susanti et al., 2016). Meanwhile, the incidence of twisted disease in the Bima Brebes variety under treatment without trichocompost and KCl fertilizer in Palangka Raya reached 45.76% (Supriati et al., 2019). The impact of twisted disease on shallot can lead to a production decrease of more than 50%, even resulting in crop failure (Juwanda et al., 2016; Ahmad et al., 2020).

The shallot production in Palangka Raya city in 2016 was 911 quintals. It increased to 1417 quintals in 2017, then decreased from 2018 to 2020, amounting to 660, 25.5, and 22.0 quintals, respectively (Palangka Raya city Central Bureau of Statistics, 2021; Central Kalimantan Central Bureau of Statistics, 2022). These data show that increasing shallot production in Palangka Raya city creates a dilemma because diseases attack the shallot crops, making farmers relatively reluctant to plant them.

The symptoms of twisted disease include twisted leaves, yellowing, and fragile roots, making them easy to pull out (Hikmahwati et al., 2020). According to information from shallot farmers, if the infection occurs at 2 weeks of age, the plants will fail to form bulbs. Losses due to twisted disease can exceed 50% (Juwanda et al., 2016; Sataral et al., 2020; Sudantha & Suwardji, 2021). This fungus also infects shallot bulbs during storage and marketing (Sinaga et al., 2016).

Generally, twisted disease control still uses fungicides, but currently, we need alternatives methods that are safe, relatively cheaper, and environmentally friendly (Suryadi et al., 2023). This necessitates environmentally friendly alternative control methods using biological control with antagonistic microbes. Antagonistic fungi are reported to have the ability to suppress plant diseases (Adhi & Suganda, 2020), by utilizing biological agents that have been proven to play an effective role in controlling plant diseases, such as *Trichoderma* spp. (Abdullah, 2022). An environmentally friendly alternative control method for managing twisted disease involves the application of organic fertilizers combined with biological agents. Organic fertilizers commonly used for plant fertilization include chicken manure and trichocompost. Chicken manure has good potential and plays a significant role in improving the physical, chemical, and biological properties of the soil. It also contains higher levels of N, P, and K compared to other types of manure (Bhoki et al., 2021; Yulianto et al., 2021). Trichocompost is a form of organic fertilizer containing *Trichoderma* sp. As a fertilizer, trichocompost provides nutrients for plants, and the presence of *Trichoderma* sp. as decomposers can accelerate the decomposition process as well as exhibit antagonistic abilities against soilborne pathogens such as *Sclerotium rolfsii*, *Phytium* sp., *Fusarium* sp., and *Rhizoctonia* sp. (Ginanjar et al., 2016).

The application of *Trichoderma* spp. on organic fertilizers can be done individually or in consortium with various other *Trichoderma* species (Puspita et al., 2020). The types of isolates used in this study are *Trichoderma harzianum* TKdG3, *Trichoderma viride* TKdG7, *Trichoderma longibrachiatum* Tr-GA9, *Trichoderma koningii* TTG2, and *Trichoderma* RTG1. According to Sihombing (2019), a consortium of *T. longibrachiatum* Tr-GA9, *T. koningii* TTG2, and *Trichoderma* RTG1 showed the ability to suppress the growth of *Ganoderma* sp. in palm oil seedlings by 13.97%, while the consortium of *T. harzianum* TKdG3 and *T. viride* TKdG7 could supress the growth of *Ganoderma* sp. by up to 18.15%.

The aim of the research was to determine the effect of applying a consortium of *Trichoderma* spp. isolates to a type of organic fertilizer that is effective in controlling twisted disease and on the growth and yield of shallot plants.

MATERIALS AND METHODS

Research Site. The research was carried out in the experimental field and laboratory of the Department of Crop Cultivation, Faculty of Agriculture, University of Palangka Raya. The experiment was conducted over for 4 months, from June to September 2021.

Experimental Design. This research utilized a completely randomized design (CRD) consisting of eight treatments with four replications. The experimental units were placed randomly. They were:

P_0 = Control;

P_1 = 5 tons per ha of chicken manure;

P_2 = 5 tons per ha of chicken manure and consortium of two *Trichoderma* isolates (*T. harzianum* TKdG3 and *T. viride* TKdG7);

P_3 = 5 tons per ha of chicken manure and consortium of three *Trichoderma* isolates (*T. longibrachiatum* Tr-GA9, *T. koningii* TTG2, and *Trichoderma* RTG1);

P_4 = 5 tons per ha of chicken manure, 20 tons per ha of trichocompost, and consortium of two *Trichoderma* isolate (*T. harzianum* TKdG3 and *T. viride* TKdG7);

P_5 = 5 ton per ha of chicken manure, 20 ton per ha of trichocompost, and consortium of three *Trichoderma* isolates (*T. longibrachiatum* Tr-GA9, *T. koningii* TTG2, and *Trichoderma* RTG1);

P_6 = 20 tons per ha of trichocompost and consortium of two *Trichoderma* isolate (*T. harzianum* TKdG3 and *T. viride* TKdG7);

P_7 = 20 tons per ha of trichocompost and consortium of three *Trichoderma* isolates (*T. longibrachiatum* Tr-GA9, *T. koningii* TTG2 and *Trichoderma* RTG1).

Multiplication of Isolates of *Trichoderma* spp. Each *Trichoderma* spp. isolate was cultured on Potato Dextrose Agar (PDA) medium (Merck, Germany) in petri dishes with a diamater of 9 cm for 5 days. After that, 5 pieces of agar plugs from each isolate with a diameter of 5 mm were inoculated onto 100 g of semi-cooked sterile rice in transparent PP plastic bags measuring 15 cm × 30 cm and incubated for 14 days at the room temperature. Before used, the semi-cooked rice was sterilized using an autoclave at 121 ºC for 15 min. Isolates of *T. harzianum* TKdG3, *T. viride* TKdG7, *T. longibrachiatum* Tr-GA9, *T. koningii* TTG2, and *Trichoderma* RTG1 were each propagated on 100 g of sterile semi-cooked rice. The number of *Trichoderma* spp. isolates packages required is 10.

Preparation of Planting Media and Application of Organic Fertilizer. The planting medium consisted of sandy mineral soil from Bukit Tunggal village, Jekan Raya subdistrict (located at coordinate 2°11'13.9"S-113°51'38.5"E), at a rate of 10 kg per polybag, supplemented with 5 g of dolomite per polybag mixed into the planting medium. It was incubated for 1 week at room temperature. After the incubation period, chicken manure and trichocompost were applied according to the treatments. A total of 32 polybags of planting media were required. The trichocompost used for treatment was a year-old stock and prepared with a starter of different species of *Trichoderma* spp. There were two types od trichocompost: one with a starter consortium of *T. harzianum* TKdG3 and *T. viride* TKdG7, and another with a starter consortium of *T. longibrachiatum* Tr-GA9, *T. koningii* TTG2, and *Trichoderma* RTG1 (isolated from the rhizosphere of eggplant plants grown in peat soils). Trichocompost material consists of: aquatic weed *Salvinia molesta* (air dried for 3 days) 60 kg, chicken manure 30 kg, dolomite lime 300 g, fine bran 1 kg, *Trichoderma* isolates on semi-cooked rice substrate media 1000 g, and 2 L of water). This was prepared based on the method described by Supriati et al. (2019).

Application of *Trichoderma* spp. Isolates in Planting Media. The application of a consortium of 2 *Trichoderma* spp. isolates (*T. harzianum* TKdG3 two and *T. viride* TKdG7) or three *Trichoderma* spp. isolates (*T. longibrachiatum* Tr-GA9, *T. koningii* TTG2, and *Trichoderma* RTG1) at a dose of 20 g per polybag was done simultaneously with the application of organic fertilizers in the planting holes and mixed with the planting medium. The mixture was then watered with 230 mL of water evenly on the surface of the planting medium. The application of the consortium of two *Trichoderma* isolates, *T. harzianum* TKdG3 and *T. viride* TKdG7, was 10 g per polybag each, while the application of the consortium of three isolates, *T. longibrachiatum* Tr-GA9, *T. koningii,* TTG2 and *Trichoderma* RTG1, was 6.67 g per polybag.

Fertilization and Planting Shallot Bulbs. The planting of shallot seedlings was carried out one week after the incubation period of the *Trichoderma* spp. isolate consortium application. In each planting medium, one shallot bulb was planted. Plant maintenance activities for shallots, in addition to watering, included fertilization with inorganic fertilizers. The doses of inorganic fertilizers applied were in accordance with the recommendations by Firmansyah & Anto (2013). The inorganic fertilizers applied one day before planting were SP 36 (130 kg per ha), Urea (100 kg per ha), and KCl (100 kg per ha). NPK fertilizer 16:16:6 (100 kg per ha) was given at the ages of 15, 30, and 45 days after planting (DAP) (Firmansyah & Anto, 2013).

Inoculation of *Fusarium oxysporum* f.sp. *cepae* Isolates in Shallot Plants. The *F. oxysporum* f.sp. *cepae* FBK1 isolate was cultured on PDA (Merck, Germany) medium in petri dishes and incubated for 7 days. The multiplication of the *F. oxysporum* f.sp. *cepae* FBK1 isolate on Potato Dextrose Broth (PDB) (Merck, Germany) medium was cultured for 48 hours in a 500 mL Erlenmeyer flask under aeration conditions. A volume of 10 mL of the *F. oxysporum* f.sp. *cepae* FBK1 pathogen from the PDB culture was inoculated onto the roots of shallot plants by sprinkling it on the roots of shallot plants, 2 weeks after planting (WAP). The conidial density of *F. oxysporum* f.sp. *cepae* FBK1 before inoculation on shallot plants was counted using a hemocytometer, with a conidial density of 9×10^6 per mL.

Watering Plants and Harvesting. Plant watering was done every morning by applying 230 mL of water per polybag. Shallot plants were harvested at 65 days after planting (DAP), characterized by the plants showing signs of wilting, drooping leaves, 70–80% of the plants turning yellow, the neck of the bulb becoming soft when pressed, bulbs protruding above the soil, and turning red in color. Harvesting was done by carefully pulling out the shallot bulbs to ensure none were left behind in the soil.

Observations. The observed variables consisted of main variables and supporting variables. The main variable observed in this study was:

Disease incidence (%)

The disease incidence was recorded at 4, 5, 6, 7, and 8 WAP. It was calculated using the formula provided by The Directorate General of Food Crops Protection (2018):

$$I = \frac{a}{a+b} \times 100\%$$

I = Disease incidence (%);
a = Number of leaves affected by twisted disease (pieces);
b = Total number of healthy leaves per clump observed (pieces).

While the supporting variables were plant growth and yield. Supporting variables for plant growth observed in this study were:

Plant height
The plant height per clump (cm), measured at 1, 3, 5, and 7 WAP by summarizing the plant clumps up to the tallest leaf.

Number of leaves
Number of leaves per clump (pieces), counted at 1, 3, 5, and 7 WAP.

Observed shallot yield variables were:

Number of bulbs
Number of bulbs per clump, counted after harvesting.

Wet bulb weight and dry bulb weight
Wet bulb weight and dry bulb weight per clump (g) were measured using an Ohaus analytical balance NJ07054 (Adventurer, USA). The wet weight of shallot bulbs was measured after the plants were cleaned. The dry weight of the shallot bulbs was measured after the shallot clumps were air-dried for one week (Sinaga et al., 2023).

Data Analysis. Data analysis was performed using the F-test at the α = 5% and α = 1% levels. If there was a significant effect on the treatments, it was followed by Duncan's multiple range test at the α = 5% level. The data tested using the F-test included disease incidence, plant height, number of leaves, number of bulbs, wet bulb weight, and dry bulb weight.

RESULTS AND DISCUSSION

Twisted Disease Incidence. The incidence of disease increases at each observation age from 4 to 8 WAP, with a range of disease incidence between 5.91% and 57.18%. The treatment with a consortium of *Trichoderma* spp. isolates on various types of organic fertilizers resulted in significantly lower twisted disease incidence compared to the control. The lowest disease incidence at 8 WAP was observed in treatment P_4 (14.52%), while the highest was in P_0 (57.18%). This demonstrates that the *Trichoderma* spp. isolate consortium on organic fertilizers can suppress the development of *Fusarium oxysporum* f.sp. *cepae* FBK1 (Table 1).

Trichoderma possesses antagonistic properties, such as antibiosis, by producing enzymes and toxins capable of destroying pathogen hyphae, competitiveness for nutrient availability and growing space, and mycoparasitic properties (Ali et al., 2021). *Trichoderma* spp. can produce metabolites such as chitinase, cellulase, β-(1,3) glucanase, protease, and antibiotics that are toxic to soilborne pathogens (Domsch et al., 2008). *T. harzianum* can utilize various nutrient sources for growth by breaking down

Table 1. The average of twisted disease incidence at 4–8 WAP

Perlakuan	Disease incidence (%)/Age (WAP)				
	4	5	6	7	8
P_0	31.88 f	45.59 f	53.41 f	53.70 g	57.18 g
P_1	23.58 de	28.11 e	32.64 de	37.17 f	37.89 f
P_2	10.02 b	13.55 b	17.08 b	20.61 b	24.14 bc
P_3	15.59 cde	18.58 cde	21.57 bcd	24.56 bcd	25.13 bcd
P_4	5.91 a	6.53 a	7.15 a	13.68 a	14.52 a
P_5	12.22 bc	15.02 bc	17.82 bc	20.62 b	23.42 bc
P_6	14.61 bcd	17.95 bcd	21.29 bcd	24.63 cde	27.97 cde
P_7	15.83 cde	19.46 cde	23.09 cde	26.72 cde	30.35 def

Numbers in the same coloumn followed by same letter were showed non significant difference based on Duncan's test at α= 5%. P_0 = control; P_1 = 5 ton per ha of chicken manure; P_2 = 5 ton = ha of chicken manure + two *Trichoderma* isolates; P_3 = 5 ton per ha of chicken manure + three *Trichoderma* isolates; P_4 = 5 ton per ha of chicken manure + 20 ton per ha trichocompost + two *Trichoderma* isolates; P_5 = 5 ton per ha of chicken manure + 20 ton per ha trichocompost + three *Trichoderma* isolates; P_6 = 20 ton per ha trichocompost + two *Trichoderma* isolates; P_7 = 20 ton per ha trichocompost + three *Trichoderma* isolates.

cellulose, starch, lignin, and other soluble compounds such as proteins and sugars. *Trichoderma* can also inhibit the growth of spores and pathogen hyphae by wrapping around and penetrating the pathogen fungal cells, causing them to lyse (Sudantha & Suwardji, 2021; Muhibbudin et al., 2021).

Trichoderma spp. have the potential to be developed as biopesticides and biofertilizers for integrated crop management because they can induce plant resistance and boost crop production. Istifadah et al. (2019) stated that the application of a microbial consortium consisting of *T. harzianum, Bacillus subtilis,* and *Pseudomonas* sp., combined with chicken manure, can suppress bacterial wilt disease by 31.0%–82.2% and reduce late blight disease in potato plants. In addition to chicken manure, the application of *Trichoderma* spp. can also be combined with other organic materials, such as compost. Jaya et al. (2021) stated that the application of 5 g of *Trichoderma* spp. per plant combined with 200 g of vermicompost per plant can inhibit *Sclerotium rolfsii* incidence up to 0% at 4 weeks after application on chili.

The Growth of Shallot Plants. The observation results of the application of *Trichoderma* spp. isolate consortium on various types of organic fertilizers on the height and number of leaves of shallot plants are presented in Table 2. Based on the results of the mean comparison test for plant height and number of leaves, the application of *Trichoderma* spp. isolate consortium on various types of organic fertilizers shows significant differences at each observation age of the shallot plants compared to the control (Table 2). The observation at 7 WAP showed the best result in treatment P_5, which was significantly different from the other treatments regarding the number of leaves. The treatment that showed the lowest number of leaves was treatment P_0 with an average of 18.3 leaves. Meanwhile, in terms of plant height, there was no significant difference between treatments P_2, P_3, P_4, P_5, P_6 and P_7, but these treatments showed significantly greater plant height compared to treatments P_1 and P_0.

Organic fertilizers derived from chicken manure or trichocompost, with the addition of *Trichoderma* spp. isolate consortium, can speed up the decomposition process of organic materials. This enhancement leads to an increase in the content of macro (N, P, and K) and micro (Zn, Fe) nutrients required by plants, thus supporting plant growth, accompanied by increased plant height and leaf count (Yulianto et al., 2021). Nitrogen (N) plays a crucial role in stimulating overall plant growth, particularly in stems, shoots, and leaves. Shallot plants that experience healthy growth and develop leaves optimally will also maximize the bulb formation process (Hendarto et al., 2021).

The application of trichocompost has also been reported to significantly affects the height of celery plants (Sujatna et al., 2017). Trichocompost, as a biofertilizer, improves soil physical structure, soil permeability, and soil chemistry, leading to increased availability of NPK nutrients. Biologically, the applied organic matter serves as a site for the activity of decomposer microbes. *Trichoderma* spp. secrete active substances such as auxin hormones that stimulate lateral root formation. Good nutrient and water absorption is influenced by root growth. *Trichoderma* species

Table 2. The average plant height and number of shallot leaves for each experimental unit at 1–7

Treatment	Plant height (cm/WAP)				Number of leaves/WAP			
	1	3	5	7	1	3	5	7
P_0	2.30 a	23.80 a	31.30 a	31.10 a	4.30 a	9.80 a	15.00 a	18.30 a
P_1	3.80 ab	28.50 bc	36.40 b	37.50 b	5.80 ab	12.50 ab	18.50 ab	22.30 b
P_2	5.00 bcd	29.00 bcd	36.10 b	41.50 c	6.30 bc	16.00 bcd	22.00 bcd	27.00 cde
P_3	6.10 cdef	30.20 bcde	37.60 b	40.90 bc	8.00 bcd	17.00 de	23.80 cde	26.00 cd
P_4	5.00 bc	31.40 ef	36.00 b	39.10 bc	7.80 bcd	22.30 e	26.80 e	29.80 e
P_5	7.60 f	32.50 efg	39.10 b	41.90 c	7.50 bcd	24.50 ef	29.80 f	33.30 f
P_6	6.70 def	28.20 b	35.60 b	38.80 bc	6.30 bcd	18.80 bc	22.00 bcd	26.00 cd
P_7	5.50 cde	31.50 ef	38.30 b	38.40 bc	7.00 bcd	16.00 bcd	21.50 bc	25.30 bc

Numbers in the same coloumn followed by same letter were showed non significant difference based on Duncan's test at α= 5%. P_0 = control; P_1 = 5 ton per ha of chicken manure; P_2 = 5 ton = ha of chicken manure + two *Trichoderma* isolates; P_3 = 5 ton per ha of chicken manure + three *Trichoderma* isolates; P_4 = 5 ton per ha of chicken manure + 20 ton per ha trichocompost + two *Trichoderma* isolates; P_5 = 5 ton per ha of chicken manure + 20 ton per ha trichocompost + three *Trichoderma* isolates; P_6 = 20 ton per ha trichocompost + two *Trichoderma* isolates; P_7 = 20 ton per ha trichocompost + three *Trichoderma* isolates.

have antagonistic abilities to control pathogenic fungi such as *Alternaria*, *Pythium*, *Sclerotinia*, *Fusarium*, and *Botrytis*, both in vitro and in vivo, by producing antifungal antibiotic compounds and employing other mechanisms, including mycoparasitism, antibiosis, and competition for nutrient acquisition in the growing media (Ali et al., 2021).

Moreover, according to Istikorini & Budiman (2023), in general, the mechanism of *Trichoderma* spp. suppresses pathogens through mycoparasitism and aggressive competition, by producing antibiotics such as gliotoxin and viridin. These antibiotics are produced when *Trichoderma* spp. hyphae coil around and penetrate the host cell wall, causing the host hyphae to experience vacuolation, lysis, and ultimately disintegration. *Trichoderma* spp. produce cell wall- degrading enzymes such as chitinase, protease, and glucanase, and utilize the contents of the host's hyphae as a food source. Another *Trichoderma* species, *T. viride*, produces alkaloid compounds with antimicrobial activity, inhibiting the growth of pathogenic fungi (Muhibbudin etal., 2021).

With the application of *Trichoderma* spp. consortium, root growth improves, and nutrient and water absorption processes run smoothly, resulting in better plant growth and development. On the other hand, the application of trichocompost—chicken manure supplemented with *Trichoderma* spp. isolate consortium—can prevent the disease incidence of *F. oxysporum* f.sp. *cepae*, resulting in healthy leaf growth and better photosynthesis compared to other treatments without organic fertilizers. This is in accordance with the statement of Dawood et al. (2019) that *T. harzianum* solubilizies insoluble minerals and captures more nutrients, wich plants can easly uptake. Compost manure significantly increased the number of leaves per plants, as compost manure contains all the essential nutrients, which can increase the growth of shallot crops.

Shallot Production Yield. The results of observations on the treatment of the consortium of *Trichoderma* spp. isolates and types of organic fertilizer on the number of bulbs, wet bulb weight, and dry bulb weight of shallots are presented in Table 3. The results showed that the treatment with the consortium of *Trichoderma* spp. isolates combined with organic fertilizer resulted in significant differences in the number of bulbs, wet bulb weight, and dry bulbs weight compared to treatment without organic fertilizer and without the consortium of *Trichoderma* spp. isolates. The number of shallot bulbs was greater in treatments P_1 to P_7, but there was no significant difference between these treatments. In the treatment without organic fertilizer and without a consortium of *Trichoderma* spp. (P_0), the number of shallot bulbs produced was lower.

The highest wet weight of shallots per clump was observed in treatment P_5. However, when comparing the dry bulb weight of shallots per clump between treatments P_5, P_4 and P_3, with these treatments showing a higher dry bulb weight than the others. The success of shallot bulb formation depends greatly on the vegetative growth of the plant. A broad surface area for photosynthesis and a strong root structure are crucial before the plant can form bulbs. *Trichoderma* spp. play a role in improving plant growth media, which positively impacts the growth of the plant canopy and root system, both of which contribute in increasing

Tabel 3. The average number of bulbs, wet bulb weight, and dry bulb weight of shallot for each experimental

Treatment	Numbers of bulb	Wet bulb weight (g)	Dry bulb weight (g)
P_0	4.0 a	42.0 a	30.6 a
P_1	6.0 b	99.5 bc	77.3 b
P_2	6.8 b	111.7 bcde	99.3 cd
P_3	6.8 b	118.2 bcdef	103.1 cde
P_4	6.8 b	129.2 def	112.4 de
P_5	6.8 b	148.3 g	119.8 e
P_6	6.8 b	106.6 bcd	99.2 cd
P7	6.0 b	97.5 b	85.8 bc

Numbers in the same coloumn followed by same letter were showed non significant difference based on Duncan's test at α= 5%. P_0 = control; P_1 = 5 ton per ha of chicken manure; P_2 = 5 ton = ha of chicken manure + two *Trichoderma* isolates; P_3 = 5 ton per ha of chicken manure + three *Trichoderma* isolates; P_4 = 5 ton per ha of chicken manure + 20 ton per ha trichocompost + two *Trichoderma* isolates; P_5 = 5 ton per ha of chicken manure + 20 ton per ha trichocompost + three *Trichoderma* isolates; P_6 = 20 ton per ha trichocompost + two *Trichoderma* isolates; P_7 = 20 ton per ha trichocompost + three *Trichoderma* isolates.

the rate of plant photosynthesis, thereby affecting the production of shallot bulbs by the plant (Sudantha & Suwardji, 2021).

The highest weight loss occurred in treatment P_5, followed by treatments P_4 and P_3, but these three treatments showed the same high dry bulb weight compared to other treatments. This indicates that the application of organic fertilizers combined with a consortium of *Trichoderma* isolates can improve the growth and yield of shallot plants. This is consistent with Kalay et al. (2016), who found that the application of *Trichoderma* spp. and liquid biofertilizers reduced the incidence of leaf blight disease in mustard greens and increased the fresh weight of mustard greens. Additionally, Sataral et al. (2020) reported that the application of 10 g of *Trichoderma* spp. per liter of water was the best treatment for reducing Fusarium wilt disease and increasing the average yield of shallots.

CONCLUSION

The most effective application of a consortium of *Trichoderma* spp. isolates on organic fertilizers for controlling twisted disease in shallot plants is found in treatment with 5 ton per ha of chicken manure + 20 tons per ha of trichocompost + a consortium of two *Trichoderma* isolates. This treatment showed the lowest disease incidence (14.52% at 8 weeks after planting). On average, the plant height was 39.1 cm, with 29.8 leaves per clump and 6.8 bulbs per plant. The wet bulb weight was 129.2 g, and the dry bulb weight was 112.4 g per plant.

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AUTHORS' CONTRIBUTIONS

LS and AAD considered, planned and arranged the manuscript. OO and MMR collected and filtered the data, while LS, AAD and SZ analyzed and interpreted the data, discussed the results, and wrote the manuscript. The authors provided responses and comments on the research flow, data analysis, interpretation, and the shape of the manuscript. All the authors have read and approved the final manuscript.

COMPETING INTEREST

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

REFERENCES

Abdullah M. 2022. Aplikasi *Trichoderma* sp. dalam menekan penyakit moler pada tanaman bawang merah (*Allium ascalonicum* L.) [Application of *Trichoderma* sp. in suppressing moler disease in shallot plants (*Allium ascalonicum* L.)]. *Jurnal Penelitian Agrosamudra.* 9(1): 10–18. https://doi.org/10.33059/jupas.v9i1.5412

Adhi SR & Suganda T. 2020. Potensi jamur rizosfer bawang merah dalam menekan *Fusarium oxysporum* f.sp. *cepae*, penyebab penyakit busuk umbi bawang merah [The potential of shallot rhizosphere fungi in suppressing *Fusarium oxysporum* f.sp. *cepae,* the causal agent of basal rot disease]. *Jurnal Kultivasi.* 19(1): 1015–1022. https://doi.org/10.24198/kultivasi.v19i1.22877

Ahmad Z, Ramadhani C, Peranginangin CD, & Fuskhah E. 2020. Pengaruh pemberian kompos tablet diperkaya mineral dan *Trichoderma* sp. terhadap produktivitas bawang merah (*Allium ascalonicum*) [Effect of mineral-enriched compost and *Trichoderma* sp. on growth and the production of shallots plants]. *J. Agro Complex.* 4(2): 143–147.

Ali A, Zeshan MA, Mehtab M, Krursheed S, Mudasir M, Abid M, Mahdi M, Rauf HA, Ameer S, Younis M, Altaf MT, & Tahir A. 2021. A comprehensive note on *Trichoderma* as a potential biocontrol agent against soil borne fungal pathogens: A review. *Plant Prot.* 5(3): 171–196. https://doi.org/10.33804/pp.005.03.3934

Bhoki M, Jeksen J, & Beja HD. 2021. Pengaruh pemberian pupuk kandang ayam terhadap pertumbuhan dan hasil tanaman sawi hijau (*Brassica juncea* L.) [The effect of giving chicken manure on the growth and yieldof green mustard plants (*Brassica juncea* L.)]. *Jurnal*

Agro Wiralodra. 4(2): 64–68.

BPS [Central Bureau of Statistics]. 2023. *Produksi Tanaman Sayuran [Vegetable Crop Production]*. https://www.bps.go.id/id/statistics-table/2/NjEjMg==/produksi-tanaman-sayuran.html. Accessed 28 April 2024.

BPS Kota Palangka Raya [Palangka Raya City Central Bureau of Statistics]. 2021. *Produksi Tanaman Sayuran Semusim menurut Jenis Tanaman [Production of annual vegetable crops according to plant type]*. https://palangkakota.bps.go.id/indicator/55/341/1/produksi-tanaman-sayuran-semusim-menurut-jenis-tanaman-2020. Accessed 16 April 2021.

BPS Provinsi Kalimantan Tengah [Central Kalimantan Central Bureau of Statistics]. 2022. *Produksi Bawang Merah (Ku) [Shallot Production (Ku)]*. https://kalteng.bps.go.id>indicator>produksi-bawang. Accessed 1 March 2024.

Dawood, Ara N, Khan MN, Sattar S, Irfan I, Shah SQ, Said B, & Bakhtiar M. 2019. Effect of trichoderma and compost manure on the growth and yield of onion. *Pure Appl. Biol.* 8(1): 321–330. https://doi.org/10.19045/bspab.2018.700192

Dirjen Perlindungan Tanaman Pangan [Directorate General of Food Crops Protection]. 2018. *Petunjuk Teknis Pelaporan dan Pengamatan Organisme Pengganggu Tumbuhan dan Dampak Perubahan Iklim (OPT-DPI)*. [Technical Instructions for Reporting and Observing Plant Pest Organisms and the Impact of Climate Change]. Kementerian Pertanian. Jakarta.

Domsch KH, Gams W, & Anderson TH. 2008. Compendium of soil fungi. *Eur. J. Soil Sci*. 59(5): 1007–1007. https://doi.org/10.1111/j.1365-2389.2008.01052_1.x

Firmansyah MA & Anto A. 2013. Teknologi budidaya bawang merah di lahan marjinal di luar musim [Technology for cultivating shallots on marginal lands outside the season]. Kantor Perwakilan Bank Indonesia. Palangkaraya..

Ginanjar A, Yetti H, & Yoseva S. 2016. Pemberian pupuk tricho kompos jerami jagung terhadap pertumbuhan dan produksi bawang merah (*Allium ascalonicum* L.) [Giving corn straw compost tricho fertilizer on the growth and production of shallots (*Allium ascalonicum* L.)]. *JOM Faperta.* 3(1): 1–11.

Hendarto K, Widagdo S, Ramadiana S & Meliana FS. 2021. Pengaruh pemberian dosis pupuk NPK dan jenis pupuk hayati terhadap pertumbuhan dan produksi tanaman bawang merah (*Allium ascalonicum* L.) [Effect of NPK fertilizer dosage and bio-fertilizer types on growth and yield of shallot (*Allium ascalonicum* L.)]. *Jurnal Agrotropika*. 20(2): 110–119. https://doi.org/10.23960/ja.v20i2.5086

Hikmahwati, Auliah MR, Ramlah, & Fitrianti. 2020. Identifikasi cendawan penyebab penyakit moler pada tanaman bawang merah (*Allium ascalonicum* L.) di Kabupaten Enrekang [Identification of the fungus that causes twisted disease in shallot plants (*Allium ascalonicum* L.) in Enrekang district]. *Agrovital: Jurnal Ilmu Pertanian*. 5(2): 83–86. https://doi.org/10.35329/agrovital.v5i2.1745

Istifadah N, Fatiyah N, Fitriatin BN, & Djaya L. 2019. Effects of dosage and application frequensi of microbial consortium mixed with animal manure on bacterial wilt and late blight diseases of potato. *IOP Conf. Ser.: Earth Environ. Sci.* 334: 012038 https://doi.org/10.1088/1755-1315/334/1/012038

Istikorini Y & Budiman T. 2023. Uji potensi mikrob rizosfer sebagai pengendali hayati penyebab penyakit tanaman [Potential test of rhizosphere microbes as biological controls that cause plant diseases]. *Jurnal Silvikultur Tropika.* 4(3): 242–249.

Jaya A, Lautt BS, Antang EM, Supriati L, & Dohong S. 2021. Effect of individual and combined application of *Trichoderma* sp. and vermicompost on the management of *Sclerotium rolfsii* and growth of chilli under peatland agro-climate conditions. *JEBAS*. 9(4): 445-456. https://doi.org/10.18006/2021.9(4).445.456

Juwanda M, Khotimah K, & Amin M. 2016. Peningkatan ketahanan bawang merah terhadap penyakit layu fusarium melalui induksi ketahanan dengan asam salisilat secara *invitro* [The improvement of shallot resistance against fusarium wilt disease trough induction resistance by salisilyc acid *in-vitro*]. *Agrin.* 20(1): 15–28.

Kalay AM, Uluputty MR, Leklioy J, Hindersah R, & Talahaturuson A. 2016. Aplikasi pupuk hayati konsorsium dan inokulan padat *Trichoderma* *harzianum* terhadap produktivitas tanaman sawi pada lahan terkontaminasi *Rhizoctonia solani* [Application of *Trichoderma harzianum* solid inokulan and biofertilizer consortium on choy sum productivity grown on *Rhizoctonia solani* contaminated lands]. *J. Agrolodia.* 5(2): 78–86. https://doi.org/10.30598/a.v5i2.185

Kementerian Pertanian [Ministry of Agriculture]. 2021. Analisis kinerja perdagangan komoditas bawang merah [Analysis of shallot trading performance]. Pusat Data dan Sistim Informasi Pertanian [Center for Agricultural Data and Information Systems]. https://www.google.com/search?client=firefox-b-e&q=analisis+kinerja+perdagangan+komoditas+bawang+merah. Accessed 28 April 2024.

Kementerian Pertanian [Ministry of Agriculture]. 2022. Statistik konsumsi angan [Statistic of food consumption]. Pusat Data dan Sistim Informasi Pertanian [Center for Agricultural Data and Information Systems]. https://satudata.pertanian.go.id/details/publikasi/407. Accessed 28 April 2024.

Muhibbudin A, Setiyowati EM, & Sektiono AW. 2021. Mechanism antagonism of *Trichoderma viride* against several types of pathogens and production of secondary metabolites. *Agrosaintifika: Jurnal Ilmu-ilmu Pertanian*. 4(1): 243–253. https://doi.org/10.32764/agrosaintifika.v4i1.2375

Puspita F, Ali M, & Supriyadi. 2020. Kompatibilitas dan daya hambat konsorsium *Trichoderma* spp. endofit terhadap penyakit busuk buah kakao *Phytophthora palmivora* [Compatibility and inhibition activity of endophytic *Trichoderma* spp. consortium against cacao pod rot disease *Phytophthora palmivora*]. *J. Agrikultura*. 31(2): 126–133. https://doi.org/10.24198/agrikultura.v31i2.26063

Sataral M, Nurdiansyah D, & Lamandasa FH. 2020. The effect of *Trichoderma* sp. on the incidence fusarium disease and production of shallot. *Jurnal Online Pertanian Tropik* 7(2): 192–199. https://doi.org/10.32734/jpt.v7i2.4581

Sihombing NH. 2019. Pemberian konsorsium agens hayati *Trichoderma* sp. dan mikoriza untuk mengendalikan busuk pangkal batang (*Ganoderma* sp.) pada bibit kelapa sawit di media gambut [Application of a consortium of *Trichoderma* sp. and mycorrhizal biological agents to control stem rot (*Ganoderma* sp) in oil palm seedlings in pet media]. *Undergraduate Thesis*. Universitas Palangka Raya. Palangka Raya.

Sinaga SF, Simanungkalit T, & Hasanah Y. 2016. Respons pertumbuhan bawang merah (*Allium ascalonicum* L.) terhadap pemberian sampah kota dan pupuk [Response yield of shallot (*Allium ascalonicum* L.) on the application urban waste compost and fertilizer]. *J. Agroteknologi.* 4(3): 2181–2187.

Sinaga R, Waluyo N, Arief RW & Manurung GO. 2023. Uji adaptasi beberapa varietas bawang merah (*Allium cepa* var. *agregatum* L.) pada musim hujan (off season) di lahan kering masam Lampung [Adaption test of some varities shallots (*Allium ascalonicum* L.) on the rain season in acid dry land, Lampung. *Jurnal Penelitian Pertanian Terapan*. 23(2): 419–428. http://dx.doi.org/10.25181/jppt.v23i3.2524

Sudantha IM & Suwardji S. 2021. *Trichoderma* biofungicides formulations on shallot growth, yield and fusarium wilt disease resistance. *IOP Conf. Ser.: Earth Environ. Sci*. 824: 012032. https//doi.org//10.1088/1755-1315/824/1/012032

Sujatna I, Muchtar R, & Banu LS. 2017. Pengaruh trichokompos terhadap pertumbuhan dan hasil tanaman seledri (*Apium graveolens* L.) pada sistem wall garden [The effect trichocompost on the growth and yield of celery plants (*Apium graveolens* L.) in a wall garden system]. *J. Ilmiah Respati Pertanian.* 8(2): 731–738.

Supriati L, Basuki, Mulyani RB, Muliansyah, & Muliana. 2019. Peranan trichokompos dan pupuk KCl dalam mengendalikan penyakit layu fusarium pada tanaman bawang merah di tanah berpasir [The role of trichocompost and KCL fertilizer to control fusarium wilt disease on onion in sandy soil]. *J. Agripeat.* 20(1): 19–26. https://doi.org/10.36873/agp.v20i01.21

Suryadi MI, Dirmawati SR, Nurdin M, & Ginting C. 2023. Pengaruh pemberian pupuk kompos dan pupuk hayati cair terhadap intensitas moler (*Fusarium oxysforum*) dan pertumbuhan bawang merah (*Allium ascalonicum* L.) [The effect of fertilizing compost and fertilizer liquid biodivers on moler (*Fusarium oxysforum*) incidence and only growth (*Allium ascalonicum*

L.)]. *J. Agrotek Tropika.* 11(4): 679–685. http://dx.doi.org/10.23960/jat.v11i4.7525

Susanti D, Mulyadi, & Wiyatiningsih S. 2016. Karakterisasi isolat-isolat *Fusarium oxysporum* f.sp. *cepae* penyebab penyakit moler pada bawang merah dari daerah Nganjuk dan Probolinggo [Characterization of isolates *Fusarium oxysporum* f.sp. *cepae* moler cause shallot of diseases in the region of Nganjuk and Propolinggo]. *Plumula*. 5(2): 153–160.

Syarifudin R, Kalay AM, & Uruilal C. 2021. Efek pemberian pupuk hayati dan fungisida kimia terhadap serangan penyakit layu Fusarium, pertumbuhan dan hasil pada bawang merah (*Allium ascalonicum* L.) [Effect of biological fertilizer and chemical fungicides on fusarium wilt disease, growth and yield in shallots (*Allium ascalonicum* L.)]. *Agrolodia.* 10(2): 69–79. https://doi.org/10.30598/ajibt.v10i2.1426

Yulianto S, Bolly YY, & Jeksen Y. 2021. Pengaruh pemberian pupuk kandang ayam terhadap pertumbuhan dan hasil mentimun (*Cucumis sativus* L.) di Kabupaten Sikka [The effect of giving chiken manure on the growth and yield of cucumbers (*Cucumis sativus* L.) in Sikka district]. *Jurnal Inovasi Penelitian*. 1(10): 2165–2170.