



RESPONSE OF RED ONION GROWTH AND YIELD TO *TRICHODERMA ASPERELLUM* AND COW MANURE UNDER *FUSARIUM* DISEASE PRESSURE

Friska Hasugian¹, Syamsafitri^{2*}, Asmanizar², Murni Sari Rahayu², Nurhayati²

¹Master of Agrotechnology, Universitas Islam Sumatera Utara, Medan-20144, Indonesia.

²Faculty of Agriculture, Universitas Islam Sumatera Utara, Medan-20144, Indonesia.



*Corresponding Author: Syamsafitri

Faculty of Agriculture, Universitas Islam Sumatera Utara, Medan-20144, Indonesia.

DOI: <https://doi.org/10.5281/zenodo.23036683>



How to cite this Article: Friska Hasugian¹, Syamsafitri^{2*}, Asmanizar², Murni Sari Rahayu², Nurhayati² (2026). Response of Red Onion Growth And Yield To *Trichoderma Asperellum* And Cow Manure Under *Fusarium* Disease Pressure. World Journal of Pharmaceutical and Life Sciences, 12(10), 16–24.

This work is licensed under Creative Commons Attribution 4.0 International license.

Article Received on 13/08/2026

Article Revised on 03/09/2026

Article Published on 01/10/2026

ABSTRACT

Fusarium solani is one of the soil-borne pathogens that can reduce the growth and yield of red onions. Biological control using *Trichoderma asperellum* combined with organic matter has the potential to be an alternative to improve plant growth under pathogen pressure. This study aims to evaluate the effects of various doses of *T. asperellum* and cow manure on the growth and yield of three red onion varieties inoculated with *F. solani*. The research used a factorial design with five application treatments and three red onion varieties. The treatments consisted of P0 (no application), P1 (*F. solani* inoculation), P2 (0.5 kg *T. asperellum* + 5 kg cow manure), P3 (0.25 kg *T. asperellum* + 5 kg cow manure), and P4 (0.167 kg *T. asperellum* + 5 kg cow manure). The varieties used were Batu Ijo, Bima Brebes, and Tajuk. The results showed an interaction between treatment and variety on several growth and yield parameters. The combination P2V1 produced the highest fresh bulb weight of 67.36 g and dry bulb weight of 46.18 g, while P3V1 resulted in the highest number of leaves at 37.13 leaves. These findings indicate that the response of red onion varieties to *T. asperellum* and cow manure differs. The combination of *T. asperellum* and cow manure, especially P2, can enhance the growth and yield of red onions under *F. solani* pressure.

KEYWORDS: Cattle manure fertiliser, *Fusarium solani*, Red onion, *Trichoderma asperellum*.

INTRODUCTION

Red onion (*Allium cepa* L. *Aggregatum* Group) is one of the important horticultural commodities with high economic value and is widely cultivated in Indonesia. The productivity of red onions is influenced by genetic factors, growing environment, nutrient availability, and pest and disease disturbances. In addition to cultivation factors, the presence of soil-borne pathogens becomes a significant obstacle in maintaining red onion productivity. Diseases caused by *Fusarium spp.* are among the major diseases affecting onion plants and can lead to growth disturbances and yield reduction (Suryaningsih, 2016; Aprilia *et al.*, 2020). This research thesis also indicates that *Fusarium* wilt disease is one of the main factors affecting the growth and yield of red onions.

Fusarium spp. are a group of pathogens that can infect root tissues and the base of tubers, thereby disrupting root function as well as water and nutrient transport. Such infections can lead to a decrease in vegetative growth and hinder the formation and filling of tubers. Research on the resistance of red onion genotypes indicates that the response to *Fusarium* disease can vary between varieties, so the genetic factors of the plants need to be considered in disease management strategies (Aprilia *et al.*, 2020). Other studies on onions also highlight the importance of varietal characteristics in determining the plant's response to *Fusarium* wilt disease.

Control of soil-borne diseases through the continuous use of fungicides can lead to various problems, making biological control approaches an important alternative in sustainable crop production systems. *Trichoderma spp.*

are a group of fungi extensively studied as biological control agents because they can interact with pathogens while also providing benefits to plant growth. The mechanisms of *Trichoderma* control include competition for space and nutrients, antibiosis, mycoparasitism, as well as the production of various hydrolytic enzymes and secondary metabolites that can inhibit pathogen development (Poveda, 2021; Guzmán-Guzmán *et al.*, 2023).

In addition to functioning as a biological control agent, *Trichoderma* can provide plant growth-promoting effects through colonisation of the root zone, enhancement of root development, increased efficiency of nutrient uptake, and stimulation of plant physiological mechanisms. The presence of *Trichoderma* in the rhizosphere can create a mutually beneficial relationship between microorganisms and plants, thereby supporting the formation of vegetative biomass and plant productivity. Guzmán-Guzmán *et al.* (2023) emphasise that the interaction between *Trichoderma* and plants can involve physiological changes and activation of plant defence mechanisms. This supports the use of *Trichoderma* not only as a biocontrol agent but also as a microorganism with the potential to support plant growth.

The effectiveness of *Trichoderma* in suppressing diseases in red onions has also been reported in previous studies. Sari *et al.* (2021) reported the effectiveness of *Trichoderma* in suppressing Fusarium disease in red onions, while Prasetyo *et al.* (2019) demonstrated the potential application of *Trichoderma* in controlling Fusarium wilt disease in red onions. More recent research also indicates that *T. asperellum* can enhance plant responses while simultaneously inhibiting Fusarium development through plant defence mechanisms (Sehim *et al.*, 2023).

The use of organic materials combined with bioagents has the potential to enhance disease control effectiveness. Cattle manure not only functions as a source of nutrients but also provides organic matter that can support soil microorganism activity. An increase in organic matter can create more favourable conditions for the development of antagonistic microorganisms and improve biological competition against soil-borne pathogens. Rahman *et al.* (2021) reported that organic matter can support the biological control of Fusarium wilt disease, while an increase in soil organic matter can strengthen the soil's suppressive properties through enhanced activity and diversity of microorganisms involved in pathogen control (Bonanomi *et al.*, 2022).

The combination of *T. asperellum* with cattle manure fertiliser becomes important because the success of biological agents in the soil not only depends on the presence of antagonistic microorganisms but also on the rhizosphere environmental conditions that support their colonisation and activity. Organic matter can provide

energy and nutrients for microorganisms, while colonisation of *T. asperellum* in the root zone has the potential to increase competition against *F. solani*. Therefore, integrating biological agents and organic matter can be a more comprehensive approach to suppressing disease while maintaining plant growth. This concept aligns with the findings of the thesis research, which shows a relationship between *T. asperellum*, cattle manure fertiliser, soil conditions, and the suppression of Fusarium disease.

Although the effectiveness of *Trichoderma* against Fusarium pathogens has been widely reported, plant responses to the application of biological agents can vary between varieties. Genetic differences can influence the level of resistance to pathogens, root system development, the ability to maintain vegetative growth, and plant interactions with rhizosphere microorganisms. In this study, the thesis shows that the interaction between the dose of *T. asperellum* and cow manure fertiliser with the variety has a significant effect on disease occurrence, indicating that the effectiveness of the treatment is not entirely the same across all varieties.

However, information regarding the growth response and yield of several red onion varieties to the combination of *T. asperellum* doses and cow manure fertiliser under *F. solani* pressure still needs to be strengthened. Specifically, it is necessary to determine whether an increase in disease control is also accompanied by enhanced vegetative growth and bulb biomass accumulation, and whether these responses differ among varieties. Therefore, this study aims to evaluate the effect of the combination of *T. asperellum* and cow manure fertiliser on the growth and yield of three red onion varieties under *F. solani* pressure, as well as to identify the treatment combination and variety that provide the best growth and yield responses.

MATERIALS AND METHODS

a) Time and Place of the Research

This research was conducted at the Laboratory and PHP Land in Medan Johor UPTD. PTPH and PMKP of the North Sumatra Provincial Agriculture and Food Security Office, at an altitude of 37.5 metres above sea level, and at the Plant Pest Forecasting Centre Laboratory in Karawang, West Java Province, from September 2025 to December 2025.

b) Research Materials and Tools

The materials used in this study are parts of red onion plants infected with the pathogen *Fusarium spp.* (stem base), Potato Dextrose Agar (PDA) medium, 70% and 96% alcohol, distilled water, cling wrap, aluminium foil, labels, tissue, spirit, white plastic, stencil paper, and cotton wool.

The tools used in this research are a compound microscope, analytical balance, coke borer, petri dish, Bunsen burner, glass slide, cover slip, test tubes,

Laminar Air Flow, spatula, rubber gloves, mask, scissors, mortar, freezer, tube rack, 1000 µl micropipette, tweezers, 1000 µl pipette tips, autoclave, hot plate, magnetic stirrer, glassware (measuring cylinder, beaker, Erlenmeyer flask), camera, and writing tools.

c) Research Methodology

The research used a factorial Randomised Complete Block Design (RCBD) consisting of two factors with three replications (blocks). The first factor is the combination dose of *Trichoderma asperellum* and cow manure fertiliser (P0: No application (negative control), P1: Application of *Fusarium solani* (positive control), P2: 0.5 kg of *Trichoderma asperellum* + 5 kg of cow manure fertiliser (1:10), P3: 0.25 kg of *Trichoderma asperellum* + 5 kg of cow manure fertiliser (1:20), P4: 0.167 kg of *Trichoderma asperellum* + 5 kg of cow manure fertiliser (1:30)). The second factor is red onion variety (V1: Batu Ijo, V2: Bima Brebes, V3: Tajuk).

Thus, there are 15 treatment combinations (5 × 3) which are repeated three times, resulting in 45 experimental units. Each experimental unit consists of 7 red onion plants, so the total number of plants used in this study is 315. The number of sampled plants observed was set at 5 plants per plot using a zig-zag sampling method (Manandhar *et al.*, 2016). Therefore, the total number of sampled plants observed was 225, obtained from 5

treatments × 3 varieties × 3 replications × 5 sampled plants per plot.

The dose of *T. asperellum* is determined based on previous research recommendations and adjusted according to the scale of the experiment in the greenhouse. According to Muliana *et al.* (2024), the optimal dose of *T. harzianum* application for controlling fusarium wilt disease in shallot plants is 450 kg/ha, but it is recommended to increase the dose to 500 kg/ha to achieve higher effectiveness. This dose of 500 kg/ha is then converted to a micro-scale experiment using a planting media volume of 5 kg of cow manure per plot, employing the following conversion equation (Dina and Suhartono, 2023):

$$\text{Trial Dose (kg)} = \text{Field Dose (kg/ha)} \times \text{Plot Area (m}^2\text{)} \times 10,000 \text{ m}^2/\text{ha}$$

The dose conversion calculation is as follows:

- Trial dose = 500 kg/ha ÷ 10,000 m²/ha × 0.01 m² (trial volume)
- Trial dose = 500 × 0.001 = 0.5 kg

Based on the calculations, treatment P2 with a dose of 0.5 kg of *Trichoderma asperellum* mixed with 5 kg of cattle manure produces a ratio of 1:10 (w/w), which is equivalent to a field dose of 500 kg/ha. This P2 treatment is then used as the baseline dose to determine the reduced doses for P3 and P4.

Table 1: Dose Conversion Calculation.

Treatment	Concentration of <i>Trichoderma asperellum</i>	Cow Manure Fertiliser	Ratio (w/w)	Equivalent to the Field Dose
P2	0,5 kg	5 kg	1:10	500 kg/ha
P3	0,25 kg	5 kg	1:20	250 kg/ha
P4	0,167 kg	5 kg	1:30	167 kg/ha

Description: P2: 0.5 kg of *Trichoderma asperellum* + 5 kg of cattle manure fertiliser (1:10), P3: 0.25 kg of *Trichoderma asperellum* + 5 kg of cattle manure fertiliser (1:20), P4: 0.167 kg of *Trichoderma asperellum* + 5 kg of cattle manure fertiliser (1:30)

The parameters observed include disease incidence, disease severity, plant growth (plant height and number of leaves), as well as red onion productivity, which encompasses the number of bulbs, fresh bulb weight, and dry bulb weight.

d) Observed Variable

Observations of the agronomic parameters of red onion plants were conducted periodically to assess the plants' response to treatments and the effectiveness of Organic Fertiliser and *Trichoderma spp.* in controlling Fusarium wilt disease. The variables observed included plant height, number of leaves, number of bulbs per plant, as well as the weight of fresh and dry bulbs both on an individual and plot basis.

1) Plant Height (cm), plant height is measured weekly from 1 to 6 weeks after planting (WAP) using a ruler, from the base of the stem to the tip of the highest leaf. This parameter provides an overall picture of the plant's vegetative growth (Ibrahim *et al.*, 2023).

2) Number of Leaves (leaf blades), the total number of leaves is counted weekly on sample plants by recording the number of active and fully open leaf blades. This parameter indicates the plant's photosynthetic activity that contributes to tuber formation (Patil *et al.*, 2016).

3) The weight of fresh shallot bulbs (g), the weight of fresh shallot bulbs is observed at harvest using a digital scale. Weighing is carried out immediately after uprooting to obtain fresh yield data.

4) Dry Red Onion Bulb Weight (g), the weight of the dried onion bulb after the bulb has been air-dried for 1 week or until the weight stabilises. This measurement provides an estimate of the stored red onion yield (Rangkuti, 2017).

e) Data Analysis

The observation data were analysed using analysis of variance (ANOVA) at a 5% significance level ($\alpha = 0.05$). If the analysis results indicate a significant effect, then Duncan's Multiple Range Test (DMRT) is conducted at the 5% level to determine differences between treatments. If the data do not meet the assumptions of normality and homogeneity of variance, data transformation using the Arcsin transformation is performed before the analysis of variance is carried out (Gomez & Gomez, 1984).

Results

The research results indicate that the combination of *T. asperellum* application and cattle manure fertiliser with

red onion varieties has an effect on the vegetative growth of the plants, such as plant height, number of leaves, fresh weight of bulbs, and dry weight of bulbs.

a) Height of Red Onion Plants

Plant height is one of the main indicators of vegetative growth that reflects the plant's ability to undergo cell division, enlargement, and elongation as a result of physiological processes occurring during growth.

Table 2: Effect of *T. asperellum* application dose, cattle manure fertiliser, and red onion variety on plant height at Observation 7 (49 HSI).

Application dose of <i>T. asperellum</i> and cattle manure (kg)	Varieties of red onions (V)			Average
	V1	V2	V3	
P0 (Without application)	38,80 tn	47,50 tn	38,30 tn	41,53
P1 (<i>Fusarium solani</i> application)	46,10 tn	34,20 tn	43,60 tn	41,30
P2 (0,5 kg <i>T. asperellum</i> + 5 kg cow manure fertiliser / 1:10)	43,80 tn	47,30 tn	45,10 tn	45,40
P3 (0,25 kg <i>T. asperellum</i> + 5 kg cow manure fertiliser / 1:20)	44,20 tn	44,50 tn	42,80 tn	43,83
P4 (0,167 kg <i>T. asperellum</i> + 5 kg cow manure fertiliser / 1:30)	42,30 tn	34,40 tn	41,20 tn	39,30
Average	43,04	41,58	42,20	

Note: Numbers followed by the same letter notation in the same column are not significantly different at the 5% Duncan test level. The disease incidence data presented are actual data, while the statistical analysis was performed using Arcsin transformation.

V1 = Batu Ijo variety; V2 = Bima Brebes variety; V3 = Tajuk variety

The growth height of plants is influenced by genetic factors, nutrient availability, environmental conditions, activity of rhizosphere microorganisms, and the health of the root system which plays a role in water and nutrient absorption. Therefore, plant height parameters are often used to evaluate the plant's response to cultivation treatments as well as the effects of biotic stresses such as soil-borne pathogen attacks.

Based on the variance analysis results in Table 2, the analysis shows that the treatments of dose and variety, both individually and in combination/interactions, do not have a significant effect on the seventh observation (49 HSI). When viewed from the average results based on the combination of treatments and varieties, the tallest plant height was found in P0V2 (47.50 cm) and P2V2 (47.30 cm), while the shortest plant height was observed in P1V2 (34.20 cm) and P4V2 (34.40 cm). These variations indicate that the Bima Brebes variety exhibits a more diverse growth response to the treatments compared to the Batu Ijo and Tajuk varieties. In treatment P1, which involved inoculation with *F. solani*

without the application of a biotic agent, the Bima Brebes variety showed a considerable decrease in plant height compared to other treatments. This condition suggests that *F. solani* infection can disrupt the physiological functions of the roots, thereby reducing the plant's ability to absorb water and nutrients necessary for vegetative growth. Conversely, in treatment P2, the plant height of Bima Brebes increased to 47.30 cm, indicating that the application of *T. asperellum* can mitigate the negative effects of pathogen infection on plant growth.

Physiologically, the tendency for increased plant height in treatments containing *T. asperellum* can be associated with the fungus's ability as a Plant Growth-Promoting Fungus (PGPF). In addition to functioning as a biocontrol agent, *T. asperellum* is known to enhance plant growth through various mechanisms, including increasing nutrient availability, solubilising phosphate that is unavailable to plants, producing growth-promoting compounds such as auxins and gibberellins, and stimulating root system development. Root colonisation by *Trichoderma* can also increase root surface area and the efficiency of water and nutrient absorption, thereby supporting vegetative growth of the plant (Poveda, 2021; Guzmán-Guzmán *et al.*, 2023).

Additionally, cattle manure used as a carrier medium and source of organic material plays a role in improving the physical, chemical, and biological properties of the soil. The high organic matter content can increase cation

exchange capacity, improve soil structure, enhance the soil's water retention ability, and provide an energy source for beneficial soil microorganisms. These conditions create a rhizosphere environment that is more conducive to the development of *Trichoderma* and plant root growth. According to research by Yağmur *et al.* (2024), the combination of biological agents and organic materials can enhance soil microbial activity and improve rhizosphere health, ultimately contributing to increased plant growth.

The results of this study are in line with the research by Guzmán-Guzmán *et al.* (2023), which states that the effect of *Trichoderma* on plant growth is not always indicated by a significant increase in plant height, as growth response is highly influenced by the type of plant, genotype, soil conditions, and the interaction between microorganisms and the environment. However, the presence of *Trichoderma* still provides benefits through improved root health, nutrient absorption efficiency, and protection against soil-borne pathogens. Therefore, although it does not have a significant effect on plant height, the application of *T. asperellum* combined with cow manure, particularly at a dose of 0.5 kg *T. asperellum* + 5 kg cow manure (P2), shows a tendency to support the vegetative growth of red onions by improving rhizosphere conditions and overall plant health.

b) Number of Red Spring Onions

The number of leaves is one of the indicators of vegetative growth that reflects the plant's ability to form photosynthetic organs. The more leaves that are formed,

the greater the plant's capacity to carry out photosynthesis and produce the photosynthate necessary to support growth and tuber formation. Beneficial microorganisms such as *Trichoderma spp.* are known to enhance vegetative growth by improving root system development, increasing nutrient uptake, and stimulating the production of growth-promoting compounds that support leaf formation and plant biomass (Guzmán-Guzmán *et al.*, 2023).

Based on the DMRT 5% test results in Table 3, the combination of *T. asperellum* application dose, cow manure fertiliser, and onion variety significantly affected the number of leaves at the 7th observation (49 HSI). These results indicate that the vegetative growth response of the plants is influenced by the interaction between treatment and variety (P×V), so the effectiveness of *T. asperellum* application varies for each variety. The highest number of leaves was obtained with the P3V1 treatment combination (0.25 kg *T. asperellum* + 5 kg cow manure fertiliser on Batu Ijo variety), which was 37.13 leaves and grouped in letter 'a'. This value was not significantly different from P2V1 (33.61 leaves), P1V3 (31.86 leaves), and P1V1 (31.81 leaves), but was significantly different from most other treatment combinations. Conversely, the lowest number of leaves was observed in the P4V2 treatment (0.167 kg *T. asperellum* + 5 kg cow manure fertiliser on Bima Brebes variety), which was 23.03 leaves and grouped in letter 'e'. These results show that the Batu Ijo variety exhibits a better vegetative growth response to *T. asperellum* application compared to other varieties, while Bima Brebes shows a relatively lower response.

Table 3. The effect of *T. asperellum* application dose, cattle manure fertiliser, and onion variety on the number of leaves at Observation 7 (49 HSI).

Application dose of <i>T. asperellum</i> and cattle manure (kg)	Variety of red onion (V)			Average
	V1	V2	V3	
P0 (Without application)	28,03 bcde	30,99 abcd	29,73 bcde	41,53
P1 (<i>Fusarium solani</i> application)	31,81 abc	24,92 cde	31,86 abc	41,30
P2 (0,5 kg <i>T. asperellum</i> + 5 kg cow manure fertiliser / 1:10)	33,61 ab	28,46 bcde	26,50 cde	31,04
P3 (0,25 kg <i>T. asperellum</i> + 5 kg cow manure fertiliser / 1:20)	37,13 a	24,69 de	26,12 cde	30,91
P4 (0,167 kg <i>T. asperellum</i> + 5 kg cow manure fertiliser / 1:30)	31,63 abcd	23,03 e	26,55 cde	27,07
Average	32,44	26,42	29,38	

Note: Numbers followed by the same letter notation in the same column are not significantly different at the 5% Duncan test level. The disease incidence data presented are actual data, while the statistical analysis was performed using Arcsin transformation.

V1 = Batu Ijo variety; V2 = Bima Brebes variety; V3 = Tajuk variety

Based on the average of the varieties, Batu Ijo produces the highest number of leaves, with 32.44 leaves, followed by Tajuk with 29.38 leaves and Bima Brebes with 26.42 leaves. This pattern indicates that genetic

factors play an important role in determining the ability to form leaves. The high number of leaves in the Batu Ijo variety is suspected to be related to a better level of resistance to *F. solani* infection, allowing the plants to maintain physiological activity and vegetative growth more optimally compared to more susceptible varieties.

The increase in the number of leaves in treatments containing *T. asperellum* indicates that the antagonistic fungus not only functions as a biological control agent but also as a plant growth-promoting fungus. Colonisation of *Trichoderma* on the root system is

known to enhance nutrient uptake, particularly nitrogen and phosphorus, stimulate the formation of lateral roots, and produce growth-promoting compounds such as auxins and gibberellins that play a role in cell division and elongation. These conditions support the formation of more leaves and improve the vegetative growth of the plant (Guzmán-Guzmán *et al.*, 2023).

Additionally, cattle manure fertiliser plays a role in improving the physical, chemical, and biological properties of the soil, thereby creating a rhizosphere environment that better supports root development and beneficial microorganism activity. Sufficient organic matter availability can also increase the population and activity of *T. asperellum* in the root zone, making its benefits for plant growth more optimal. According to Yağmur *et al.* (2024), the combination of organic materials and beneficial microorganisms can enhance soil biological activity, nutrient uptake efficiency, and vegetative growth of plants.

Overall, the research results indicate that the interaction between the dose of *T. asperellum*, cow manure fertiliser,

and the variety affects the number of red onion leaves. The best treatment combination was obtained in P3V1 (0.25 kg of *T. asperellum* + 5 kg of cow manure fertiliser on Batu Ijo variety) with a total of 37.13 leaves. These results suggest that the success of vegetative growth enhancement is not only determined by the dose of the biological agent applied but also by the variety's ability to respond to the presence of beneficial microorganisms in the root zone.

c) Wet Onion Bulb Weight

Based on the DMRT test at the 5% level in Table 4, the combination of *T. asperellum* application dose, cattle manure fertiliser, and red onion variety significantly affected the fresh weight of the plants. These results indicate an interaction between treatment and variety (P×V), suggesting that the plant growth response to the application of biological agents is influenced by the genetic characteristics of each variety. The differences in response are evident from the variations in fresh weight produced by each treatment combination.

Table 4. Effect of *T. Asperellum* Application Dose, Cattle Manure Fertiliser, and Red Onion Variety on Fresh weight (g).

Application dose of <i>T. asperellum</i> and cattle manure (kg)	Variety of red onion (V)			Average
	V1	V2	V3	
P0 (Without application)	23,42 f	33,42 e	17,11 g	24,65
P1 (<i>Fusarium solani</i> application)	20,93 fg	10,17 h	21,91 fg	17,67
P2 (0,5 kg <i>T. asperellum</i> + 5 kg cow manure fertiliser / 1:10)	67,36 a	51,62 c	61,96 b	60,31
P3 (0,25 kg <i>T. asperellum</i> + 5 kg cow manure fertiliser / 1:20)	57,46 bc	46,19 d	54,04 c	52,56
P4 (0,167 kg <i>T. asperellum</i> +5 kg cow manure fertiliser / 1:30)	54,91 c	43,67 d	53,19 c	50,59
Average	44,82	37,01	41,64	

Note: Numbers followed by the same letter notation in the same column are not significantly different at the 5% Duncan test level. The disease incidence data presented are actual data, while the statistical analysis was performed using Arcsin transformation.

V1 = Batu Ijo variety; V2 = Bima Brebes variety; V3 = Tajuk variety

The research results indicate that the combination treatment P2V1 (0.5 kg *T. asperellum* + 5 kg cattle manure on Batu Ijo variety) produces the highest fresh weight, namely 67.36 g, which is significantly different from all other treatments. The high fresh weight in this treatment suggests that a dose of 0.5 kg *T. asperellum* is the most effective in supporting plant growth. This condition is suspected to be related to *T. asperellum*'s ability to colonise the root zone optimally, thereby increasing the efficiency of water and nutrient absorption, while also suppressing the development of *F. solani*. This aligns with the findings of Maharani *et al.* (2024), who reported that the application of *T.*

asperellum on seed-grown red onions could suppress disease development and increase tuber resistance to the pathogen *F. solani* during the post-harvest period, with the infected area of the pathogen in the *T. asperellum* treatment (26.63 mm²) being much lower compared to the control (37.66 mm²). The study also noted that this biological agent could influence tuber production by up to 35.6% compared to the control, consistent with the role of *Trichoderma* as both a growth-promoting agent and a biocontrol agent that works through mechanisms such as competition for space and nutrients, production of microlytic enzymes, and induction of plant resistance against soil-borne pathogens (Maharani *et al.*, 2024). Therefore, the low disease pressure in treatment P2V1 allows more photosynthetic assimilates to be allocated to vegetative biomass formation rather than supporting the plant's defence mechanisms against *F. solani* infection.

Conversely, the lowest fresh weight was obtained in the P1V2 treatment combination (application of *F. solani* without control on the Bima Brebes variety), which was 10.17 g, and also significantly different from all other

treatments. The low fresh weight in this treatment indicates that *F. solani* infection has caused serious physiological disturbances in the plant. This pathogen is known to infect root tissues and the base of the tuber, then develop within the vascular tissues, thereby hindering the transport of water and nutrients from the roots to the upper parts of the plant. This is consistent with Manang *et al.* (2024), who explained that *Fusarium* infection in roots and tubers causes rotting, colour changes, and necrosis at the base layer of the tuber, followed by rapid development of the fungal mycelium from the tuber base spreading to the upper and side parts of the plant, resulting in leaves that do not grow upright but instead curl and twist until the plant wilts and eventually dies. These findings are reinforced by the characterisation results of Hanif and Zamriyetti (2023), who reported that symptoms of basal stem rot in red onions begin with a change in the size of the stem base, which becomes smaller and soft, followed by drying, twisting, and yellowing of the leaves due to damage to the roots, tubers, and stem base where *Fusarium* fungi are found infecting, and can even cause the plant to dwarf or die at a young age if not controlled. Due to this disruption in translocation, photosynthetic activity decreases, vegetative growth is hampered, and biomass accumulation becomes low. These findings align with the high incidence and severity of the disease observed in the Bima Brebes variety under the same treatment, indicating that damage to the root system caused by pathogen infection directly contributes to the decline in plant growth and biomass accumulation.

When examined based on the average treatment, P2 produced the highest fresh weight at 60.31 g, followed by P3 (52.56 g) and P4 (50.59 g), while P1 resulted in the lowest average at 17.67 g. This pattern indicates that the application of *T. asperellum* combined with cattle manure fertiliser can enhance plant biomass accumulation compared to treatments without a biological agent. Interestingly, although the doses of *T. asperellum* in P3 and P4 were lower than in P2, these two treatments still produced significantly higher fresh weights than the control. This suggests that the presence of *T. asperellum* in the root zone continues to benefit plant growth, even though its effectiveness diminishes with decreasing application doses.

Based on the average of the varieties, Batu Ijo produces the highest fresh weight at 44.82 g, followed by Tajuk (41.64 g) and Bima Brebes (37.01 g). These results indicate that the Batu Ijo variety has a better growth capability compared to the other varieties. The high fresh weight of the Batu Ijo variety is suspected to be related to its higher resistance to *F. solani* infection, as evidenced by the lower incidence and severity of the disease in this variety. Better resistance allows the root system to function optimally, thereby making water and nutrient absorption more efficient and supporting plant biomass formation.

The increase in fresh weight in treatments containing *T. asperellum* can be explained through several mechanisms. In addition to acting as a biocontrol agent, *Trichoderma* is known to function as a plant growth-promoting fungus (PGPF) that enhances plant growth by producing phytohormones such as auxins, gibberellins, and cytokinins, which stimulate cell division and elongation. This fungus also improves the solubility and availability of nutrients, especially phosphorus (P), through the production of organic acids that dissolve bound phosphates in the soil into forms accessible to roots, as well as microelements such as iron (Fe) through siderophore production that chelates Fe³⁺ from the soil, and zinc (Zn), manganese (Mn), and copper (Cu), which are mobilised through enzymatic activity and rhizosphere acidification around the roots. Additionally, it expands the root absorption area by stimulating the formation of lateral roots and root hairs. As a result, the efficiency of water and macro (P) and micro (Fe, Zn, Mn, Cu) nutrient uptake increases, leading to improved plant growth (Guzmán-Guzmán *et al.*, 2023; Woo *et al.*, 2020).

The combination of *T. asperellum* and cattle manure fertiliser produces a synergistic effect that creates a healthier and more conducive rhizosphere environment for plant growth. According to Yağmur *et al.* (2024), the integration of biological agents and organic materials can enhance soil microbial activity, nutrient utilisation efficiency, and significantly increase plant biomass accumulation. Overall, the research results indicate that the increase in fresh weight of the plants is closely related to the success of *T. asperellum* in suppressing the development of *Fusarium solani* while simultaneously promoting plant growth through improved rhizosphere conditions. The treatment of 0.5 kg of *T. asperellum* combined with 5 kg of cattle manure fertiliser (P2) was the most effective in increasing the fresh weight of the plants, especially in the Batu Ijo variety. These findings suggest that disease control and plant growth enhancement occur simultaneously, resulting in higher biomass accumulation compared to other treatments.

d) Dry Weight of Red Onion Bulb

The dry weight of tubers is one of the production parameters that reflects the accumulation of photosynthetic products stored in the tuber tissue after the water content is removed. This parameter illustrates the plant's ability to accumulate biomass from photosynthesis, the efficiency of nutrient absorption and utilisation, as well as the success of the translocation process of photosynthates from the leaves to the storage organs. Therefore, the dry weight of tubers is often used as a more accurate indicator than fresh weight when evaluating plant productivity, as it is not affected by fluctuations in water content within the plant tissues (Taiz *et al.*, 2018).

The results of the DMRT 5% test in Table 5 indicate that the interaction between the dose of *T. asperellum* application combined with cattle manure fertiliser and

the red onion variety has a significant effect on the dry weight of the tuber. This shows that each variety's response to *T. asperellum* application varies, so the effectiveness of the treatment in increasing tuber dry matter accumulation is highly influenced by the genetic characteristics of the variety used.

In the Batu Ijo variety (V1), the increase in dry tuber weight was very evident after the application of *T. asperellum*. The dry weight of the tuber increased from 25.93 g in the control (P0V1) to 46.18 g in treatment P2V1 (0.5 kg *T. asperellum* + 5 kg cow manure), or an

increase of 78.09%. Treatments P3V1 and P4V1 also produced relatively high dry weights, at 38.63 g and 35.03 g respectively. These results indicate that the Batu Ijo variety is capable of responding optimally to the application of *T. asperellum*, resulting in better tuber formation and filling compared to treatments without a biological agent. The high dry weight of the tubers in this variety is suspected to be related to the low incidence and severity of Fusarium wilt disease, which allows photosynthesis results to be more efficiently translocated into the tubers.

Table 5. Effect of *T. Asperellum* Application Dose, Cattle Manure Fertiliser, and Red Onion Variety on Dry Weight (g).

Application dose of <i>T. asperellum</i> and cattle manure (kg)	Varietas bawang merah (V)			Rataan
	V1	V2	V3	
P0 (Without application)	25,93 e	26,13 e	23,49 ef	25,18
P1 (<i>Fusarium solani</i> application)	22,35 f	16,86 g	21,74 f	20,32
P2 (0,5 kg <i>T. asperellum</i> + 5 kg cow manure fertiliser / 1:10)	46,18 a	33,39 d	44,05 a	41,21
P3 (0,25 kg <i>T. asperellum</i> + 5 kg cow manure fertiliser / 1:20)	38,63 b	34,78 cd	38,03 bc	37,15
P4 (0,167 kg <i>T. asperellum</i> + 5 kg cow manure fertiliser / 1:30)	35,03 cd	33,35 d	35,62 bcd	34,67
Average	33,62	28,90	32,59	

Note: Numbers followed by the same letter notation in the same column are not significantly different at the 5% Duncan test level. The disease incidence data presented are actual data, while the statistical analysis was performed using Arcsin transformation.

V1 = Batu Ijo variety; V2 = Bima Brebes variety; V3 = Tajuk variety

A similar response is also observed in the Tajuk variety (V3). The dry weight of the tubers increased from 23.49 g in the control (P0V3) to 44.05 g in treatment P2V3, representing an increase of 87.52%. In treatments P3V3 and P4V3, the dry weight of the tubers reached 38.03 g and 35.62 g, respectively. The high dry weight of the tubers in treatments containing *T. asperellum* indicates that the Tajuk variety has a good ability to utilise the presence of biological agents to support the tuber filling process. This condition suggests that the suppression of *Fusarium solani* infection by *Trichoderma* contributes to an increased efficiency of photosynthate accumulation in the storage organs.

Unlike Batu Ijo and Tajuk, the Bima Brebes (V2) variety shows a lower response to all treatments. In treatment P1V2 (application of *F. solani* without control), the dry weight of the tuber only reaches 16.86 g and is the lowest value among all treatment combinations. This low value indicates that the Bima Brebes variety is more susceptible to *F. solani* infection, resulting in disrupted tuber formation due to damage to the root system and vascular tissues. Nevertheless, the application of *T. asperellum* still managed to increase the dry weight of the tuber from 26.13 g in P0V2 to 33.39 g in P2V2,

34.78 g in P3V2, and 33.35 g in P4V2. These increases demonstrate that *T. asperellum* can reduce the negative impact of pathogen infection, although its response remains lower compared to Batu Ijo and Tajuk.

The best treatment combination was obtained at P2V1 with a dry tuber weight of 46.18 g, which was not significantly different from P2V3 at 44.05 g. The high dry weight of the tuber in both combinations indicates a synergy between the optimal dose of *T. asperellum*, cattle manure fertiliser, and a variety with a better level of resistance to Fusarium wilt disease. This combination allows the plant to maintain its physiological functions optimally, thereby enabling photosynthesis results to be translocated and accumulated in the tuber more efficiently.

Physiologically, the increase in dry weight of the tuber in treatments containing *T. asperellum* is related to the fungus's ability to enhance root system health, improve nutrient absorption, and increase the availability of phosphorus and potassium, which play important roles in tuber formation and filling. Additionally, colonisation of *Trichoderma* in the root zone is also known to improve photosynthesis efficiency and the translocation of photosynthates to storage organs. According to Guzmán-Guzmán *et al.* (2023), *Trichoderma spp.* act as plant growth-promoting fungi capable of enhancing plant growth and yield through stimulating root development, increasing nutrient uptake, and improving plant metabolic efficiency. These findings are supported by Gu *et al.* (2025), who reported that application of *T. asperellum* can increase biomass and crop yield by

improving rhizosphere health and suppressing diseases caused by *Fusarium spp.*

Overall, the $P \times V$ interaction indicates that the success of *T. asperellum* application in increasing dry tuber weight is highly influenced by the variety used. Batu Ijo and Tajuk varieties show a better response compared to Bima Brebes, especially in treatment P2. This suggests that the effectiveness of the biotic agent is not only determined by the application dose but also by the level of compatibility between the biotic agent and the plant genotype in supporting the process of tuber formation and filling.

CONCLUSION

The application of *Trichoderma asperellum* with cattle manure fertiliser can enhance the growth and yield of red onions under *Fusarium solani* pressure, although the response varies among different varieties. The combination of 0.5 kg of *T. asperellum* and 5 kg of cattle manure fertiliser (P2), particularly in the Batu Ijo variety, produced the highest fresh bulb weight (67.36 g) and dry bulb weight (46.18 g). Treatment P3V1 resulted in the greatest number of leaves (37.13 leaves). These findings indicate that integrating *T. asperellum* with organic fertiliser has the potential as a sustainable biological management strategy to reduce *Fusarium* pressure and increase red onion productivity.

REFERENCE

1. Aprilia, N., Suryadi, Y., & Wiyono, S. Genetic variability and resistance of shallot to *Fusarium* wilt disease. *Jurnal Hortikultura Indonesia*, 2020; 11(2): 85–94. <https://doi.org/10.29244/jhi.11.2.85-94>
2. Bonanomi, G., De Filippis, F., Cesarano, G., La Stora, A., Ercolini, D., & Scala, F. Organic farming induces changes in soil microbiota that affect suppressiveness to soilborne pathogens. *Environmental Microbiology*, 2020; 22(12): 4968–4984. <https://doi.org/10.1111/1462-2920.15282>
3. Gu, Y., Deng, J., Li, Y., & Liu, D. *Trichoderma asperellum* Ta1 alleviates root rot caused by *Fusarium solani* and promotes plant growth. *Journal of Fungi*, 2025; 11(12): 879. <https://doi.org/10.3390/jof11120879>
4. Guzmán-Guzmán, P., Porras-Troncoso, M. D., Olmedo-Monfil, V., & Herrera-Estrella, A. *Trichoderma* species: versatile plant symbionts. *Nature Reviews Microbiology*, 2023; 21(5): 312–326.
5. Hanif, A., & Zamriyetti. Morphological characterisation of fungi causing basal rot disease in red onions (*Allium cepa*). *Agrium*, 2023; 26(1): 76–82. <https://doi.org/10.30596/agrium.v26i1.13430>
6. Maharani, P., Suryanti, Joko, T., & Somowiyarjo, S. *Rhizophagus intraradices* dan *Trichoderma asperellum* as a bioprotector and biofertiliser for red onions TSS. *Indonesian Journal of Agricultural Science*, 2024; 29(2): 287–297. <https://doi.org/10.18343/jipi.29.2.287>
7. Manang, A. P. L., Sutoyo, & Sumiati, A. Review of *Fusarium* wilt disease and its control in red onions (*Allium escalonicum* L.). *Buana Sains*, 2024; 24(3): 87–92. <https://doi.org/10.33366/bs.v24i3.6729>
8. Poveda, J. *Trichoderma* as biocontrol agent against pests: New uses for a mycoparasite. *Biological Control*, 2021; 159: 104634.
9. Prasetyo, A., Sari, D., & Wibowo, A. Application of *Trichoderma spp.* to control *Fusarium* wilt on shallots. *Jurnal Perlindungan Tanaman Indonesia*, 2019; 23(1): 33–40. <https://doi.org/10.22146/jpti.43912>
10. Rahman, M. A., Begum, M. F., & Alam, M. F. Biological control of *Fusarium* wilt using organic amendments. *Biological Control*, 2021; 152: 104421. <https://doi.org/10.1016/j.biocontrol.2020.104421>
11. Sari, D., Prasetyo, A., & Hidayat, N. Effectiveness of *Trichoderma spp.* in suppressing *Fusarium* disease on shallot. *Jurnal Fitopatologi Indonesia*, 2021; 17(3): 101–108. <https://doi.org/10.14692/jfi.17.3.101-108>
12. Sehim, A. E., Hewedy, O. A., Altammar, K. A., Alhumaidi, M. S., & Abd Elghaffar, R. Y. *Trichoderma asperellum* empowers tomato plants and suppresses *Fusarium oxysporum* through priming responses. *Frontiers in Microbiology*, 2023; 14: 140378.
13. Suryaningsih, E., & Wiyono, S. Epidemiology of *Fusarium* wilt disease in shallots under tropical conditions. *Jurnal Fitopatologi Indonesia*, 2018; 14(3): 89–96. <https://doi.org/10.14692/jfi.14.3.89-96>
14. Taiz, L., Zeiger, E., Møller, I.M. and Murphy, A. (2018) *Plant Physiology and Development*. Oxford University Press, Oxford. 10.4236/ajps.2023.142017
15. Woo, S. L., Ruocco, M., Vinale, F. *Trichoderma*-based products and their widespread use in agriculture. *Open Life Sciences*, 2020; 15(1): 126–138. <https://doi.org/10.1515/biol-2020-0014>
16. Yağmur, A., Demir, S., Canpolat, S., Danesh, Y. R., Farda, B., Djebaili, R., Pace, L., & Pellegrini, M. Onion *Fusarium* basal rot disease control by arbuscular mycorrhizal fungi and *Trichoderma harzianum*. *Plants*, 2024; 13(3): 386. <https://doi.org/10.3390/plants13030386>