

RESEARCH PAPER

Potency of two *Trichoderma harzianum* isolates in liquid and solid organic formula for controlling bacterial wilt on tomato in the field

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ABSTRACT

This research aimed to determine the potency of two *Trichoderma harzianum* isolates in solid and liquid organic formulas to control bacterial wilt and on growth and yield of tomato in the field. This research was carried out at the Laboratory of Plant Protection and the tomato field at Banteran Village, Sumbang Sub-District, Banyumas Regency at altitude of 600 m above sea level for four months. A randomized block design was used with five replicates. The treatments were control, *T. harzianum* T10, *T. harzianum* T215, combination of *T. harzianum* T10 + *T. harzianum* T215, and bactericide (a.i. 20% streptomycin sulfate). Variables observed were pathosystem components (incubation period, infection rate, disease intensity, and late populations of the antagonists), growth components (plant height, plant fresh and dry weight, and root fresh and dry weight), yield components (number of fruits, fruit weight), and phenolic compounds analysis qualitatively. The results showed that *T. harzianum* T10 + *T. harzianum* T215 was effective to suppress the disease as 58.61%. The treatment of *T. harzianum* T10 + *T. harzianum* T215 was effective to increase crop height, fresh weight of plants, dry weight of plants, fresh weight of roots, dry weight of roots, number of fruits and fruit weight as 38.86, 35.37, 51.67, 24.78, 37.41, 40.61, and 53.22%, respectively. All treatments could increase phenolic compound content qualitatively.

Key words: bacterial wilt, chicken manure, rice washing water, tomato, *Trichoderma harzianum*

INTRODUCTION

Tomato (*Lycopersicon esculentum* Mill.) is a horticultural commodity that has economic value with relatively stable price fluctuations when compared to other horticultural commodities (Abera et al., 2020). Indonesia's tomato production in 2020 increased compared to 2019, which was 1094.01 tons from 1020.33 tons (Statista Research Department, 2021). Increasing tomato production in Indonesia should continue to be done to meet the increasing needs of consumers. Several factors influence the increase in tomato production, including the fertility of cultivated land, environmental conditions, and plant pests and diseases (Merga & Haji, 2019; Raza et al., 2019). One of the tomato plant diseases is bacterial wilt disease due to the attack of the bacterium *Ralstonia solanacearum* E. F. Smith (Mohammed et al., 2019). These bacteria cause the growth of tomato plants to be not optimal

and reduce production yields (Kago et al., 2016). The bacteria can also destroy crops if they attack tomato plants in the first place and develop similar symptoms (Peeters et al., 2013).

Tomato bacterial wilt control tactic in Indonesia still uses synthetic bactericide because it is considered more effective and faster in responding to disease and the growth and yield of tomato plants (Schreinemachers & Tipraqsa, 2012). However, the continuous use of synthetic bactericides has a negative impact on human health and pollutes the environment (Grenni et al., 2018). Consumers of agricultural products are getting smarter in consuming healthy agricultural products, so an environmentally friendly management of tomato diseases is needed (Yuliar et al., 2015). The use of biological agents in controlling plant diseases has been widely studied and used, even marketed (Woo et al., 2014). This is driven by the increasingly intelligent consumers of healthy agricultural products without chemical residues (Mesías et al., 2021). One of the most widely used biological agents is *Trichoderma* spp. (Zin & Badaluddin, 2020). Utilization of *Trichoderma* spp. as a biological agent of plant disease is very widespread in various plant commodities. This is because of its ability to control various plant pathogens by various mechanisms (Mukhopadhyay & Kumar, 2020). In

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addition, *Trichoderma* spp. can also decompose organic matter so that it can function as a decomposer (Zin & Badaluddin, 2020).

Trichoderma harzianum T10 and *T. harzianum* T215 were two isolates isolated from the rhizosphere of ginger and shallot, respectively, which were able to reduce disease intensity, suppress pathogen attack and increase plant growth and yield. The ability of these two isolates has been tested in several studies, including the results of Latifah et al. (2011), which showed that *T. harzianum* T215 reduce the intensity of Fusarium wilt of shallot and *T. harzianum* T10 reduce the population of *Pythium* sp. (Soesanto et al., 2020). *T. harzianum* can also act as a Plant Growth Enhancer due to enhance root growth, promotes plant growth, improves seedling vigour, promotes plant development, and increases absorption of nutrients (Debnath et al., 2020).

Because adaptability greatly determines the success of *Trichoderma* spp. application (Contreras-Cornejo et al., 2016), the two isolates of *T. harzianum* will be tested for their potential in controlling bacterial wilt disease in tomato plants in the field. The purpose of this study was to determine the potency of two *T. harzianum* isolates in solid and liquid organic formulas to control bacterial wilt disease and their effect on the growth and production of tomato in the field.

MATERIALS AND METHODS

Research Site. This research was carried out for four months in tomato plantations with natural inoculation, Banteran Village, Sumbang District, Banyumas Regency with an altitude of 600 m above sea level and the type of soil was brown latosol and at the Plant Protection Laboratory, Faculty of Agriculture, Jenderal Soedirman University, Purwokerto.

Preparation of *Trichoderma harzianum*. Each isolate of *T. harzianum* T10 (Soesanto et al., 2020) and *T. harzianum* T215 (Latifah et al., 2011) was prepared separately on Potato Dextrose Agar (composed of 200 g potatoes slice, 15 g dextrose, and 20 g agar in 1000 mL of water) and incubated for 5 days at room temperature. Furthermore, the two isolates were prepared for this study.

Preparation of *Trichoderma harzianum* in Broken Corn Seeds (Panahian et al., 2012). Broken corn was sterilized in an autoclave at 121 °C for 30 min. Sterile crushed corn was put into a plastic bag as much as 50 g and inoculated with 1 cork drill (0.5 cm diameter) each pure isolate of *T. harzianum*, then incubated at room

temperature for 2 weeks (Soesanto et al., 2020).

Preparation of *Trichoderma harzianum* in Chicken Manure. Chicken manure obtained from chicken farms was then measured as much as 7.5 kg each and put in a plastic bag. Then, each of the two isolates of *T. harzianum* as much as 20 cork borers (0.5 diameter) was added and fermented for 4 weeks while shaking and adjusting the humidity (Akter et al., 2016).

Preparation of *Trichoderma harzianum* in Liquid Organic Formula. The liquid formula used rice washing water and coconut water (4 : 1) mixed, then added 2 tablespoons of sugar and brought to a boil and sterilized using an autoclave at 121 °C for 30 min (Soesanto et al., 2021). After sterilization, the mixed solution is put into a sterile jerry can. Next, *T. harzianum* was inoculated into jerry can from corn medium. The antagonists were harvested by means of 50 g broken corn formula put into a glass beaker then given 150 mL of sterile mixed solution, stirred then filtered and put into sterile jerry cans. The jerry cans were then incubated by shaking at 350 rpm for 7 days at room temperature (Wu et al., 2017). After incubation, the conidia density was calculated using a haemocytometer.

Preparation of Tomato Seeds. Tomato seeds (Betavila F1, Panah Merah) were soaked in each liquid formula of *T. harzianum* and sterile water as a control for 15 min according to treatment, after that the seeds were planted in 5 cm polybags prepared in the screen house, and watered every day.

Application of *Trichoderma harzianum*. Transplanting was carried out at the age of the plant in the nursery \pm 21 days after planting the seeds. The soil was processed and loosened first, and then mounds were made with a height of 60 cm and a distance between mounds of 50 cm and a length according to the length of the land. Next, silver black plastic mulch was installed. In each planting hole, the formula of *T. harzianum* in chicken manure enriched with each of the two isolates of *T. harzianum* was filled as 50 g/planting hole before the tomato seedlings were planted with a spacing of 60 × 50 cm. The application of each of the two *T. harzianum* isolates in the liquid formula was carried out 5 days after the start. Applications were carried out 8 times as much as 50 mL/plant with an interval of 3 days. The combined application of *T. harzianum* was carried out by mixing the two formulas in the same ratio.

Maintenance of the Plants. Maintenance was carried

out intensively on plants, including watering as long as needed, manual weeding, and fertilizing according to the recommended dose.

Research Design. This study was arranged in a non-factorial randomized block design consisting of 5 treatments, namely control, *T. harzianum* T10, *T. harzianum* T215, a combination of *T. harzianum* T215 + T10, bactericide (a.i. streptomycin sulfate 20%). The five treatments that were tried were allocated with five replications so that 25 experimental units were obtained and each experimental unit consisted of 6 plants.

Variables Observed

Pathosystem component. Pathosystem components observed were incubation period (hsi), disease intensity (%), infection rate (% unit⁻¹), and final density of antagonist (cfu g⁻¹ soil). The incubation period was calculated from the inoculation of the pathogen until the symptoms of the disease in the plant first appeared, with units of days after inoculation. Calculation of disease intensity using the formula, as follows:

$$DI = \left[\frac{\sum (v \times n)}{Z \times N} \right] \times 100\%$$

DI = disease intensity (%);

v = attack category score;

n = number of plants attacked in each category;

Z = the highest attack category score;

N = number of plants observed.

A six-point rating scale (0–5) modified from Winstead & Kelman (1952) was used to assess disease severity, where 0= no symptoms, 1= one leaf wilted, 2= two or three leaves wilted, 3= four leaves wilted, 4= all leaves wilted, and 5= plant dead (collapse). Infection rate was calculated based on the formula of van der Plank (1963), as follow:

$$r = \frac{2.30259}{t_2 - t_1} \left(\log_{10} \frac{1 - x_1}{1 - x_2} \right)$$

r = infection rate (% unit⁻¹);

t₂ = 2nd observation time;

t₁ = 1st observation time;

x₂ = proportion of sick leaves at t₂ time interval;

x₁ = proportion of sick leaves at initial time.

The late density of *T. harzianum* was calculated using the total plate count method (Brugger *et al.*, 2012).

Growth and yield component. The growth components included plant height, plant fresh weight, plant dry weight, root fresh weight, and root dry weight. Plant height was measured when the plant was one week old

after transplanting and at the end of the observation, the fresh weight of the plant and roots was carried out at the end of the observation by weighing the plant and root parts separately, and the dry weight of the plant and roots after each part was dried in the oven at 70–80 °C for 2 days. Yield components include the number of fruit and fruit weight. The number of fruits is counted from the first harvest to the fifth harvest; while the weight of the fruit is weighed at harvest per plant.

Phenolic compound analysis. Qualitative analysis of phenolic compounds was carried out at the end of the study on tomato leaf tissue. 10 g of tomato leaves were extracted using percolation process in a mixture of 95% mL ethanol and 5 mL of distilled water at ambient temperature overnight (Rufai *et al.*, 2016). A total of 5 mL of plant extract was then put into a test tube. Add 3 drops of FeCl₃ to the extract. Hydrolyzed tannins gave a blackish blue color, while tannin condensation gave a blue green color, then compared to the control (Bele *et al.*, 2010). Saponin was tested by taking 1 drop of *Sapindus rarak* solution and then adding 10 mL of water (as a control) and the extract to the test tube, respectively, then shaken vigorously for 30 s and let stand for 30 min. The foam that was formed more than 3 cm from the surface of the solution means that it was positive for saponins. If the foam was formed a little, then add a little Na₂CO₃ solution (Ribeiro *et al.*, 2013). The foam condition that remains stable and hard indicated the presence of free fatty acids (Vidal *et al.*, 2018). For glycosides test, 1 mL of H₂SO₄, 2 mL glacial acetic acid, and 1 drop of FeCl₃ solution were added to 5 mL extract. The appearance of the brown ring indicates the presence of glycosides (Rufai *et al.*, 2016).

Data Analysis. Data were analyzed by analysis of variance. If there was a difference among treatments, further tests were carried out using Duncan Multiple Range Test (DMRT) at an error rate of 5%.

RESULTS AND DISCUSSION

Effect of Treatments on Pathosystem Component.

Incubation period. The results of statistical analysis showed that application of *T. harzianum* liquid formulation showed significant differences in the incubation period (Table 1). *T. harzianum* T10 and the combination of *T. harzianum* T10 + *T. harzianum* T215 were able to delay or prolong the incubation period of bacterial wilt. The combined of *T. harzianum* T10 + *T. harzianum* T215 was able to delay the incubation period by 57.94% compared to the control. The delay

in the incubation period was due to the activity of *T. harzianum* in inhibiting the growth and development of the pathogen. This statement is supported by Leclerc et al. (2014), the appearance of visible disease symptoms can be delayed when infection occurs late in the crop season due to the antagonist application. If the onset of the epidemic is late and therefore the host is aged, the mean incubation period will be long, and a fitted incubation period distribution model is clear enough to produce the opposite dynamics between latent infection and observable disease.

Disease intensity and infection rate. The intensity of disease in tomato plantations showed a very significant difference. The combined of *T. harzianum* T10 + *T. harzianum* T215 was able to reduce the disease intensity by 58.61% compared to the control (Table 1). The percentage of inhibition indicates that the combination of the two isolates of *T. harzianum* was able to synergize in the mechanism of inhibiting pathogens other than the antagonist to produce antibiotic compounds to suppress the intensity of bacterial wilt. This statement is supported by the opinion of Taha et al. (2019) that the increased disease suppression in the combination of isolates can be caused by the synergistic effect of the combination of isolates. The combination will reduce the impact of different strains, both caused by genetic diversity of pathogens or the diversity of the environment (Miljaković et al., 2020; Niu et al., 2020).

Disease intensity in *T. harzianum* T10, *T. harzianum* T215 and bactericide decreased by 44.84, 28.74, and 25.86%, respectively, compared to control (Table 1). The high disease intensity in the control was thought to be due to the activity of bacterial pathogens that entered and infected tomato roots more quickly. This is due to the absence of antagonist which is a barrier to pathogens in protecting plants by colonizing the plant rhizosphere. This statement is supported by Hastopo et al. (2008), the high disease intensity in the control treatment was caused by the activity of pathogens that

enter and infect tomato roots more quickly (Buttimer et al., 2017) and the absence of antagonistic microbes that protect the rhizosphere from pathogen attack (Beneduzi et al., 2012).

The infection rate was in accordance with the disease intensity that occurred in the field. Infection rates in bactericide and control treatments tended to be high compared to *T. harzianum* liquid formula application (Table 1). Higher infection rate in bactericide indicated that the bactericide could not manage the bacterial pathogen. This is supported by Mohsin et al. (2016) that treatment with Streptomycin, Neomycin and Bactrol resulted in the moderate incidence and yield compared to bleaching powder resulted in the lowest incidence and highest yield. Based on the results, at high disease intensity the infection rate was also high; on the contrary at low disease intensity the infection rate was also low. The infection rate that occurs in the field was relatively low. It is suspected that there is an effect of *T. harzianum* liquid formula application in suppressing the intensity of bacterial wilt so that it can reduce the rate of infection. This statement is supported by Enebe & Babalola (2019), the low rate of infection is caused by the presence of avirulent pathogens after spraying antagonist microbes, so that plants are quite capable of carrying out defense mechanisms.

Late population density of *T. harzianum*. The final density of *T. harzianum* in all treatments tended to be lower than the initial density of 10^7 conidia mL⁻¹. This is presumably because *T. harzianum* has not been able to adapt to environmental conditions. The condition of the research environment has an air temperature of 34.69 °C, a soil pH of 6–6.5, and a humidity of 67%. According to Zehra et al. (2017), suitable environmental conditions for the development of *Trichoderma* sp. namely the temperature ranged from 15 to 35 °C with a pH of 5–6.4 and 30% soil moisture, so that the antagonists were able to adapt well in the research environment. The combination of *T. harzianum* T10 + *T. harzianum*

Table 1. Effect of treatments on pathosystem component

Treatments	Incubation period (dai)	Disease intensity (%)	Infection rate (% unit ⁻¹)	Late population of <i>T. harzianum</i> (cfu g ⁻¹ soils)
Control	29.58 b	48.33 a	0.0388	1.1×10^2
<i>T. harzianum</i> T10	45.72 a	26.66 bc	0.0300	2.6×10^2
<i>T. harzianum</i> T215	34.50 b	34.44 b	0.0253	3.6×10^2
<i>T. harzianum</i> T10+T215	46.72 a	20.00 c	0.0168	2.0×10^2
Bactericide	44.78 a	35.83 b	0.0541	0.4×10^2

Number followed by the different letters in the same column showed a significant difference in DMRT at the 5% level. dai = days after inoculation.

T215 had a lower final density than *T. harzianum* T215 and *T. harzianum* T10 alone although it was able to suppress disease intensity by 58.61% (Table 1). Since both *T. harzianum* T215 and *T. harzianum* T10 have their respective advantages and mechanisms in the production of secondary metabolites that inhibit pathogen activity, the two isolates together become higher effectiveness mechanism of pathogen control. It is supposed to have a big impact. This statement is supported by the opinion of Soesanto et al. (2013) that match between *Trichoderma* sp. isolates can be applied in the field in order to obtain an increase in their management power against plant pathogens.

Based on the data in Table 1, the control and bactericidal treatments showed the presence of *T. harzianum*. The presence of *T. harzianum* is suspected because the soil used as a planting medium already contains antagonistic microbes due to chicken manure enriched with *T. harzianum*, but in low concentrations or over time the antagonistic microbes are able to reproduce in a new environment so that they can be carried away by the flow of water in the soil in the ground. Another possibility is that the presence of *T. harzianum* in the bactericidal treatment is thought to be due to *Trichoderma* sp. has resistance to chemicals, so it is able to live in soil that contains bactericides. This statement is supported by Zin & Badaluddin (2020) that *Trichoderma* sp. is the best ability microbial antagonist in chemical residual soils. However, based on the results of the treatment of *Trichoderma* sp. still showed high final density compared to control and bactericide.

Effect of Treatments on Growth and Yield Components.

Plant height. The results of statistical analysis of plant height showed significant differences in each treatment (Table 2). Plant height in *T. harzianum* T10 liquid formula increased by 38.86 % compared to control. This happened because the application of *T. harzianum* T10 liquid formula was able to suppress the pathogen growth

so that the plants could grow better. This statement is supported by Halifu et al. (2019) that the application of *Trichoderma* spp. can increase plant growth and nutrient content in the soil. *Trichoderma* is also able to decompose organic matter in the medium, so that it becomes a simpler structure, easily soluble, and can be used by plants as a source of nutrition (Sapareng et al., 2018). In addition, *T. harzianum* also produces several growth hormones, so it is known as a plant growth enhancer. This is in accordance with the opinion of Debnath et al. (2020) that *Trichoderma* spp. stimulates root and plant growth.

Plant fresh and dry weight. The results of statistical analysis of plant fresh weight showed significant differences between treatments. *T. harzianum* T215, the combination of *T. harzianum* T10 + *T. harzianum* T215, and *T. harzianum* T10 had a significant effect on increasing fresh plant weight by 35.37, 30.82, and 30.51 %, respectively, compared to control. Based on the results, plants treated with bactericide and *T. harzianum* liquid formula had the same effect in responding to plant fresh weight. Therefore, if the two treatments were applied in the field, they had the same ability to control *R. solanacearum* causing bacterial wilt in tomato. According to Contreras-Cornejo et al. (2016), *Trichoderma* sp. as a biopesticide that is environmentally friendly effectively can increase the plants fresh weight, in line with the use of bactericide.

The dry weight of the plants showed a significant difference. The combination of *T. harzianum* T10 + *T. harzianum* T215 was able to increase plant dry weight by 51.67 % compared to control. The increase in plant dry weight was caused by *T. harzianum* able to suppress pathogens so that plants can grow well. However, the combination of *T. harzianum* T10 + *T. harzianum* T215 compared to *T. harzianum* T10, *T. harzianum* T215 and bactericide did not show any significant difference. This is consistent with the *T. harzianum* liquid formula on plant fresh weight, which is supported by the statement

Table 2. Effect of the treatments on growth and yield component

Treatments	Plant height (cm)	Plant fresh weight (g)	Plant dry weight	Root fresh weight (g)	Root dry weight (g)	Number of fruits plant ⁻¹	Fruit weight plant ⁻¹ (g)
Control	32.37 b	32.74 b	13.18 b	11.91 b	2.70 b	9.90 b	103.79 b
Th T10	44.95 a	42.73 a	18.90 a	12.50 b	3.45 ab	13.55 a	157.91 a
Th T215	42.78 ab	44.32 a	18.42 a	13.53 ab	3.71 a	13.92 a	159.03 a
Th T10+T215	42.09 ab	42.83 a	19.99 a	14.86 a	3.63 a	11.19 ab	121.04 ab

Number followed by the different letters in the same coloumn showed a significant difference in DMRT at the 5% level.

of Contreras-Cornejo et al. (2016), that the existence of *Trichoderma* sp. in the soil plays a role in increasing the fresh weight of the plant, which in turn affects the dry weight of the plant.

Root fresh and dry weight. The results of the statistical analysis of root fresh weight showed a significant difference between treatments (Table 2). The combined treatment of *T. harzianum* T10 + *T. harzianum* T215 had a significant effect on increasing fresh root weight by 24.78% compared to control. This statement is supported by the opinion of Oliveira et al. (2020), the roots colonized by *Trichoderma* sp. will be denser than the roots that are not colonized by *Trichoderma* sp. The dry root weight variable showed significant differences in each treatment (Table 2). *T. harzianum* T215 was able to increase root dry weight by 37.41 % compared to control. This is presumably due to the activity of pathogens around plant roots being hampered by the presence of antagonistic microbial activity so that root growth and development are protected and undisturbed. According to, the presence of *Trichoderma* sp. in the soil was able to increase the dry root weight although among the *Trichoderma* sp. did not show any real difference.

The results of observations during field research on bactericidal treatment for plant height, plant fresh weight, and root dry weight showed a good growth response compared to antagonistic microbial treatment. However, when the bactericidal treatment was compared with *T. harzianum* have the same effect on the growth of tomato plants. Treatment using bactericide and *T. harzianum* when applied by tomato farmers in the field had the same ability to respond to growth and yield of tomato plants. The use of this bactericide has a negative impact that is harmful to environmental health, according to Grenni et al. (2018), various types of pesticides and chemical fertilizers that accumulate in soil and water have a negative impact on the entire ecosystem.

Number of fruits and fruit weight. Based on the results of statistical analysis, the number of fruit showed a very significant difference and fruit weight showed a significant difference. The number of fruit and fruit weight in *T. harzianum* T215 increased by 40.61 and 53.22, respectively, compared to control. The increase in fruit number and fruit weight also resulted from the application of *T. harzianum* T10, an increase of 36.87 and 52.14%, respectively. This result is in line with the results of the above pathosystem and growth components. *T. harzianum* has a very significant effect in increasing the number of tomatoes, in addition to

control pathogen; the presence of antagonistic microbial activity in the soil is also able to increase the growth and yield of tomato plants (Contreras-Cornejo et al., 2016; Debnath et al., 2020).

The number of tomato fruits increase because plants can grow well without any obstacles from pathogens. The presence of pathogen attacks will interfere with plant growth, especially photosynthesis and plant metabolism (Yang & Luo, 2021). Healthy plants are able to carry out photosynthesis well so that plants will produce a lot of photosynthate for fruit formation (Cocaliadis et al., 2014). According to Zin & Badaluddin (2020) and Vukelić et al. (2021), the introduction of *Trichoderma* spp. has an effect on increasing the results of photosynthesis played by leaves, so that it will increase the number of fruits.

Based on the results of the study, *T. harzianum* was able to increase the yield of tomato compared to bactericide. The bactericidal treatment showed the lowest yields because the tomato plants were only able to harvest once and after the fruit was harvested the plants dried up and died. It is suspected that the use of a bactericide with the active ingredient streptomycin sulfate is only able to increase plant growth in the vegetative phase, while in the generative phase the plant is unable to survive infection with the pathogen *R. solanacearum* so that its yield decreases, which is different from *T. harzianum* which in the generative phase is able to increase yields. According to Mukhopadhyay & Kumar (2020), the use of *Trichoderma* spp. able to provide optimum production results while maintaining harmony, harmony and environmental balance.

Phenolic Compound Analysis Qualitatively.

Qualitative analysis of phenolic compounds from tomato plants showed that the application of *T. harzianum* liquid formula was able to increase the content of phenolic compounds in plant tissues. This was seen in all *T. harzianum* treatments when compared with controls and with bactericides (Table 3). The increase in the content of phenolic compounds (glycosides, saponins, and tannins) in plants is thought to be due to the role of antagonistic microbes as an inducer of systemic resistance in plants. Phenolic compounds in plants function as biochemical resistance of plants against plant pathogens (Wallis & Galarneau, 2020).

The results of the analysis of these phenolic compounds are in accordance with the data on the intensity of diseases that occur in the field (Table 1). Plants that were applied the liquid formula *T. harzianum* T10, *T. harzianum* T215, and the combination of *T. harzianum* T10 + *T. harzianum* T215 had lower disease

Table 3. The analysis results of phenolic compounds content qualitatively

Treatments	Glycosides	Tannins	Saponins
Control	-	-	-
<i>T. harzianum</i> T10	++	+++	++
<i>T. harzianum</i> T215	+++	++	+++
<i>T. harzianum</i> T10+T215	++	+++	+
Bactericide	-	+	+

- = no phenol; + = a little; ++ = enough; +++ = a lot.

intensity than the control and bactericide. The content of phenolic compounds in plants is directly related to the level of plant resistance to disease infection (Kulbat, 2016). Plants with low content of phenolic compounds have low plant resistance to disease infection, so that the disease intensity becomes high and *vice versa* (Wachjadi et al., 2013; Wallis & Galarneau, 2020).

CONCLUSIONS

The combination of *T. harzianum* T10 + *T. harzianum* T215 drenched on tomato plants had potency in suppressing bacterial wilt as 58.61 %. *T. harzianum* was effective for increasing plant height by 38.86%, plant fresh weight by 35.37%, plant dry weight by 51.67%, root fresh weight by 24.78%, root dry weight by 37.41%, the number of fruit by 40.61%, and the weight of the fruit by 53.22%. All treatments of *T. harzianum* can increase the content of phenol compounds qualitatively.

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AUTHORS' CONTRIBUTIONS

LS and EW considered and planned the experiment, NN collecting data on the plant damage area and in the laboratory, EW and NN performing analysis and interpreting the plant damage and weather data., LS and MWRS prepared the manuscript. The authors provided response and comments on the research flow, data analysis and interpretation as well as shape of the manuscript. All the authors have read and approved the final manuscript.

COMPETING INTEREST

Authors declare that they are no any competing interest regarding this publication.

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