

Evaluation of the Effectiveness of *Trichoderma* sp. as a Biological Agent on the Growth of Chili Peppers (*Capsicum frutescens* L.) in Organic Crop Systems

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ABSTRACT

Trichoderma sp. is an antagonistic fungus known to improve soil fertility, suppress pathogens, and stimulate plant growth. *Trichoderma* sp. not only improves soil fertility but also stimulates plant growth through the production of growth hormones or other bioactive compounds, and can reduce dependence on chemical fertilizers, thereby lowering production costs and making food prices more affordable. This study aims to test the effectiveness of *Trichoderma* sp. biological agents on the growth of cayenne pepper (*Capsicum frutescens* L.) in organic crop systems. This study used a completely randomized design with 6 treatments (Treatment P0: Without *Trichoderma*/control; Treatment P1: 10 g; Treatment P2: 20 g; Treatment P3: 30 g; Treatment P4: 40 g; Treatment P5: 50 g) with 5 replicates, followed by a post-hoc test to determine significant differences between treatments. The parameters measured were plant growth (plant height, number of leaves, and biomass weight). Our results showed that Application of *Trichoderma* sp. clearly increased the plant height and number of leaves in cayenne pepper plants throughout the experimental period and showed significant differences between treatment P0 and treatments P1, P2, P3, P4, and P5, while wet weight and dry weight did not differ significantly between treatments. The research data provides information on the effectiveness of using the biological agent *Trichoderma* sp. in organic chili pepper cultivation, as well as the role of this biological agent in supporting efforts to increase sustainable local food production.

Key words: biological agents; chlorophyll content; organic farming; plant growth; trichoderma

INTRODUCTION

The increase in population and various agricultural alternatives, such as the use of chemical or synthetic fertilizers, pesticides, and insecticides, have been used to produce high-yield crops in the shortest possible time and to protect them from insects and pest attacks during and after harvest. However, the use of these fertilizers and insecticides has raised many public concerns about sustainability, safety, and food supply security (Shanmugavel et al., 2023). Several agricultural practices are implemented to achieve sustainability and produce organic crops. However, one of the most commonly used and accepted methods is the use of biological control agents, which are essentially based on microorganisms such as bacteria, fungi, and viruses that suppress plant diseases through various mechanisms, including competition, antibiosis, and parasitism (Köhl et al., 2019; Thomine et al., 2022).

Biological fertilizers are microorganisms that play an important role in enhancing plant growth by increasing the supply of nutrients to host plants. They can be found in the rhizosphere and inside plants, and require the use of plant growth-promoting microorganisms that participate in various biotic activities in the soil ecosystem to make it dynamic and sustainable (Kundan et al., 2015). Biofertilizers are used to accelerate microbial activity that increases the availability of nutrients that can be easily absorbed by plants. These microbes improve soil fertility by fixing atmospheric N₂ and dissolving insoluble phosphates in the soil, thereby producing chemicals that promote plant growth (Widawati et al., 2018). Biofertilizers utilize the naturally available biological nutrient mobilization system, which greatly improves soil fertility and, as a result, plant productivity. This study uses *Trichoderma* fungi as a biofertilizer agent, which synergizes with *Rhizobium* bacteria and mycorrhizal fungi (Glick, 2014). Therefore, there is a need to find environmentally friendly approaches

such as biofertilizers, which play an important role in sustainable agriculture (Ahemad et al., 2012; Mambu et al., 2018).

Chili peppers (*Capsicum* sp.) are widely cultivated horticultural crops that have several health benefits, including capsaicin, a substance that has been reported to control cancer (Thaib et al., 2015). Based on data from the Central Statistics Agency, Indonesia's cayenne pepper production is estimated to reach 1.39 million tons in 2021. The Central Statistics Agency (BPS) recorded a decline of 8.09% in 2020, equivalent to 1.5 million tons. Cayenne pepper production declined in 2021, the first decline in the last five years. One of the causes of the decline in chili production in Indonesia is pest attacks and pathogen infections (Trisnawati et al., 2019). More environmentally friendly methods, such as *Trichoderma* sp. are needed to increase chili production. The application of *Trichoderma* sp. together with bioameliorants has a beneficial interactive relationship that accelerates decomposition, improves soil fertility, stimulates plant growth, and increases chili yields (Sonia and Tri, 2022).

In North Sulawesi Province, many chili plants cannot grow well due to a lack of nutrients in the soil and a lack of organic fertilizer, and they are often affected by disease, resulting in chili peppers that cannot be harvested and do not grow well. Based on the above description, the specific objectives of this study are: (1) to provide information on the effectiveness of using *Trichoderma* sp. biological agents in organic chili pepper cultivation, and (2) to examine the role of these biological agents in supporting efforts to increase sustainable local food production.

METHODS

Propagation of *Trichoderma* sp.

The production of *Trichoderma* spp. begins with the preparation of a *Trichoderma* sp. starter culture. The *Trichoderma* sp. starter culture is prepared by mixing *Trichoderma* spp. isolate propagules and rice that has been soaked overnight, autoclaved at 36°C for 3 hours, and cooled to room temperature. The mixture is incubated in a clean, closed container at room temperature (25-32°C) for 1 week. The appearance of greenish mycelium indicates successful starter production. The *Trichoderma* spp. starter is then ready for use (Sutarman and Miftkhurrohmat, 2020).

Trichoderma sp. Application

After sowing, 30 of the best seedlings were selected. The seedlings selected for transplanting were uniform in size, had the same number of leaves, were green in color, were not wilted, were disease-free, and grew upright. Next, they were transferred from the sowing medium to a growing medium containing 3 kg of soil, with the following details:

1. Treatment P0: (Without *Trichoderma* sp./control)
2. Treatment P1: 10 g *Trichoderma* sp.
3. Treatment P2: 20 g *Trichoderma* sp.
4. Treatment P3: 30 g *Trichoderma* sp.
5. Treatment P4: 40 g *Trichoderma* sp.
6. Treatment P5: 50 g *Trichoderma* sp.

The plant growth parameters observed in this study were plant height and number of leaves taken at 0, 7, 14, and 21 days after transplanting from the nursery, while wet weight and dry weight data were taken at harvest (21 days after transplanting).

The data obtained were analyzed using ANOVA (Analysis of Variance) at a 95% confidence level, and for data that were significantly different, the least significant difference (LSD) test was continued at a 5% level.

RESULTS AND DISCUSSION

The Parameter Measurements

Observations of the height of cayenne pepper plants presented in **Table 1** from the 6 treatments given for 21 days after planting (DAP), showed that P0, which was not given *Trichoderma* sp. Biofertilizer was significantly different from P1, P2, P3, P4, and P5 treatments, which were given 10 gram, 20 gram, 30 gram, 40 gram and 50 gram. This shows that the administration of *Trichoderma* sp. biofertilizer has a significant effect on the growth of cayenne pepper plants in the vegetative phase.

Table 1 Plant Height Chilli Rawit 21 HST

Treatment	Plant Height (cm)±SD
P0 (Control)	11.2 ± 0.11 b
P1 (<i>Trichoderma</i> sp.) 10 g	11.7 ± 0.25 a
P2 (<i>Trichoderma</i> sp.) 20 g	11.5 ± 0.17 a
P3 (<i>Trichoderma</i> sp.) 30 g	11.5 ± 0.33 a
P4 (<i>Trichoderma</i> sp.) 40 g	11.4 ± 0.22 a
P5 (<i>Trichoderma</i> sp.) 50 g	11.8 ± 0.35 a

SD = Standard Deviation; numbers followed by the same letter are not significantly different based on the 5% BNT Test.

The results of this study indicate that the height of cayenne pepper plants during the vegetative period in the P5 Biofertilizer *Trichoderma* sp. treatment. with a concentration of 50 grams with a value of 11.8 cm is higher than the 4 treatments, while the K treatment (control) without *Trichoderma* sp. biofertilizer has a lower value than the four treatments given a concentration with a resulting value of 11.2 cm. This proves that the administration of *Trichoderma* sp. biofertilizer has an effect and can increase plant height growth. Hossain et al., 2023 revealed that *Trichoderma* sp. fungi have the ability to colonize the rhizosphere and phyllosphere areas, and contribute to encouraging the growth and development of plant roots.

From the 6 treatments given for 21 days after planting (DAP), it shows that P0, which was not given *Trichoderma* sp. Biofertilizer was significantly different from treatments P1, P2, P3, P4, and P5, which were given 10 gram, 20 gram, 30 gram, 40 gram and 50 gram on the height of cayenne pepper plants. *Trichoderma* sp. can increase plant growth due to the high activity of cellulase and xylanase enzymes, which play a role in the decomposition of organic matter and the provision of nutrients needed by plants. In addition, the application of *Trichoderma* sp. to plants not only increases growth but also strengthens the root system. *Trichoderma* sp. colonies can interact with plant roots, stimulate the formation of a defense system, and increase the number and strength of roots. Overall, research shows that the higher the concentration of *Trichoderma* sp. The higher the dose, the better the chili plant growth, as indicated by increased plant height. These results are similar to those achieved by increasing growth using *Trichoderma* sp. on shallots (Sutarman and Prahasti, 2022).

The data on the number of leaves (**Table 2**) showed that the P1 Biofertilizer *Trichoderma* sp. treatment using a concentration of 10g produced a value of 4.55 strands more than the other 4 treatments. The C treatment (control) was lower than all treatments, given a concentration with a value of 4 strands.

Table 2.2 Number of Chili Leaves Rawit 21 HST

Treatment	Number of Leaves (cm)±SD
P0 (Control)	4.0 ± 0.00 b
P1 (<i>Trichoderma</i> sp.) 10 g	4.6 ± 0.37 a
P2 (<i>Trichoderma</i> sp.) 20 g	4.2 ± 0.11 b
P3 (<i>Trichoderma</i> sp.) 30 g	4.5 ± 0.40 a
P4 (<i>Trichoderma</i> sp.) 40 g	4.2 ± 0.27 b
P5 (<i>Trichoderma</i> sp.) 50 g	4.5 ± 0.33 a

SD = Standard Deviation; numbers followed by the same letter are not significantly different based on the 5% BNT Test.

The data results in **Table 2** from the 6 treatments that have been given concentrations for 21 HST, show that the P0, P2, and P4 treatments given concentrations of 20 gram and 40 gram are significantly different from the P1, P3, and P5 treatments. Biofertilizer can increase the growth of the number of leaf blades because the nutrients and nutrients in the soil increase and can be absorbed by the plants optimally. While the C treatment (control) was without *Trichoderma* sp. Biofertilizer produces the lowest value and is significantly different from P1, P3, and P5 because P0 cannot receive additional nutrients, so it can inhibit the growth of leaf blades.

These results are in line with Sudantha et al. (2023) who stated that the application of *Trichoderma* sp. can increase the height and number of leaves in plants. This occurs because the fungus produces gibberellin and auxin hormones, which play an important role in plant growth. Auxin produced by *Trichoderma* sp. also contributes to the use of *Trichoderma* sp., not only improving vegetative growth but also supporting the development of a better root system, thereby increasing the efficiency of nutrient absorption.

Based on **Table 3**, treatment P5 with a concentration of 50 g of *Trichoderma* sp. biofertilizer with a value of 0.22 g is higher than the 6 treatments but is not significantly different from the 5 treatments given concentration, P3 which is given a concentration of 30 g with a value of 0.19 g, P1 which is given a concentration of 10 gr with a value of 0.18 g, P4 which is given a concentration of 40 g with a value of 0.15 g, P2 which is given a concentration of 20 g with a value of 0.13 g, and K (control) which obtains a lower value compared to all treatments, namely with a value of 0.11 g.

Table 3. Wet Weight Plant Chilli Rawit 21 HST

Treatment	Wet Weight (gr)±SD
P0 (Control)	0.11 ± 0.02
P1 (<i>Trichoderma</i> sp.) 10g	0.18 ± 0.03
P2 (<i>Trichoderma</i> sp.) 20g	0.13 ± 0.03
P3 (<i>Trichoderma</i> sp.) 30g	0.19 ± 0.07
P4 (<i>Trichoderma</i> sp.) 40g	0.15 ± 0.03
P5 (<i>Trichoderma</i> sp.) 50g	0.22 ± 0.11

Description: SD = Standard Deviation

From 6 treatments with a P5 concentration of 50 gr gives more results than all treatment, namely with a value of 0.22 grams while for P1, P2, P3, and P4 with amount values of 0.18 gram, 0.13 gram, 0.19 gram and 0.15 gram. Treatment P0 (control) reached heavy wet 0.11 gram of all generated value, no difference in real, and not to be continued with 5% BNT Test.

Administration of *Trichoderma* sp. biofertilizer. show no significant results, because the plant is still in the vegetative growth period, namely including the growth beginning as well as nutrition from the land is still not yet sufficient for the plant chilli cayenne pepper. Suanda et al., 2019 stated that fungi can grow well in nutrient-rich media, especially those containing carbohydrate sources. Carbohydrates and their derivatives are the main substrates in fungal carbon metabolism. Carbon is a very important element; approximately 50% of the weight of microorganisms consists of carbon. This indicates that the presence of carbohydrates in the growth medium is crucial to support metabolic processes and energy in fungal cells.

Table 4, the treatment of giving *Trichoderma* sp. biofertilizer as much as 50 g shows higher data compared to other treatments, with a value of 0.038 g. This shows that P5 with the provision of 50 g of *Trichoderma* sp. biofertilizer is able to stimulate the growth of cayenne pepper plants during the vegetative period, while the provision below 50 g such as in P1, P2, P3, P4 with each obtaining a value of 0.004 g, 0.018 g, 0.031 g, 0.023 g and 0.019 g indicates that the amount produced is low compared to P5.

Table 4. Dry Weight of Plants 21 HST

Treatment	Dry Weight (gr)±SD
P0 (Control)	0.004 ± 0.002
P1 (<i>Trichoderma</i> sp.) 10 g	0.018 ± 0.050
P2 (<i>Trichoderma</i> sp.) 20 g	0.031 ± 0.014
P3 (<i>Trichoderma</i> sp.) 30 g	0.023 ± 0.005
P4 (<i>Trichoderma</i> sp.) 40 g	0.019 ± 0.008
P5 (<i>Trichoderma</i> sp.) 50g	0.038 ± 0.010

Description: SD = Standard Deviation

The data shows that treatment given namely in 6 treatments, show no difference significant real with the results obtained by P5 were 0.038 grams of all treatment this is what shows the highest number P4 with value of 0.19 gram, P3 0.023 gram, P2 0.031 gram, P1 0.018 gram and P0 with value of 0.004 gram show no significant difference because in the phase vegetative need nutrients and adequate nutrition , from administration of *Trichoderma* sp. biofertilizer isn't give effect straight to the phase vegetative plant chilli cayenne pepper. This is supported by research conducted by Oktapia (2021), which states that although the application *Trichoderma* sp. give impact positive on the growth of tall plant chilli cayenne pepper, analysis show that in some treatment, including higher dose low, no there is difference significant difference in heavy dry plants. This indicates that the effects of *Trichoderma* sp. may not be immediately apparent in the early vegetative phase of the plant.

The high and low dry weight of plants is greatly influenced by the amount of nutrients absorbed by the roots during growth (Lakitan, 2002). The more nutrients absorbed, the better the plant growth and the higher the dry weight. Dry weight is also closely related to wet weight. A good increase in wet weight will contribute to an increase in dry weight (Nurdin, 2011). Therefore, the resulting data was not continued with the 5% LSD test. The application of *Trichoderma* sp. biofertilizer did not show a significant difference in the dry weight of cayenne pepper plants in the vegetative phase. Tigahari et al. (2021) stated that the use of compost containing *Trichoderma* sp. did not show a significant effect on the dry weight of chili plants in the early phase of growth. The results of the analysis of variance showed that although there were variations in the treatments, the resulting differences were not enough to be considered statistically significant. In addition, the number of plant leaves also plays an important role because leaves are the main site of accumulation of photosynthesis results. The

more leaves, the more efficient the photosynthesis process, which will increase the dry weight of the plant. Thus, the availability of nutrients and the number of leaves were the key factors in determining the dry weight of the plant.

CONCLUSION

The application of *Trichoderma* sp. biofertilizer effectively had a significant effect on the growth of cayenne pepper plants, with the highest growth in the 50g treatment (plant height) and 10g treatment (number of leaves), but had no effective effect on plant fresh weight and dry weight. From the results of this study, it can be concluded that the application of *Trichoderma* sp. biofertilizer is effective as a biofertilizer agent in cayenne pepper plants in the vegetative phase of plant height and number of leaves.

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