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Application of Trichoderma Biopesticide on Chili Plants (*Capsicum frutescens* L.) Catas Variety

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Abstract. This study aims to determine the effect of the interaction between the application of Trichoderma solid formula biopesticide applied to the soil and through canopy spraying on the growth and health of vegetative phase cayenne pepper (Capsicum frutescens) plants. This study was conducted from September to December 2024 in Pacet, Pasinan Hamlet, Cepokolimo Village, at an altitude of 450 meters above sea level. This field study was designed as a factorial Randomized Block Design. The first factor was the application of solid biofertilizer (soil treatment), which consisted of three levels: no biofertilizer application but using complete chemical fertilizer; soil treatment at planting or starting from sowing; and soil treatment one month after planting. The second factor was the application of liquid Trichoderma biofertilizer. The observation variables were length increase (cm), leaf number increase, average time of first flowering (days), branch increase, and plant health. The interaction effect of biopesticide application through soil treatment had a significant effect on plant health with a disease symptom intensity of 9.38% compared to the control of 16.67%. The interaction effect on plant growth was not significant.

Keywords: Trichoderma, biopesticide, canopy spraying

1 Introduction

The cayenne pepper plant (*Capsicum frutescens*) plays an important role in Indonesia's economy, but farmers often face challenges such as pest and disease attacks, as well as soil fertility decline due to excessive use of chemical fertilizers [1]. In this context, the application of Trichoderma Biofertilizer and Biopesticide has emerged as a sustainable and environmentally friendly solution. Biofertilizer, which contains beneficial microorganisms, can improve soil fertility and nutrient availability, while Trichoderma functions as an effective biopesticide in controlling fungal diseases. By adopting both approaches, farmers can not only increase the productivity of chili pepper plants, but also maintain soil and environmental health, and support more sustainable agricultural practices. Implementing this strategy is crucial to meeting the growing market demand while maintaining ecosystem balance.

Chili peppers are a leading Indonesian horticultural commodity with high economic value and are in high demand by the public as a cooking spice [2]. Each chili pepper variety has a different level of adaptability to the environment, so it is very important to adjust the growing environment to optimize plant growth. Soil microorganisms are applied to support the growth and development of chili plants. However, the application of chemical fertilizers and pesticides in plantations often leads to a decline in soil and agricultural land quality. One way to improve the physical, chemical, and biological properties of soil is to implement an organic farming system that utilizes natural materials available in nature [3]. One solution that can be applied is to use biofertilizers as an alternative to inorganic fertilizers. Biofertilizers are alternative fertilizers that can increase soil fertility, quality, and health, provide sufficient nutrients, increase crop production, and are environmentally friendly [4].

Biofertilizers are an environmentally friendly alternative that is gaining attention in agriculture, including for chili pepper crops [5]. The use of biofertilizers can improve soil fertility and support plant growth by improving the quality of microbes in the soil. In the context of cayenne pepper, biofertilizer serves to increase nutrient absorption, strengthen plant resistance to disease, and increase crop yields. By utilizing biofertilizer, farmers can not only reduce their dependence on chemical fertilizers, but also preserve the environment. Therefore, research and application of biofertilizer in cayenne pepper cultivation is very important to increase productivity while maintaining the agricultural ecosystem. In addition to its role as a biofertilizer, Trichoderma also protects plants from diseases and other pests, thus acting as a biopesticide. Anthracnose, caused by the fungus Colletotrichum spp. [6], is one of the main problems in chili pepper (*Capsicum frutescens*) cultivation. The inoculation of

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Trichoderma sp. fungi in organic fertilizer/compost and sprinkled on chili pepper fields before seedlings are planted provides effective control against wilt disease caused by the Fusarium oxysporum fungus [7].

Trichoderma sp. is known for its ability as an effective biocontrol agent for various plants and is commonly found in soil [8]. The use of biopesticides, particularly Trichoderma, in chili pepper cultivation is gaining attention due to its ability to control pathogens and improve plant health [9]. The use of Trichoderma spp. as a type of biological control fungus in pest and disease management can prevent crop failure in agricultural commodities [10]. Trichoderma is a saprophytic fungus known to be effective in reducing disease attacks, such as fungi and bacteria, which often attack cayenne peppers. In addition to functioning as a biological control agent, Trichoderma can also stimulate root growth and increase nutrient absorption, thereby contributing to more optimal plant growth. With the application of this biopesticide, farmers can reduce the use of chemical pesticides, which not only has a positive impact on the environment but also improves the quality and safety of agricultural products. Therefore, research and application of Trichoderma as a biopesticide in chili pepper cultivation is a strategic step to support sustainable agriculture.

The application of Trichoderma sp. had a positive effect on the growth of chili plants (*Capsicum frutescens*) [11]. The higher the concentration of Trichoderma sp. applied, the better the growth of chili plants, as indicated by an increase in plant height and number of leaves. Treatment with a concentration of 15 grams showed a higher average plant height and number of leaves compared to other treatments. Meanwhile, the application of papaya leaf biopesticide at various concentrations affected the mortality of insects attacking *Brassica rapa* L. intercropped with Sawi Sendok [12]. Thus, Trichoderma biopesticides are an alternative to reduce the use of synthetic fertilizers and chemical pesticides [13]. Therefore, farmers as production operators in the field should increase their knowledge and skills regarding the application of biopesticides for the control of plant pests (OPT) [14].

However, to date, Trichoderma applications, both as biofertilizers and biopesticides, have always been administered in the form of *soil treatment.* Meanwhile, surface application in the form of spraying has not been widely practiced, and its effectiveness in controlling plant diseases, particularly in chili peppers, while also providing plant protection in the form of increased plant resistance as a result of Trichoderma metabolites being responded to by the plants, has not been tested.

The urgency of this research is the need for safe and environmentally friendly disease control measures. One method that has been widely developed is the use of biological agents, such as Trichoderma spp., which play an antagonistic role in inhibiting the growth of pathogens that interfere with plant growth, especially in the vegetative phase of plants. The objective of this study is to determine the effect of the biological agent *Trichoderma esperellum* applied through *soil treatment* and *foliar spray*, as well as its possible interaction with the vegetative growth of Catas variety cayenne pepper plants.

2 Method

This study was conducted on land in Pasinan Village, Pacet District, Mojokerto, at an altitude of 450 meters above sea level. The experimental requirements were supported by the Microbiology and Biotechnology Laboratory of Muhammadiyah University Sidoarjo. This study was conducted from September to December 2024. The materials used in this study were cayenne pepper seeds, Trichoderma solid biofertilizer, and liquid biofertilizer. The tools used were sacks, hoes, buckets, scales, calipers, rulers, measuring tapes, writing instruments, and cameras. The experiments in this study were arranged factorially in a randomized block design (RBD). The first factor was the application of solid biofertilizer (*soil treatment*), which consisted of three levels, namely: No biofertilizer application, but using complete chemical fertilizer (C0); *Soil treatment* at planting, or carried out from the start of sowing (C1); *Soil treatment* one month after planting (C2). The second factor was the application of liquid Trichoderma biofertilizer, which was carried out every two weeks starting 28 days after planting, consisting of two levels, namely: No spraying of liquid Trichoderma biofertilizer (R0):

Spraying of Trichoderma liquid biofertilizer (R1). The experiment was repeated four times, so that with six treatment combinations, 24 experimental units were obtained.

This study began with the dilution of Trichoderma used for spraying, namely by opening the wrapping containing Trichoderma, then adding 500 ml of clean water to a blender, adding Trichoderma to the blender and blending until homogeneous, after which the solution was poured into bottles and stored in a refrigerator. The Trichoderma solution stored in the refrigerator can last for 3 months. This was followed by mixing biofertilizer with ordinary soil at a ratio of 2:1. After mixing the fertilizer, land preparation began by clearing the land of weeds and wild grass. The next stage was planting the seeds by transferring the prepared chili seedlings. Planting was done by making 6 holes 3 cm deep in each experimental plot. Then, 1 cayenne pepper seedling is inserted into each hole and the hole is covered again with soil and pressed down firmly. Watering is done twice a day, in the morning and afternoon, and weeding is also done every day to minimize the growth of weeds around the plants.

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The observation variables in this study were plant height (cm), increase in the number of leaves, average time of first flowering (days), increase in branches, and plant health. All quantitative data from the observations were processed using analysis of variance in accordance with the Randomized Block Design (RBD). If there was a significant or very significant effect, a BNJ test was performed at a 5% level.

3 Results and Discussion

3.1 Plant Height

The results of the analysis of variance showed that the application of Trichoderma biopesticide to the soil (*soil treatment*) as fertilizer had a significant effect ($p<0.05$) on plant height growth 28-42 days after planting (DAP). However, the effect of canopy spraying and its interaction with *soil treatment* was not significant ($p>0.05$) at all observation times. The average effect of biopesticide application as fertilization and canopy spraying is presented in Table 1.

Table 1. Average Effect of Biopesticide Plus Applied as *Soil Treatment* and Canopy Spraying on Chili Plant Height at 28, 42, 56, and 70 DAP (cm)

Application Method of Trichoderma Biopesticid	**Plant Height**			
	28 HST	**42 HST**	**56 DAP**	**70 days after sowing**
Without *soil treatment* (C0)	21.95 b	27.96 ab	31.76	31.03
Soil treatment at planting (C1)	21.15 b	31.93 b	32.81	34.57
Soil Treatment 1 Month After Planting (C2)	14.90 a	24.02 a	30.44	31.78
BNJ 5%	3.76	5.70	tn	tn
Without canopy spraying (R0)	18.97	28.17	31.29	31.83
Crown spraying (R1)	19.70	27.76	32.05	33.09
BNJ 5%	tn	tn	tn	tn

The numbers followed by the same letter in the same column for the application method of biopesticide are not significantly different based on the BNJ 5% test.

The application of biopesticide plus *soil* treatment resulted in the highest growth of chili plants at 28-70 days after planting. Spraying biofertilizer on the canopy (*foliar spray*) showed no significant difference from the treatment without spraying at all observation times.

3.2 Number of Leaves

Analysis of variance revealed that the application of biopesticide plus through the soil had a significant effect on the number of leaves ($p>0.05$) at 42, 56, and 70 days after planting. Meanwhile, the effect of canopy spraying and its interaction with *soil treatment* had no significant effect at all observation times ($p>0.05$). The average effect of biofertilizer application through fertilization and canopy spraying is presented in Table 2.

Table 2. Average Effect of Biopesticide Plus Applied as *Soil Treatment* and Canopy Spraying on the Number of Chili Pepper Leaves at 28, 42, 56, and 70 Days After Planting

Application Method of Trichoderma Biofertilizer	**Number of Leaves (pieces)**			
	28 DAP	42 DAP	56 DPA	70 HST
Without *soil treatment* (C0)	11.94 a	4.08 a	5.04 b	5.06
Soil treatment at planting (C1)	11.52 a	6.29 b	5.58 b	5.75
Soil Treatment 1 Month After Planting (C2)	7.71 b	5.10 ab	4.19 a	5.1
BNJ 5%	tn	1.38	0.74	tn
Without canopy spraying (R0)	8.82	5.23	4.92	5.08
Top dressing (R1)	11.96	5.08	4.96	5.53
BNJ 5%	tn	tn	tn	tn

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The numbers followed by the same letter in the same column for the biopesticide application method are not significantly different based on the BNJ 5% test.

The number of leaves achieved in the biopesticide application plus *soil treatment treatment* was highest compared to the control (without *soil treatment*) and application one month after planting, at 6.29, 5.58, and 5.75 leaves at 42, 56, and 70 days after planting, respectively (Table 2).

3.3 Plant Health

Pepper plant health was measured at the end of plant growth during the phase when flowers began to appear, which is a phase prone to attack by pathogens causing infection and rot at the base of the stem and seedling fly damage.

The application of biopesticide plus through fertilization (*soil treatment*) and canopy spraying had no significant effect on plant health ($p>0.05$), but the interaction effect was significant ($p<0.05$). The average interaction effect between the application of biopesticide plus applied through the soil as *soil treatment* and as foliar spray is presented in Table 3.

Table 3. Average Interaction Effect of Biopesticide Plus Application as *Soil Treatment* and Foliar Spraying on Chili Plant Health (Scale 0-100)

Treatment	Symptom Intensity
No *soil treatment* and no foliar spray (C0R0)	16.67 b
Soil Treatment and no canopy spraying (C1R0)	9.38 a
Soil Treatment 1 BST and without canopy spraying (C2R0)	9.38 a
Without *soil treatment* and canopy spraying (C0R1)	10.42 b
Soil Treatment and canopy spraying (C1R1)	10.42 b
Soil Treatment 1 BST and canopy spraying (C2R1)	11.46 b
BNJ 5%	6.27

3.4 Time of First Branch Shoot Emergence

The application of biopesticide plus fertilization (*soil treatment*) had a very significant effect ($p<0.01$) on the time of first branch bud emergence. The effect of spraying biopesticide on the canopy surface and its interaction with *soil treatment* on the canopy was not significant on the time of first branch bud emergence ($p>0.05$). The average effect of applying biofertilizer through fertilization and canopy spraying is presented in Table 4.

Table 4. Average Effect of Biopesticide Application Plus Soil Treatment and Canopy Spraying on the Time of Emergence of the First Branch Bud of Chili Plants (Days)

Application Method of Trichoderma Biofertilizer	Initial Emergence Time of Stem Shoots (Days)
Without *soil treatment* (C0)	38.13 a
Soil Treatment during planting (C1)	36.00 ab
Soil Treatment 1 Month After Planting (C2)	39.38 ab
BNJ 5%	1.96
Without canopy spraying (R0)	37.92
Canopy spraying (R1)	37.75
BNJ 5%	tn

Numbers followed by the same letter in the application method of biopesticides as *soil treatment* indicate no significant difference in the 5% BNJ Test

The application of biofertilizer through fertilization (*soil treatment*) resulted in the shortest initial emergence time of chili pepper branch shoots, namely 36 days (Table 4). Meanwhile, the application of biopesticide through spraying resulted in the first shoot emergence at 38 days.

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3.5 Initial Flower Emergence Time

The application of biopesticide plus through fertilization (*soil treatment*) had a significant effect on the initial time of flower emergence in chili plants ($p<0.05$). On the other hand, canopy spraying and its interaction with *soil treatment* had no significant effect on the time of first flower emergence ($p>0.05$). The average effect of biopesticide application through fertilization and canopy spraying is presented in Table 5.

Table 5. Average Effect of Biopesticide Applied as *Soil Treatment* and Foliar Spraying on the Onset of Flowering in Chili Plants

Application Method of Trichoderma Biofertilizer	Time of first flower emergence (Days)
Without *soil treatment* (C0)	43.88 a
Soil treatment at planting (C1)	42.88 a
Soil Treatment 1 Month After Planting (C2)	44.13 ab
BNJ 5%	1.02
Without canopy spraying (R0)	43.75
Crown spraying (R1)	43.50
BNJ 5%	tn

Numbers followed by the same letter in the same column are not significantly different in the 5% BNJ test Table 6 shows that the application of biofertilizer through *soil* treatment resulted in the shortest time to flower emergence, namely 42.88 days. The application of biofertilizer through *foliar* spray did not accelerate flowering time compared to without foliar spray.

3.6 Discussion

Soil treatment with Trichoderma biopesticide at the beginning of planting had no significant effect on plant height because it was carried out in the early stages of development, which is crucial for the plant's ability to grow optimally, as shown in Table 1. At 28 days after planting, *soil* treatment had a significant effect in the early stages. Conversely, soil treatment performed a month later had no significant effect because the plants had passed the critical phase and had begun to adapt to environmental conditions.

There were significant differences in the percentage of plant height at several HSTs across all biological treatments, as shown in Table 1. In addition, the biological agent Biofertilizer Trichoderma played a direct role in providing nutrients and growth regulators for cayenne pepper plants [15], as well as an indirect role in inducing plant growth in terms of the number of leaves, as shown in Table 3. The effect *of soil* treatment showed a significant effect compared to *foliar spray* during the vegetative period, as shown in Table 4. Chili growth with the application of Trichoderma as a biological fertilizer can have significant results. The application of biological agents through fertilization (*soil treatment*) provides optimal results, while *foliar spraying* provides optimal growth in the early vegetative phase [16]. Analysis of variance of the treatment combinations shows a significant interaction effect on the number of leaves but no significant effect on plant height [17].

The application of Trichoderma biopesticide on Catas variety cayenne pepper (*Capsicum frutescens* L.) plants is an environmentally friendly solution to control diseases that often attack these plants, such as Phytophthora and Fusarium fungal infections. Trichoderma, as a fungus that has antagonistic properties against pathogens, works by parasitizing, producing enzymes that destroy the cell walls of pathogens, and stimulating the plant's defense system. The application of Trichoderma can increase plant resistance to disease, accelerate root growth, and optimize nutrient absorption, resulting in healthier and more productive chili plants. Additionally, the use of this biopesticide reduces dependence on chemical pesticides that can pollute the environment. Trichoderma can be applied by mixing it into the growing medium, spraying it on leaves, or soaking seeds before planting. Despite its many benefits, challenges in using Trichoderma include dependence on supportive environmental conditions and limited product availability in the market. Overall, Trichoderma offers great potential to support sustainable, environmentally friendly chili farming and significantly increase crop yields.

4 Conclusion

The application of Trichoderma biopesticide with *soil treatment* had a significant effect on plant health compared to *foliar spray* treatment. The interaction effect of biopesticide application through *soil treatment* had a significant effect on plant health, with a disease symptom intensity of 9.38% compared to 16.67% in the control

group. The interaction effect on plant growth was not significant. Trichoderma biopesticide with *soil treatment* has the potential to protect plant health and chili pepper production of the Catas variety can help the early growth phase of chili pepper plants.

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