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Growth Response of Caisim Mustard (*Brassica rapa* var. *parachinensis*) to *Trichoderma* sp. Induced Cocoa Pod Husk Compost in Soilless Culture System

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Abstract: *Cocoa pod husk waste (Theobroma cacao L.) is an abundant plantation by-product that has not been optimally utilized, despite containing organic compounds such as cellulose, hemicellulose, lignin, and nitrogen nutrients that have potential as compost materials. The utilization of this waste can serve as an environmentally friendly organic resource to reduce dependence on chemical fertilizers. The decomposition process of cocoa pod husk can be accelerated by Trichoderma sp., which enhances organic matter degradation and increases nutrient availability. This study aimed to evaluate the effect of Trichoderma sp. induced cocoa pod husk compost in a soilless culture system on the growth of mustard greens (Brassica rapa var. parachinensis). The experiment was arranged in a completely randomized design with six replications and four treatments P0 (2:1:2:1:0), P1 (2:1:2:1:2), P2 (2:1:2:1:3) and P3 (2:1:2:1:4), consisting of combinations of rice husk, vermicompost, leaf litter compost, cocopeat, and Trichoderma sp. induced cocoa pod husk compost. Observed parameters included vegetative growth (number of leaves, leaf area, and plant height), chlorophyll content (chlorophyll a, chlorophyll b, and total chlorophyll), and plant biomass (fresh weight, dry weight, and shoot to root ratio). Data were analyzed using analysis of variance (ANOVA) followed by Duncan's multiple range test at a 5% significance level. The results showed that media composition significantly affected all observed parameters, with the best treatment obtained in P3 (2:1:2:1:4), which produced the most optimal plant growth compared to the other treatments.*
Keywords: Cocoa peel compost, Trichoderma sp., SCS Composition, Caisim mustard greens.

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I. INTRODUCTION

Cocoa pod husk *(Theobroma cacao L.)* is one of the plantation wastes in Indonesia that is produced in large quantities but has not been optimally utilized and is often discarded around plantation areas, which may potentially cause environmental pollution (Haderiah et al., 2024). Cocoa pod husk contains organic compounds such as cellulose, hemicellulose, lignin, pectin, and nutrients that have potential use as compost material. Its lignocellulosic content makes it suitable as a compost raw material that can improve the physical properties of planting media after decomposition (Kamal et al., 2023). However, the high lignin and cellulose content causes slow natural decomposition so microbial decomposers are required to accelerate the process (Pallawagau et al., 2019).

Trichoderma sp. is known to produce cellulase and ligninase enzymes that play a role in breaking down complex organic compounds such as lignin and cellulose. The activity of Trichoderma during composting can accelerate compost maturation and improve its quality, including nutrient availability and the physical properties of the growing media (Khoiriyah et al., 2025). The use of organic compost derived from agricultural waste can also serve as an alternative to reduce excessive chemical fertilizer application, which may degrade soil quality if continuously used without organic matter addition (Awang & Jawang, 2024). Compost plays an important role in improving the physical, chemical, and biological properties of the growing media by increasing organic matter content, water holding capacity, and microbial activity (Yunidawati, 2022).

The soilless culture system is a cultivation method without soil that is increasingly applied due to its ability to create more controlled growth conditions, improve water and nutrient efficiency, and reduce soil borne diseases (Gruda et al., 2023). The growing media in this system must have good aeration, water retention, and nutrient availability, making media composition an important factor. Mustard greens *Brassica rapa* var *parachinensis* is a leafy vegetable that requires sufficient nutrient availability to support optimal vegetative growth

(Supriyono & Wibowo, 2023). Research on the use of *Trichoderma* induced cocoa pod husk compost in a soilless culture system for mustard green growth is still limited, therefore this study was conducted.

II. EXPERIMENTAL PROCEDURE

This research was conducted from November 2025 to February 2026 at the Microbiology Laboratory and Botany Laboratory, Department of Biology, Faculty of Mathematics and Natural Sciences, University of Lampung. The study used a completely randomized design with four treatments of soilless culture system media composition and six replications for each treatment, resulting in a total of 24 experimental units. The soilless culture system media consisted of rice husk, vermicompost, leaf litter compost, cocopeat, and *Trichoderma* sp. induced cocoa pod husk compost. The treatments included P0 as the control with a composition of 2:1:2:1:0 without the addition of *Trichoderma* sp. induced cocoa pod husk compost, P1 with 2:1:2:1:2, P2 with 2:1:2:1:3, and P3 with 2:1:2:1:4.

The collected data were quantitative and analyzed statistically. Prior to hypothesis testing, the data were subjected to normality and homogeneity tests to meet the assumptions of statistical analysis. The data were then analyzed using analysis of variance (ANOVA) to determine the effect of treatments on the observed parameters. When significant differences were found, further analysis was performed using Duncan's multiple range test at a significance level of 5 percent.

1.1 Subculturing of *Trichoderma* sp.

Potato Dextrose Agar (PDA) medium with a concentration of 39 g/1000 ml was prepared by weighing 9.75 g of PDA powder and dissolving it in 250 ml of distilled water, followed by heating until boiling. The medium was then sterilized using an autoclave at 121°C for 20 minutes. After the temperature decreased, chloramphenicol was added and the solution was homogenized. The medium was poured into Petri dishes and allowed to solidify. After solidification, the medium was inoculated with *Trichoderma* sp. using a sterile inoculating loop and incubated at 36°C for 7 days until the culture developed (Qolbi et al., 2024).

1.2 Production of *Trichoderma* sp. Inoculum

A total of 300 g of sorghum grains was weighed and placed into a 1 kg heat resistant ziplock plastic bag, then sterilized using an autoclave for 15 minutes. Subsequently, $CaSO_4$ at 4 percent (4 g) and $CaCO_3$ at 2 percent (2 g) were weighed and dissolved in 100 ml of sterile distilled water. A volume of 75 ml of the $CaSO_4$ and $CaCO_3$ solution was added into the ziplock bag containing sorghum grains and shaken until homogeneous. After that, *Trichoderma* sp. isolate was inoculated using one inoculating loop into the medium, then the bag was tightly sealed and incubated at room temperature for 14 days. During incubation, the culture was shaken every 2 days until the inoculum developed properly (Qolbi et al., 2024).

1.3 Composting of Cocoa Pod Husk Induced by *Trichoderma* sp.

Compost preparation was carried out using a perforated container whose sides were covered with cardboard and the bottom was provided with 3 to 5 holes. A total of 20 kg of cocoa pod husk and 10 kg of goat manure were placed into the container and homogenized, followed by gradual addition of water while mixing until reaching approximately 60 percent moisture content measured using a soil moisture meter. Subsequently, 300 g of Trichoderma sp. inoculum was evenly applied, after which the container was covered with newspaper and placed in a shaded area. The compost was turned every 5 days to maintain aeration and prevent water accumulation, with a composting period of one month until maturity, indicated by a darker color and the absence of foul odor (Farisi et al., 2022).

1.4 Application of cocoa pod husk compost induced with *Trichoderma* sp. on mustard greens (*Brassica rapa* var. *parachinensis*).

The preparation of the soilless culture system growing media was carried out using a mixture of rice husk, vermicompost, leaf litter compost, cocopeat, and solid cocoa pod husk compost inoculated with *Trichoderma* sp. The treatments were arranged with composition ratios of P0 2:1:2:1:0 without the addition of cocoa pod husk compost, P1 2:1:2:1:2, P2 2:1:2:1:3, and P3 2:1:2:1:4. Each treatment consisted of six replications, with each replication using 3000 g of growing media placed in a 30 cm × 35 cm polybag, resulting in a total of 18,000 g of media per treatment, which was used as the basis for calculating the proportion of each material. All components of the growing media were thoroughly mixed until homogeneous before being placed into polybags according to the number of replications. Mustard green seedlings aged 14 days were then transplanted into the prepared media. Plant maintenance was carried out by watering twice daily in the morning and afternoon, and replanting was performed when plants were wilted or dead. Vegetative growth observations were conducted once a week throughout the study period (Sdgs et al., 2025).

III. RESULTS AND DISCUSSIONS

3.1. Number of Leaves

The results of the study on observation of the number of leaves of the mustard greens plant in various treatments using *Trichoderma* sp. Induced cocoa husk compost on the Soilless Culture System (SCS) media are presented in **Figure 1.**

Figure 1. The growth chart of the number of caisim (mustard greens) leaves from 1 WAP - 5 WAP (Week After Planting).

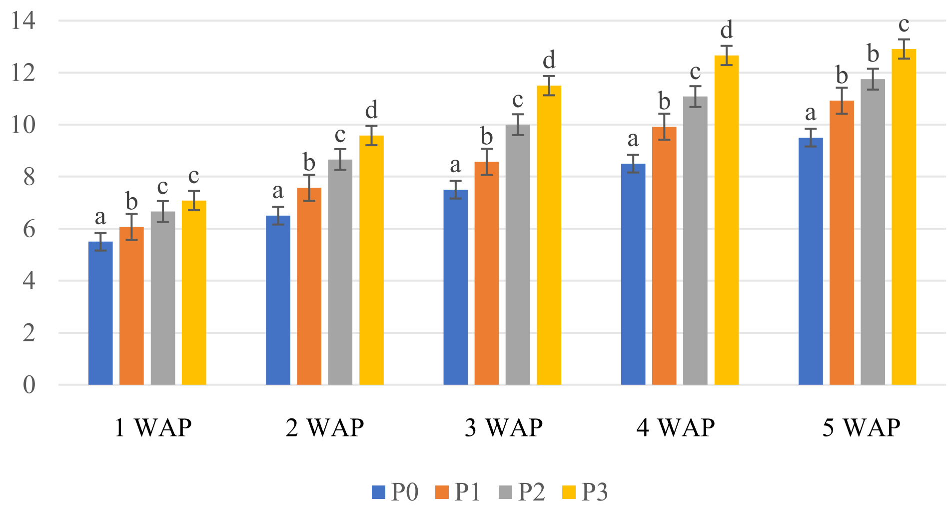

Figure 1. Treatment P3 (2:1:2:1:4) showed the highest number of mustard green leaves compared to the other treatments, followed by P2, P1, and P0. This increase is presumed to be due to the addition of *Trichoderma* sp. induced cocoa pod husk compost, which enhances the availability of nutrients for plant growth.

The increase in leaf number in treatment P3 is presumed to be associated with the role of *Trichoderma* sp. induced cocoa pod husk compost in supplying nutrients through the decomposition of organic matter. The activity of Trichoderma sp. helps accelerate the breakdown of complex compounds, thereby making nutrients more available to plants. In addition, goat manure in the compost also contributes nutrients such as nitrogen, phosphorus, and potassium, which support vegetative growth, particularly leaf formation. This is in line with (Jufri, 2024), who reported that the application of Trichoderma sp. together with organic compost can improve nutrient availability and enhance plant vegetative growth.

Furthermore, the composition of the soilless culture system medium also influences plant growth performance. Rice husk improves media porosity and aeration, cocopeat helps maintain moisture due to its high water holding capacity, while vermicompost and leaf litter compost act as additional sources of organic matter and nutrients. The combination of these materials is presumed to create favorable conditions that support plant growth.

3.2 Leaf Area

The results of the study on observation of the leaf area of the mustard greens plant in various treatments using Trichoderma sp. Induced cocoa husk compost on the Soilless Culture System (SCS) media are presented in **Figure 2.**

Figure 2. The growth chart of the leaf area of caisim (mustard greens) leaves from 1 WAP - 5 WAP (Week After Planting).

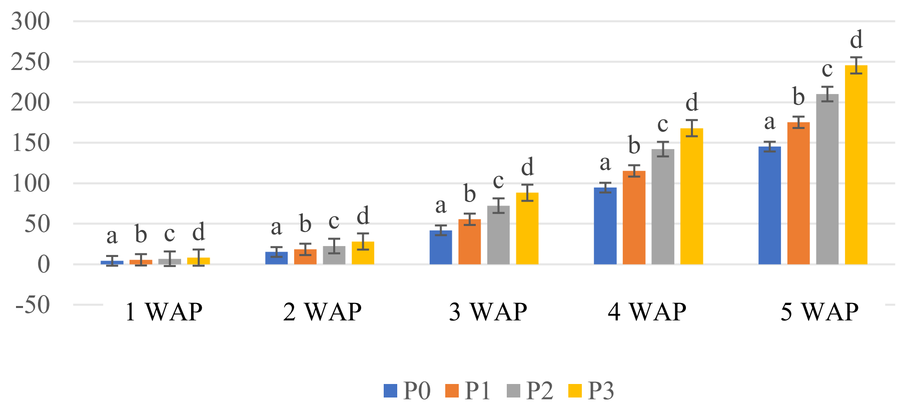

Figure 2. shows an increase in the leaf area of mustard greens (*Brassica rapa* var. *parachinensis*) from 1 WAP to 5 WAP, with the highest value observed in the fifth week in treatment P3. Overall, treatment P3 produced the highest leaf area compared to the other treatments, followed by P2, P1, and P0.

The increase in leaf area in treatment P3 is presumed to be associated with more optimal nutrient availability, particularly nitrogen, which plays an important role in chlorophyll formation and photosynthesis. The better nitrogen availability in this treatment originates from Trichoderma sp. induced cocoa pod husk compost, which accelerates the decomposition of organic matter, making nutrients more easily available and absorbed by plants. These conditions support cell division and leaf expansion, resulting in increased leaf area. This is in line with (Ridwan et al., 2025), who stated that *Trichoderma* sp. as a compost activator can enhance nutrient availability and nutrient uptake efficiency, thereby supporting plant vegetative growth.

In addition, the composition of the soilless culture system medium also contributes to the increase in leaf area. Rice husk improves media porosity and enhances root aeration, while cocopeat helps maintain moisture content. Vermicompost and leaf litter compost act as additional sources of organic matter that increase nutrient availability. The combination of these physical and chemical properties is presumed to create favorable conditions for root development, leading to more efficient water and nutrient uptake, which ultimately increases leaf area. This is consistent with (Nursery, 2021), who reported that organic-based growing media with good porosity and water holding capacity can improve root growth and nutrient uptake efficiency, thereby enhancing leaf area development.

3.3 Plant Height

The results of the study on observation of the plant height of leaves of the mustard greens plant in various treatments using *Trichoderma* sp. Induced cocoa husk compost on the Soilless Culture System (SCS) media are presented in **Figure 3.**

Figure 3. The growth chart of the plant height of caisim (mustard greens) leaves from 1 WAP - 5 WAP (Week After Planting).

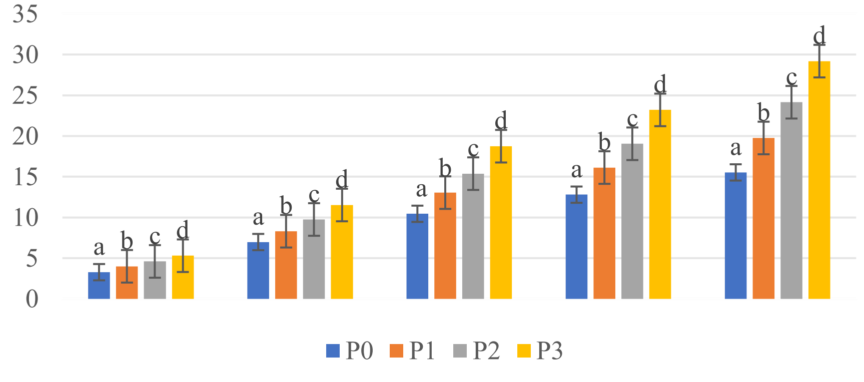

Figure 3. shows an increase in the plant height of mustard greens (*Brassica rapa* var. *parachinensis*) from 1 WAT to 5 WAT, with the highest value observed in the fifth week in treatment P3. Overall, treatment P3 produced the highest plant height compared to the other treatments, followed by P2, P1, and P0.

The increase in plant height in treatment P3 is presumed to be associated with more optimal nutrient availability, particularly nitrogen, which plays an important role in supporting cell division and stem elongation. The nitrogen availability in this treatment originates from *Trichoderma* sp. induced cocoa pod husk compost, which accelerates the decomposition of organic matter, making nutrients more readily available and absorbable by plants. In addition, goat manure in the compost also serves as an organic nitrogen source that is further decomposed by *Trichoderma* sp. into plant available forms. This nitrogen contributes to enhanced vegetative growth, particularly stem elongation. This is in line with (Kurniawati et al., 2022), who reported that goat manure as an organic fertilizer can increase nitrogen availability in the growing medium, thereby supporting plant height growth.

3.4 Chlorophyll a, Chlorophyll b, and total Chlorophyll

The results of the study on observation of the chlorophyll a, chlorophyll b, and totsl chlorophyll of leaves of the mustard greens plant in various treatments using Trichoderma sp. Induced cocoa husk compost on the Soilless Culture System (SCS) media are presented in **Figure 4.**

Figure 4. Graph of Chlorophyll a, Chlorophyll b, and total chlorophyll of caisim mustard plants.

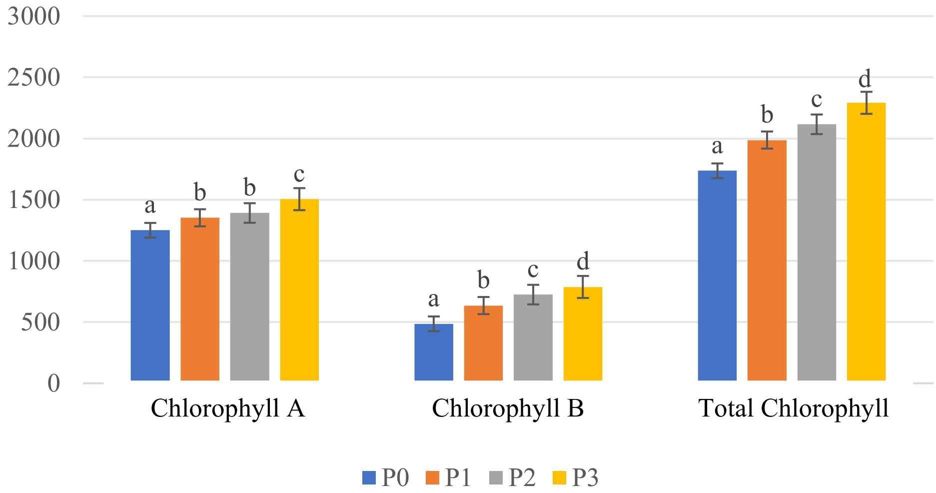

Figure 4. shows an increase in chlorophyll a, chlorophyll b, and total chlorophyll in mustard greens (*Brassica rapa* var. *parachinensis*), with the highest values observed in treatment P3. Overall, P3 produced the highest chlorophyll content compared to the other treatments, followed by P2, P1, and P0, and showed significant differences among treatments.

The higher chlorophyll content in treatment P3 is presumed to be caused by more optimal nutrient availability in the soilless culture system. The Trichoderma sp. induced cocoa pod husk compost in this treatment is more effective in enhancing nutrient release through the decomposition of organic matter, making nutrients more readily available for plant uptake. The soilless culture system media, consisting of rice husk, vermicompost, leaf litter compost, cocopeat, and *Trichoderma* sp. induced cocoa pod husk compost, contributes to nutrient supply, particularly nitrogen and magnesium. Nitrogen plays an important role in chlorophyll formation, while magnesium is a structural component of chlorophyll. The increased availability of these nutrients in P3 leads to higher chlorophyll content. This is consistent with (Sumiati et al., 2023), who reported that nitrogen and magnesium availability in the growing medium influences chlorophyll content in plants.

Differences in chlorophyll content among treatments are also associated with variations in media composition. The higher proportion of *Trichoderma* sp. induced cocoa pod husk compost in P3 is presumed to enhance the nutrient-supplying capacity of the medium, while P0, which did not receive this compost, had lower nutrient availability and consequently lower chlorophyll content. This is in agreement with (Sumiati et al., 2023), who stated that increased decomposition of organic matter in the growing medium can improve chlorophyll content in plants.

3.5 Wet Weight of Caisim Mustard Plants

The results of the study on observation of the wet weight of leaves of the mustard greens plant in various treatments using Trichoderma sp. Induced cocoa husk compost on the Soilless Culture System (SCS) media are presented in **Figure 5.**

Figrue 5. Wet weight graph of mustard greens

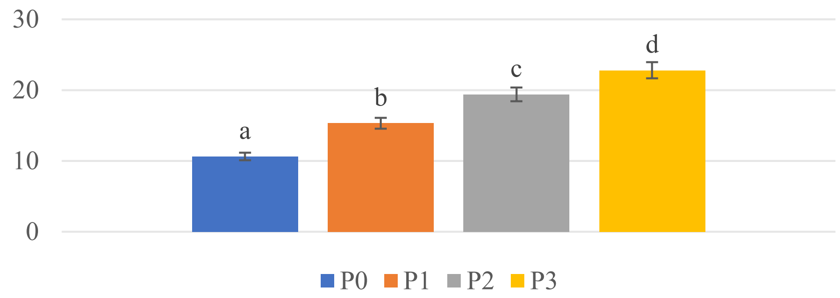

Figure 5. shows an increasing trend in the fresh weight of mustard greens (*Brassica rapa* var. *parachinensis*). Statistical analysis indicated significant differences among treatments. Treatment P3 produced the highest mean fresh weight compared to the other treatments, followed by P2, P1, and P0.

The higher fresh weight observed in treatment P3 is presumed to be related to more optimal nutrient availability in the growing medium due to the addition of Trichoderma sp. induced cocoa pod husk compost. This condition enhances water and nutrient uptake by the plants, thereby supporting physiological processes such as cell division and cell enlargement, which ultimately increase plant biomass. As a result, the accumulation of fresh biomass is higher in this treatment compared to the others. This is in line with (Fadhilah et al., 2021), who reported that sufficient nutrient availability in the growing medium can enhance vegetative growth through increased metabolic activity and tissue formation.

3.6 Dry Weight of Mustard Greens

The results of the study on observation of the dry weight of leaves of the mustard greens plant in various treatments using *Trichoderma* sp. Induced cocoa husk compost on the Soilless Culture System (SCS) media are presented in **Figure 6.**

Figrue 6. Dry weight graph of mustard greens

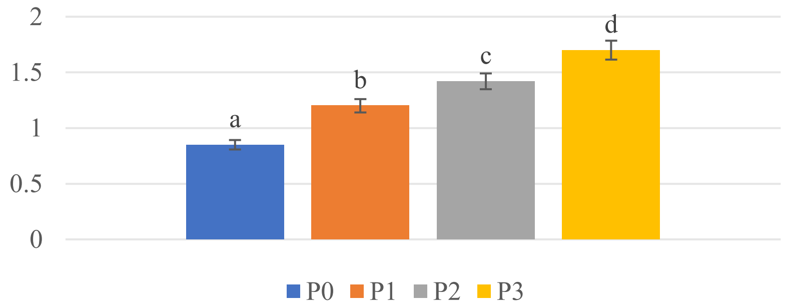

Figure 6. shows an increasing trend in the dry weight of mustard greens (*Brassica rapa* var. *parachinensis*). Statistical analysis indicated significant differences among treatments, with P3 showing the highest mean dry weight compared to the other treatments.

The dry weight of the plants showed a similar pattern to the other growth parameters, where treatment P3 consistently produced the highest values. The higher dry weight in P3 indicates better biomass accumulation compared to the other treatments. This suggests that growth conditions in this treatment were more favorable for plant development. This is in line with (Dewi et al., 2021), who stated that dry weight is a key indicator of photosynthetic output as it reflects the accumulation of organic matter in plant tissues after water content is removed. In addition, (Anindya et al., 2024) lained that photosynthetic efficiency and nutrient availability strongly influence biomass formation in plants. Better nutrient availability in treatment P3 likely supported more efficient photosynthesis, resulting in higher accumulation of plant biomass compared to the other treatments.

3.7 Root Crown Ratio

The results of the study on observation of the root crown ratio of leaves of the mustard greens plant in various treatments using *Trichoderma* sp. Induced cocoa husk compost on the Soilless Culture System (SCS) media are presented in **Figure 7.**

Figrue 7. Root crown ratio graph

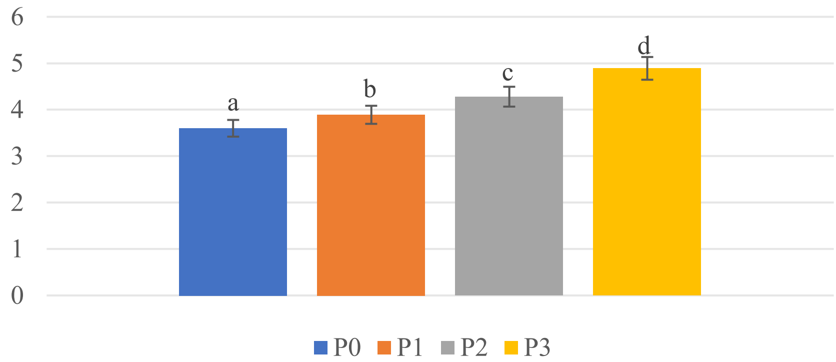

Figure 7. shows an increasing trend in the shoot to root ratio of mustard greens (*Brassica rapa* var. *parachinensis*). Statistical analysis indicated significant differences among treatments, with P3 showing the highest mean value, followed by P2, P1, and the control (P0).

The higher shoot to root ratio in treatments P1, P2, and P3 indicates that plant growth was more directed toward shoot development compared to root growth, while P0 showed the lowest ratio, indicating overall lower growth performance. Among all treatments, P3 was the most optimal, suggesting that shoot development such as leaves and stems was more dominant than root development under this treatment. This condition is presumed to be associated with better nutrient availability from *Trichoderma* sp. induced cocoa pod husk compost, which supported overall plant growth. This is in line with (Sari et al., 2021), who reported that the shoot to root ratio is influenced by nutrient availability, particularly nitrogen, which promotes shoot growth. In addition, (Makmur et al., 2023) stated that under sufficient nutrient conditions, plants tend to allocate more growth to shoots rather than roots. Therefore, the results of this study indicate that treatment P3 provided the most favorable growing conditions for mustard green development.

IV. CONCLUSION

The addition of *Trichoderma* sp. induced cocoa pod husk compost in the soilless culture system positively affected the growth and physiological performance of mustard greens (*Brassica rapa* var. *parachinensis*), as shown by all observed parameters. The best treatment was P3 (2:1:2:1:4), which consistently produced the highest results across growth and physiological traits.

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