



THE EFFECT OF *TRICHODERMA ASPERELLUM* FROM VARIOUS HOSTS AND APPLICATION METHODS ON THE GROWTH AND PRODUCTION OF EDAMAME SOYBEANS (*GLYCINE MAX L.*)

Suci Hafsah Lestari¹, Syamsafitri^{*2}, Darius El Pebrian³

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

^{*2}Faculty of Agriculture, Universitas Islam Sumatera Utara, Medan-20144, Indonesia.

³Fakulty Perladangan dan Agroteknologi, Universiti Teknologi Mara, Malaka-77300, Malaysia.



***Corresponding Author: Syamsafitri**

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

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ABSTRACT

Soybean edamame is one of the vegetable soybean commodities that has economic value and development potential in Indonesia. *Trichoderma asperellum* is a biological agent that, besides potentially suppressing pathogens, can also support plant growth by enhancing nutrient utilisation and stimulating root development. This study aimed to determine the effect of *T. asperellum* originating from different host plants and application methods on the growth and production of soybean edamame. The research used a factorial Complete Randomised Design with two factors. The first factor consisted of no *Trichoderma* (P0), *Trichoderma* from healthy soybean roots (P1), from bamboo roots (P2), from banana roots (P3), and a fungicide (P4). The second factor comprised seed coating (A1) and spraying (A2), with three replications. Growth parameters included plant height and the number of trifoliate leaves, while production parameters included the number and weight of wet pods. The results showed that all isolates used were molecularly identified as *T. asperellum*. The treatment did not show significant differences in plant height and the number of leaves between 4–10 Weeks After Planting (WAP), although the combination P2A2 exhibited the highest average growth value at the end of the observation. In terms of production, the combination P1A2 produced the highest number of wet pods, amounting to 56.11 pods, and the highest weight of wet pods, at 84.78 g per plant.

KEYWORDS: Edamame, *Glycine max*, growth, production, *Trichoderma asperellum*.

INTRODUCTION

Soybeans are one of the important food commodities that play a role in meeting food needs and as raw materials for industry. One form of soybean with high economic value is edamame (*Glycine max* (L.) Merr.), which is harvested at the young pod stage and has characteristics of larger pod and seed sizes compared to regular soybeans. Edamame also contains protein, carbohydrates, vitamins, and minerals, making it a promising commodity for development as a valuable food and horticultural product (Akbar & Syarif, 2020).

The production of edamame soybeans is influenced by genetic, environmental, and pest factors. One significant

obstacle in soybean cultivation is leaf rust disease caused by *Phakopsora pachyrhizi* Syd. This disease can lead to damage of leaf tissues, accelerate leaf fall, and disrupt the plant's photosynthesis process. The reduction in active leaf area due to the disease can ultimately hinder pod formation and filling, potentially decreasing crop yields (Sjamsijah *et al.*, 2022). In the study by Martanto *et al.* (2020), biological control using *Trichoderma harzianum* was also reported to be associated with a reduction in leaf rust disease severity and an increase in soybean production.

Conventional plant disease control generally still relies on the use of fungicides. Continuous use of fungicides

can increase dependence on chemical inputs and potentially cause environmental problems if not managed properly. Therefore, utilisation of antagonistic microorganisms as biological control agents becomes one of the alternatives that can be developed within more sustainable crop cultivation systems. One of the microorganisms widely used as a biological agent is *Trichoderma*. This fungus has antagonistic capabilities against various pathogenic microorganisms through competition for space and nutrients, mycoparasitism, and antibiosis. In addition to its ability to suppress pathogens, *Trichoderma* is relatively easy to isolate, has broad adaptive capabilities, and can grow rapidly on various substrates (Sanathan *et al.*, 2023; Pramesti *et al.*, 2024).

The role of *Trichoderma* is not limited to as a disease control agent. This microorganism can also have positive effects on plant growth through enhancing soil biological health, root development, and nutrient utilisation. Martanto *et al.* (2020) stated that the use of biological control such as *T. harzianum* on soybeans can support soil biological health, nutrient absorption, and root growth, thereby indirectly increasing crop production. *Trichoderma*'s ability to promote plant growth is also related to its capacity to form associations with the root system. *Trichoderma asperellum* can colonise the rhizosphere and root surfaces, improve nutrient uptake, stimulate root development, and play a role in inducing plant resistance against pathogens. Additionally, *Trichoderma* is capable of producing extracellular compounds that can support plant growth (Jumadi *et al.*, 2021; Sokra *et al.*, 2026).

The effectiveness of *Trichoderma* can vary between isolates even if they originate from the same species. Differences in the source of the host plant may be related to the ability to adapt, colonise, and interact with the target plant. In this study, *Trichoderma* isolates were obtained from three plant sources: healthy soybean roots, bamboo, and banana. Based on molecular identification using the ITS region, all three isolates were identified as *T. asperellum*. These results indicate that different sources of isolates do not necessarily produce different species, but can result in different biological responses when applied to the target plant.

In addition to the source of the isolate, the application method is an important factor in determining the success of *Trichoderma* utilisation. Application through seed coating allows the introduction of microorganisms from the early stages of plant growth, while spraying enables microorganisms to be applied directly onto the plant surface. The different locations of application can influence the chances of colonisation and interaction between *Trichoderma* and the plant. Therefore, an evaluation of the application method is necessary to identify the most effective technique to support plant growth and production. Research on the application of *Trichoderma* in soybeans has demonstrated the potential of this microorganism to suppress diseases while also

supporting yield. Martanto *et al.* (2020) reported that the application of *T. harzianum* was effective in controlling leaf rust disease and was related to soybean production in the lowlands of West Papua. Another study by Ardiansyah *et al.* (2020) also showed that the administration of *Trichoderma* and the regulation of application intervals could influence soybean yield.

Nevertheless, information regarding the response of growth and production of edamame soybeans to *T. asperellum* originating from different host plants and applied using various methods still requires further investigation. Specifically, it is not yet known whether isolates derived from different host plants will produce the same response in the growth and yield of edamame plants. Therefore, this study was conducted to evaluate the effects of *T. asperellum* from different host plant sources and application methods on the growth and yield of edamame soybeans. The aim of this research is to determine the influence of *T. asperellum* originating from the roots of healthy soybean plants, bamboo, and banana, as well as the application methods through seed coating and spraying, on the growth and yield of edamame soybeans, and to identify the treatment combination that provides the best response.

MATERIALS AND METHODS

a) Time and Place of the Research

The research was conducted from April to December 2025 at the Pest and Disease Observation Laboratory and the House of Insects, UPTD for Plant Protection, Horticulture, and Food Safety Quality Control, Department of Agriculture and Food Security of North Sumatra Province.

b) Research Materials and Tools

The materials used include Edamame soybean seeds of the Biomax 1 variety, Potato Dextrose Agar (PDA) medium, 70% and 96% alcohol, distilled water, ground corn, soil, compost, manure fertiliser, NPK fertiliser, *Trichoderma* isolate from healthy soybean roots, bamboo and banana, *P. pachyrhizi* inoculum, as well as fungicides containing the active ingredients azoxystrobin and difenoconazole. The equipment used comprises petri dishes, microscopes, an analytical balance, haemocytometer, laminar flow cabinet, autoclave, glassware, polibags, and hand sprayers.

c) Research Methodology

The research used a Complete Randomised Design (CRD) factorial with two factors. The first factor was the source of the isolate/treatment (P0 = without *Trichoderma*; P1 = *Trichoderma* from healthy soybean root; P2 = *Trichoderma* from bamboo root; P3 = *Trichoderma* from banana root; P4 = fungicide). The second factor was the application method (A1 = seed coating; A2 = spraying). Each treatment combination consisted of three replications. Each plot comprised five polythene bags, with three bags randomly selected as sample plants. The total population of the study was 150

polythene bags. The *Trichoderma* isolate used had a conidia density of $>10^6$ conidia mL^{-1} .

d) Observed Variable

Growth parameters consist of plant height and the number of trifoliate leaves. Plant height is measured from the base of the stem to the highest leaf. Observations are made starting from 4 weeks after sowing (WAS) and repeated weekly until 10 WAS. The number of trifoliate leaves is counted during the same observation periods. Production parameters are observed at harvest at 12–13 WAS, including the number of wet pods and the weight of wet pods.

e) Data Analysis

Data analysis was conducted using analysis of variance according to the experimental design. If there was a significant difference, the test was continued using Duncan's test at a 95% confidence level.

RESULTS

1. Plant growth

1.1. Plant height

The height of the plants was observed from 4 to 10 MST. The research results indicate that the combination of *Trichoderma* treatment and application methods did not produce significant differences in plant height throughout the observation period. However, numerically, there were differences in response among the treatments, especially at the end of the observation period (Table 1).

T1. Table 1. Average Height of Edamame Soybean Plants under Various Treatment Combinations.

Px A Interaction	Average Plant Height (cm)						
	4 MST	5 MST	6 MST	7MST	8 MST	9 MST	10 MST
P0A1	63,94	81,17	85,44	86,94	89,00	92,33	93,06
P0A2	64,11	82,61	86,89	89,39	93,83	96,44	97,06
P1A1	61,61	84,56	88,56	90,33	95,17	97,06	97,67
P1A2	63,50	83,00	89,94	92,44	95,72	98,44	99,72
P2A1	66,33	86,17	92,67	95,61	98,33	101,28	102,44
P2A2	66,33	87,78	93,50	95,83	102,33	105,11	106,56
P3A1	67,17	87,56	89,28	91,00	93,11	96,28	96,61
P3A2	64,78	85,06	87,50	89,61	91,22	92,17	92,33
P4A1	68,67	85,00	87,67	89,78	93,50	94,17	95,06
P4A2	63,39	84,56	92,94	97,89	102,44	104,22	105,33

Note: Numbers followed by the same letter notation in the same column are not significantly different at the 5% Duncan test level.

P0 = without *Trichoderma*; P1 = *Trichoderma* from healthy soybean roots; P2 = *Trichoderma* from bamboo roots; P3 = *Trichoderma* from banana roots; P4 = fungicide. A1 = seed coating; A2 = spraying.

Based on the processed statistical data, the plant height parameter shows that there is no significant difference

for each treatment combination from 4 MST to 10 MST. However, as seen in Table 1 above, at the end of the observation week (9 to 10 MST), the treatment combination of *Trichoderma* spp. type and application method that has a significant effect on the plant height parameter is the P2A2 treatment (bamboo-derived *Trichoderma* with spraying application method), which shows the highest average plant height values of 105.11 cm and 106.56 cm. The plant height observation results can be presented in the following graph.

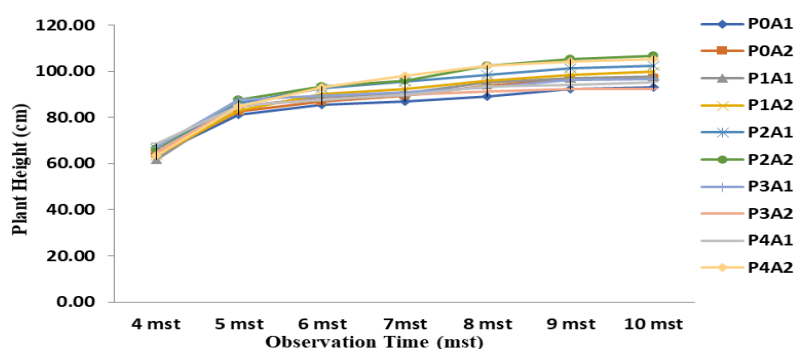


Figure 1. Graph of the Effect of *Trichoderma* spp. Treatment and Application Method on Plant Height (cm).

The growth stages of each plant can vary due to differences in the specific growth characteristics of the plant (Asbur *et al.* 2024). *Trichoderma asperellum* forms a beneficial association with plants by colonising the rhizosphere and root surfaces, enhancing nutrient uptake, stimulating root development, and inducing systemic resistance against pathogens (Sokra *et al.* 2026).

In Jumadi *et al.* (2021), it is stated that several studies show that the function of *Trichoderma* sp. as a biological agent provides significant results in supporting plant growth, considering its ability to degrade organic

materials and produce nutrients for plants, as well as the extracellular compounds it produces which can be absorbed by plants and act as growth regulators.

1.2. Number of trifoliolate leaves

The number of trifoliolate leaves was also observed between 4–10 MST. The analysis results showed that all treatment combinations did not differ significantly across the entire observation period. However, in the last three weeks, P2A2 showed the highest number of leaves numerically (Table 2).

Table 2. Average Number of Trifoliolate Soybean Leaves (Edamame) under Various Treatment Combinations.

PxA Interaction	Average Number of Leaves (pieces)						
	4 MST	5 MST	6 MST	7MST	8 MST	9 MST	10 MST
P0A1	8,56	17,22	21,89	25,11	26,44	26,89	28,89
P0A2	9,44	15,44	21,89	25,78	28,00	27,89	28,56
P1A1	8,33	15,67	20,22	22,89	24,44	25,22	25,22
P1A2	8,33	16,11	22,56	25,78	27,33	28,67	29,00
P2A1	8,11	15,78	20,22	24,56	26,11	27,67	27,56
P2A2	9,11	15,56	20,22	24,00	28,44	30,78	31,00
P3A1	8,00	15,78	18,78	24,89	27,00	29,44	30,00
P3A2	9,56	15,67	19,78	24,44	26,33	26,44	26,89
P4A1	10,33	15,78	19,22	24,78	26,11	27,89	28,00
P4A2	8,22	15,89	19,67	24,33	26,00	26,67	27,11

Note: Numbers followed by the same letter notation in the same column are not significantly different at the 5% Duncan test level.

P0 = without *Trichoderma*; P1 = *Trichoderma* from healthy soybean roots; P2 = *Trichoderma* from bamboo roots; P3 = *Trichoderma* from banana roots; P4 = fungicide. A1 = seed coating; A2 = spraying.

Based on the testing data that has been conducted, the parameter of the number of leaves on the plant also

shows no significant difference for each treatment combination from 4 MST to 10 MST. From Table 2, it can be seen that during the last three weeks of observation (8 to 10 MST), the treatment combination of *Trichoderma* spp. and the application method that has a significant effect on the growth parameter of the number of leaves on the plant is the P2A2 treatment (bamboo-origin *Trichoderma* with spraying application method).

The results of the leaf count observations can be presented in the following graph.

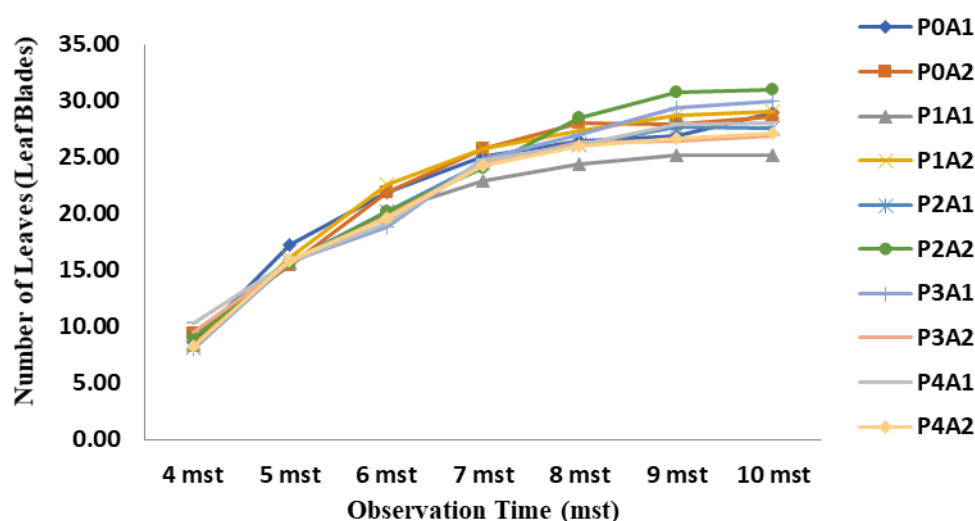


Figure 2. Graph of the Effect of *Trichoderma* spp. Treatment and Application Method on the Number of Leaves (Foliage)

The increase in soybean plant height is directly proportional to the increase in the number of leaves, where the taller the plant, the more leaves are produced. This occurs because taller plants have more stems and branches, which can support more leaves with the plant's ability to absorb sunlight and generate energy. As a result, the taller the plant, the more space is available for growth and the production of new leaves (Irna *et al.*, 2023).

In Ardiansyah *et al.* (2020), *Trichoderma* sp. is an antagonistic fungus commonly found in soil, particularly in organic soils, and is frequently used for biological control, both against soil-borne pathogens or rhizosphere pathogens and phyllosphere pathogens. As a result, the soil structure becomes more loose, allowing roots to absorb nutrients, especially phosphate (P), and can enhance microbial activity within the soil. The

relationship between plants and *Trichoderma* sp. is mutualistic. Plants benefit in terms of growth and disease control, while *Trichoderma* sp. benefits by obtaining nutrients produced by the plants.

2. Plant production

2.1. Number of Wet Pods

Observation of the number of wet pods was conducted during harvest (plant age 12 to 13 weeks after planting). The statistical test results for the treatment combinations showed that the average number of wet pods in treatment P1A1 (*Trichoderma* from healthy soybeans with seed coating) was significantly different from P1A2 (*Trichoderma* from healthy soybeans with spraying). However, for the other treatment combinations, the statistical tests indicated no significant difference. The following are the observation results obtained (Table 3).

Table 3. Average number of wet edamame soybean pods.

PxA Interaction	Average Number of Wet Polong (Polong)
P0A1	30,55 g
P0A2	32,89 fg
P1A1	45,89 b
P1A2	56,11 a
P2A1	39,22 cd
P2A2	42,22 c
P3A1	35,44 ef
P3A2	38,77 de
P4A1	36,11 def
P4A2	37,33 de

Note: Numbers followed by the same letter notation in the same column are not significantly different at the 5% Duncan test level.

roots; P3 = *Trichoderma* from banana roots; P4 = fungicide. A1 = seed coating; A2 = spraying.

P0 = without *Trichoderma*; P1 = *Trichoderma* from healthy soybean roots; P2 = *Trichoderma* from bamboo

The results of the observation of the number of wet pods can be presented in the following graph..

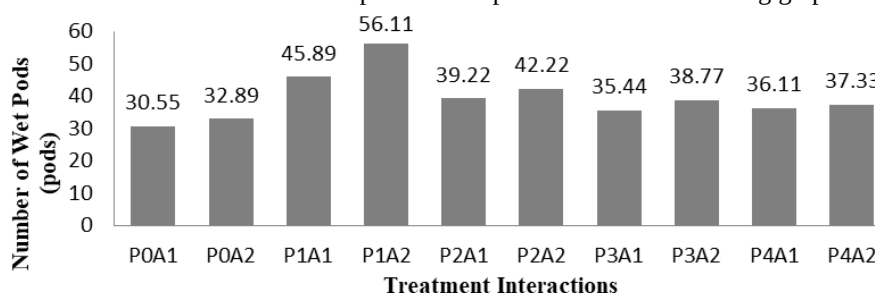


Figure 3. Histogram of the Effect of *Trichoderma* spp. Treatment and Application Method on the Number of Wet Pods (Pods).

From the observations, it was found that the highest number of pods was obtained in treatment P1A2 (*Trichoderma* from the roots of healthy soybean plants with spraying application) with an average of 56.11 pods. Meanwhile, the lowest number of pods was in

treatment P0A1 (Control with seed coating application) with an average of 30.55 pods.

In Martanto *et al.* (2020), it is stated that the use of biological control agents such as *Trichoderma harzianum* for disease prevention will also provide organic nutrients

in the soil because biological control can improve soil biological health by supporting nutrient absorption and root growth, thereby indirectly enabling the application of *Trichoderma* to increase crop yields.

2.2. Wet broad beans

Observation of the wet pod weight parameter was conducted during harvest (plant age 12 to 13 MST). The

wet pod weight is a production component that shows the most evident response to the treatment. The following are the observation results obtained (Table 4).

Table 4. Average weight of fresh edamame soybeans.

Interaction Treatment	Average weight of wet beans (g)
P0A1	35,49 h
P0A2	49,56 g
P1A1	79,64 b
P1A2	84,78 a
P2A1	70,76 de
P2A2	75,88 bc
P3A1	70,03 de
P3A2	73,25 cd
P4A1	65,47 f
P4A2	67,08 ef

Note: Numbers followed by the same letter notation in the same column are not significantly different at the 5% Duncan test level.

P0 = without *Trichoderma*; P1 = *Trichoderma* from healthy soybean roots; P2 = *Trichoderma* from bamboo roots; P3 = *Trichoderma* from banana roots; P4 = fungicide. A1 = seed coating; A2 = spraying.

From the observations, it was found that the highest weight of wet pods was obtained in treatment P1A2 (*Trichoderma* from healthy soybean roots applied by spraying) with an average of 84.78 grams. Meanwhile, the lowest weight of wet pods was in treatment P0A1 (control with seed coating application), which was 35.49 grams. In the description of edamame soybean plants, it

appears that the total weight of young pods per plant can reach approximately 58.31-82.67 grams per plant. The observation results indicate that for the combination of *Trichoderma* and fungicide treatments, whether through seed coating or spraying, the yield results are consistent with the description, except for the control treatments (P0A1 and P0A2). The P1A2 treatment, however, produced a pod weight above the range specified in the plant description, at 84.78 grams. Therefore, it can be concluded from this study that the combination of *Trichoderma* from healthy soybean plants with spraying can increase plant production through parameters such as the number of wet pods and the weight of wet pods. The results of the wet pod weight observations can be presented in the following graph.

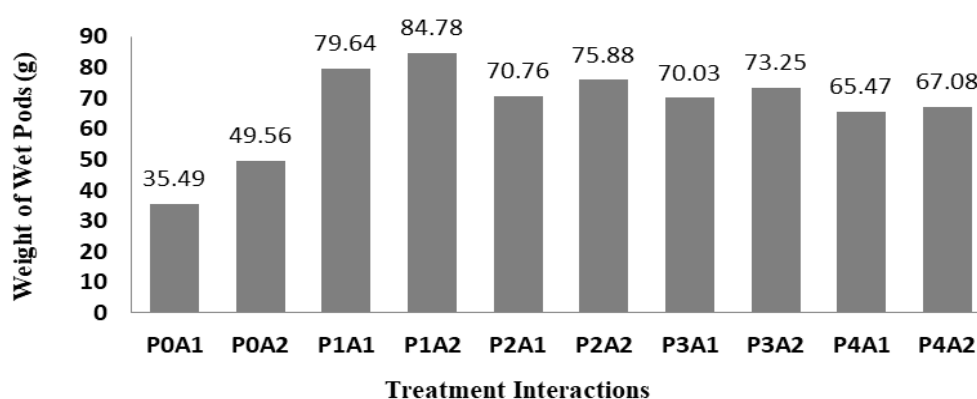


Figure 4. Histogram of the Effect of *Trichoderma* spp. Treatment and Application Method on Wet Pod Weight (g).

According to Zin and Badaluddin (2020), *Trichoderma* spp. produce secondary metabolites that are secreted to suppress the growth of pathogenic microorganisms and stimulate plant growth. Furthermore, the interaction

between plants and *Trichoderma* species successfully regulates root architecture, increases the length of lateral roots and primary roots, resulting in improved nutrient absorption efficiency by the plants.

The availability of water, chlorophyll content, the process of photosynthesis, increased plant height, and the number of leaves on soybean plants cause the plants to have a large biomass and influence the fresh weight and dry weight of the plants. Plants can increase biomass depending on external and internal factors. The viability of *T. asperellum* against the fresh weight of the plants can be affected by environmental conditions such as temperature, humidity, and soil pH (Nisa *et al.* 2025).

3. Relationship between growth, disease control, and production

The research results show an interesting response pattern. Treatment P2A2 provides the highest numerical values for plant height and the number of leaves at the final growth stage, while P1A2 produces the highest number of pods and wet pod weight. Therefore, the isolate that results in the highest vegetative growth does not automatically produce the highest yield.

The pattern indicates that vegetative growth indicators cannot always be used as the sole measure of *Trichoderma* application success. In edamame plants, the ultimate success of cultivation is largely determined by the plant's ability to maintain physiological conditions until the pod formation and filling phases.

P1A2 has an additional advantage because this study also resulted in the lowest leaf rust disease intensity over the last three weeks of observation. On 8, 9, and 10 weeks after planting, the disease intensity of P1A2 was 12.17%, 12.80%, and 13.44%, respectively, while the control P0A2 reached 20.93%, 22.24%, and 22.45%.

The emphasis on disease development can help maintain leaves as a source of photosynthate during the critical period of pod formation. On the other hand, *Trichoderma* can also contribute through improved root health and nutrient utilisation efficiency. Therefore, the increased production in P1A2 is likely not caused by a single mechanism, but rather results from the interaction between biocontrol effects and *Trichoderma*'s ability to support plant growth.

However, since this research did not specifically measure root biomass, nutrient content, photosynthesis rate, or other physiological parameters, the mechanism remains an interpretation based on observed patterns and the literature used in the thesis. Further research is needed to directly test this mechanism.

CONCLUSION

The application of *Trichoderma asperellum* and its method of application showed different responses in the growth and production of edamame soybeans. The three isolates originating from the roots of healthy soybeans, bamboo, and banana were identified as *T. asperellum*. In terms of growth parameters, all treatment combinations did not show significant differences in plant height and number of leaves from 4 to 10 weeks after planting,

although the combination of *T. asperellum* from bamboo with spraying (P2A2) provided the highest mean values numerically at the end of the observation. Regarding production parameters, the combination of *T. asperellum* from healthy soybean roots with spraying (P1A2) resulted in the highest number of wet pods, with 56.11 pods, and the highest wet pod weight, at 84.78 g per plant. Based on these results, P1A2 is the most promising treatment combination to support edamame soybean production under the conditions of this study.

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