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Application of Trichoderma Biofertilizer on Sweet Potato Plants (Ipomoea Batatas L.)

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Abstract. The objective of this study was to determine the effect of Trichoderma esperellum biological agent applied through soil treatment and foliar spray, as well as the possibility of their interaction on the vegetative growth of sweet potato plants. The density of fungal spores in the propagule suspension ready to be sprayed onto the canopy surface was the same as that contained in the solid form for fertilization application, namely 105 CFU.mL-1. The experiment was arranged factorially in a Randomized Block Design (RBD) with four replicates. The variables observed were plant height, number of leaves, stem diameter, and harvest weight per 1.5 m2 plot area. The data were analyzed using Analysis of Variance followed by a 5% BNJ test. The results showed that the application of Trichoderma biofertilizer as soil fertilization had a significant effect on plant growth and harvest weight, while application through canopy spraying had no significant effect. The interaction effect was only significant for plant height. Fertilizer application at planting time yielded the highest results at the end of the observation period, namely 34.0 cm, 114 shoots, 10.05 cm, and 2,686.6 g for plant height, number of leaves, stem diameter, and harvest weight, respectively.

Keywords: biological fertilizer, Trichoderma, canopy spraying, soil treatment

1 Introduction

Currently, farmers' dependence on pesticides and chemical fertilizers is increasingly alarming. The use of pesticides and chemical fertilizers seems to have become an inseparable phenomenon in crop production by farmers. Although the use of chemicals has been proven to provide quick and maximum results, continuous use of chemicals can actually have negative impacts on soil quality, the surrounding environment, and human health. The impact of excessive use of chemical fertilizers can result in decreased soil fertility, reduced diversity of microorganisms that are beneficial to the soil, and residues that can pollute the environment [1]. Excessive use of chemical pesticides can cause resistance in plant pests. Pests that are continuously exposed to chemical pesticides will adapt more quickly and evolve to become more resistant. This forces farmers to increase the dosage of pesticides, which tends to increase over time. Worse still, this will actually make pests stronger, creating a vicious cycle that is difficult to break [2].

According to data published by the Secretary General of the Ministry of Agriculture [3], since 2019, national sweet potato production has reached 1,516,000 tons, peaking in 2022 at 1,990,000 tons before a drastic decline to 1,684,000 tons in 2023, with a production decline rate of 15.4%. With various potential constraints in production, there is a threat of further decline in the coming years. This condition will encourage imports, especially in the context of providing food ingredients related to sweet potato derivatives.

The potential threats to production decline are usually complex, consisting of a combination of biotic and abiotic factors, namely pest and disease attacks and low soil fertility due to stress caused by the use of synthetic chemicals as fertilizers and pesticides, soil acidity, and increased salinity due to irrigation water deposits [4].

Sweet potatoes (Ipomoea batatas L.) are one of the local food commodities that have the potential to be an alternative source of carbohydrates to replace rice. One of the advantages of this plant is that sweet potatoes are easily adaptable to various types of land and climates, so they can be widely cultivated in various regions. With proper management, sweet potatoes have great potential to be developed as an alternative food source that can support local food security [5]. Unfortunately, sweet potato productivity is often hampered by soil fertility issues and pest attacks that require special treatment. Sweet potato farmers are faced with the need to maintain production while considering the environmental and health impacts that may result from the use of chemicals.

Organic farming is one approach to achieving environmentally friendly sustainable agriculture. Sustainable

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agriculture, or what is commonly referred to as sustainable agriculture, is the practice of cultivating crops by utilizing renewable and non-renewable resources. The goal is to minimize the negative impact on the environment caused by the use of pesticides and chemical fertilizers [2]. The concept of organic farming covers several important aspects, such as resource utilization, production quality and quantity, and environmental sustainability. In practice, sustainable production processes focus more on the use of biological fertilizers that are more environmentally friendly [6].

In order to find solutions for sustainable agriculture, innovative alternatives to chemical fertilizers and pesticides have emerged, namely the use of biological agents such as Trichoderma. Trichoderma sp. is a soil saprophytic fungus that can naturally become a parasite that attacks many types of fungi that cause plant diseases (broad control spectrum) [7]. Trichoderma sp. is a fungus that occurs naturally in the soil and has the ability to enhance plant growth and protect plants from pathogens around the roots [8]. The use of Trichoderma as a biofertilizer can be integrated with its function as a biocontrol agent, so that this fungus can support sustainable crop production while preventing pathogens from becoming resistant to fungicides. As a biopesticide, Trichoderma can function as a natural disease control agent in plants. There are several mechanisms of action of Trichoderma fungi, including competing with pathogens for space and nutrients, producing antagonistic compounds that inhibit pathogen growth, and stimulating the plant's defense system [9].

The use of Trichoderma biological agents as biofertilizers and biopesticides in sweet potato crops offers an environmentally friendly natural solution, while also improving soil health in the long term [10]. Not only does it help reduce dependence on chemical fertilizers and pesticides, the use of Trichoderma also supports safer and more efficient sustainable agricultural practices. Thus, this study is expected to make a real contribution to supporting agricultural productivity, maintaining environmental quality, and encouraging farmers to switch to healthier and more sustainable farming methods [11].

This study will explore the effectiveness of Trichoderma biofertilizer and biopesticide applications on sweet potato plants, particularly in improving soil quality, strengthening plant resistance, and optimizing crop yields. Currently, the downstreaming of research related to Trichoderma biological agents, especially isolates from the Microbiology and Technology Laboratory collection at Muhammadiyah University Sidoarjo, has begun. Therefore, it is necessary to test its effectiveness both as a biofertilizer, due to its function of providing nutrients for plants, and as a biopesticide, due to its protective role for plants. The objective of this study is to determine the effect of Trichoderma esperellum biological agents applied through the soil (soil treatment) and through the canopy (foliar spray) and the possibility of their interaction with the vegetative and generative growth of sweet potato plants.

2 Method

This study was conducted on agricultural land in Pasinan Village, Pacet District, Mojokerto Regency, which is located at an altitude of 450 meters above sea level. The study took place from September to December 2024, with experimental support from the Microbiology and Biotechnology Laboratory of Muhammadiyah University Sidoarjo.

The tools and materials used in this study were simple yet functional. The main materials included sweet potato seeds, Trichoderma solid formula biofertilizer, Trichoderma liquid biopesticide, and liquid nanoparticles.

The auxiliary tools used include sacks, hoes, buckets, scales, calipers, rulers, measuring tapes, writing instruments, and cameras for visual documentation.

The experimental design was arranged factorially in a Randomized Block Design (RBD), with two treatment factors. The first factor was the application of solid biofertilizer formula (soil treatment), which consisted of three treatment levels, namely: no biofertilizer application but using complete chemical fertilizer (S0), biofertilizer application two weeks after planting (S1), and biofertilizer application 1.5 months after planting (S2). The second factor was the application of a liquid formula consisting of two levels: no liquid biofertilizer spraying (A0), and spraying of Trichoderma liquid biofertilizer formula (A1). All of these treatments were repeated four times, resulting in a total of 24 experimental units arranged randomly as shown in the experimental layout scheme.

The research implementation stages began with land preparation, which was carried out by hoeing or using a tractor to break up the soil until it was loose, accompanied by the creation of ridges to support irrigation [12]. Propagation was carried out using the stem cuttings method, using stems from healthy sweet potato plants that were approximately 2 months old. Each cutting is planted 15x20 cm apart on ridges 3 meters long and 70 cm wide [13]. Solid biofertilizer is applied at 2 weeks (S1) and 1.5 months (S2) after planting, at a rate of 50 grams per plant. The control treatment (S0) was given basic chemical fertilizers in the form of Phonska, Urea, and TSP (10-10-5) at a dose of 10 grams per plant. Meanwhile, liquid biofertilizer was made by mixing liquid Trichoderma and nanoparticles in a 2:1 ratio, then diluted in 1 liter of water, stirred and incubated for 6 hours before being sprayed onto the plant canopy every two weeks starting at 2 weeks after planting. Planting was carried out by inserting 8–10 cm long stem cuttings, and plant maintenance included weeding every 7 days,

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incidental pest and disease control, and fertilization according to plant needs.

Sweet potato plant care during the trial period was carried out intensively until harvest to ensure optimal growth. Watering was carried out regularly according to plant needs and weather conditions, and weeding was done manually to avoid nutrient competition. Pest and disease control was carried out preventively using plant-based pesticides as needed, without interfering with biofertilizer activity. Biofertilizer spraying on the canopy was applied according to the treatment, with a predetermined frequency. The plants were harvested at the optimal harvest age after 91 Days After Planting (DAP), and yield parameters such as tuber weight were measured immediately after harvest to obtain accurate data.

The variables observed included: plant length measured from the base of the plant to the tip of the canopy during the vegetative period, the number of leaves counted at the same time, stem diameter measured using calipers, and tuber weight measured at harvest to determine the yield per plant. The observation data were analyzed using analysis of variance according to RAK. If there was a significant or very significant effect, it was followed by a BNJ test at a 5% level.

3 Results and Discussion

3.1 Plant Vine Length

The results of the analysis of variance showed that the application of biofertilizer as soil treatment and canopy spraying interacted in all observations, namely at 35, 65, and 92 days after planting. This was because the calculated F was greater than the F table of 5% and 1%. The average effect of the interaction between biofertilizer application as fertilization and foliar spraying is presented in Table 1.

Table 1. Average effect of the interaction between biofertilizer applied as soil treatment and foliar spraying on sweet potato plant length increase at 35, 65, and 91 days after planting

Application of Trichoderma biofertilizer	**Plant vine length (cm)**		
	35 days after planting	**65 HST**	**91 HST**
Without *soil treatment* and without canopy spraying	16.78d	24.60d	32.10d
Soil treatment and without canopy spraying	17.90f	26.23f	33.98f
Soil treatment 1.5 BST and without canopy spraying	15.88b	23.23b	29.98b
Without *soil treatment* and canopy spraying	17.08e	24.93e	32.58e
Soil treatment and canopy spraying	15.15a	21.95a	28.68a
Soil treatment 1.5 BST and canopy spraying	16.40c	24.10c	30.95c
BNJ 5%	0.11	0.31	0.24

Numbers followed by the same letter in the same column are not significantly different at the 5% BNJ test; 1 BST is one month after planting.

Table 1 shows significant differences between biofertilizer treatments in sweet potato vine length at each observation period (35, 65, and 91 days after planting). At 35 DAP, the "soil treatment and canopy spraying" treatment (15,15a) had the lowest value and was significantly different from all other treatments, while "soil treatment without canopy spraying" (17,90f) gave the highest value. A similar pattern was observed at 65 and 91 DAP, where the combination of soil treatment and canopy spraying consistently resulted in the shortest growth (a), while soil treatment without canopy spraying (f) showed the best growth. This confirms that the interaction between the soil treatment application method and canopy spraying has a significant effect on vine growth.

The differences in letters in the columns also reveal that the effects of treatment become more apparent over time. For example, at 91 HST, all treatments have unique letters (a-f), indicating that each combination of biofertilizer application has a completely different effect on vine length increase. The BNJ value increased from 0.11 (35 HST) to 0.31 (65 HST) and 0.24 (91 HST), reflecting an increase in plant response diversity as they grew. The combination of soil treatment 1.5 BST and canopy spraying (30.95c) at 91 HST was significantly better than the soil treatment + canopy spraying treatment (28.68a), but still lower than the control without treatment (32.10d). These data indicate that soil treatment alone (without spraying) is more effective, while the combination with spraying actually inhibits growth. Thus, the choice of biofertilizer application method needs to be carefully considered based on the plant growth phase. This significant growth confirms that Trichoderma is not just an ordinary soil inhabitant, but a major player in the symphony of plant growth, especially sweet potatoes [14].

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3.2 Number of Leaves

The analysis of variance results show that the application of biofertilizer as soil treatment and foliar spraying interacted at all observation points, namely 35, 65, and 92 days after planting. This is because the calculated F value was greater than the F table value of 5% and 1%. The average effect of the interaction between biofertilizer application as fertilization and foliar spraying is presented in Table 2.

Table 2. Average number of leaves in the interaction of biofertilizer application as soil treatment and foliar spraying on sweet potato plants at 35, 65, and 91 days after planting.

Application of Trichoderma biofertilizer	Number of Leaves (pieces)		
	35 days after planting	65 days after sowing	91 HST
Without *soil treatment* and without canopy spraying	93.50a	105.25a	114.00bc
Soil treatment and no canopy spraying	94.00a	98.25a	106.50a
Soil treatment 1.5 BST and without canopy spraying	103.25b	106.25a	113.25abc
Without *soil treatment* and canopy spraying	103.25b	111.00b	116.50c
Soil treatment and canopy spraying	94.25a	103.00a	108.75ab
Soil treatment 1.5 BST and canopy spraying	93.25a	108.50b	116.00c
BNJ 5%	7.62	8.18	6.89

Numbers followed by the same letter in the same column are not significantly different at the 5% BNJ test; 1 BST is one month after planting

Table 2 presents the average data on the number of sweet potato leaves at 35, 65, and 91 days after planting (DAP) based on the interaction of Trichoderma biofertilizer treatment applied through soil treatment and foliar spraying. At 35 DAP, the treatments "Soil treatment 1.5 BST and no foliar spraying" and "No soil treatment and foliar spraying" showed the highest number of leaves (103.25 leaves), which was significantly different from the other treatments. This indicates that both long-term soil treatment (1.5 months after planting) and foliar spraying separately were able to stimulate faster leaf growth in the early growth phase.

At 65 and 91 HST, the pattern of leaf number increase tended to continue, especially in treatments involving canopy spraying. At 65 HST, two treatments accompanied by canopy spraying showed higher leaf numbers and were significantly different from treatments without spraying. This difference continued at 91 HST, where treatments with canopy spraying—including those combined with soil treatment 1.5 BST—produced the highest number of leaves (up to 116.50 leaves), which was significantly different from several other treatments.

3.3 Stem Diameter

The results of the analysis of variance showed that the application of biofertilizer as soil treatment and foliar spraying interacted at all observations, namely at 35, 65, and 92 days after planting. This was because the calculated F was greater than the F table at 5% and 1%. The average effect of the interaction between biofertilizer application as fertilization and foliar spraying is presented in Table 3.

Table 3. Average diameter of sweet potato stems interacting with various biofertilizer applications applied as soil treatment and foliar spraying at 35, 65, and 91 days after planting.

Application of Trichoderma biofertilizer	Stem Diameter (leaves)		
	35 HST	65 HST	91 HST
Without *soil treatment* and without canopy spraying	8.35a	9.03b	9.53b
Soil treatment and without canopy spraying	7.50a	8.03a	9.30a
Soil treatment 1.5 BST and without canopy spraying	8.63a	9.30cd	9.88bc
Without *soil treatment* and canopy spraying	9.10a	9.50d	10.23c
Soil treatment and canopy spraying	7.55a	8.28a	9.03a
Soil treatment 1.5 BST and canopy spraying	7.83a	8.83b	9.50b
BNJ 5%	3.6	0.41	0.47

Numbers followed by the same letter in the same column are not significantly different at the 5% BNJ level.

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Table 3 shows the average diameter of sweet potato stems at 35, 65, and 91 days after planting based on the combination of Trichoderma biofertilizer treatment through soil treatment and canopy spraying. At 35 DAP, there were no significant differences between treatments because all diameter values were followed by the same letter ("a"), and the 5% BNJ value of 3.60 was too large compared to the differences between values. This indicates that in the early stages of growth, the application of biofertilizer did not have a significant impact on stem diameter.

However, at 65 and 91 HST, significant differences began to appear. The treatment "Without soil treatment and canopy spraying" produced the largest stem diameter, namely 9.50 mm at 65 HST and 10.23 mm at 91 HST, which was significantly different from most of the other treatments. This indicates that canopy spraying has a greater effect on stem enlargement than soil treatment, especially without initial treatment of the soil. Conversely, soil treatment alone, whether conventional or 1.5 BST, resulted in relatively smaller stem diameters, especially at the end of the observation period. The smaller 5% BNJ values at 65 and 91 HST (0.41 and 0.47) allowed for more sensitive detection of differences between treatments, reinforcing the conclusion that canopy spraying contributes positively to stem growth in the middle and late growth phases.

The results of this study are in line with other studies, which show that the application of PGPR bamboo roots affects the stem diameter of plants [15]. The application of Trichoderma sp. can increase the weight of potato tubers with an application time of once every 8 days [16]. Although this study is not directly related to the stem diameter of sweet potatoes, the results show that Trichoderma sp. can increase the growth and yield of tuber crops. The average effect of the interaction between biofertilizer application through fertilization and foliar spraying is presented in Table 3.

3.4 Tuber Weight

The analysis of variance shows that the application of biofertilizer as soil treatment and foliar spraying interacted in all tuber weight observations. This is because the calculated F is greater than the table F of 5% and 1%. The average effect of the interaction between biofertilizer application as fertilization and foliar spraying is presented in Table 4.

Table 4. Average Interaction of Sweet Potato Weight at Various Biofertilizer Applications Applied as Soil Treatment and Foliar Spraying.

Application of Trichoderma biofertilizer	Sweet potato weight (g)
Without *soil treatment* and without foliar spraying	3003.25b
Soil treatment and without canopy spraying	2695.13a
Soil treatment 1.5 BST and without canopy spraying	2693.95a
Without *soil treatment* and canopy spraying	4218.38b
Soil treatment and canopy spraying	2926.13a
Soil treatment 1.5 BST and canopy spraying	2443.70a
BNJ 5%	**1110.06**

Numbers followed by the same letter in the same column are not significantly different in the 5% BNJ test

Table 4 presents data on sweet potato tuber weight based on the interaction of Trichoderma biofertilizer treatment applied through soil treatment and foliar spraying. From the results shown, it can be seen that the treatment "Without soil treatment and canopy spraying" produced the highest tuber weight, namely 4218.38 grams, although statistically it was not significantly different from the treatment "Without soil treatment and without canopy spraying" (3003.25 grams), because both were followed by the same letter.

Meanwhile, other treatments, especially those involving soil treatment either at the usual time or 1.5 months after planting (BST), with or without canopy spraying, showed lower tuber weights and no significant differences between them. This indicates that the use of Trichoderma biofertilizer as soil treatment alone is not necessarily effective in increasing tuber weight. In fact, the combination of soil treatment and canopy spraying resulted in lower tuber weight compared to treatments without soil treatment. These findings are in line with other studies showing that the use of Trichoderma sp.-based biofertilizers significantly increases sweet potato yields [15]. The combination of biofertilizers with organic materials such as fish bones and plant residues contributes to nutrient availability and supports the growth of soil microbes that play a role in yield formation.

3.5 Discussion

The application of biofertilizer into the soil or in liquid form through foliar spraying had a very significant effect on several parameters of sweet potato growth and yield. This treatment was proven to significantly increase vine length, number of leaves, stem diameter, and tuber weight at all observation times.

The increase in vine length and number of leaves can be attributed to the active role of Trichoderma microorganisms in increasing the availability of nutrients in the soil, especially nitrogen and phosphorus, which supports optimal vegetative tissue formation in plants. In addition, metabolites produced by Trichoderma, such as auxins and other growth-regulating compounds, also contribute to stimulating the formation of new shoots and leaves. This supports faster growth and a more lush canopy, allowing photosynthesis to proceed efficiently.

Stem diameter also shows a significant increase, indicating that plant tissue has become stronger and healthier. Larger stems indicate better water and nutrient transport efficiency and strengthen the physical support of the plant. This efficiency has a direct impact on the plant's ability to absorb nutrients during the growth period.

The effectiveness of biofertilizer treatment is not only limited to the vegetative phase, but is also reflected in the increase in tuber weight as the main parameter of yield. Heavier tubers indicate optimal accumulation of photosynthates from the plant canopy, as well as the support of a healthy root system due to increased soil microbial activity. Biofertilizers also help improve soil structure, increase cation exchange capacity, and provide an environment that supports optimal root growth.

These findings are in line with research on sweet potatoes, which shows that a combination of topsoil and organic fertilizer can significantly increase vine length, number of leaves, and tuber weight in sweet potato plants due to increased soil microbial activity and nutrient availability [17]. Other studies support these findings, namely that the application of trichocompost can increase stem diameter and improve overall plant growth [18].

Microorganisms contained in biofertilizers, such as phosphate-solubilizing bacteria and arbuscular mycorrhizal fungi, work synergistically with plant roots to increase nutrient availability. Some of the most important nutrients are phosphorus and nitrogen, which are very important in the vegetative growth phase of plants.

The results of the observation show that fertilization treatment using biofertilizer can significantly increase the length of vines, the number of leaves, and the diameter of plant stems, which is not inferior to the control treatment. This finding is in line with other studies that mention that the combination of biofertilizer and organic matter can improve soil structure and accelerate nutrient uptake by roots [14].

Not only that, the application of biofertilizer also has a positive impact on increasing tuber yield. The process of adding nutrients through microbial activity in the soil, which binds nitrogen and dissolves phosphate, has been proven to optimally increase tuber tissue growth. This is in line with other studies that mention a drastic increase in sweet potato yields with the use of a combination of biofertilizers and macro elements, proving that this approach is feasible for large-scale cultivation. However, the application of biofertilizer through canopy spraying did not have a significant effect on vegetative growth or tuber weight. Nevertheless, this treatment showed a tendency to increase tuber sweetness, which was likely due to increased metabolic activity and the accumulation of simple sugar compounds in storage tissues [19].

The effectiveness of biofertilizer is highly dependent on environmental factors such as temperature, soil moisture, and the physical structure of the growing medium. Other studies confirm that under less favorable environmental conditions, the performance of biofertilizer tends to decline [20]. Therefore, optimizing the dosage and timing of application, as well as understanding the characteristics of the land, are key to maximizing the potential of biofertilizer. The results obtained in this study indicate that the application of biofertilizer, especially through the soil, has great potential to increase sweet potato productivity in a sustainable and environmentally friendly manner, making it a viable alternative in modern agricultural systems.

4 Conclusion

The application of biofertilizer as soil treatment and foliar spraying interacts with all measurements, namely plant length, number of leaves, stem diameter, and tuber weight. The use of Trichoderma biofertilizer as fertilizer in sweet potato cultivation is highly recommended as an environmentally friendly alternative to chemical fertilizers, and has the potential to be a sustainable solution in increasing agricultural yields ecologically and economically.

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DOI: https://doi.org/10.58905/demeter.v3i3.702

References

[1] A. I. Marwantika, “Pembuatan Pupuk Organik Sebagai Upaya Pengurangan Ketergantungan Petani Terhadap Pupuk Kimia Di Dusun Sidowayah, Desa Candimulyo, Kecamatan Dolopo, Kabupaten Madiun,” *InEJ Indones. Engagem. J.*, vol. 1, no. 1, pp. 17–28, 2020, doi: 10.21154/inej.v1i1.2044.

[2] N. Rachma and A. S. Umam, “Pertanian Organik Sebagai Solusi Pertanian Berkelanjutan Di Era New Normal,” *J. Pembelajaran Pemberdaya. Masy.*, vol. 1, no. 4, p. 328, 2021, doi: 10.33474/jp2m.v1i4.8716.

[3] Kementerian Pertanian, *Laporan Tahunan Direktorat Jenderal Tanaman Pagan*. 2021. [Online]. Available: https://tanamanpangan.pertanian.go.id/assets/front/uploads/document/LAPORAN TAHUNAN 2023.pdf

[4] R. G. Moulick, S. Das, N. Debnath, and K. Bandyopadhyay, “Potential use of nanotechnology in sustainable and ‘smart’ agriculture: advancements made in the last decade,” *Plant Biotechnol. Rep.*, vol. 14, no. 5, pp. 505–513, 2020, doi: 10.1007/s11816-020-00636-3.

[5] R. Aisy *et al.*, “Pemanfaatan Ubi Jalar sebagai Alternatif Karbohidrat yang Meningkatkan Ekonomi Warga Banten,” *SEMAR (Jurnal Ilmu Pengetahuan, Teknol. dan Seni bagi Masyarakat)*, vol. 12, no. 1, p. 47, 2023, doi: 10.20961/semar.v12i1.62162.

[6] D. Dadi, “Pembangunan Pertanian dan sistem Pertanian Organik,” *J. Educ. Dev.*, vol. 9, no. 3, pp. 566–572, 2021, [Online]. Available: http://journal.ipts.ac.id/index.php/ED/article/view/3031

[7] R. T. Qisthi *et al.*, *Pengendalian Hama dan Penyakit Tanaman Pangan dan Hortikultura*. 2021.

[8] D. Y. Molebila, A. Rosmana, and U. S. Tresnaputra, “Trichoderma Asal Akar Kopi Dari Alor : Karakterisasi Morfologi dan Keefektifannya Menghambat Colletotrichum Penyebab Penyakit Antraknosa secara in Vitro .
Trichoderma of Coffee Roots From Alor : Morphological characteristic and in vitro Efficacy to Inhibi,” vol. 16, pp. 61–68, 2020, doi: 10.14692/jfi.16.2.

[9] M. Sutarman, *Biofertillizer Fungi Trichoderma & Mikoriza*. UMSIDA PRESS, 2016.

[10] U. Pengendalian, H. Tajuk, D. A. N. Layu, and T. Kentang, “UJI Trichoderma harzianum SEBAGAI BIOFERTILIZER DAN BIOPESTISIDA,” pp. 209–217, 2017.

[11] S. Purwantisari and B. Hastuti, “Uji Antagonisme Jamur Patogen Phytophthora infestans Penyebab Penyakit Busuk Daun dan Umbi Tanaman Kentang Dengan Menggunakan Trichoderma spp . Isolat Lokal,” vol. 11, no. 1, 2009.

[12] D. Indrarosa, “APLIKASI PUPUK ORGANIK BERBAHAN KOTORAN SAPI DAN AYAM RUMPUT
ODOT (Pennisetum Purpureum cv.Mott),” *J. AgroSainTa Widyaiswara Mandiri Membangun Bangsa*, vol. 5, no. 2, pp. 62–76, 2021, doi: 10.51589/ags.v5i2.71.

[13] F. Ahmad, “Pengaruh Panjang Stek Terhadap Pertumbuhan dan Hasil Tanaman Ubi Jakar (Ipomoea batatas L.),” *J. Ilm. Cendekia Eksakta*, no. 82, pp. 67–71, 2021.

[14] Nadia Kusuma Fardany, “Pengaruh Aplikasi Pupuk Hayati Trichoderma sp. dan Kompos terhadap Pertumbuhan Ubi Jalar,” *Nadia Kusuma Fardany*, pp. 1–10, 2016.

[15] A. C Novianantya, N. K Fardany, and N. Nuraini, “Improvement of sweet potato yield using mixtures of ground fish bone and plant residues,” *J. Degrad. Min. Lands Manag.*, vol. 4, no. 2, pp. 759–765, 2017, doi: 10.15243/jdmlm.2017.042.759.

[16] M. Fadail, “Pengujian Bahan Aktif Formula Biofertilizer Cair terhadap Pertumbuhan dan Produksi Bawang Wakegi (Allium × wakegi Araki) Testing the Active Ingredients of Liquid Biofertiliser Formula on Growth and Production of Wakegi Onion (Allium × wakegi Araki),” vol. 27, no. 2, pp. 154–165, 2024.

[17] R. Hindersah, E. F. L. Lilipaly, I. Mudakir, I. N. Asyiah, and R. Harni, “ROLE OF MYCORRHIZA HELPER BACTERIA ON MYCORRHIZAL COLONIZATION AND NEMATODE Pratylenchus coffeae INFECTION,” *Biotropia (Bogor).*, vol. 29, no. 3, pp. 244–253, 2022, doi: 10.11598/btb.2022.29.3.1711.

[18] E. D. I. Rahman *et al.*, “TANDAN KOSONG KELAPA SAWIT PADA BUDI DAYA WORTEL (Daucus carota L .) TANDAN KOSONG KELAPA SAWIT PADA BUDI DAYA WORTEL (Daucus carota L .),” 2023.

[19] R. W. Mukhongo, J. B. Tumuhairwe, P. Ebanyat, A. A. H. AbdelGadir, M. Thuita, and C. Masso, “Combined application of biofertilizers and inorganic nutrients improves sweet potato yields,” *Front. Plant Sci.*, vol. 8, no. March, pp. 1–17, 2017, doi: 10.3389/fpls.2017.00219.

[20] D. Kristanto, P. Priyono, and S. Bahri, “UJI PUPUK HAYATI TERHADAP PERTUMBUHAN DAN HASIL UBI JALAR (Ipomea batatas L),” *InnofarmJurnal Inov. Pertan.*, vol. 21, no. 2, p. 15, 2020, doi: 10.33061/innofarm.v21i2.3424.