Agro Bali : Agricultural Journal
Vol. 8 No. 2: 407-421, July 2025

e-ISSN 2655-853X
https://doi.org/10.37637/ab.v8i2.2356

Effect of NPK Fertilizer and *Trichoderma harzianum*-Enriched Oil Palm Empty Fruit Bunch Compost on the Growth of Oil Palm Seedlings

Benang Purwanto♥, Wildan Shalihy, and Indrawati
Department of Agriculture, Agricultural Development Polytechnic of Manokwari, Manokwari, Indonesia
♥Corresponding author email: benang.purwan15@gmail.com

Article history: submitted: April 15, 2025; accepted: June 24, 2025; available online: July 10, 2025

Abstract. Early-stage oil palm seedlings require organic fertilizer as a growth biostimulant to produce healthy seedlings with optimal growth. Providing oil palm empty fruit bunch (OPEFB) compost in a planting medium supplies nutrients, improves the medium, and introduces the biological agent *Trichoderma harzianum*. The purpose of this study was to analyze how the interaction of NPK fertilizer and *T. harzianum*-enriched OPEFB compost affected the growth of oil palm seedlings. This study used a factorial Randomized Block Design (RBD) with two treatments: three levels of NPK fertilizer (2.5, 5.0, and 7.5 g. plant^{-1}) and four levels of *T. harzianum*-enriched OPEFB compost (0, 300, 600, and 900 g. plant^{-1}). The results showed that the interaction of NPK fertilizer and *T. harzianum*-enriched OPEFB compost only affected root fresh weight, while the independent test revealed that NPK fertilizer affected plant height, number of leaves, and stem diameter. OPEFB compost affected plant height, number of leaves, stem diameter, and shoot fresh weight. The application of NPK 2.5 g. plant^{-1} and *T. harzianum*-enriched OPEFB compost at a dose of 300 g. plant-^{1} independently contributed positively to the growth of oil palm seedlings during the pre-nursery stage, where NPK fertilizer was not needed in large amounts. Additionally, the release of phosphorus (P) and potassium (K) nutrients occurred gradually, making them slowly accessible to plants.

Keywords: balanced fertilizer; biological agent; biostimulant; pre-nursery; organic fertilizer

INTRODUCTION

Palm oil, as one of Indonesia's mainstay export products, is considered a strategic commodity by the Ministry of Agriculture. According to data from the Central Statistics Agency (CSA), palm oil production in Indonesia increased to 14.50 million ha in 2019 from 11.26 million ha in 2015. However, the expansion of the production area is not comparable to palm oil productivity (Ariyanti et al., 2017).

Efforts to increase palm oil production can begin at the nursery stage. The nursery serves as the preliminary stage before moving to the planting field. Fertilization, in addition to seedlings from superior and certified seeds, plays a crucial role in ensuring the success of the initial nursery to the main nursery. Nursery is carried out in polybags to reduce the amount of available nutrients, and fertilization is essential for promoting seedling growth. However, maintenance costs borne by plantation companies and farmers have increased due to rising prices and scarcity of inorganic fertilizers. Efforts made to reduce the need for fertilizers include exploring alternative sources of nutrients, one of which is utilizing oil palm waste to reduce the reliance on inorganic fertilizers.

Converting oil palm waste in the form of empty fruit bunches into compost holds potential to be developed to decrease the use of inorganic fertilizers. In the main oil palm plantation, vegetative growth and root growth of oil palm seedlings are shown by a combination of oil palm empty fruit bunch (OPEFB) compost and dolomite (Amri et al., 2018)

Soil living conditions can be improved, its structure can be enhanced, groundwater absorption can be increased, and organic fertilizers can serve as a source of nutrients for plants (Dewanto et al., 2017).

Organic fertilizers are not decomposed promptly into mineral ions. *Trichoderma* sp. fungus is one of the microorganisms used as a biological soil fertilizer. It can function as a

e-ISSN 2655-853X
https://doi.org/10.37637/ab.v8i2.2356

decomposing fungus, a biofertilizer, a bioconditioner for seeds, a decomposer in the composting process, a plant growth biostimulant, a moisture retainer in the root system to reduce the effects of drought on the growing medium, and supported sustainable soil management Tan et al., 2017; Purwanto et al., 2022a; Purwanto et al., 2022b; Simamora et al., 2025) In addition, mushrooms or fungi can decompose organic matter such as lignin, cellulose, and carbohydrates (Purwanto et al., 2022b).

Composting *T. harzianum* in bokashi not only functions as a decomposer, but also contains cellulase enzymes capable of degrading the cell walls of pathogens. *Trichoderma* can help create a healthy root area in oil palm seedlings so that oil palm seedlings can absorb nutrients and water optimally (Sofian et al., 2022). The application of *Trichoderma* at a dose of 10 g. seedling^{-1} yielded favorable outcomes in terms of weekly average growth of seedling height, increase in seedling stem diameter, and increase in leaf area index (LAI) (Sofian et al., 2022).

The treatment of a *Trichoderma* dose of 15 g.polybag^{-1} gave the best results on the fresh weight of the shoot, dry weight of the shoot, and dry weight of oil palm seedlings in the pre-nursery (Mintawi et al., 2025). According to the statements of Ariyanti et al. (2017) and Sofian et al. (2022) that the interaction between the dose of 200 g.polybag^{-1} OPEFB compost and the dose of 10 g.polybag^{-1} Trichoderma gave the best growth in oil palm seedlings in the pre-nursery. Based on previous studies, Trichoderma is mostly applied directly mixed with compost and planting media. Considering that Trichoderma acts as a decomposer of organic matter, to optimize its work it is given during OPEFB composting, so that when it is applied to plants, the OPEFB compost has been completely decomposed and the Trichoderma has grown more, ultimately the addition of NPK fertilizer will be optimally absorbed by the plants. Application of NPK fertilizer at a dose of 2.5 g.polybag^{-1} provided the best growth in oil palm seedlings in pre-nursery, other studies state that an NPK fertilizer dose of 15 g is better (Wahyudi et al., 2025).

Further research needs to be conducted to determine the appropriate dose through the combination of NPK fertilizer and *T. harzianum*-enriched OPEFB compost. Subsequently, the relationship between the two fertilizers and the development of oil palm seedlings can also be examined.

METHODS

The study was located at Campus I of the Agricultural Development Polytechnic of Manokwari at an altitude of 37 meters above sea level.

The materials utilized in the study included Marihat variety oil palm seeds from the Medan Oil Palm Research Center (OPRC), OPEFB, mass cultivation of *T. harzianum* containing spores of 30 x 10^6 cfu g^{-1}, Mutiara 16:16:16 NPK fertilizer, and topsoil. The tools used comprised hoes, shovels, shredders, calipers, rulers, digital scales, and stationery.

The composting process begins with preparing a *T. harzianum* starter (30 x 10^6 cfu g^{-1}) of 250 g. The starter is mixed with the following ingredients: 100 kg of chopped OPEFB, 15 kg of rice bran, 20 L of water, 250 g of granulated sugar and incubated under anaerobic conditions for 1 week. Preparation of the planting medium is done by mixing 2 kg of soil and *T. harzianum*-enriched OPEFB compost according to the treatment and then stirred and put into a polybag and incubated for 1 week.

This study used a factorial Randomized Block Design (RBD). The first factor was the dose of NPK compound fertilizer (N) consisting of 3 levels: N1 = 2.5 g NPK fertilizer plant^{-1}; N2 = 5.0 g NPK fertilizer plant^{-1}; and N3 = 7.5 g NPK fertilizer plant^{-1}. The second factor was the dose of *T. harzianum*-enriched OPEFB compost (P) consisting of 4 levels: P0 = Not using any *T. harzianum*-enriched OPEFB compost; P1 = 300 g. plant^{-1}; P2 = 600 g. plant^{-1}; and P3 =

e-ISSN 2655-853X
https://doi.org/10.37637/ab.v8i2.2356

900 g. plant^{-1}. The combination of treatments was repeated three times, with each research unit containing 10 plants, resulting in a total of 360 plants.

The measured parameters included plant height, number of leaves, stem diameter, root length, root fresh weight, root dry weight, shoot fresh weight, and shoot dry weight. Observations were conducted every seven days after the oil palm seedlings reached two months of age. Data were analyzed using Analysis of Variance (ANOVA) with the aid of Statistical Package for the Social Sciences (SPSS) version 25 software. To assess factors with a significant effect at $p < 0.05$, the Duncan's Multiple Range Test (DMRT) was used.

RESULTS AND DISCUSSION

The C-Organic content (45.15%), C/N ratio (22.57%), water content (25.61%), pH (6.8), and macronutrients N, P, K, and Mg ($\geq$ 4) of the *T. harzianum*-enriched OPEFB compost met the standards set by the Indonesian National Standards (SNI) 19-7030-2004 and Regulation of the Minister of Agriculture (Permentan) No. 70 of 2011 criteria (Table 1)

As shown in Table 1, OPEFB compost reduced the initially high C/N ratio (45–55) to approximately 22%, regardless of *T. harzianum* application. This value approached the C/N ratio of high-quality organic fertilizer (approximately 15%). Additionally, the moisture content of the OPEFB compost of around 40% served as a suitable medium for *T. harzianum* activity in the decomposition of organic matter (Wahyuni & Nasution, 2019). The addition of biological OPEFB compost will improve the soil pH, so that microorganisms increase their activity (Kassim et al., 2024). In addition, the application of *T. harzianum* is also able to reduce the C/N of compost. This is in line with research Oktafiyanto et al. (2020) that *T. harzianum* T10 and T14 are able to reduce the C/N ratio in cow manure.

Table 1. Results of analysis of OPEFB compost without and with *T. harzianum*

Number	Parameters	Without *T. harzianum*	With *T. harzianum*
1.	C-Organic	43.51 %	45.15 %
2.	Ratio C/N	22.90 %	22.57 %
3.	Moisture content	40.14 %	40.61 %
4.	Macro nutrient :		
	N	1.90 %	2.00 %
	P_2O_5	0.60 %	0.64 %
	K_2O	1.36 %	0.73 %
	Mg	0.77ppm	1.54ppm

Source: Soil and Nutrition Laboratory, Padjadjaran University

The results of the independent test demonstrated that plant height, number of leaves, stem diameter, and shoot weight were significantly affected by the supply of *T. harzianum*-enriched OPEFB compost, whereas plant height and number of leaves were markedly influenced by the supply of NPK.

Plant Height

According to the independent test results, plant height was influenced by the application of NPK fertilizer. In comparison to doses of 5.0 and 7.5 g. plant^{-1}, NPK fertilizer exhibited the highest average plant height at a dose of 2.5 g. plant^{-1}. The application of *T. harzianum*-enriched OPEFB compost had an effect on plant height. Although it did not differ considerably from the dose of 900 g. plant^{-1}, *T. harzianum* at 300 g.plant^{-1} displayed the highest average plant height. Oil palm seedlings that did not receive *T. harzianum*-enriched OPEFB compost exhibited the shortest plant height (Table 2).

e-ISSN 2655-853X
https://doi.org/10.37637/ab.v8i2.2356

When NPK fertilizer was applied at a dose of 2.5 g. plant^{-1}, the growth of oil palm seedlings showed a good response to the average plant height (28.24 cm). The addition of NPK fertilizer doses (5 g and 7.5 g) had a significant effect on the decrease in the average plant height. This is different from the opinion of Wahyudi et al. (2025), who stated that the addition of NPK fertilizer doses up to 15 g.plant^{-1} showed a better growth response with a combination of bokashi fertilizer. The addition of NPK fertilizer doses actually resulted in a decrease in the average plant height, it is suspected that too high a fertilizer dose can damage the root and stem tissue of seedlings or the condition of the soil solution is too thick, making it difficult for the roots to absorb. However, plant height decreased as the NPK dose increased. Nutrient toxicity symptoms, such as yellowing and even wilting plants, have a quadratic effect on the reduction in seedling growth if the dose of NPK compound fertilizer is higher than the ideal amount (Ramadhaini et al., 2014). Plant cultivation requires additional nutrients N, P and K to support plant growth and yield (Lay et al., 2023).

The application of OPEFB compost resulted in a more positive effect on plant height compared to the control group, which received no compost. Compost can loosen the soil so that it can encourage root development and increase its ability to optimally absorb nutrients (Onggo et al., 2017). Compost is also highly suitable for improving soil structure, as well as enhancing both physical and chemical properties of the soil (Elmizan et al., 2014). The enrichment of *T. harzianum* will increase the amount of healthy space in the root scope (rhizosphere), provide space, degrade organic matter, and stimulate plant growth. Furthermore, *T. harzianum* can reduce the impact of drought because the mycelium that colonizes plant roots can moisturize the rhizosphere and reach deeper groundwater (Purwanto et al., 2022b). The application of *T. harzianum*-enriched OPEFB compost combined with the right NPK fertilizer will obtain optimal plant height (Syam et al., 2023).

Table 2. Effect of NPK fertilizer doses and *T. harzianum*-enriched OPEFB compost on oil palm plant height

Treatments	Observation of the week					Average
	1	2	3	4	5	
NPK fertilizer (g)						
2.5	24.63^{a}	26.68^{a}	28.64^{a}	30.05^{a}	31.44^{a}	28.24^{a}
5.0	23.01^{b}	24.89^{b}	26.30^{b}	28.00^{ab}	29.45^{ab}	26.33^{b}
7.5	22.72^{b}	24.79^{b}	26.18^{b}	27.69^{b}	28.65^{b}	26.01^{b}
OPEFB compost (g)						
0	23.07^{ab}	25.43^{ab}	25.87^{b}	27.34^{a}	27.47^{b}	25.78^{b}
300	24.63^{a}	26.33^{a}	28.25^{a}	29.73^{a}	31.80^{a}	28.15^{a}
600	22.32^{b}	24.32^{b}	26.25^{ab}	27.87^{a}	29.14^{ab}	25.98^{b}
900	23.80^{ab}	25.73^{ab}	27.78^{ab}	29.37^{a}	30.99^{a}	27.53^{ab}

Note: Means in the same column followed by the same letters are not significantly different according to Duncan's Multiple Range Test at $\alpha = 0.05$

Number of Leaves

The independent test revealed that the average amount of NPK fertilizer applied to oil palm seedlings had the biggest impact on the number of leaves. NPK fertilizer at a dose of 2.5 g. plant^{-1} did not significantly differ from NPK at a dose of 5.0 g. plant^{-1}. The number of leaves in oil palm seedlings was most significantly affected by the application of *T. harzianum*-enriched OPEFB compost at a concentration of 300 g. plant^{-1} and 900 g. plant^{-1} dose. The application of an NPK dose of 7.5 g. plant^{-1} and the absence of *T. harzianum*-enriched OPEFB compost

e-ISSN 2655-853X
https://doi.org/10.37637/ab.v8i2.2356

resulted in the lowest number of leaves (Table 3).

The number of leaves on oil palm seedlings was optimally influenced by the use of 2.5 g of NPK complex fertilizer plant^{-1}. The number of leaves did not instantly increase after fertilization with NPK chemical fertilizer. The gradual release of N, P, and K nutrients leads to their slow availability for plants, and oil palm seedlings are thought to not require large amounts of NPK nutrients at the early stage (Wu et al., 2008). The application of NPK can increase root development, biomass production (de Barros et al., 2007), and tissue nutrient content (Costa, 2012). This most commonly affects plant height, number of leaves, and stem diameter of oil palm seedlings at 4, 5, and 6 months of age.

The application of *T. harzianum*-enriched OPEFB compost had a favorable impact on the number of leaves compared to the control group. The doses of 300 and 900 g. plant^{-1} were the most effective with a tendency towards increasing the dose of compost. Improvement of physical, chemical, and biological properties of the soil was expected to increase root development, plant biomass, and nutrient content in plant tissues, thus encouraging leaf expansion.

Table 3. Effect of NPK fertilizer dose and *T. harzianum*-enriched OPEFB compost on the number of leaves of oil palm plants

Treatments	Observation of the week					Average
	1	2	3	4	5	
NPK fertilizer (g)						
2.5	5.03^{a}	5.03^{b}	5.44^{a}	5.67^{a}	6.20^{a}	5.47^{a}
5.0	4.83^{ab}	4.83^{ab}	5.33^{a}	5.58^{a}	6.06^{a}	5.33^{ab}
7.5	4.78^{ab}	4.78^{b}	5.19^{a}	5.53^{a}	5.89^{a}	5.23^{b}
OPEFB compost (g)						
0	4.70^{b}	4.70^{b}	5.03^{b}	5.22^{c}	5.67^{a}	5.06^{b}
300	5.07^{a}	5.07^{a}	5.55^{a}	5.89^{a}	6.19^{ab}	5.55^{a}
600	4.74^{b}	4.74^{b}	5.29^{ab}	5.52^{bc}	5.96^{bc}	5.25^{b}
900	5.00^{a}	5.00^{a}	5.40^{ab}	5.74^{ab}	6.37^{a}	5.50^{a}

Note: Means in the same column followed by the same letters are not significantly different according to Duncan's Multiple Range Test at $\alpha = 0.05$

Stem Diameter

The independent test results indicated that the maximum stem diameter of oil palm seedlings was attained at an NPK dose of 2.5 g. plant^{-1}. However, the average dose of NPK fertilizer had no discernible effect on the stem diameter. The stem diameter was affected by the amount of *T. harzianum*-enriched OPEFB compost. The application of *T. harzianum*-enriched OPEFB compost at a dose of 900 g. plant^{-1} resulted in the maximum stem diameter. However, the difference was not statistically significant compared to the 300 g. plant^{-1} and 600 g. plant^{-1} doses. In contrast, the minimum stem diameter of oil palm seedlings was observed in plants that did not receive any application of *T. harzianum*-enriched OPEFB compost (Table 4).

The application of NPK at a dose of 2.5 g. plant^{-1}, which resulted in a larger stem diameter compared to higher doses, suggested that oil palm seedlings in the pre-nursery stage did not require large amounts of inorganic NPK fertilizer inputs from external sources (Table 4). The optimal NPK dose of 2.5 g. plant^{-1} had a positive effect on the stem diameter of oil palm seedlings, because the increase in stem diameter is influenced by the availability of K elements (Waruwu et al., 2018).

The application of compost enhanced soil fertility, improved soil structure, boosted

e-ISSN 2655-853X
https://doi.org/10.37637/ab.v8i2.2356

soil microbial activity, and raised the availability of soil nutrients. *T. harzianum*-enriched OPEFB compost used in this study contained 45.15% C-Organic, 2% nitrogen (N), 0.64% phosphorus (P), 0.73% potassium (K), and 1.54% magnesium (Mg) which provided nutrients for oil palm seedlings. According to Hartatik et al. (2015), more than 2% C-Organic is required to achieve optimal plant growth. Sufficient C-Organic in the planting medium provides nutrients for plants, increases fertilization efficiency, and helps neutralize the toxic properties of aluminum (Al) and iron (Fe) present in the subsoil, so that nutrients are available and increase the stem diameter of the oil palm seedlings (Nasution et al., 2014).

Table 4. Effect of NPK fertilizer dose and *T. harzianum*-enriched OPEFB compost on stem diameter of oil palm plants

Treatments	Observation of the week					Average
	1	2	3	4	5	
NPK fertilizer (g)						
2.5	9.11^{a}	9.70^{a}	9.48^{a}	10.22^{a}	10.10^{a}	9.60^{a}
5.0	8.72^{a}	9.48^{a}	9.47^{a}	9.88^{a}	9.51^{a}	9.31^{a}
7.5	8.74^{a}	8.93^{a}	8.99^{a}	9.79^{a}	10.52^{a}	9.03^{a}
OPEFB compost (g)						
0	8.03^{b}	8.20^{b}	8.27^{b}	8.85^{b}	9.37^{a}	8.33^{b}
300	9.51^{a}	9.77^{a}	9.72^{a}	10.46^{a}	9.54^{a}	9.78^{a}
600	8.54^{ab}	9.35^{a}	9.43^{a}	10.14^{a}	9.84^{a}	9.31^{a}
900	9.35^{a}	10.16^{a}	9.83^{a}	10.40^{a}	10.76^{a}	9.82^{a}

Note: Means in the same column followed by the same letters are not significantly different according to Duncan's Multiple Range Test at $\alpha = 0.05$

Root Length

The results of the independent test showed that the application of NPK fertilizer had no considerable impact on the root length of oil palm seedlings. The application of *T. harzianum*-enriched OPEFB compost also did not make a substantial difference on the root length of oil palm seedlings (Table 5). The results of the study by Aminullah et al. (2019) showed a significant effect of the interaction of OPEFB compost and NPK fertilizer on the root length of 3-month-old oil palm seedlings (main nursery) at a dose of OPEFB compost of 270 g. plant-1 and NPK 60 g. plant-1. The difference in research results was due to the different doses of OPEFB compost and NPK fertilizer, as well as the difference in plant age between the pre-nursery and main nursery. The root response in the main nursery was more responsive to the addition of organic and inorganic fertilizer inputs.

The findings of the study suggested that the application of NPK compound fertilizer with increasing doses led to longer root growth of oil palm seedlings. The effect was linear although according to the variance test, it was not markedly different. According to (de Barros et al., (2007), it is stated that NPK 15:15:15 promotes root development and plant biomass, whereas in this study, using NPK 16:16:16 during the reproductive phase was proven to be more useful to stimulate flowering and prevent fruit drop. This supports the assumption that there is no notable impact on root length.

e-ISSN 2655-853X
https://doi.org/10.37637/ab.v8i2.2356

Table 5. Effect of NPK fertilizer dose and *T. harzianum*-enriched OPEFB compost on root length of oil palm plants

NPK fertilizer (g)	Root length (cm)
2.5	18.13[a]
5.0	20.10[a]
7.5	27.17[a]
OPEFB compost (g)	
0	19.17[a]
300	23.29[a]
600	20.89[a]
900	23.84[a]

Note: Means in the same column followed by the same letters are not significantly different according to Duncan's Multiple Range Test at α = 0,05

The application of *T. harzianum*-enriched OPEFB compost also gave no discernible impact. However, increasing the compost dose could potentially lead to longer root growth in oil palm seedlings. This is believed to be related to improvements in soil structure, making it looser, which was supported by better microbial development, thereby stimulating the growth of longer plant roots. Biostimulants are thought to show a significant positive effect on vegetative growth (Sari et al., 2019). In line with research Pradana et al., (2024) that the application of *T. harzianum* tends to increase root length, number of leaves, and stem diameter in Cavendish bananas from tissue culture.

Root Fresh Weight

The results of the variance test demonstrated an interaction between multilayer NPK fertilizer and *T. harzianum*-enriched OPEFB compost in their effect on root fresh weight. Root fresh weight was significantly affected by the combination of NPK fertilizer and *T. harzianum*-enriched OPEFB compost, except in the treatment combining 300 g. plant^{-1} of compost with varying NPK fertilizer doses. Meanwhile, the application of complex NPK fertilizer at a dose of 2.5 g. plant^{-1} and varying doses of OPEFB compost presented no significant difference in effectiveness.

The highest root fresh weight was achieved with the combination of NPK compound fertilizer 2.5 g. plant^{-1} and OPEFB compost 300 g. plant^{-1}, while the combination of NPK compound fertilizer 7.5 g. plant^{-1} and OPEFB compost 600 g. plant^{-1} resulted in the lowest root fresh weight (Table 6).

Root fresh weight was influenced by the ability of the roots to absorb nutrients and water around the roots, thereby increasing the fresh weight and dry weight of roots. The application of complex NPK fertilizer contributed to the growth and development of oil palm seedlings. Nitrogen supply affected the growth, appearance, color, and yield of plants. Nitrogen contributes to making plant parts green because it is a key component of chlorophyll, which is essential for photosynthesis (Pramitasari et al., 2016). Phosphorus (P) and potassium (K) were involved in stimulating plant growth and enhancing root formation. Phosphorus (P) is part of the cell nucleus and plays a vital role in cell division and meristem development (Sarman et al., 2021).

T. harzianum-enriched OPEFB compost contained small amounts of macro and micro nutrients which also supported the growth and development of plant roots. The nitrogen element contained in OPEFB stimulated the vegetative root growth, supported by the photosynthesis process, which in turn enhanced nutrient absorption by the roots. In addition, Phosphorus (P) in OPEFB acts as a root growth stimulant (Waruwu et al., 2018). The development of a good root system also affected the fresh weight of plant roots. Therefore, the use of OPEFB compost helped

e-ISSN 2655-853X
https://doi.org/10.37637/ab.v8i2.2356

loosen the root zone, allowing more water to be absorbed and keeping the roots hydrated.

Root Dry Weight

The independent test presented that the application of *T. harzianum*-enriched OPEFB compost and NPK fertilizer did not influence the root dry weight of the oil palm seedlings. The application of *T. harzianum*-enriched OPEFB compost at a dose of 300 g. plant^{-1} and NPK fertilizer at a dose of 2.5 g. plant^{-1} demonstrated the highest average root dry weight (Table 7).

In line with the statement of Mintawi et al. (2025), the growth of oil palm seedlings in the pre-nursery has not been affected by the addition of OPEFB compost doses and *Trichoderma* doses, because it is suspected that the OPEFB compost doses and *Trichoderma* doses given at the beginning of planting have not been able to significantly affect plant growth.

Table 6. Effect of NPK fertilizer dose and *T. harzianum*-enriched OPEFB compost on root fresh weight of oil palm plants

NPK fertilizer (g)	Root fresh weight (g)			
	P0 (0 g)	P1 (300 g)	P2 (600 g)	P3 (900 g)
N1 (2.5 g)	9.70 [a]	10.90 [a]	10.50 [a]	8.20 [ab]
	A	A	A	A
N2 (5.0 g)	10.73 [a]	10.30 [a]	7.40 [b]	6.30 [b]
	A	A	B	B
N3 (7.5 g)	6.80 [b]	8.80 [a]	6.20 [b]	10.40 [a]
	B	AB	B	A

Note: Means followed by the same lowercase letter (vertical) in the same column are not significantly different, while numbers followed by capital letters (horizontal) in the same row are not significantly different in the Duncan's Multiple Range Test at α = 0.05

Table 7. Effect of NPK fertilizer dose and *T. harzianum*-enriched OPEFB on root dry weight of oil palm plants

NPK fertilizer (g)	Root dry weight (g)
2.5	3.11[a]
5.0	2.72[a]
7.5	2.89[a]
OPEFB compost (g)	
0	3.11[a]
300	3.48[a]
600	2.30[a]
900	2.73[a]

Note: Means in the same column followed by the same letters are not significantly different according to Duncan's Multiple Range Test at α = 0.05

Plants efficiently absorbed the optimum dose of NPK compound fertilizer, preventing NPK fertilizer waste. It is recommended that pre-nursery oil palm seedlings receive 2.5 g. plant^{-1} of NPK complex fertilizer. Increasing the dose of NPK fertilizer had no discernible impact. The appropriate dose of NPK fertilizer will be effectively absorbed by the roots and provide an optimal contribution to increasing the dry weight of the plant. Application of NPK Phonska fertilizer affects plant height, shoot dry weight, and root dry weight of the rice plants (Effendi AR et al., 2024). The dry weight of a plant indicates the

e-ISSN 2655-853X
https://doi.org/10.37637/ab.v8i2.2356

degree of efficiency of the plant's metabolism (Nasution et al., 2014). The absorption of various nutrients by plants increased the process and progress of photosynthesis. Additionally, the products of photosynthesis were stored in the stem and leaf tissues. As a result of the photosynthesis, the plant dry weight increased, and this reflected the nutritional status of the plants or its ability to absorb nutrients.

The maximum root dry weight was obtained when the NPK complex fertilizer at a dose of 2.5 g. plant^{-1} and the *T. harzianum*-enriched OPEFB compost at a dose of 300 g. plant^{-1} were distributed. As the dose was considered optimal, the absorption of N, P, and K nutrients from both NPK complex fertilizer and OPEFB compost indicated that the metabolic process of plant tissue, particularly the roots, was performing smoothly.

Shoot Fresh Weight and Shoot Dry Weight

The findings of the independent test demonstrated that NPK fertilizer had no effect on shoot fresh weight, whereas the addition of *T. harzianum*-enriched OPEFB compost did have an effect. Utilizing *T. harzianum*-enriched OPEFB compost at a dose of 900 g. plant^{-1} produced the maximum fresh weight of leaves. Nevertheless, this dose did not have a notable distinction from the 300 g. plant^{-1} dose. At 600 g. plant^{-1}, the shoot fresh weight was at its lowest and not significantly different from the control group (Table 8).

Table 8. Effect of NPK fertilizer dose and *T. harzianum*-enriched OPEFB compost on fresh and dry weight of shoot of oil palm plants

NPK fertilizer (g)	Shoot fresh weight (g)	Shoot dry weight (g)
2.5	95.92^{a}	28.75^{a}
5.0	120.25^{a}	28.50^{a}
7.5	99.00^{a}	32.33^{a}
OPEFB compost (g)		
0	86.78^{b}	25.56^{a}
300	127.44^{a}	33.44^{a}
600	77.22^{b}	27.78^{a}
900	128.78^{a}	32.67^{a}

Note: Means in the same column followed by the same letters are not significantly different according to Duncan's Multiple Range Test at α = 0.05

The capacity of plant tissue to absorb nutrients affected shoot fresh weight, thereby increasing the fresh weight and dry weight of the plants. Nitrogen supplies affected plant growth, appearance, color, and yield.

The results of the independent test indicated that the application of *T. harzianum*-enriched OPEFB compost and NPK fertilizer did not affect the dry weight of oil palm seedlings. The highest dry weight of the shoot was obtained when NPK fertilizer was given at a dose of 7.5 g. plant^{-1} and when OPEFB compost was given at a dose of 300 g. plant^{-1} (Table 8).

The results of this study differ from the statement of Mintawi et al.(2025), who stated that the provision of OPEFB and *Trichoderma* compost had a significant effect on the dry weight of the canopy. This difference is thought to be due to differences in the treatment of adding NPK so that the dominant influence of the nutrients N, P, and K is more quickly available to plants.

Shoot dry weight reflects the degree of metabolic efficiency of the tissues formed in the leaf sheaths and stems of the plant (Nasution et al., 2014). Plants that received adequate nutrient supply exhibited maximum shoot growth and development.

e-ISSN 2655-853X
https://doi.org/10.37637/ab.v8i2.2356

Nitrogen influenced the chlorophyll status in leaves, which was formed through the process of photosynthesis. The photosynthetic products were stored in the stems and leaf tissues, contributing to an increase in shoot dry weight. Shoot dry weight, subsequently, reflected the nutritional status of the plant and its ability to absorb nutrients.

Although the distribution test revealed no discernible impact, the application of NPK complex fertilizer at a dose of 7.5 g. plant^{-1} and *T. harzianum*-enriched OPEFB compost at a dose of 300 g. plant^{-1} produced the maximum shoot dry weight. Since this dose was considered optimal, the absorption of N, P, K nutrients from both NPK complex fertilizer and OPEFB compost indicated that the metabolic processes in plant shoot tissues were performing effectively. The absorption of other nutrients such as Ca, Mg, B, Zn, Cu and Cl. also increased significantly with the application of OPEFB compost (Hasibuan et al., 2023).

Total Fresh Weight and Dry Weight

Results of the ANOVA statistical analysis showed that the interaction of NPK fertilizer application and *T. harzianum*-enriched OPEFB compost did not have a significant effect on the total fresh weight and dry weight variables of plants. This is suspected that NPK fertilizer and *T. harzianum*-enriched OPEFB compost have different properties, especially the speed of nutrient provision, where inorganic fertilizers are available faster than organic fertilizers. In addition, dissolution and loss of nutrients due to rainfall can affect soil pH, the ability of the soil to store and provide nutrients for plants, so that the effect of the interaction of the two treatments is not significant. However, there is a tendency that the higher the dose of NPK fertilizer and *T. harzianum*-enriched OPEFB compost, the higher the total fresh weight and dry weight of plants. The application of NPK fertilizer at a dose of 7.5 g. plant^{-1} obtained the highest dry weight of 55.25 g, while the application of *T. harzianum*-enriched OPEFB compost at a dose of 900 g. plant^{-1} obtained the highest dry weight of 61.67 g (Tabel 9). In line with the research results of Mintawi et al., (2025), the application of a dose of 150 g. plant^{-1} of OPEFB compost has provided better fresh weight and dry weight of oil palm seedlings in the pre-nursery compared to without OPEFB compost.

Table 9. Effect of NPK fertilizer dose and *T. harzianum*-enriched OPEFB compost on total fresh weight and dry weight of oil palm plants

NPK fertilizer (g)	Total fresh weight (g)	Total dry weight (g)
2.5	336.58[a]	44.83[a]
5.0	386.58[a]	54.92[a]
7.5	386.08[a]	55.25[a]
OPEFB compost (g)		
0	362.89[a]	50.00[a]
300	377.33[a]	58.22[a]
600	318.22[a]	36.78[a]
900	420.56[a]	61.67[a]

Note: Means in the same column followed by the same letters are not significantly different according to Duncan's Multiple Range Test at α = 0.05

Total fresh weight of the plant will increase by 9.9 g for every one unit increase in NPK fertilizer dose (Figure 1). The provision of NPK fertilizer is thought to increase plant growth and development, which will ultimately increase the fresh weight of the plant. However, excessive NPK fertilizer administration has a negative impact (Fadila et al., 2021). The increase in fresh plant weight is due to the provision of nitrogen (N) elements which will increase vegetative growth, especially chlorophyll for

 e-ISSN 2655-853X
https://doi.org/10.37637/ab.v8i2.2356

the continuation of photosynthesis so that photosynthate is produced which is distributed throughout the plant tissue. Likewise, plants will absorb most of the P element in the form of primary ions ($H_2PO_4^-$) and a small part of secondary ions (HPO_4^{-2}) so that high phosphorus absorption results in heavier plant tissue weight (Pardede. et al., 2023). The K element as an activator of various important enzymes will facilitate plant metabolism.

Total fresh weight of the plant tends to increase in line with the increase in each one unit dose of *T. harzianum*-enriched OPEFB compost by 0.04 g (Figure 2). The role of *T. harzianum*-enriched OPEFB compost in increasing plant fresh weight is very small because the nutrients produced by organic fertilizer are slowly available to plants.

Total dry weight of the plant will increase by 2.08 g for every one-unit increase in NPK fertilizer dose (Figure 3). The dry weight of the plant shows the accumulation of organic matter produced by the plant during photosynthesis. The administration of NPK fertilizer at a dose of 7.5 g. plant-1 is the optimum dose so that a total dry weight of 55.25 g is obtained.

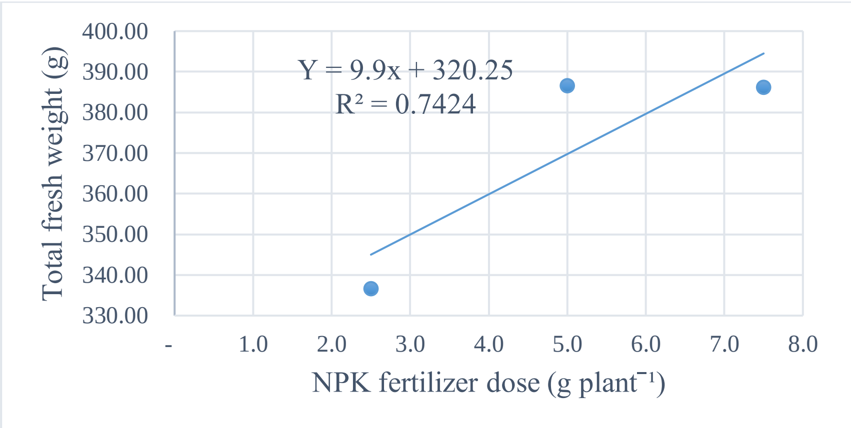

Figure 1. Effect of NPK fertilizer dose on the total fresh weight of oil palm plants

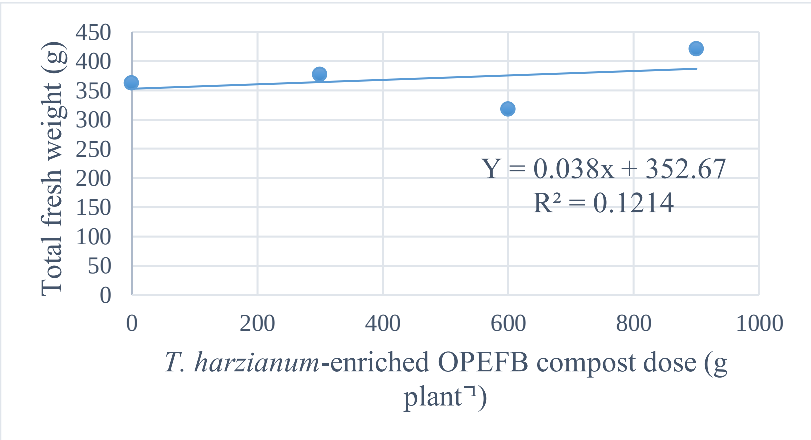

Figure 2. Effect of *T. harzianum*-enriched OPEFB compost dose on total fresh weight of oil palm plants

A higher total fresh weight does not necessarily result in a higher dry weight, because it can be caused by high water content in the stems and roots, so what determines the dry weight of the plant is a good photosynthesis rate, indicated by optimal plant growth and development so that more photosynthate is produced in the

e-ISSN 2655-853X
https://doi.org/10.37637/ab.v8i2.2356

form of plant biomass such as roots, stems and leaves. This statement is in line with Pardede. et al. (2023), the administration of NPK fertilizer increases the dry weight of rice plants.

Total dry weight of the plant tends to increase in line with each one-unit increase in the dose of *T. harzianum*-enriched OPEFB compost by 0.005 g (Figure 4). The application of *T. harzianum*-enriched OPEFB compost did not significantly affect the increase in dry weight. The regression equation showed a small increase in each unit addition of *T. harzianum*-enriched OPEFB compost. This is thought to be due to the time required for the decomposition of biofertilizer by microbes, so that nutrient absorption does not increase immediately after application.

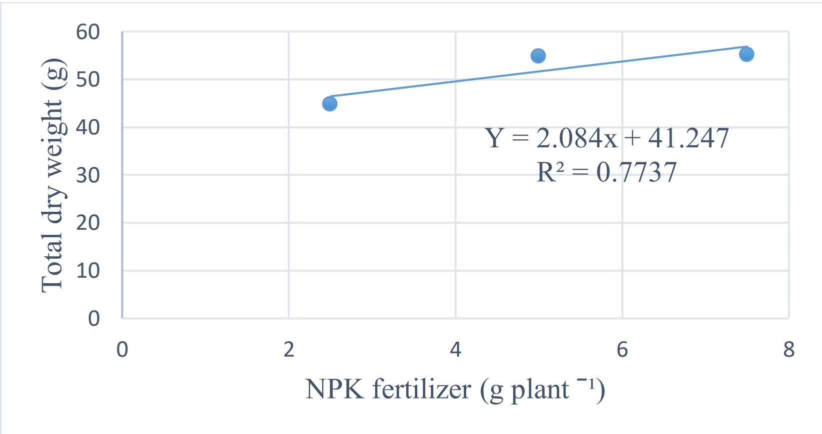

Figure 3. Effect of NPK fertilizer dose on the total dry weight of oil palm plants

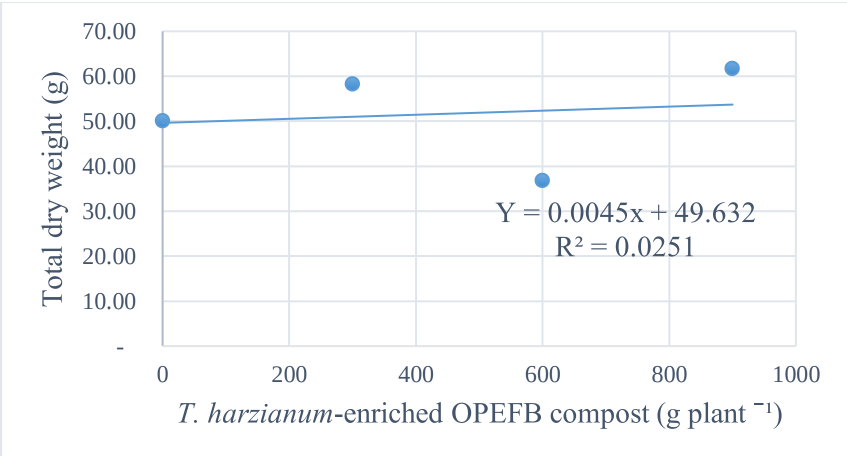

Figure 4. Effect of *T. harzianum*-enriched OPEFB compost dose on total dry weight of oil palm plants

CONCLUSION

The interaction effect of *T. harzianum* enriched OPEFB compost and NPK fertilizer application only occurred in the fresh weight parameter of oil palm seedling roots, the highest at a dose of NPK fertilizer of 2.5 g. plant^{-1} with *T. harzianum* enriched OPEFB compost of 600 g. plant^{-1}. In general, increasing the dose of T. harzianum enriched OPEFB compost is better than without *T. harzianum* enriched OPEFB compost, while the application of NPK fertilizer at a dose of 2.5 g. plant^{-1} has a better effect on oil palm seedlings in the pre-nursery because the seedlings still rely on endosperm (food reserves in seeds). *T. harzianum* enriched OPEFB compost as an alternative biofertilizer is useful for increasing soil fertility so that the growth of oil palm

e-ISSN 2655-853X
https://doi.org/10.37637/ab.v8i2.2356

seedlings in the pre-nursery is better.

REFERENCES

Aminullah, A., Rosmawati, T., & Sulhaswardi, S. (2019). Uji Pemberian Kompos Tandan Kosong Sawit dan NPK 16:16:16 Pada Pembibitan Kelapa Sawit (Elaeis guineensis Jacq.) Main Nursery Dengan Media Sub Soil Ultisol. *Dinamika Pertanian*, *33*(3), 275–284. https://doi.org/10.25299/dp.2017.vol33(3).3840

Amri, A. I., Armaini, A., & Amindo Purba, M. R. (2018). Aplikasi kompos tandan kosong kelapa sawit dan dolomit pada medium sub soil inceptisol terhadap bibit kelapa sawit (Elaeis guineensis Jacq.) di pembibitan utama. *Jurnal Agroteknologi*, *8*(2), 1-8. https://doi.org/10.24014/ja.v8i2.3349

Ariyanti, M., Natali, G., & Suherman, C. (2017). Respons Pertumbuhan Bibit Kelapa Sawit (Elaeis guineensis Jacq.) terhadap Pemberian Pupuk Organik Asal Pelepah Kelapa Sawit dan Pupuk Majemuk NPK. *Agrikultura*, *28*(2), 64–67. https://doi.org/10.24198/agrikultura.v28i2.14955

Costa, M. C. G. (2012). Soil and crop responses to lime and fertilizers in a fire-free land use system for smallholdings in the northern Brazilian Amazon. *Soil and Tillage Research*, *121*, 27–37. https://doi.org/10.1016/j.still.2012.01.017

de Barros, I., Gaiser, T., Lange, F. M., & Römheld, V. (2007). Mineral nutrition and water use patterns of a maize/cowpea intercrop on a highly acidic soil of the tropic semiarid. *Field Crops Research*, *101*(1), 26–36. https://doi.org/10.1016/j.fcr.2006.09.005

Dewanto, F. G., Londok, J. J. M. R., Tuturoong, R. A. V., & Kaunang, W. B. (2017). Pengaruh Pemupukan Anorganik Dan Organik Terhadap Produksi Tanaman Jagung Sebagai Sumber Pakan. *Zootec*, *32*(5), 1–8. https://doi.org/10.35792/zot.32.5.2013.982

Effendi AR, A., Ariani, E., & Yudiandani, Y. (2024). The Effect of Biological Fertilizers and Inorganic Fertilizers on Upland Rice Plants (Oryza sativa L.) Growth and Production. *Jurnal Agronomi Tanaman Tropika (Juatika)*, *6*(2). https://doi.org/10.36378/juatika.v6i2.3597

Elmizan, E., Muyassir, & Fikrinda. (2014). Sifat Kimia Tanah, Pertumbuhan dan Hasil Padi Sawah (Oryza sativa L.) Akibat Pemberian Azolla (azolla pinnata L.) dalam Bentuk Pupuk Hijau dan Kompos. *Jurnal Manajemen Sumberdaya Lahan*, *3*(1), 441–446.

Fadila, A. N., Widagdo, S., & Hendarto, K. (2021). Pengaruh Dosis Pupuk NPK Terhadap Pertumbuhan dan Hasil Produksi Kailan (Brassica oleracea var . alboglabra) pada Pertanaman Kedua. *Jurnal Agrotek Tropika*, *9*(3), 473–480.

Hartatik, W., Husnain, H., & Widowati, L. R. (2015). Peranan pupuk organik dalam peningkatan produktivitas tanah dan tanaman. *Jurnal Sumberdaya Lahan*, 107–120.

Hasibuan, S., Hamdani, H., & Astuti Kuswardani, R. (2023). The Effect of Empty Bunch Applications on Production of Oil Palm. *Jurnal Penelitian Kelapa Sawit*, *31*(3), 191–200. https://doi.org/10.22302/iopri.jur.jpks.v31i3.263

Kassim, N. Q. B., Sari, N. A., Othman, N. M. I., Nor, M. N. M., Adam, S., Hani, N. W., & Alias, M. L. Bin. (2024). Long-Term Biofertilizers and Chemical Fertilizer Use on Selected Peat Soil Properties of Oil Palm Plantation. *Agrivita*, *46*(2), 268–275. https://doi.org/10.17503/agrivita.v46i2.4305

Lay, F. R., Wijana, G., & Maya Dewi, N. N. A. (2023). Pengaruh Media Tanam dan

e-ISSN 2655-853X
https://doi.org/10.37637/ab.v8i2.2356

Dosis NPK (16-16-16) terhadap Pertumbuhan dan Hasil Bunga Gumitir (Tagetes erecta L.). *Agro Bali : Agricultural Journal*, *6*(3), 740–749. https://doi.org/10.37637/ab.v6i3.1315

Mintawi, R. W., Muin, A., & Wirianata, H. (2025). *Pengaruh Aplikasi Kompos Tandan Kosong Kelapa Sawit Dan Trichoderma sp terhadap Pertumbuhan Bibit Kelapa Sawit Di Pre Nursery*. *3*, 52–58.

Nasution, S. H., Hanum, C., & Ginting, J. (2014). Pertumbuhan Bibit Kelapa Sawit (Elaeis guineensis Jacq.) Pada Berbagai Perbandingan Media Tanam Solid Decanter dan Tandan Kosong Kelapa Sawit Pada Sistem Single Stage. *Jurnal Online Agroteknologi*, *2*(2), 691–701.

Oktafiyanto, F., Soesanto, M., Mugiastuti, L., Rahayuniati, E., & Feti, R. (2020). Uji Empat Isolat Trichoderma harzianum Pada Pengomposan Kotoran sapi Dan Ayam Dan Pengaruhnya Terhadap Pertumbuhan Mentimun In Planta. *Agro Bali*, *3*(1), 52–66. https://doi.org/10.37637/ab.v3i1.424

Onggo, T. M., Kusumiyati, K., & Nurfitriana, A. (2017). Pengaruh penambahan arang sekam dan ukuran polybag terhadap pertumbuhan dan hasil tanaman tomat kultivar 'Valouro' hasil sambung batang. *Kultivasi*, *16*(1), 298–304. https://doi.org/10.24198/kultivasi.v16i1.11716

Pardede., S., Prof. Dr. Ir. Sudiarso, M. S., & Prof. Dr. Ir. Husni Thamrin Sebayang, M. S. (2023). *Pengaruh Aplikasi Pupuk Hayati dan Pupuk NPK Terhadap Serapan Hara N, P, K dan Hasil Tanaman Padi (Oryza sativa L.)Varietas Inpari 32*. *12*(7), 446–453. http://repository.ub.ac.id/id/eprint/207797/

Pradana, I. K. W., Dwiyani, R., & Wirya, G. N. A. S. (2024). Pengaruh Penambahan Trichoderma Spp. pada Media Tanam Terhadap Pertumbuhan Bibit Pisang (Musa acuminata) Cavendish Hasil Kultur Jaringan. *Agro Bali : Agricultural Journal*, *7*(1), 205–211. https://doi.org/10.37637/ab.v7i1.1568

Pramitasari, H. E., Wardiyati, T., & Nawawi, M. (2016). Pengaruh Dosis pupuk Nitrogen dan Tingkat Kepadatan Tanaman terhadap Pertumbuhan dan Hasil Tanaman Sawi (Brassica juncea L.). *Jurnal Produksi Tanaman*, *4*(1), 49–56.

Purwanto, B.-, Indrawati, I.-, Sumadi, S., Nuraini, A.-, & Setiawati, M. R. (2022). Pemanfaatan Trichoderma harzianum dan biochar untuk mengatasi cekaman kekeringan pada kedelai fase reproduktif. *Jurnal AGRO*, *9*(2), 219–230. https://doi.org/10.15575/20684

Purwanto, B., Sumadi, Nuraini, A., & Setiawati, M. R. (2022). Effect of water content on conidia of Trichoderma spp., indole acetic acid content, electrical conductivity, and pH. *Biodiversitas*, *23*(5), 2553–2560. https://doi.org/10.13057/biodiv/d230536

Ramadhaini, R. F., Sudradjat, & Wachjar, A. (2014). Optimasi dosis pupuk majemuk NPK dan kalsium pada bibit kelapa sawit (Elaeis guineensis Jacq .) di pembibitan utama optimation of NPK and calcium fertilizer rates for the growth of oil palm (Elaeis guineensis Jacq .) seedling in main nursery. *J. Agron. Indonesia*, *42*(1), 52–58.

Sari, D. A., Kresnawati, I., Priyono, ., Budiani, A., & Santoso, D. (2019). Peningkatan Hasil Panen Kedelai (Glycine max L.) Varietas Wilis dengan Aplikasi Biostimulan Tanaman. *E-Journal Menara Perkebunan*, *87*(1), 1–10.

Sarman, S., Indraswari, E., & Husni, A. (2021). Respons Pertumbuhan Bibit Kelapa Sawit (Elaeis guineensis Jacq) Terhadap Decanter Solid dan Pupuk Phospor di Pembibitan Utama. *Jurnal Media Pertanian*, *6*(1), 14. https://doi.org/10.33087/jagro.v6i1.110

Simamora, A. V, Nenotek, P. S., Hahuly, M.

e-ISSN 2655-853X
https://doi.org/10.37637/ab.v8i2.2356

V, Ishaq, L. F., Widinugraheni, S. R. I., Kana, Y. R., Pasi, S. C. U., & Ola, A. R. B. (2025). *In vitro growth assessment of Trichoderma spp . from paddy rhizosphere on glyphosate- and fipronil-containing medium*. *26*(5), 2028–2038. https://doi.org/10.13057/biodiv/d260502

Sofian, K., Ryan Firman Syah, & Hastuti, P. B. (2022). Aplikasi Trichoderma Dan Mikoriza: Meningkatkan Pertumbuhan Bibit Kelapa Sawit Di Pre Nursery. *AGROISTA : Jurnal Agroteknologi*, *6*(1), 1–10. https://doi.org/10.55180/agi.v6i1.212

Syam, N., Hidrawati, Alimuddin, S., & Rijal, S. (2023). Growth and Development Responses of Soybean (Glycine max L.) Under Several Combinations of Inorganic and Organic Fertilizer. *Agrivita*, *45*(1), 79–86. https://doi.org/10.17503/agrivita.v45i1.3921

Tan, Z., Lin, C. S. K., Ji, X., & Rainey, T. J. (2017). Returning biochar to fields: A review. *Applied Soil Ecology*, *116*(September 2016), 1–11. https://doi.org/10.1016/j.apsoil.2017.03.017

Wahyudi, E., , Hulu, K. M., & Landak, K. (2025). *Pengaruh Bokashi dan Pupuk NPK Terhadap Pertumbuhan Kelapa Sawit di Pre Nursery*. 20–29.

Wahyuni, S. H., & Nasution, D. P. Y. (2019). Utilization of Trichoderma viride as organic fertilizer to induce the resistance of banana seeds on Fusarium oxysporum f.sp cubense (FOC). *IOP Conference Series: Earth and Environmental Science*, *260*(1). https://doi.org/10.1088/1755-1315/260/1/012149

Waruwu, F., Simanihuruk, B. W., Prasetyo, P., & Hermansyah, H. (2018). Pertumbuhan bibit kelapa sawit di pre nursery dengan komposisi media tanam dan konsentrasi pupuk cair azolla pinnata berbeda. *Jurnal Ilmu-Ilmu Pertanian Indonesia*, *20*(1), 7–12. https://doi.org/10.31186/jipi.20.1.7-12

Wu, L., Liu, M., & Rui Liang. (2008). Preparation and properties of a double-coated slow-release NPK compound fertilizer with superabsorbent and water-retention. *Bioresource Technology*, *99*(3), 547–554. https://doi.org/10.1016/j.biortech.2006.12.027