International Journal of Life Science and Agriculture Research

ISSN (Print): 2833-2091, ISSN (Online): 2833-2105

Volume 05 Issue 06 June 2026

DOI: https://doi.org/10.55677/ijlsar/V05I06Y2026-04

Impact Factor: 7.88 , Page No : 445-452

Effect of Npk Fertilizer and Rice Husk Charcoal Compost Mixture on the Growth of Oil Palm Seedlings (*Elaeis Guineensis* Jacq.) in the Main Nursery

Ety Rosa Setyawati[1], Githa Noviana[1], Boby Saputra Manurung[2]

[1]Lecturer at Institut Pertanian STIPER, Indonesia

[2]Student at Institut Pertanian STIPER, Indonesia

ABSTRACT

This study aimed to determine the effect of rice husk charcoal media dosage, NPK fertilizer dosage, and their interaction on the growth of oil palm seedlings in the main nursery stage. The research was conducted at the Educational and Research Plantation of Institut Pertanian STIPER located in Maguwoharjo Village, Depok District, Sleman Regency, Yogyakarta, Indonesia, at an altitude of 118 meters above sea level. The experiment was carried out from October 2025 to January 2026.

The study employed a Completely Randomized Design (CRD) consisting of two factors. The first factor was the dosage of rice husk charcoal growing media with three levels: 200 g/polybag, 250 g/polybag, and 300 g/polybag. The second factor was the dosage of NPK 16-16-16 fertilizer with three levels: 5 g/polybag, 7.5 g/polybag, and 10 g/polybag. Growth observation data were analyzed using Analysis of Variance (ANOVA). Significant differences among treatments were further tested using Duncan's Multiple Range Test (DMRT) at a 5% significance level.

The results showed a significant interaction effect on the fresh weight of oil palm seedlings, with the highest value of 40.60 g obtained from the combination of 200 g/polybag rice husk charcoal and 10 g/polybag NPK fertilizer. Rice husk charcoal dosage significantly affected stem diameter and leaf number, with the highest values of 19.97 mm and 6.75 leaves, respectively, obtained at 300 g/polybag. NPK fertilizer dosage significantly increased plant height and leaf number, with the highest values of 18.78 cm and 6.58 leaves, respectively, recorded at 10 g/polybag.

KEYWORDS: oil palm seedlings, main nursery, rice husk charcoal dosage, NPK fertilizer dosage

Published online: June 09, 2026

Cite the Article: Setyawati, E.R., Noviana, G., Manurung, B.S. (2026). Effect of Npk Fertilizer and Rice Husk Charcoal Compost Mixture on the Growth of Oil Palm Seedlings (Elaeis Guineensis Jacq.) in the Main Nursery. International Journal of Life Science and Agriculture Research, 5(6), 445-452.

https://doi.org/10.55677/ijlsar/V05I06Y2026-04

Corresponding Author:
Ety Rosa Setyawati

1. INTRODUCTION

Indonesia is the world's leading producer of palm oil. Oil palm (*Elaeis guineensis* Jacq.) has high economic value and contributes significantly to national foreign exchange earnings. Indonesia possesses more than 16.8 million hectares of oil palm plantations capable of producing approximately 50 million tons of palm oil annually (Paspi, 2024). According to the Ministry of Agriculture (2025), oil palm plantations in Indonesia are categorized into three sectors: State-Owned Plantations covering approximately 0.6 million hectares (3.4%), Private Plantations covering around 8.4 million hectares (51.3%), and Smallholder Plantations occupying approximately 6.8 million hectares (40.3%) of the total national oil palm plantation area. The expansion of plantation areas and replanting of old palms require the availability of high-quality seedlings in large quantities.

Oil palm seedling production generally consists of two stages: pre-nursery and main nursery. During the main nursery stage, seedlings that have completed the pre-nursery phase are transferred into larger polybags and maintained until they are ready for field planting. The quality of seedlings produced during the nursery stage strongly influences future plant growth and productivity.

At this stage, seedlings require balanced nutrients and suitable growing media to support optimal growth before transplanting to the field.

Nursery management plays an essential role in preparing high-quality planting materials; therefore, nursery practices must be properly managed. Soil used as a nursery medium often has sandy characteristics. Regosol soil is commonly used as a planting medium in oil palm nurseries. According to Hardjowigeno (2003), Regosol soil is classified as coarse-textured soil containing more than 60% sand. This soil type is characterized by high infiltration rates, low fertility, and susceptibility to erosion, making it less suitable as a planting medium. Regosol soil generally has loose structure, large pores, rapid permeability, and low water and nutrient retention capacity (Sarief, 1986). Consequently, the addition of organic matter is necessary to improve the physical properties of Regosol soil. Sutedjo (2002) stated that organic matter can bind soil particles and improve soil water-holding capacity.

Rice husk charcoal compost is produced through the decomposition of rice husks, which are agricultural waste materials derived from rice milling. Improper disposal of rice husks may create environmental problems; therefore, converting rice husks into compost provides an environmentally beneficial solution. Rice husk charcoal significantly influences the physical, chemical, and biological properties of soil. Besides improving growing media quality, nutrient availability also plays an important role in the growth of oil palm seedlings. Adequate nutrient availability significantly affects plant development. Rice husk charcoal compost enhances nutrient availability in the soil, thereby improving nutrient absorption efficiency by plant roots and stimulating plant growth (Ramadhan & Nasrul, 2022; Pane, Setyawati, & Firmansyah, 2022).

This study also examined the effect of NPK fertilizer on the growth of oil palm seedlings in the main nursery stage. NPK fertilizer contains nitrogen, phosphorus, and potassium, which are essential macronutrients required for vegetative growth, protein synthesis, and plant metabolic processes (Noggle & Fritz, 1979).

2. MATERIALS AND METHODS

Time and Location of the Study

This research was conducted at the Educational and Research Plantation of Institut Pertanian STIPER located in Maguwoharjo, Depok District, Sleman Regency, Yogyakarta, Indonesia. The study was carried out from October 2025 to January 2026.

Materials and Equipment

The equipment used in this study included sieves, measuring tapes, hoes, plastic materials, polybags measuring 35 cm × 35 cm, stationery, adhesive tape, and weighing scales. The materials used consisted of three-month-old oil palm seedlings, NPK 16-16-16 fertilizer, rice husk charcoal, and Regosol soil.

Experimental Design

The experiment employed a Completely Randomized Design (CRD) with two factors.

The first factor was the dosage of rice husk charcoal consisting of three levels:

- 200 g/polybag,
- 250 g/polybag,
- 300 g/polybag.

The second factor was the dosage of NPK 16-16-16 fertilizer consisting of three levels:

- 5 g/polybag,
- 7.5 g/polybag,
- 10 g/polybag.

Thus, a total of 3 × 3 = 9 treatment combinations were obtained. Each treatment combination was replicated four times, resulting in 36 experimental units.

The observed growth data were analyzed using Analysis of Variance (ANOVA). When significant differences were detected, further analysis was conducted using Duncan's Multiple Range Test (DMRT) at a 5% significance level.

3. RESULTS AND DISCUSSION

The results showed that the interaction between rice husk charcoal media dosage and NPK fertilizer dosage significantly affected the fresh weight of oil palm seedlings in the main nursery stage. Table 1 presents the effect of the combined treatments of rice husk charcoal dosage and NPK fertilizer dosage on the fresh weight of oil palm seedlings.

Table 1. Effect of Rice Husk Charcoal Media and NPK Fertilizer Dosages on Fresh Weight of Oil Palm Seedlings in the Main Nursery

Rice Husk Charcoal Dosage (g/polybag)	**NPK Fertilizer Dosage (g/polybag)**			
	5	7.5	10	Mean
200	16.43 c	20.80 bc	40.60 a	25,94
250	33,98 ab	25,83 abc	28,25 abc	29.35
300	30.28 abc	34,98 ab	35.18 ab	33.48
Rata-rata	26,90	27.20	34,68	(+)

Note: Means followed by the same letter within the same row or column are not significantly different according to Duncan's Multiple Range Test (DMRT) at the 5% significance level.
(+) = Significant interaction occurred.

The ANOVA results revealed a significant interaction between rice husk charcoal dosage and NPK fertilizer dosage on the fresh weight parameter of oil palm seedlings. The best treatment combination was obtained from 200 g/polybag rice husk charcoal combined with 10 g/polybag NPK fertilizer, producing the highest fresh weight value of 40.60 g. This result was not significantly different from the treatments using 250 g/polybag and 300 g/polybag rice husk charcoal combined with all NPK fertilizer dosages. The findings indicate that the combination of 200 g/polybag rice husk charcoal and 10 g/polybag NPK fertilizer created optimal growing media conditions while simultaneously supplying sufficient nutrients for oil palm seedling growth, thereby enhancing biomass accumulation. Fresh weight is an important indicator of seedling growth because it reflects the total accumulation of water, nutrients, and photosynthates stored within plant tissues. Higher fresh weight values indicate better vegetative growth performance. The increase in seedling fresh weight under the combined rice husk charcoal and NPK fertilizer treatments was attributed to the synergistic effect between improved physical soil properties and enhanced nutrient availability. Rice husk charcoal at 200 g/polybag improved the structure of the planting medium by increasing porosity, looseness, and aeration. These conditions promoted better root development, allowing more efficient water and nutrient uptake. Furthermore, rice husk charcoal enhanced the water-holding capacity of the medium, ensuring sufficient water availability during seedling growth. Improved media conditions accelerated physiological processes, particularly photosynthesis and new tissue formation.

Meanwhile, the application of 10 g/polybag NPK fertilizer provided adequate nitrogen (N), phosphorus (P), and potassium (K) to support vegetative growth. Nitrogen plays an important role in chlorophyll and protein formation, phosphorus supports root development and energy transfer, while potassium regulates plant metabolism and photosynthate translocation. Balanced nutrient availability increased biomass formation, resulting in greater fresh weight accumulation.

The combination of 200 g/polybag rice husk charcoal and 10 g/polybag NPK fertilizer was considered the most balanced treatment in terms of growing media quality and nutrient sufficiency. Insufficient rice husk charcoal application may not optimally improve soil physical properties, whereas excessive application could make the medium excessively porous and reduce nutrient retention capacity. Similarly, appropriate NPK fertilizer application can optimize seedling growth without causing nutrient imbalance.

These results suggest that the use of organic material in the form of rice husk charcoal combined with inorganic NPK fertilizer can serve as an effective and efficient nursery management technology in oil palm main nurseries. This combination improved seedling quality through increased fresh biomass accumulation, resulting in more vigorous seedlings with better potential for field establishment.

Under low NPK fertilizer application rates (5 g/polybag), optimal plant growth could only be achieved when combined with higher rice husk charcoal dosages of 250 g/polybag and 300 g/polybag. This condition indicates that adequate aeration provided by rice husk charcoal is necessary to maximize the efficiency of nutrient utilization from NPK fertilizer. In addition, rice husk charcoal contains silica, which is beneficial for plant growth (Indah, 2025). These findings suggest that planting media composition creates favorable root zone conditions that support maximum nutrient uptake.

According to Hickman and Whitney (2000), soil amendments are materials capable of improving the physical and chemical properties of soil. Sinaga (2010) reported that the addition of soil amendments promotes the formation of soil pores that facilitate root penetration and growth. Rice husk charcoal application can increase soil pH, improve phosphorus availability, and enhance soil water-holding capacity. Wahyudi, Susana, and Zulfita (2023) demonstrated that rice husk charcoal application at 25 tons/ha produced the best growth and yield of mung bean plants cultivated on Red Yellow Podzolic soil.

Soil analysis conducted before the experiment showed an initial soil pH of 5.38. After rice husk charcoal application, soil pH increased to 6.4–6.6 based on pH meter measurements. Rice husk charcoal also improved soil chemical properties by increasing nutrient availability. According to Indah (2025), rice husk charcoal contains organic carbon (39.15%), nitrogen (0.63%), phosphorus (0.50%), potassium (0.64%), calcium (0.11%), and magnesium (0.10%). Jumini *et al*. (2011) stated that nitrogen, phosphorus, and potassium are essential nutrients and major limiting factors for plant growth. Increasing N, P, and K concentrations in the soil directly supports vegetative development and chlorophyll formation, thereby enhancing photosynthesis and plant growth, including stem, root, and leaf development.

The lowest fresh weight value (16.43 g) was recorded in the combination treatment of 200 g/polybag rice husk charcoal and 5 g/polybag NPK fertilizer. Under low dosages of both NPK fertilizer and rice husk charcoal, nutrient availability was insufficient to meet plant requirements, particularly under conditions of low soil organic matter and poor soil porosity. Nitrogen deficiency reduces leaf and vegetative growth, while phosphorus and potassium limitations inhibit new tissue formation and metabolic efficiency. These conditions directly reduce seedling biomass accumulation (Zuliati *et al.*, 2023).

The analysis of variance also showed that rice husk charcoal dosage significantly affected stem diameter and leaf number, as presented in Table 2.

Table 2. Effect of Rice Husk Charcoal Dosage on the Growth of Oil Palm Seedlings in the Main Nursery

Parameters	**Rice Husk Charcoal Dosage (g/polybag)**		
	200	250	300
Plant height increment (cm)	15.40 a	15.58 a	16,97 a
Stem diameter increment (mm}	15,68 b	16,64 b	19,97 a
Leaf number increment (leaves)	5,67 b	5,83 b	6,75 a
Leaf area (cm^2)	62,25 a	64,61 a	70.19 a
Shoot dry weight (g)	8.30 a	8,93 a	9.07 a
Root fresh weight (g)	14.56 a	14,93 a	15.30 a
Root dry weight (g)	4,95 a	5.09 a	5,25 a
Leaf chlorophyll content (mg/cm^2)	49,26 a	50,59 a	54.09 a

Note : Means followed by the same letter within the same row are not significantly different according to Duncan's Multiple Range Test (DMRT) at the 5% significance level.

Rice husk charcoal dosage significantly affected stem diameter and leaf number, with the highest values of 19.97 mm and 6.75 leaves obtained at 300 g/polybag, respectively (Table 2}. The application of rice husk charcoal up to 300 g/polybag positively influenced stem diameter and leaf number growth in oil palm seedlings during the main nursery stage. These findings indicate that rice husk charcoal improved the physical condition of the planting media, thereby supporting optimal vegetative growth.

Stem diameter and leaf number are important indicators of oil palm seedling quality because they are closely associated with seedling vigor and adaptability after field transplantation. Increased stem diameter under rice husk charcoal treatment was likely due to improved soil looseness, porosity, and aeration. Rice husk charcoal possesses a lightweight and porous structure that enhances soil pore spaces, facilitating root absorption of water and nutrients. Optimal nutrient uptake improves cell division and enlargement processes within stem tissues, resulting in greater stem diameter development. Additionally, rice husk charcoal improved the water-holding capacity of the growing medium, ensuring sufficient water availability during the seedling growth period.

The increase in leaf number at 300 g/polybag indicates that rice husk charcoal supported photosynthesis and vegetative organ formation. Improved nutrient availability resulting from enhanced physical and chemical soil properties promoted chlorophyll formation and increased photosynthetic activity. Enhanced photosynthesis produced greater photosynthate accumulation for new leaf formation. Furthermore, the more porous growing medium improved root development, thereby enhancing nitrogen uptake as the primary nutrient responsible for leaf formation.

The highest dosage treatment demonstrated that optimal rice husk charcoal application improved soil physical properties, particularly soil porosity. Improved soil aeration supported root system development and enhanced nutrient absorption efficiency. Consequently, the planting medium became looser and less compact, allowing plant physiological activities to proceed more efficiently (Maulana et al., 2023). Rice husk charcoal contains SiO_2 (52%), C (31%), K (0.3%), N (0.18%), P (0.08%), and Ca (0.14%), as well as CaO, MnO, and Cu (Indah, 2025). These components positively improve soil physical and chemical characteristics, ultimately enhancing stem and leaf tissue formation. Increased leaf number also contributes to higher photosynthetic capacity.

The growth response of oil palm seedlings to rice husk charcoal dosage demonstrates that organic matter content within the growing medium is a key factor determining seedling vigor during the main nursery stage. Dosages of 200–250 g/polybag were considered insufficient to create optimal media conditions, resulting in relatively lower stem diameter and leaf number. In contrast, the 300 g/polybag dosage provided a better balance between aeration, moisture retention, and nutrient availability, as reflected in the simultaneous improvement of stem and leaf growth (Maulana *et al*., 2023).

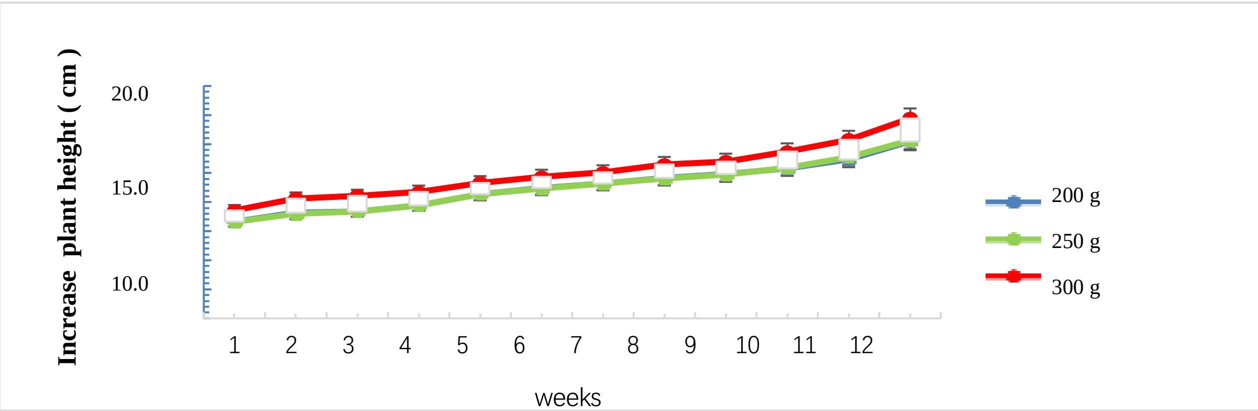

Figure 1. Effect of Rice Husk Charcoal Dosage on the increase in plant height (cm) on weeks of Oil Palm Seedlings in the Main Nursery

The application of rice husk charcoal at dosages of 200, 250, and 300 g/polybag showed similar effects from the initial observation until the twelfth week of observation (Figure 1). However, at the twelfth week, the treatment with 300 g/polybag showed a difference, with an increase of 13.00% compared with the treatment of 200 g/polybag.

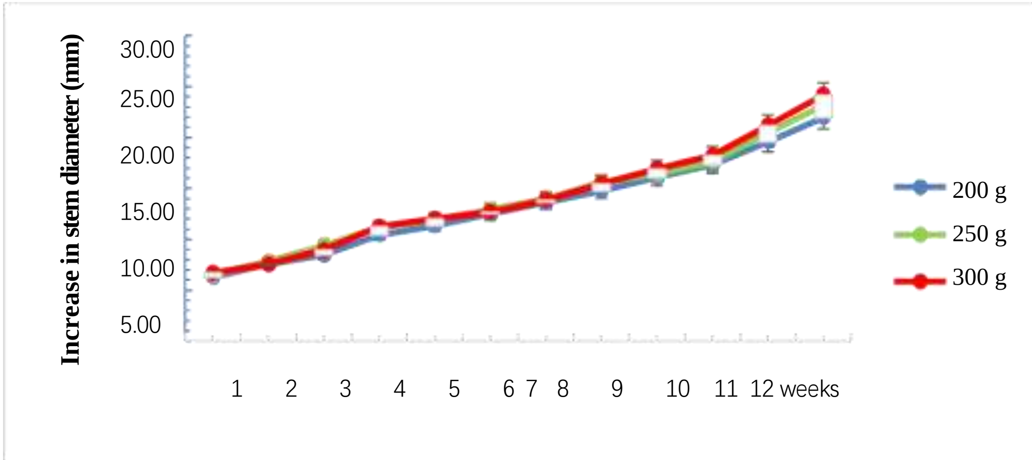

Figure 2. The effect of rice husk charcoal dosage to increase in stem diameter (mm) on weeks of palm oil seedling in main nursery.

The application of rice husk charcoal growing media at dosages of 200, 250, and 300 g/polybag resulted in relatively similar increases in stem diameter from the first until the twelfth week of observation (Figure 2). However, at the twelfth week of observation, the treatment with 300 g/polybag showed an increase of 10.16% compared with the 200 g/polybag treatment.

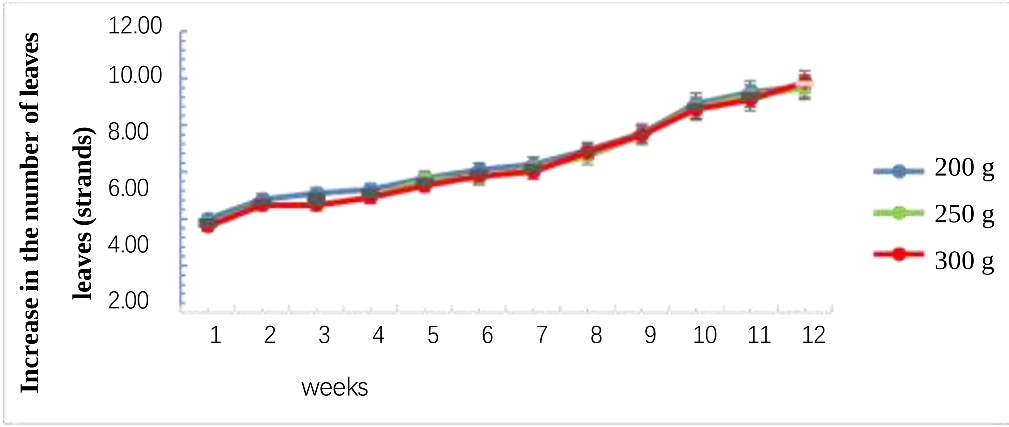

Figure 3. The effect of rice husk charcoal dosages to increase in the number of leaves on weeks of palm oil seedling in main nursery.

The application of rice husk charcoal growing media at dosages of 200, 250, and 300 g/polybag resulted in relatively similar increases in leaf number during the twelve weeks of observation (Figure 3). However, at the final observation, the treatment with 300 g/polybag showed an increase of 2.61% compared with the treatment of 200 g/polybag.

Table 3 presents the effect of NPK fertilizer dosage on the growth of oil palm seedlings in the main nursery stage.

Table 3. Effect of NPK Fertilizer Dosage on the Growth of Oil Palm Seedlings in the Main Nursery

Parameters	**NPK Fertilizer Dosage (g/polybag)**		
	5	7.5	10
Plant height increment (cm)	13,98 q	15.18 q	18,78 p
Stem diameter increment (mm)	16.11 p	17,92 p	18.25 p
Leaf number increment (leaves)	5.58 q	6.08 pq	6.58 p
Leaf area (cm²)	60,69 p	63,65 p	72,72 p
Shoot dry weight (g)	8.08 p	8.47 p	9,75 p
Root fresh weight (g)	13.52 p	13,66 p	17.60 p
Root dry weight (g)	4.59 p	4,98 p	5,73 p
Leaf chlorophyll content (mg/cm²)	50,00 p	53.33 p	50.60 p

Note : Means followed by the same letter within the same row are not significantly different according to Duncan's Multiple Range Test (DMRT) at the 5% significance level.

Table 3 shows that NPK fertilizer dosages of 5, 7.5, and 10 g/polybag significantly affected plant height increment and leaf number increment. The highest values were obtained at the dosage of 10 g/polybag, with plant height increment reaching 18.78 cm and leaf number increment reaching 6.58 leaves.

The application of NPK fertilizer significantly improved plant height and leaf number of oil palm seedlings in the main nursery stage. Higher fertilizer dosages resulted in greater plant height and leaf number increments, indicating that the availability of essential macronutrients such as nitrogen (N), phosphorus (P), and potassium (K) was more adequate to support vegetative growth. Nitrogen plays an important role in cell elongation and enlargement, while phosphorus supports cell division and root system development (Shabnam & Iqbal, 2016). Potassium functions in regulating plant metabolism and photosynthate translocation (Sustr et al., 2019). The combination of these three nutrients supplied through 10 g/polybag NPK fertilizer increased photosynthetic activity and biomass accumulation, thereby promoting optimal plant height growth (Saputra, 2024).

Nitrogen is a major component of amino acids, proteins, nucleic acids (DNA/RNA), and chlorophyll. Its fundamental role makes nitrogen essential for promoting vegetative growth, including leaf, stem, and shoot development, as well as optimizing photosynthesis and enzyme formation. Phosphorus functions as a center for energy storage and transfer in the form of ATP and stimulates root growth. Potassium acts as a regulator of metabolic processes. It also plays an important role in stomatal opening and closing for water-use efficiency, activates various enzymes, and assists in the transport of photosynthates throughout plant tissues (Noggle & Fritz, 1979).

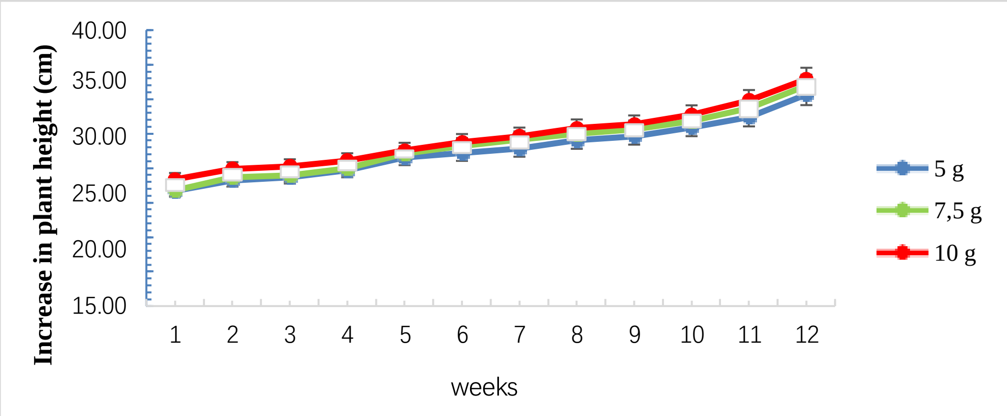

Figure 4. The Effect of NPK dosage on the Increase in plant height on weeks on oil palm seedling in Main nursery.

The application of NPK fertilizer at dosages of 5, 7.5, and 10 g/polybag resulted in relatively similar increases in plant height from the first until the twelfth week of observation (Figure 4). However, at the twelfth week of observation, the treatment with 10 g/polybag increased plant height by 7.27% compared with the treatment of 5 g/polybag.

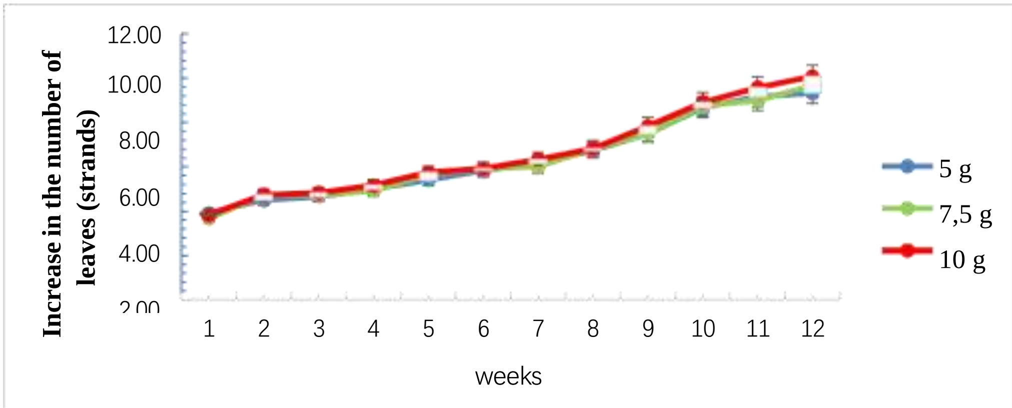

Figure 5. The Effect of NPK dosage on the increase in the number of leaves on weeks on oil palm seedling in main nursery.

The application of NPK fertilizer at dosages of 5, 7.5, and 10 g/polybag resulted in relatively similar increases in leaf number from the first until the twelfth week of observation (Figure 5). However, at the twelfth week of observation, the treatment with 10 g/polybag showed an increase of 8.04% compared with the treatment of 5 g/polybag.

Analysis of soil N, P, and K contents before the application of rice husk charcoal and NPK fertilizer is presented in Table 4.

Table 4. Analysis of Soil NPK Nutrient Content Before the Experiment

Analysis Parameters	**Results**
Nitrogen (mg/kg)	643.84
Phosphorus (mg/kg)	65.36
Potassium (mg/kg)	265.57

Analysis Parameters	Results
Moisture Content (%)	0.05

Source: Primary data (2026)

The results presented in Table 4 indicate that before treatment application, the soil contained nitrogen at 643.84 mg/kg, phosphorus at 65.36 mg/kg, potassium at 265.57 mg/kg, and moisture content of 0.05%.

CONCLUSION

1. Rice husk charcoal dosage and NPK fertilizer dosage showed a significant interaction effect on seedling fresh weight, with the highest value of 40.60 g obtained from the combination of 200 g/polybag rice husk charcoal and 10 g/polybag NPK fertilizer.
2. Rice husk charcoal dosage significantly affected stem diameter and leaf number increment, with the highest values obtained at the dosage of 300 g/polybag.
3. NPK fertilizer dosage significantly affected plant height increment and leaf number increment, with the highest values obtained at the dosage of 10 g/polybag.

REFERENCES

1. Hardjowigeno, S. (2003). *Soil classification and pedogenesis*. Jakarta, Indonesia: Akademika Pressindo.
2. Hickman, J. S., & Whitney, D. A. (1990). *Soil conditioners*. Department of Agronomy, Kansas State University, North Central Regional Extension Publication 295.
3. Indah, K. (2025). *Rice husk charcoal nutrient content*. Retrieved February 19, 2025, from Mitra Bertani
4. Jumini, Nurhayati, & Murzani. (2011). Effect of combined NPK fertilizer and fertilization methods on the growth and yield of sweet corn. *Jurnal Floratek, 6*, 156–170.
5. Kementerian Pertanian Indonesia. (2023). *National superior plantation statistics 2021–2023: Palm oil*. Jakarta, Indonesia: Directorate General of Plantations.
6. Maulana, T. Y., Sugiono, D., & Rahayu, Y. S. (2023). Effect of rice husk charcoal planting media composition on the growth of oil palm seedlings (*Elaeis guineensis* Jacq.) DxP Yangambi variety in pre-nursery. *Jurnal Agroplasma, 10*(2), 527–534.
7. Noggle, G. R., & Fritz, G. J. (1979). *Introductory plant physiology*. Englewood Cliffs, NJ: Prentice Hall International.
8. Pane, T. R. S., Setyawati, E. R., & Firmansyah, E. (2022). Growth response of oil palm seedlings (*Elaeis guineensis* Jacq.) in pre-nursery to rice husk charcoal composition and phosphate fertilizer dosage. *AGROFORETECH, 1*(2), 478–486.
9. Paspi. (2024). *Indonesian oil palm plantation area*. Retrieved May 25, 2025, from Palm Oil Indonesia Analysis
10. Ramadhan, S., & Nasrul, B. (2022). Growth of oil palm seedlings (*Elaeis guineensis* Jacq.) with the application of NPK fertilizer and rice husk compost on Inceptisol media. *Jurnal Agrotech, 6*(1), 112–122.
11. Saputra, K. A. (2024). Application of Ketapang leaf POC NPK and Phonska fertilizer in oil palm (*Elaeis guineensis* Jacq.) pre-nursery. *Dinamika Pertanian, 40*(2), 161–172.
12. Sarief, S. E. (1986). *Agricultural soil science*. Bandung, Indonesia: Pustaka Buana.
13. Shabnam, R., & Iqbal, M. T. (2016). Understanding phosphorus dynamics in wheat plants under split-root systems in alkaline soil. *Brazilian Journal of Science and Technology, 3*(1), 19.
14. Sinaga. (2010). *Effect of rice husk charcoal and grass charcoal addition*. Retrieved January 5, 2023, from USU Repository
15. Suprianto, A. A., Alridiwirsah, A., Siregar, M. S., & Tarigan, D. M. (2024). Optimization of oil palm seedling growth in the main nursery through the utilization of rice husk biochar and NPK fertilizer on low nitrogen soil. *Jurnal Agrium, 26*(1), 5428–5437.
16. Sustr, M., Soukup, A., & Tylova, E. (2019). Potassium in root growth and development. *Plants, 8*(10), 435.
17. Sutedjo, M. M. (2002). *Fertilizers and their application methods*. Jakarta, Indonesia: Rineka Cipta.
18. Wahyudi, D., Susana, R., & Zulfita, D. (2023). Effect of rice husk charcoal on the growth and yield of mung bean on Red Yellow Podzolic soil. *Jurnal Pertanian Agros, 25*(2), 1299–1307.
19. Zuliati, S., Jamidi, J., Nazaruddin, M., & Irmawan, I. (2023). Improving oil palm seedling growth (*Elaeis guineensis* Jacq.) in pre-nursery through biochar and NPK fertilizer application. *Jurnal Agrium, 20*(4), 356–363.