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The Effect of Controlled Release Fertilizer On The Growth of Oil Palm (*Elaeis Guineensis* Jacq.) Seedlings In The Pre-Nursery

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ABSTRACT

Improving oil palm production can be achieved through better cultivation management, including proper nursery practices. The quality of seedlings at the early growth stage plays a crucial role in determining field performance, making efficient fertilization essential from the pre-nursery phase. One of the fertilization technologies developed to improve nutrient uptake efficiency is the application of Controlled Release Fertilizer (CRF). This study aimed to evaluate the effect of CRF compared with conventional NPK fertilizer on the growth of oil palm seedlings. The experiment was conducted for three months using a Completely Randomized Design (CRD) with four treatments: no fertilizer (P0), NPK (P1), NPK + CRF (P2), and CRF (P3). Data were analyzed using ANOVA at a 5% significance level, followed by the LSD test when significant differences were detected. The results showed that treatments P2, P3, and P4 produced better growth responses than the control in all observed parameters, including plant height, number of leaves, leaf greenness, stem diameter, and leaf area. Fertilizer application significantly improved seedling growth, while CRF, either applied alone or in combination with NPK, produced growth responses comparable to conventional fertilization. These findings indicate that CRF has the potential to be used as an effective fertilization alternative to support oil palm seedling growth in the pre-nursery.

Keywords: oil palm, Controlled Release Fertilizer (CRF), pre-nursery.

1. INTRODUCTION

Oil palm (*Elaeis guineensis* Jacq.) is an important source of vegetable oil and plays a major role in Indonesia's plantation sector. This crop produces higher volumes of oil compared with other vegetable oil sources such as soybean, olive, coconut, and sunflower (Sirait, 2021). In 2019, the total area of oil palm plantations in Indonesia reached approximately 14.60 million hectares. Although Indonesia is recognized as the world's largest producer of palm oil, the average productivity at the plantation level remains around 4 ton/ha per year, well below its maximum potential of about 8.5 tons per hectare (Sukmawan *et al*., 2022). This gap indicates the need for improved cultivation practices, including better nursery management, to enhance overall productivity.

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The nursery phase is crucial for producing healthy seedlings capable of optimal growth in the field. Oil palm seedlings are generally raised in two stages: the pre-nursery stage for about three months and the main nursery stage for 9–10 months. Seedlings are transferred from the pre-nursery to the main nursery when they are approximately three months old and have developed four to five leaves (Riniarti & Utoyo, 2024). Seedling quality at this early stage plays a crucial role in determining the plant's ability to grow and develop properly after being transplanted to the field (Hartatik & Wibowo, 2018).

Fertilization is a key factor in supporting seedling growth, both in the nursery and in the field. In the pre-nursery stage, fertilization typically involves periodic application of compound NPK fertilizers through watering. However, fast-soluble inorganic fertilizers such as urea have limitations, as nutrients are easily lost through leaching, surface runoff, and volatilization (Kautsar *et al*., 2023). Nitrogen-use efficiency from such fertilizers is relatively low, reported at only 20–31%, meaning that only a small portion of the applied nutrients is absorbed by plants. These inefficiencies not only increase fertilizer demand and production costs but also pose environmental risks and may negatively affect soil quality (Mohammad *et al.*, 2021).

To address these issues, Controlled Release Fertilizer (CRF) has been developed as an improved fertilization technology. CRF is designed to release nutrients gradually and more in line with plant uptake, thereby reducing fertilization frequency and minimizing nutrient losses (Sirait, 2021). The use of CRF has been reported to enhance fertilizer-use efficiency and may reduce application rates by 40–50% compared with conventional fertilizers. In the pre-nursery stage, CRF is considered beneficial for supporting early seedling development (Apriyanto *et al*., 2020). Therefore, this study aims to evaluate the effectiveness of CRF compared with conventional NPK fertilizer on the growth of oil palm seedlings in the pre-nursery phase.

2. RESEARCH METHOD

Time and Location of Research

The research was conducted from August to October 2025 at the oil palm nursery experimental field of Politeknik Negeri Lampung, Bandar Lampung, Lampung.

Research Design

The experiment was arranged using a Completely Randomized Design (CRD) with four treatments: P0 (Control), P1 (NPK), P2 (NPK + CRF), and P3 (CRF) (Table 1). The experiment was replicated seven times. Data were analyzed using ANOVA at a 5% significance level. If

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significant differences were observed, LSD tests were performed to determine differences between treatments.

Table 1. Treatments on the the effect of controlled release fertilizer on the growth of oil palm (*Elaeis guineensis* Jacq.) seedlings in the pre-nursery.

Treatment	Description	Type of Fertilizer	Dosage
P0	Control	No fertilizer	0 g/seedling
P1	NPK	NPK 16:16:16	0.5 g/seedling (applied weekly)
P2	NPK + CRF	NPK 16:16:16 + CRF	- 0.5 g/seedling (applied weekly) - CRF: 5 g/seedling (*single application*)
P3	CRF	CRF	5 g/seedling (*single application*)

The planting media was prepared and filled into pre-nursery polybags, and oil palm seedlings were transplanted into the polybags containing the media. NPK fertilizer (P1) was applied periodically through watering on a weekly basis according to the standard recommended dose for pre-nursery. CRF fertilizer was applied using a single application method by embedding the fertilizer into the planting media at an appropriate depth (approximately 5–7 cm) and at a sufficient distance from the base of the stem at the time of initial planting. Maintenance was carried out by watering once daily to maintain media moisture, manually weeding, and controlling pests and diseases as needed.

The observed variables included number of leaves, plant height, leaf greenness, stem diameter, and leaf area. The number of leaves was recorded at the end of the study (12 weeks after planting/WAP) by counting all leaves that emerged from planting until the end of the experiment. Plant height was measured from the base of the stem to the tip of the highest leaf at 12 WAP. Leaf greenness was assessed using the chlorophyl meter (SPAD) at 12 WAP. Stem diameter was measured at the base using a caliper at 12 WAP, while leaf area was determined using ImageJ software at 12 WAP.

3. RESULTS AND DISCUSSION

Number of Leaves

The results of this study indicated that fertilizer application had a significant effect on the number of leaves of oil palm seedlings during the pre-nursery phase (Table 2). The unfertilized treatment (P0) produced the lowest number of leaves (2.9 leaves), which was significantly different from the P1 (3.9 leaves), P2 (4.1 leaves), and P3 (4.0 leaves) treatments. The three fertilizer

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treatments did not differ significantly from each other, but all were significantly higher than the control (P0).

The increase in leaf number in seedlings receiving CRF or the NPK+CRF combination suggests that a stable and sustained nutrient supply can enhance vegetative organ development. According to Pradana *et al*. (2021), CRF improves leaf growth in oil palm seedlings due to more efficient and gradual nutrient release. CRF increased leaf formation in shallot seedlings due to a more consistent nutrient supply compared to conventional fertilizers (Finalis *et al.*, 2024).

Tabel 2. Effect of controlled release fertilizer and NPK on the number of leaves of oil palm seedlings (*Elaeis guineensis* Jacq.)

Treatment	Number of Leaves
P0	2,9 a
P1	3,9 b
P2	4,1 b
P3	4,0 b
LSD 5% = 0,4815	

Noted: Numbers followed by different letters indicate significant differences according to LSD 5%.

Plant Height

Plant height increased significantly in response to fertilizer application (Table 3). The unfertilized treatment or control (P0) produced the shortest seedlings, with an average height of 19.40 cm. The three fertilizer treatments did not differ significantly from one another, but all were significantly higher than the control (P0). The NPK+CRF treatment (P2) showed the highest mean height of 23.71 cm.

The higher value observed in the NPK+CRF treatment indicates a potential synergy between readily available fertilizer (NPK) and slow-release fertilizer (CRF). According to Amanda *et al*. (2025), CRF maintains a more stable supply of N, P, and K, thereby promoting better plant height in rice. CRF contributes to greater height growth in oil palm seedlings compared to single fertilizer applications due to its consistent nutrient release (Pradana *et al.*, 2021).

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Tabel 3. Effect of controlled release fertilizer and NPK on the height of oil palm seedlings (*Elaeis guineensis* Jacq.)

Treatment	Plant Height (cm)
P0	19,40 a
P1	22,76 b
P2	23,71 b
P3	22,39 b
LSD 5% = 2,2494	

Noted: Numbers followed by different letters indicate significant differences according to LSD 5%.

Leaf Greenness

Fertilizer application had a significant effect on the leaf greenness of oil palm seedlings, as measured by SPAD values (Table 4). Seedlings in the control treatment (P0) exhibited the lowest SPAD value (26.13), whereas P1, P2, and P3 treatments showed a significant increase in leaf greenness compared to the control (P0). This increase reflects higher chlorophyll content in the leaves.

Leaf greenness is strongly influenced by nitrogen availability, which plays a key role in chlorophyll synthesis. Afriani & Cameron (2024) reported that increased nitrogen availability through fertilization in pre-nursery oil palm seedlings enhances leaf greenness and photosynthetic capacity. Moreover, the use of CRF has been shown to maintain a gradual nitrogen supply, thereby improving chlorophyll content in various cultivated crops (Finalis *et al.*, 2024).

Tabel 4. Effect of controlled release fertilizer and NPK on leaf greenness of oil palm seedlings (*Elaeis guineensis* Jacq.)

Treatment	Leaf Greenness
P0	26,13 a
P1	54,00 b
P2	53,11 b
P3	50,94 b
LSD 5% = 5,4768	

Noted: Numbers followed by different letters indicate significant differences according to LSD 5%.

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Stem Diamete

The stem diameter of oil palm seedlings increased significantly in response to fertilizer application (Table 5). Seedlings in the control treatment (P0) had the smallest stem diameter (5.34 mm), while P1, P2, and P3 treatments showed significantly greater diameters compared to the control (P0). The increase in stem diameter indicates that a stable supply of phosphorus (P) and potassium (K) supports the development of structural tissues, thereby strengthening the stem. These results confirm that CRF plays an important role in supporting optimal structural growth in plants.

Tabel 5. Effect of controlled release fertilizer and NPK on stem diameter of oil palm seedlings (*Elaeis guineensis* Jacq.)

Treatment	Stem Diameter (mm)
P0	5,34 a
P1	7,11 b
P2	7,39 b
P3	`6,37 b
LSD 5% = 1,0282	

Noted: Numbers followed by different letters indicate significant differences according to LSD 5%.

Leaf Area

Leaf area responded positively to fertilizer application (Table 6). The CRF treatment (P3) produced the largest leaf area (61.546 cm²), which was significantly different from the control (P0) but not significantly different from the NPK (P1) and NPK+CRF (P2) treatments.

CRF is considered effective in increasing leaf area because its controlled nutrient release supports optimal leaf tissue development. According to Pradana *et al.* (2021), CRF significantly enhances leaf area in oil palm seedlings compared to conventional fertilizers. Similar findings were reported in rice and shallot, where CRF improved leaf expansion and photosynthetic capacity (Finalis *et al.*, 2024).

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Tabel 6. Effect of controlled release fertilizer and NPK on leaf area of oil palm seedlings (*Elaeis guineensis* Jacq.)

Treatment	Leaf Area (cm^2)
P0	47,864 a
P1	49,534 ab
P2	57,311 ab
P3	61,546 b
LSD 5% = 12,6298	

Noted: Numbers followed by different letters indicate significant differences according to LSD 5%.

The results of this study indicate that fertilization, whether using NPK, CRF, or a combination of NPK+CRF, had a positive and significant effect on all growth variables of oil palm seedlings during the pre-nursery phase, including leaf number, plant height, leaf greenness, stem diameter, and leaf area. The control seedlings (P0) consistently showed the lowest values across all parameters, in contrast the P1 (NPK), P2 (NPK+CRF), and P3 (CRF) treatments significantly improved growth. These increases suggest that a stable nutrient supply, particularly of N, P, and K, supports vegetative organ formation, stem tissue development, and enhanced photosynthetic capacity. These findings are consistent with previous studies reporting that CRF can support oil palm seedling growth through consistent and gradual nutrient release, thereby influencing vegetative organ development, plant height, leaf greenness, stem diameter, and leaf area (Pradana *et al.*, 2021).

4. CONCLUSIONS

The results showed that treatments P2, P3, and P4 produced better growth responses than the control in all observed parameters, including plant height, number of leaves, leaf greenness, stem diameter, and leaf area. Fertilizer application significantly improved seedling growth, while CRF, either applied alone or in combination with NPK, produced growth responses comparable to conventional fertilization. These findings indicate that CRF has the potential to be used as an effective fertilization alternative to support oil palm seedling growth in the pre-nursery.

REFERENCES

Afriani, S. R., & Cameron, R. (2024). Aplikasi Beberapa Jenis Pupuk terhadap Pertumbuhan Bibit Kelapa Sawit pada Fase Pre-Nursery. *Jurnal Plantasimbiosa*. Vol. 6(2): 118-126.

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Amanda, A. P., Ramadhan, R. A. M., & Zahra, I. N. A. (2025). Pengaruh Controlled Release Fertilizer terhadap Tanaman Padi *(Oryza sativa* L.*)* dan Tanah di Tasikmalaya. *Agroscript Journal*. Vol. 7(1): 38-45.

Apriyanto, E., Sudjatmiko, S., Susatya, A., & Starsy, D. A. (2020). *The effect of fertilizer on bambang lanang (Michelia champaca* L.) *seedling growth in mesocarp fiber from oil palm media.* IOP Conference Series: Earth and Environmental Science. Vol. 533(1).

Finalis, E. R., Noor, I., Arfiana, A., Mulyono, A., & Suratno, H. (2024*).* Pengaruh Penggunaan Teknologi CRF pada Tanaman Bawang Merah. *Jurnal Teknologi Industri Pertanian.*Vol. 34(1): 21-27.

Hartatik, W., & Wibowo, H. (2018). Efektivitas Beberapa Jenis Pupuk N Pada Pembibitan Kelapa Sawit/Effectiveness of Several Types of N Fertilizer on Palm Oil Nursery. *Industrial Crops Research Journal*. Vol. 24(1): 29-38.

Kautsar, V., Gahara, M. H., & Aldymas, B. (2023). Respon bibit kelapa sawit terhadap aplikasi urea berlapis zeolit sebagai pupuk slow release nitrogen. *Jurnal Pengelolaan Perkebunan (JPP)*. Vol. 4(1), 1-7.

Mohammad, S. M. B., Yok, M. C. K., & Mohidin, H. B. (2021). Effect Of Slow-Release Fertilizer On Nitrogen And Phosphorus Contents in Immature Oil Palm *(Elaies guineensis)* in Sandy Coastal Soil. *International Journal of Agriculture, Forestry and Plantation*. Vol. 11: 56–62.

Pradana, A. R., Suwardi, & Suryaningtyas, D. T. (2021). *Pengaruh Pemberian Controlled Release Fertilizer CRF 13-6-27 terhadap Pertumbuhan Bibit Kelapa Sawit*. IPB University.

Riniarti, D., dan Utoyo, B. (2024). *Budidaya Tanaman Kelapa Sawit Edisi 2*. Wineka Media. Malang. 172 hlm.

Sirait, F. (2021). *Pengaruh Pupuk Controlled Release Dan Abu Janjang Kelapa Sawit terhadap Pertumbuhan Bibit Kelapa Sawit (Elaeis Guineensis* Jacq.) *Di Main Nursery*. Disertasi. Universitas Islam Riau.

Sukmawan, Y., Riniarti, D., & Pranandi, G. (2022). *The Effect of Irrigation Time and Slow-Release Fertilizer on Oil Palm Seedlings Under Controlled Drip Irrigation System.* IOP Conference Series: Earth and Environmental Science. Vol. 1012(1).

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