The effect of fertilizer variation doses input on seedlings of several oil palm varieties

Ikhwan Fadli Pangaribuan[1*], *Sri* Wening[1], *Dian Rahma* Pratiwi[1], *Cut* Mardiana[1], *Retno Diah* Setiowati[1], and *Eko Novandi* Ginting[1]

[1]Indonesian Oil Palm Research Institute, Medan, North Sumatera, Indonesia

Abstract. Oil palm has a high potential for nutrient use efficiency, meaning it can produce high yields with relatively low nutrient inputs compared to other crops. Nutrient use efficiency is significant for nutrient balance and supply, like Nitrogen (N) and Potassium (K), which are vital for oil palm growth and fruit production. Research includes breeding for traits that enhance nutrient uptake and utilization and developing new fertilizer formulations and application techniques. This research aimed to investigate the response of some oil palm genetic backgrounds to the application of fertilizer level. The study was organized using randomized block design with two factors: fertilizer dosage [0% (P0), 100% (P1), 75% (P2), and 50% (P3) of the recommended dosage], and plant material [populations 1-3 (V1-V3)], repeated six times. The treatment of providing fertilizer doses at 50% of the recommendation (P3) shows more efficient and positive effect in the oil palm seedling growth. Population V2, given the treatment of fertilizer doses at 50% of the recommendation (P3), shows more efficient and positive responses in the oil palm seedling growth.

1 Introduction

Indonesia is the biggest palm oil producer country. This country still has a lot of potential marginal land that can be developed [1]. On the one hand, it enjoys high demand owing to its expanding economic potential, but on the other hand, it encounters several challenges, particularly environmental issues. One adverse consequence of oil palm cultivation is soil and water quality degradation within oil palm plantations, primarily due to the accumulation of fertilizer residues.

Fertilizer needs in oil palm plantations account for 60% of the production costs [2]. Oil palms require sufficient nutrient intake to produce well. Key macro elements required by plants include Nitrogen (N), Phosphorus (P), Potassium (K), and Magnesium (Mg) [3]. Nitrogen is integral to protein composition and the structural formation of oil palm organs. However, in practice, nutrient loss still frequently occurs, mainly due to volatilization, leaching, and run-off, which results in low fertilization effectiveness [2].

Oil palm has a high potential for nutrient use efficiency, meaning it can produce high yields with relatively low nutrient inputs compared to other crops. Nutrient use efficiency is

* Corresponding author: ikhwanfadlip@gmail.com

significant for nutrient balance and supply, like Nitrogen (N) and Potassium (K), which are vital for oil palm growth and fruit production [4]. Nowadays, fertilizer costs are relatively high, and continuous research and development efforts in agronomy and genetics aim to improve nutrient efficiency in oil palm cultivation further is conducted. Study about breeding for traits that enhance nutrient uptake and developing new fertilizer formulations and application techniques was needed to address the issue of fertilization efficiency. Our study aimed to investigate the response of some oil palm genetic backgrounds to the application of fertilizer level.

2 Materials and Methods

The study was held in IOPRI nursery site in Marihat, North Sumatera from November 2022 – September 2023. This study was organized using a randomized block design with two factors: first is fertilizer dosage divided into 4 level (0% of recommended dosage (P0); 100% of recommended dosage (P1); 75% of recommended dosage (P2), and 50% of recommended dosage (P3). Second is plant material divided to 3 populations (V1, V2, and V3), repeated six times. The standard recommended dosage for fertilizer in nursery stage based on Indonesian Oil Palm Research Institute is 31.35 g Nitrogen (N), 31.35 g Phosphorus (P), 40,60 g Potassium (K), and 19,90 g Magnesium (Mg).

Oil palm seedlings subjected to nitrogen nutrient stress were observed 1 - 10 months after trans-planting (MAP). In the main nursery stage, sand is used as the planting medium. This treatment includes urea as a source of nitrogen (N), MoP as a source of potassium (K), TSP as a source of phosphorus (P), and Kieserit as a source of magnesium (Mg). The specific dose of nitrogen fertilizer is adjusted according to the prescribed treatments. Fertilizer application is carried out by evenly distributing each type of fertilizer on the polybags, following a predetermined fertilizer application schedule with a 30-minute interval after watering. Standard of seedling treatment follow the IOPRI's standard of seedling handling guidelines [5].

The observed morphological characteristics of the plants start from 1-10 MAP i.e plant height (measured from the base of the stem to the highest leaflet using a ruler), the number of leaves (measured by counting the leaves that are fully open), and stem diameter (measured by observing the diameter of the stem using a caliper). The statistic calculation was carried out using Rstudio.

3 Results

Based on the observation of oil palm seedling height from 1 to 10 months after planting (MAP) (Fig. 1), population V1 showed consistent growth under each fertilization treatment, except for P0 (no Nitrogen applied). Interestingly, population V2 that received treatment P3 (50% of the recommended fertilizer dose) exhibited the best height growth response compared to other treatments. The application of fertilizer with treatment P3 (50% of the recommended dose) showed the highest seedling height values among all other fertilizer dose treatments. Nitrogen is an essential nutrient that is closely related to the growth of stems, leaves, and photosynthesis in plants [4].

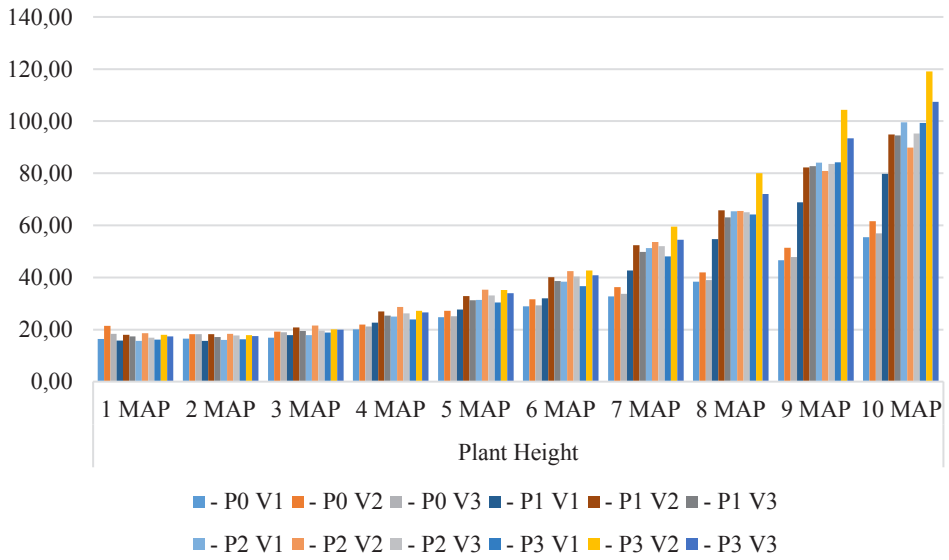

Fig 1. Plant height growth of oil palm seedlings from 1 – 10 months after trans-planting (MAP).

There is no real effect of fertilizer treatment and plant varieties on seedling height. Regarding the parameter of leaf number in oil palm seedlings (Fig. 2), the growth of each population appears quite consistent under each treatment. However, from the graphic, we can see that the application of 0% of the recommended Nitrogen fertilizer (P0) results in the lowest leaf number compared to other treatments. This indicates that Nitrogen greatly influences the increase and growth of oil palm leaves. Interestingly, in this study, the treatment with 50% of the recommended dose (P3) showed more leaf number as the 100% recommended dose (P1) across all populations. This suggests that the 50% dose could serve as a reference for more efficient fertilizer application during the seedling stage.

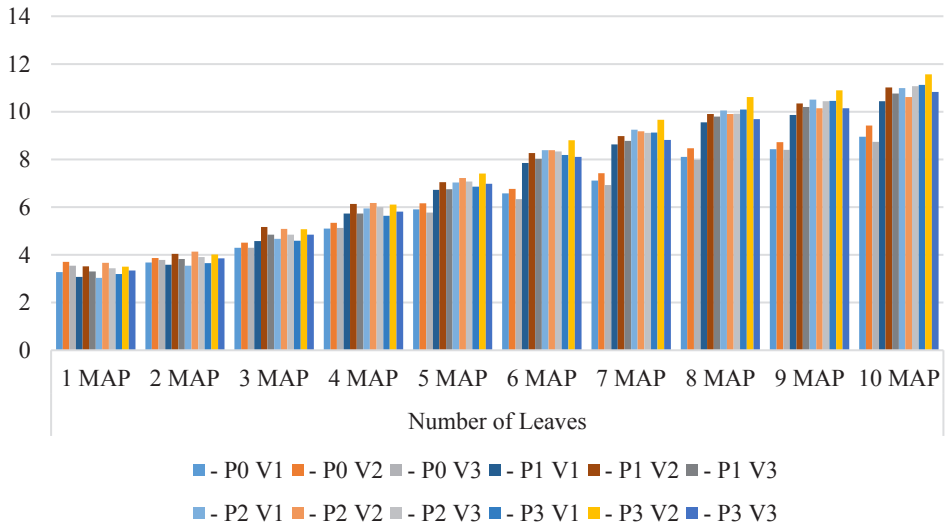

Fig 2. Leaves number growth of oil palm seedlings from 1 – 10 months after trans-planting (MAP).

In the observation of stem diameter growth in oil palm seedlings (Fig. 3), population V3 showed the largest stem diameter when given 75% of the recommended Nitrogen fertilizer dose. It was evident that the application of 0% of the recommended Nitrogen dose (P0) had the lowest impact on stem diameter growth. This indicates that Nitrogen also influences the thickening of oil palm seedling stems. It can be seen that the treatments with 75% of the recommended dose (P2) and 50% of the recommended dose (P3) resulted in greater stem diameter growth than the 100% recommended dose (P1) across all populations. This suggests that Nitrogen fertilizer application can be reduced to improve fertilizer use effeciency in the nursery stage.

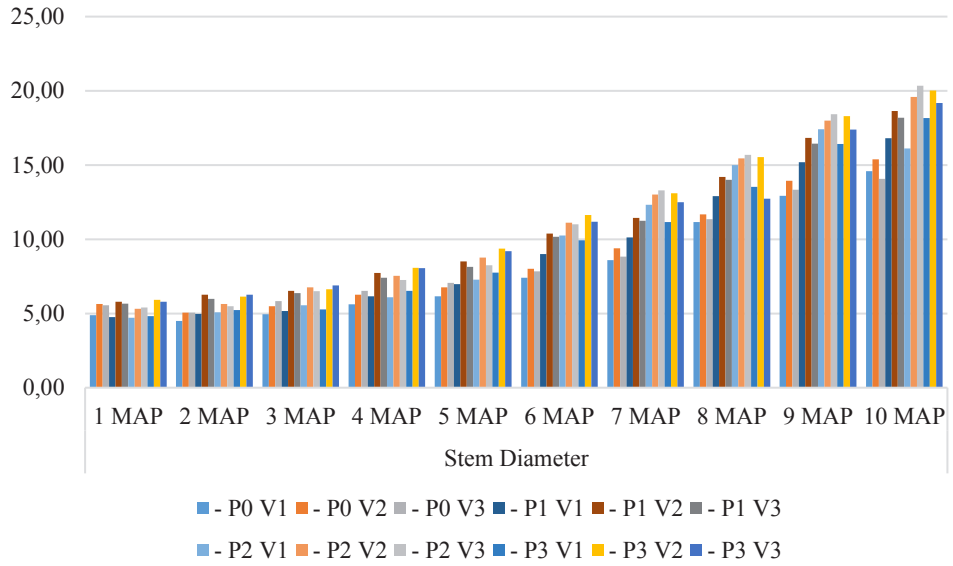

Fig 3. Stem diameter growth of oil palm seedlings from 1 – 10 months after trans-planting (MAP).

4 Discussion

Optimal seedling growth requires the right dosage and type of fertilizer. High-quality fertilizers provide the necessary nutrients for strong root development, healthy leaves, and overall vigorous growth [6]. The quality and type of fertilizer used significantly affect nutrient availability, ensuring that seedlings receive a balanced supply of essential elements such as nitrogen, phosphorus, and potassium. Therefore, selecting the appropriate dosage and type of fertilizer is crucial for supporting healthy and thriving seedling growth. Under nutrient-deficient conditions, plants often exhibit a significant drop in productivity, achieving just around 30% of their potential output [7]. This is because plants shift their resources away from growth-focused activities to prioritize survival. The nature of this stress response can differ based on the type of stress encountered and the particular plant species involved.

When plants face nutrient deficiency, their production can drop significantly, with productivity falling to only about 30% of their potential [8]. This reduction happens because plants shift their resources from growth-related activities to survival mechanisms. The response to stress varies depending on the type of stress and the specific plant species involved. For example, under drought stress, energy that would typically go to cell division, stem elongation, and biomass formation is redirected to root development, resulting in slower

growth. Conversely, in flood stress conditions, plants may elongate their stems as an adaptation to improve oxygen intake through structures like pneumatophores [9, 10].

Ensuring adequate fertilizer is essential for increasing the nitrogen available to oil palm seedlings, which is key to promoting optimal vegetative growth. Robust vegetative development allows seedlings to efficiently conduct metabolic processes, particularly photosynthesis, where the assimilates produced are converted into energy that fuels the vegetative growth process [11].

Oil palm seedling varieties vary in their metabolism and nutrient absorption abilities. Nutrient uptake is closely related to photosynthesis, which generates photosynthates that are transported from the leaves to other plant parts. Higher nutrient availability and more effective nutrient absorption lead to enhanced metabolic processes [12].

The impact of different treatments is expected to become more apparent once the plants are moved to the field. At this point, new oil palm seedling varieties will reveal how they respond to different treatments. Variations will be more evident in aspects such as average annual height, production potential, oil yield, CPO output, average bunch weight, and leaf stalk length. Each variety shows distinct growth and production responses due to genetic differences influenced by its parentage [13]. This study has demonstrated that applying Nitrogen (N) fertilizer at 50% of the recommended dose enhances morphological traits such as plant height, leaf number, stem diameter. Surprisingly, this approach proved more effective than applying 100% of the recommended N fertilizer dose. This study can be recommended to be continued and developed to identify effective selection traits point in different directions, like using a controlled system for early selection such a hydroponic selection [14] or conduct a detailed examination of the physiological mechanisms at the root level that facilitate continuous shoot growth [15]. This analysis should explore how root functions contribute to the sustained development of the shoot system, including nutrient uptake, water absorption, and hormone regulation. Understanding these root-level processes will shed light on how they support and sustain ongoing shoot growth [12].

5 Conclusions

In this study, population V2 showed better morphological responses than other populations in terms of plant height, leaf number, and stem diameter. The application of 50% of the recommended nitrogen fertilizer dose (P3) had the best impact across all treated populations. This treatment can be used as a reference for improving fertilizer use efficiency in oil palm seedlings. This study still needs to conduct deeper observations. Further research under more controlled conditions or deeper physiological observations are needed to strengthen the results of the related research.

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