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The Effect of Magnesium, Boron, and NPK Fertilizer on the Growth of Pre-Nursery Oil Palm (*Elaeis guineensis* Jacq)

Pengaruh Pupuk Magnesium, Boron, dan NPK terhadap Pertumbuhan Tanaman Kelapa Sawit Pra Pembibitan (*Elaeis guineensis* Jacq)

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ABSTRACT

Oil palm is one of Indonesia's main commodity plantation crops that can produce vegetable oil and this plant is consumptive of nutrients. This research aims to examine the effect of magnesium, boron, and NPK compound fertilizers and the interaction between magnesium, boron, and NPK compound fertilizers on the growth of oil palm seedlings. The research was conducted in February - May 2020 in a greenhouse with an altitude of 250 meters above sea level and the Laboratory of Ecology and Plant Production, Faculty of Animal and Agricultural Science, Diponegoro University. The research was conducted using a completely randomized design with a 4 × 4 factorial with 3 replications. The first factor is the provision of no fertilizer, magnesium fertilizer, boron fertilizer, and magnesium + boron fertilizers. The second factor is the NPK compound at a dose of 1.8, 2.8, 3.8, and 4.8 g/seedling. The results showed that magnesium + boron had a significant effect on the stem diameter and root length and the NPK compound at a dose of 3.8 g/seedling could increase the stem diameter, fresh and dry weight of the root. The interaction between magnesium + boron fertilizer and NPK compound fertilizer had no significant effect on the height of the seedlings, the number of leaves, stem diameter, length of the root, and fresh and dry weight of the root.

Keywords: *Oil palm seedling, growth, nutrients, fertilizer dose*

ABSTRAK

Kelapa Sawit adalah salah satu tanaman perkebunan komoditas andalan Indonesia yang dapat menghasilkan minyak nabati dan termasuk tanaman yang kosumtif terhadap unsur hara. Penelitian bertujuan untuk mengkaji pengaruh pupuk magnesium, boron, dan dosis pupuk NPK majemuk serta interaksi antara pemupukan magnesium, boron, dan pupuk dosis NPK majemuk terhadap pertumbuhan bibit kelapa sawit. Penelitian dilaksanakan pada bulan Februari – Mei tahun 2020 di *sreenhouse* dengan ketinggian 250 mdpl dan Laboratorium Ekologi dan Produksi Tanaman, Fakultas Peternakan dan Pertanian, Universitas Diponegoro. Penelitian dilaksanakan menggunakan rancangan acak lengkap pola faktorial 4×4 dengan 3 ulangan. Faktor pertama adalah pemberian tanpa jenis pupuk, pupuk magnesium, pupuk boron serta pupuk magnesium dan boron. Faktor kedua adalah dosis NPK Majemuk 1.8, 2.8, 3.8 dan 4.8 g/bibit. Hasil penelitian menunjukkan pupuk magnesium + boron berpengaruh nyata terhadap diameter batang dan panjang akar terbaik serta pemberian dosis NPK majemuk 3.8 g/bibit mampu meningkatkan diamter batang,berat segar akar, dan berat kering akar. Interaksi antara pupuk magnesium + boron dan dosis NPK majemuk berpengaruh tidak nyata terhadap tinggi bibit, jumlah daun, diameter batang, panjang akar, berat segar akar, dan berat kering akar.

Kata Kunci: Bibit kelapa sawit, pertumbuhan, unsur hara, dosis pupuk.

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INTRODUCTION

Plantation crops are one of the Indonesian's main commodities and have an important role in improving the economy and job opportunities in agriculture. Oil palm (Elaeis guinensis Jacq.) is a vegetable oil-producing crop and one of the largest foreign exchange generators with a high export value from the agricultural sector so that it has an important role for the economy of this country. The government made alternatives to increase the production and quality of oil palm by expanding the area, using superior seedlings, improving cultivation techniques, applying good post-harvest handling, and proper fertilization (Oksana et al., 2012). One of the factors affecting oil palm productivity is the use of superior seedlings. Improving the quality of oil palm seedlings is one of the efforts to increase oil palm production. It can be done by fulfilling nutrients by adding required fertilizer. Fertilization is an effort to improve soil fertility through the addition of macro and micronutrients so that it can increase the growth and development of oil palm trees (Wijaya et al., 2015). Fertilizer is one of the materials or substances containing nutrients to improve the physical, chemical, and biological properties of soil or soil fertility. Factors affecting fertilization are the time and method of application (Achmad and Susetyo, 2014), as well as the dose and type of fertilizer to improve the growth and development of the trees (Rahman et al., 2016).

The use of macronutrients in oil palm focuses on nitrogen (N), phosphorus (P), and potassium (K). N, P, and K nutrients are needed for the photosynthesis process as a constituent to form plant organs such as leaves, stems, and roots (Adnan et al., 2015). Magnesium (Mg) as a secondary macronutrient is needed by oil palm trees. Mg nutrient in Kieserite fertilizer can increase plant growth including plant height, stem diameter, and fresh and dry weight of oil palm seedlings on ultisols and oxisols (Kasno and Nurjaya, 2011). Nitrogen and potassium applications without magnesium can result in magnesium deficiency (Ningsih et al., 2015). Micronutrients are required in small amounts but they are very useful. Boron is one of the essential micronutrients also needed by oil palm trees. The addition of Boron can increase the maximum absorption of N, P, and K nutrients and even can maximize the photosynthesis process (Kaisher et al., 2010). Boron plays a role in root elongation, formation of carbohydrates and cell walls, and influencing protein synthesis and nucleic acid synthesis (Putra et al., 2105). The addition of Magnesium and Boron fertilizers as well as the appropriate NPK compound doses are expected to increase the growth of oil palm seedlings. This research aims to identify the effect of magnesium, boron, and NPK compound fertilizers and their interaction on the growth of oil palm seedlings.

MATERIALS AND METODH

The research was conducted on February 16 - May 16 2020 in a greenhouse with an altitude of 125 masl (BPS, 2020) and the Laboratory of Ecology and P lant Production, Faculty of Animal and Agricultural Science, Diponegoro University. The materials used were the sprouts of the palm oil of Pesifera species (Dura x Pesifera cross) obtained from the Medan Palm Oil Research Center (PPKS), topsoil, NPK compound fertilizer 15-15-15, Kieserite, and 48% Boron. The tools used were hoes to take soil, analytical scales for weighing fertilizers, paranets for making shade, bamboo for paranet supports, polybags for growing media, impraboard for naming polybags, water pumps and hoses for watering, rulers for measuring plant height, stationery for recording the result of observations, and a camera for documentation.

This research was conducted using a completely randomized design with a 4 × 4 factorial with 3 replications. The first factor is the application of fertilizer consisting of four types of application, namely without fertilizer (P_1), magnesium fertilizer (P_2), boron fertilizer (P_3), and magnesium + boron fertilizer application (P_4). The second factor is the dose of NPK compound fertilizer namely, 1.8 g/seedling (D_1), 2.8 g/seedling (D_2), 3.8 g/seedling (D_3), and 4.8 g/seedling (D_4). The number of treatment combinations is 16 and repeated 3 times to obtain 48 experimental units.

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The research was started with the preparation of tools and materials. The greenhouse was first cleaned and then flattened the nursery. The preparation of the planting media was by sieving the topsoil and then inserted into polybags with a size of 20 cm x 20 cm. The polybags were filled with the soil up to 2 cm from the top of the poly bag and then arranged and labeled. These polybags are arranged according to the research layout. Magnesium, boron, and NPK compound fertilizers were applied by sowing the fertilizer around 3-5 cm from the plant at the age of 2 and 8 MST (weeks after planting). Harvesting was carried out at 12 MST. The observation parameters consisted of the height of the seedlings which was observed every two weeks by measuring the longest leaves. The number of leaves was observed every two weeks by counting the number of leaves on the midrib of the seedling. The stem diameter was measured at harvest time by measuring 2 cm from the land boundary in the middle stem using a caliper. The length of the root was measured at harvest by measuring the primary root length using a ruler. The fresh weight of the root was measured by cutting the base of the root, then it was cleaned and weighed using analytical scales. The root dry weight was carried out at the harvest time by putting the roots in the oven at 105ºC for 24 hours and then weighed using analytical scales.

The obtained data were then analyzed statistically using the Analysis of Variance (ANOVA), then continued with Duncan's multiple range test (DMRT) at the 5% level to see the differences between treatments.

RESULTS AND DISCUSSION

1. The Height of the Seedlings

Table 1. The Height of the Oil Palm Seedlings in Different Types of Fertilizer and NPK Compound

Type of fertilizer	NPK Dose				Average
	D_1 (1.8 g)	D_2 (2.8 g)	D_3 (3.8 g)	D_4 (4.8 g)	
	---------------------- cm ----------------------				
P_1 (NPK without fertilizer type)	19.6	23.5	22.17	20.67	21.49
P_2 (Magnesium fertilizer)	22	21.5	23.27	23.67	22.61
P_3 (Boron fertilizer)	22.27	22.3	23.6	22.5	22.67
P_4 (Magnesium + Boron fertilizer)	21.83	23.83	22.67	22.83	22.79
Average	21.43	22.78	22.93	22.42	

The results of the analysis of variance showed that the application of magnesium, boron, magnesium + boron fertilizers, and NPK compound doses, as well as the interaction of different types of fertilizer and NPK compound doses, had no significant effect on the height of oil palm seedlings. The height of oil palm seedlings with the treatment of different types of fertilizers and NPK compound doses based on the results of Duncan's multiple range test ($p < 0.05$) can be seen in Table 1.

Based on Table 1, it can be seen that the height of the seedlings in all types of fertilizers shows the same. The height of the seedlings is an indicator of vegetative growth measured from the soil surface to the top of the longest observed leaf. The need for nutrients in oil palm seedlings with the application of magnesium, boron, and NPK compound fertilizers showed the optimal average height. Excessive application of nutrients can inhibit the growth of oil palm seedlings. Further, Rahman et al. (2016) stated that factors affecting fertilization are the doses and type of fertilizer that influence plant growth and development.

The observation of the height of the seedling showed increased growth every week. The height of the oil palm seedling forms a sigmoid curve. The height has a constant increase from week 2 to week 12. According to Marwani et al. (2013), plant growth will form a sigmoid curve and experience several phases, including the logarithmic phase (slow growth), the linear phase (constant growth), and the aging phase (decreased and ends with plant death). The continuous increase of the height indicates an increase in the number of cells in oil palm seedlings. Astuti et al. (2015) stated that the height growth of oil palm seeds related to the number of leaves in which the higher the seedlings, the more the number of leaves due to an increase in the

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number of cells in the plants. The graph of the height growth of oil palm seedlings is presented in Figure 1.

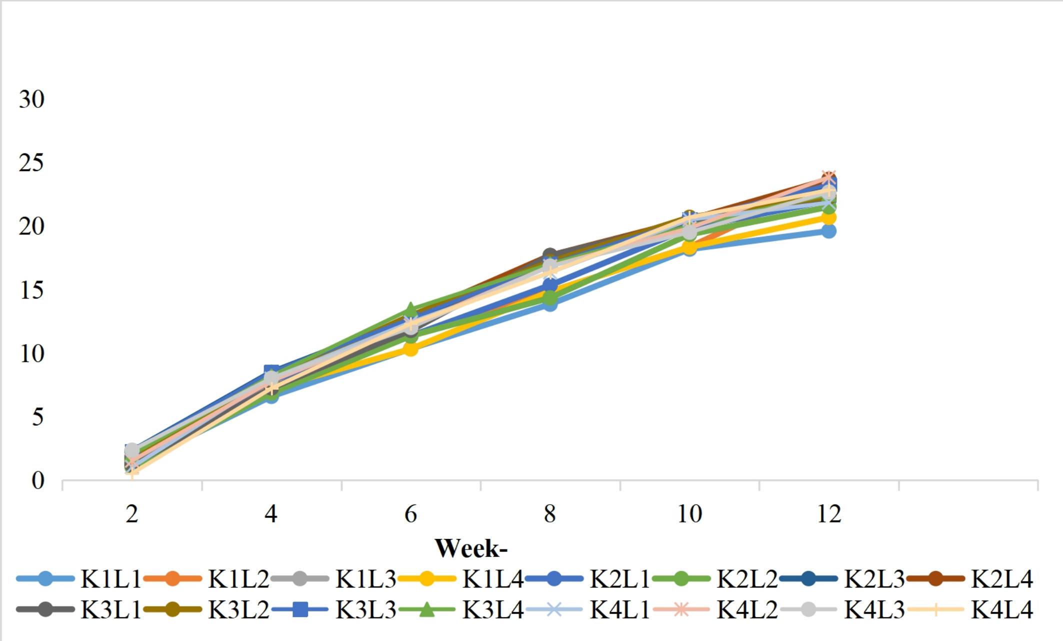

Figure 1. Graph of the Height Growth of Oil Palm Seedlings

2. Number of Leaf

Table 2. Number of Leaf of Oil Palm Seedlings on Different Types of Fertilizer and NPK Compound

Type of fertilizer	NPK Dose				Average
	D_1 (1.8 g)	D_2 (2.8 g)	D_3 (3.8 g)	D_4 (4.8 g)	
	--------------------- leaves ---------------------				
P_1 (NPK without fertilizer type)	3.67	4.33	4	3.33	3.83
P_2 (Magnesium fertilizer)	3.67	3.67	4	4	3.84
P_3 (Boron fertilizer)	3.67	3.67	4	4	3.84
P_4 (Magnesium + Boron fertilizer)	4	4	4	4	4
Average	3.75	3.92	4	3.83	

The results of the analysis of variance showed that the application of magnesium, boron, magnesium + boron fertilizers, and NPK compound doses, as well as the interaction of fertilizer types with NPK compound doses, had no significant effect on the number of the leaf. The number of the leaf of oil palm seedlings due to the application of different types of fertilizers and NPK compound doses based on the results of Duncan's multiple distance test ($p < 0.05$) can be seen in Table 2.

Table 2 showed that the number of the leaf on all fertilizers has the same value. Not all of the nutrients contained in the applied fertilizer have a direct role in the formation of leaves. The nutrients, especially P in the used soil, can work with boron to increase the number of leaves. The addition of boron nutrients can increase plant growth if the needs for boron have been met since the beginning. Timotiwu et al. (2018) stated that boron and phosphorus can work together to increase the growth and strength of cell walls and plant membranes to increase the number of leaves and reduce leaf fall. The use of NPK compound fertilizers containing N nutrients in the correct dose can fulfill the needs of nutrients. The formation of vegetative parts of plants such as leaves requires N nutrients. Astutik et al. (2011) revealed that N plays a role in supporting plant growth, especially stems, roots, and leaves. Nitrogen absorbed

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by the leaves helps in the formation of leaf chlorophyll.

The number of leaves of oil palm seedlings has increased from week 2 to week 12 in each application of fertilizer. Oil palm seedlings in the vegetative phase require sufficient nutrients. Patti et al. (2013) stated that nitrogen has an effect on plant vegetative growth and increases foliage-producing plants. The graph of the number of leaves of oil palm seedlings can be seen in Figure 2.

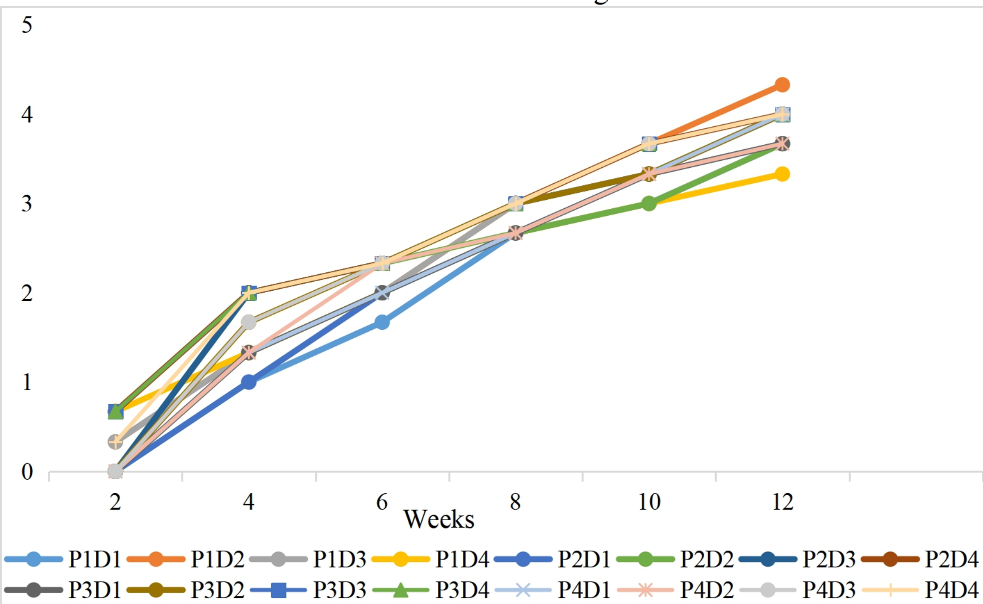

Figure 2. Graph of the Number of Leaves of Oil Palm Seedlings

3. Stem Diameter

Table 3. Stem Diameter of Oil Palm Seedlings on Different Types of Fertilizer and NPK Compound

Type of fertilizer	NPK Dose				Average
	D_1 (1.8 g)	D_2 (2.8 g)	D_3 (3.8 g)	D_4 (4.8 g)	
	---------------------- mm ----------------------				
P_1 (NPK without fertilizer type)	0.47	0.67	0.73	0.53	0.6^{b}
P_2 (Magnesium fertilizer)	0.53	0.57	0.73	0.63	0.62^{b}
P_3 (Boron fertilizer)	0.63	0.73	0.73	0.60	0.67^{ab}
P_4 (Magnesium + Boron fertilizer)	0.6	0.8	0.63	0.83	0.72^{a}
Average	0.56^{c}	0.69^{ab}	0.71^{a}	0.65^{abc}	

Different superscripts on the same column and row indicate significant differences ($p < 0.05$)

The results of the analysis of variance showed that the application of magnesium, boron, magnesium + boron fertilizers and NPK compound doses had a significant effect on the stem diameter of oil palm seedlings. However, the interaction of the types of fertilizer and the interaction of NPK compound doses did not provide a significant effect on the stem diameter. The results of stem diameter with the application of fertilizers and NPK compound doses based on Duncan's multiple distance test ($p < 0.05$) are presented in Table 3.

Based on Table 3, it can be seen that the stem diameter in the treatment of magnesium + boron (P_4) fertilizer is equivalent to boron fertilizer (P_3); treatment of boron fertilizer (P_3) is equivalent to magnesium fertilizer (P_2); and treatment of magnesium fertilizer (P_2) is equivalent to without fertilizer (P_1). It indicates that magnesium and boron fertilizers at a dose of 1.4 g/seedlings and boron at a dose of 0.4 g/seedling can fulfill the need for the nutrient of oil palm seedlings. Kasno and Nurjaya (2011) stated that Mg in Kieserite fertilizer can increase plant growth in the form of height, stem diameter, fresh and dry weight of oil palm seedlings in the nursery. The application of boron to oil palm seedlings affects the absorption of N, P, and K nutrients to increase the growth of the seedlings. Further, Kaisher et al. (2010) explained that the addition of boron can increase the maximum absorption of N, P, and K nutrients and maximize the photosynthesis process. Good plant growth is the plant's ability to do photosynthesis resulting in carbohydrates.

Treatment of NPK compound fertilizer with the dose of 3.8 g/seedling (D_3) is equivalent to a dose of 2.8 g/seedling (D_2); a dose of 2.8 g/seedling (D_2) is equivalent to a dose of 4.8 g/seedling (D_4); and a dose of 4.8 g/seedling is equivalent to a dose of 1.8 g/seedling (D_1). It shows that the NPK compound fertilizer with a dose of 3.8 g/seedling affects the stem diameter of oil palm seedlings. Optimal plant growth is affected by the need and availability of nutrients. The optimal stem diameter is determined by the availability of P and K nutrients. It is in line with the findings of Astuti et al. (2015) in which the P and K nutrients help the formation of carbohydrates and translocation of starch to the circumference of the oil palm stem smoothly resulting in the formation of pseudo-stem of oil palm seedlings. Standards of superior seedlings cover good seedlings cover stem diameter and safe from pests and disease infestation.

4. Length of the Root

Table 4. Length of the Root of Oil Palm Seedlings on Different Types of Fertilizer and NPK Compound

Type of fertilizer	NPK Dose				Average
	D_1 (1.8 g)	D_2 (2.8 g)	D_3 (3.8 g)	D_4 (4.8 g)	
	---------------------- cm ----------------------				
P_1 (NPK without fertilizer type)	18.33	22.5	21.87	18.00	20.18 ^{c}
P_2 (Magnesium fertilizer)	21.4	21.1	24.27	21.17	21.99 ^{bc}
P_3 (Boron fertilizer)	18.97	31.67	29.00	19.33	24.74 ^{ab}
P_4 (Magnesium + Boron fertilizer)	29.33	22.00	29.57	29.93	27.71 ^{a}
Average	22.01	24.32	26.18	22.11	

Different superscripts on the same column indicate significant differences ($p < 0.05$)

The results of the analysis of variance showed that the application of magnesium, boron, and magnesium + boron fertilizers had a significant effect on the length of the root of oil palm seedlings. However, the interaction of the NPK compound doses and types of fertilizer did not provide a significant effect on the length of the root. The results of the length of the root of oil palm seedlings with the application of fertilizer types and NPK compound doses based on Duncan's multiple distance test ($p < 0.05$) are presented in Table 4.

Based on Table 4, it can be seen that the length of the root with the application of magnesium + boron fertilizer (P_4) is equivalent to boron fertilizer (P_3); and boron fertilizer (P_2) and magnesium fertilizer (P_2) is equivalent to without fertilizer (P_1). It shows that magnesium fertilizer at a dose of 1.4 g/seedling and boron at a dose of 0.4 g/seedling fulfills the need for the nutrient of oil palm seedlings. Putra et al. (2015) stated that boron has a role in root elongation and carbohydrate formation. Further, boron and magnesium nutrients can optimize the absorption of nutrients in the soil, such as P nutrient. The rate of growth and root development is affected by the absorption of available nutrients. The absorption of sufficient nutrients will increase and promote root elongation. Astutik et al. (2011) found that the ability of a plant to absorb nutrients affects the length of the root. The availability of P nutrients in the soil can also increase the absorption of Mg nutrients. Besides, Budiargo et al. (2015) stated that the addition of P nutrients earlier can help increase soil KTK (Cation Exchange Capacity) so that K and Mg nutrients can be absorbed properly. The condition of the root in each plant is also affected by the plant's genetics, then it will interact with the environment resulted in plant physiological processes due to nutrient absorption by the root.

5. Fresh Weight of Root

Table 5. Fresh Weight of the Root of Oil Palm Seedlings on Different Types of Fertilizer and NPK Compound

Type of fertilizer	NPK Dose				Average
	D_1 (1.8 g)	D_2 (2.8 g)	D_3 (3.8 g)	D_4 (4.8 g)	
	---------------------- gram ----------------------				
P_1 (NPK without fertilizer type)	0.97	1.43	1.43	0.83	1.17
P_2 (Magnesium fertilizer)	1.13	1.07	1.4	1.67	1.32
P_3 (Boron fertilizer)	1.03	1.53	1.6	1.2	1.34
P_4 (Magnesium + Boron fertilizer)	1.03	1.8	1.57	1.53	1.48
Average	1.04^{c}	1.46^{ab}	1.5^{a}	1.31^{abc}	

Different superscripts on the same row indicate significant differences ($p < 0.05$)

The results of the analysis of variance showed that the application of NPK compound doses had a significant effect on the fresh weight of the root. Meanwhile, magnesium, boron, and magnesium + boron fertilizers and the interaction of the type of fertilizer with NPK compound had no significant effect on the fresh weight of oil palm roots. The results of the fresh weight of the oil palm root with the application of fertilizer types and NPK compound based on Duncan's multiple range test ($p < 0.05$) are presented in Table 5.

Based on Table 5, it can be seen that the fresh weight of the roots with the NPK compound fertilizer at a dose of 3.8 g/seedling (D_3) is equivalent to a dose of 2.8 g/seedling (D_2); and a dose of 4.8 g/seedling (D_4) and a dose of 4.8 g/seedling (D_3) is equivalent to a dose of 1.8 g/seedling (D_1). The NPK compound at a dose of 3.8 g/seedling produced the heaviest fresh weight. Ariyanti et al. (2017) stated that the decomposition of nutrients in soil obtained from NPK compound fertilizer can be absorbed gradually by plant roots properly. Plants that can absorb nutrients optimally will produce heavier fresh weight. The optimal absorption of nutrients, especially P nutrients, will increase the development of plant roots. The NPK compound at a dose of 1.8 g/seedling shows the lowest fresh weight. Weighing fresh roots aims to determine water uptake and nutrients contained in the roots. Lack of nutrients, especially P nutrients can slow the growth of the root. Aziz et al. (2014) stated that P nutrient deficiency causes slow overall growth and root growth resulting in metabolic modification by reducing P uptake and efficiency use of P. Plant fresh weight is an accumulation of photosynthesis and integration with other environmental factors so that the fresh weight of the root relates to root biomass. Weighing fresh root aims to determine water uptake and nutrients contained in the roots. The availability of water is one of the factors supporting the growth of the root. Plants that grow in a condition with limited water availability respond more to root growth so that the root becomes heavier as it tries to get enough water for growth.

6. Dry Weight of Root

Table 6. Dry Weight of the Root of Oil Palm Seedlings on Different Types of Fertilizer and NPK Compound

Type of fertilizer	NPK Dose

	D_1 (1.8 g)	D_2 (2.8 g)	D_3 (3.8 g)	D_4 (4.8 g)	Average
	---------------------- gram ----------------------				
P_1 (NPK without fertilizer type)	0.27	0.4	0.4	0.33	0.35
P_2 (Magnesium fertilizer)	0.27	0.33	0.4	0.43	0.36
P_3 (Boron fertilizer)	0.37	0.4	0.47	0.27	0.38
P_4 (Magnesium + Boron fertilizer)	0.33	0.5	0.43	0.4	0.42
Average	0.31^{c}	0.41^{ab}	0.43^{a}	0.36^{bc}	

Different superscripts on the same row indicate significant differences ($p < 0.05$)

The results of the analysis of variance showed that the application of NPK compound doses had a significant effect on the dry weight of the root. Meanwhile, the application of magnesium, boron, and magnesium + boron fertilizers and the interaction of the type of fertilizer with NPK compound doses had no significant effect on the dry weight of oil palm roots. The result of the dry weight of the oil palm root with the application of different types of fertilizers and NPK compound doses based on Duncan's multiple range test ($p < 0.05$) are presented in Table 6.

Based on Table 6, it can be seen that the dry weight of the roots at the dose of NPK compound fertilizer at a dose of 3.8 g/seedling (D_3) is equivalent to a dose of 2.8 g/seedling (D_2); a dose of 2.8 g/seedling (D_2) is equivalent to a dose of 4.8 g/seedling (D_4); and a dose of 4.8 g/seedling (D_4) is equivalent to a dose of 1.8 g/seedling (D_1). The application of the NPK compound at a dose of 3.8 g/seedling showed the optimal dry weight of the root. Aryanti et al. (2017) stated that the application of NPK compound fertilizers, especially P nutrient, which contained P2O5 can stimulate the growth of the root. The weight of the root depends on the volume of roots and the number of plant roots. The ability of the roots is proportional to the volume of the roots meaning that the greater the volume of the roots, the higher ability of the roots to absorb nutrients. Phosphorous application also affects the absorption of other nutrients. Budiargo et al., (2015) explained that applying P nutrients earlier can help increase soil KTK so that K and Mg nutrients can be absorbed properly. Good planting media function as a place for the growth of plant roots. Plants living on soil with poor chemical properties will result in stunted growth. Soil chemical properties need to be considered because they play an important role in the level of soil fertility which is associated with plant growth. Plants that can absorb nutrients optimally will increase the dry weight of the roots. Lakit (2012) stated that the roots function to absorb most of the nutrients needed by plants from the soil which are then used for vegetative growth. Root growth is affected by the availability and absorption of nutrients. Roots are useful for storing water and biomass from the soil to be distributed to plants and used in metabolic processes so that the number of roots determines the growth of the plant.

CONCLUSION

Based on the results of the research, it can be concluded that the application of magnesium + boron fertilizers has a significant effect on stem diameter and length of the root and the NPK compound at a dose of 3.8 g/seedling has a significant effect on stem diameter and fresh and dry weight of the root. However, the type of fertilizer and NPK compound fertilizer had no significant effect on the height of the seedlings and the number of leaves.

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