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Growth of Several Oil Palm Varieties (Elaeis guineensis Jacq.) in Response to Potassium Fertilizer Doses

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ABSTRACT

Oil palm (*Elaeis guineensis* Jacq.) is a major commodity in Indonesia, with productivity influenced by agronomic management, including potassium (K) fertilization. Potassium plays an essential role in photosynthesis, stomatal regulation, and the transport of photosynthetic products, but its utilization efficiency can vary depending on the plant variety. This study aims to evaluate the levels of K fertilization on nutrient uptake and plant growth in several superior oil palm varieties and to identify varieties that are efficient in K nutrient uptake. The research was conducted in the greenhouse of the PPKS Aek Pancur experimental plantation, Deli Serdang, North Sumatra, with soil and leaf analysis carried out at the PPKS Laboratory in Medan from April to November 2017. The study employed a factorial randomized block design with two factors. The first factor was the oil palm seedling varieties: DxP (540-B) AVROS, DxP (239) Yangambi, DxP (SMB) Simalungun, DxP (LTC) Langkat, and DxP (718) Yangambi. The second factor was the levels of K fertilization: no K fertilizer, 25% of the recommended dose, 50% of the recommended dose, 75% of the recommended dose, and 100% of the recommended dose. The results showed that the variety treatment significantly affected shoot fresh weight and root volume. The K fertilization level did not significantly affect any parameter. Interaction between variety treatment and K fertilization levels significantly influenced shoot fresh weight.

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1. INTRODUCTION

Oil palm plays a crucial role in increasing Indonesia's foreign exchange earnings, as Indonesia is the world's leading palm oil producer. Furthermore, oil palm plantations contribute to job creation and economic growth in the country. The area of oil palm plantations in Indonesia continues to expand, reaching 11.3 million hectares in 2015, comprising both large-scale and smallholder plantations (Deptan, 2015).

To increase the productivity of oil palm plants, several factors need to be considered, including the use of high-quality seedlings, proper maintenance, and appropriate fertilization (Ramadhaini et al., 2014). To optimize the function of fertilization, attention should be given to the type of fertilizer applied, the method of application, and the dosage of fertilization. However, one aspect that is still rarely considered is the use of varieties that are efficient in utilizing nutrients from fertilizers. To date, information regarding oil palm varieties that are efficient in fertilizer use remains very limited.

Potassium nutrients are found in all parts of the oil palm plant (roots, stems, leaves, and others) in relatively large amounts. This element has a relatively large hydrated form, making it less strongly adsorbed by the surface charges of colloids and thus easily leached from the soil. This condition causes the availability of potassium in the soil to generally be low, even though the plant's need for this nutrient is nearly equal to its need for nitrogen (Feryono et al., 2012). Therefore, it is necessary to find ways to optimize the use of potassium nutrients in plants, one of which is through a variety-based approach. This involves identifying varieties that are efficient in the absorption and utilization of potassium nutrients in their physiological processes, thereby enhancing the productivity of the plants.

The nutrient potassium plays an important role in the growth of oil palm plants. The function of potassium for oil palm plants is to form and transport carbohydrates, as a catalyst in the formation of proteins, regulate the activities of various mineral elements, neutralize reactions in cells, especially from organic acids, increase the growth of meristem tissue, regulate the movement of stomata, strengthen the uprightness of the stem (due to turgor) so that plants do not fall over easily (Rosmarkam and Yuwono, 2002; Pangaribuan et al., 2013).

Each oil palm variety has its own character and one of the important characters that can be seen visually is the characteristic of high growth. The oil palm plant material produced by PPKS has various high growth characteristics, and generally these characteristics are determined by the pisiferous parents. The differences in character of each variety require special handling in management to obtain optimal results (Sulistyo et al., 2010).

Currently, the Palm Oil Research Center has released nine recommended varieties for plantations, both for large-scale plantations and smallholder plantations. These varieties include AVROS, Simalungun, PPKS 540, Yangambi, PPKS 718, PPKS 239, Langkat, Dumpy, and La Me. However, it is not yet known which of these varieties are efficient in absorbing and utilizing nutrients, particularly potassium, in their metabolic processes. Therefore, among these nine varieties, it is hoped that some can be identified as efficient in utilizing potassium from fertilization. Additionally, these varieties are also expected to reduce the burden of fertilization costs, as fertilization accounts for the largest portion of oil palm plantation production costs, approximately 20.96% (Central Statistics Agency, 2014).

Based on the aforementioned explanation, the author is interested in conducting research to screen several oil palm varieties for potassium nutrient efficiency through fertilization in the main nursery.

2. METHOD

This research will be conducted in the greenhouse of the PPKS Aek Pancur experimental plantation, Deli Serdang, North Sumatra, and soil and leaf analyses will be carried out at the PPKS Laboratory in Medan. The study will take place from April 2017 to November 2017.

The materials used in this research include five (5) varieties of 3-month-old oil palm seedlings from the Palm Oil Research Center (PPKS) Medan, consisting of D x P (540-B) AVROS, D x P (239) Yangambi, D x P (SMB) Simalungun, D x P (LTC) Langkat, and D x P (718) Yangambi, as well as KCl fertilizer. The equipment used includes 40 cm x 50 cm polybags, measuring tape, sample plastic bags, watering cans, hand sprayers, writing tools, an oven, an analytical balance, and other tools to support the research.

This research employs a Randomized Block Design (RBD) with two treatment factors as follows: Factor I: Varieties (V) consisting of 5 varieties: V1 = D x P (540-B) AVROS; V2 = D x P (239) Yangambi; V3 = D x P (SMB) Simalungun; V4 = D x P (LTC) Langkat; V5 = D x P (718) Yangambi. Factor II: Potassium Fertilizer (K) consisting of 5 levels: K0 = no potassium fertilizer; K1 = 25% of the recommended fertilizer dose; K2 = 50% of the recommended fertilizer dose; K3 = 75% of the recommended fertilizer dose; K4 = 100% of the recommended fertilizer dose.

The planting medium used is subsoil from the area around the research site. The planting medium is placed into 40 cm x 50 cm polybags. The seedlings are planted into the planting holes after the small polybags are removed. The soil around the hole is compacted evenly, followed by the addition of soil up to the root collar level. Fertilization of the oil palm seedlings is carried out according to the treatment levels. The source of potassium fertilizer used is KCl fertilizer or MOP fertilizer.

Table 1. Recommended Fertilizer Dosage for Oil Palm Seedlings in the Main Nursery

Seedling Age (weeks)	Fertilizer Dosage (g/seedling)						
	Urea	TSP	KCl dosage according to treatment				
			100%	75%	50%	25%	0%
14-15	0,82	0,82	0,25	0,19	0,13	0,06	0
16-17	1,63	1,63	0,5	0,38	0,25	0,13	0
18-20	2,45	2,45	0,75	0,56	0,38	0,19	0
22-24	3,26	3,26	1,00	0,75	0,50	0,25	0
26	2,61	2,61	2,83	2,13	1,42	0,71	0
28	2,61	2,61	2,83	2,13	1,42	0,71	0
30	2,61	2,61	2,83	2,13	1,42	0,71	0
32	2,61	2,61	2,83	2,13	1,42	0,71	0
34	3,91	3,91	4,25	3,19	2,13	1,06	0
36	3,91	3,91	4,25	3,19	2,13	1,06	0
38	3,91	3,91	4,25	3,19	2,13	1,06	0
40	3,91	3,91	4,25	3,19	2,13	1,06	0
42	5,22	5,22	5,67	4,25	2,83	1,42	0
44	5,22	5,22	5,67	4,25	2,83	1,42	0
46	5,22	5,22	5,67	4,25	2,83	1,42	0
48	5,22	5,22	5,67	4,25	2,83	1,42	0
50	6,52	6,52	7,08	5,31	3,54	1,77	0
52	6,52	6,52	7,08	5,31	3,54	1,77	0

The parameters observed in this study are total leaf area (cm^2), wet root weight (g), wet shoot weight (g), and root volume (ml). The planting medium used is subsoil from the area around the research site. The planting medium is placed into 40 cm x 50 cm polybags. The seedlings are planted into the planting holes after the small polybags are removed. The soil around the hole is compacted evenly, followed by the addition of soil up to the root collar level. Fertilization of the oil palm seedlings is carried out according to the treatment levels. The source of potassium fertilizer used is KCl fertilizer or MOP fertilizer.

To compare means, the data were subjected to analysis of variance (ANOVA). Duncan's Multiple Range Test was used to identify the mean at a probability level of 5% using Microsoft Excel.

3. RESULTS AND DISCUSSION

3.1 Total Leaf Area (cm^2)

The analysis of variance results show that the variety treatment, potassium fertilizer dose treatment, and the interaction between both treatments had no significant effect on total leaf area. The average total leaf area for the variety treatment, potassium fertilizer dose treatment, and their interaction at 6 months after planting (MAP) can be seen in Table 2.

Table 2. Average Total Leaf Area with Variety Treatment and Potassium Fertilizer Dosage (cm^2)

Varieties	Dose of Potassium Fertilizer					Average
	K0	K1	K2	K3	K4	
	..............................(cm^2)..............................					
V1 (DxP (540-B) AVROS)	26,83	36,97	24,68	26,64	26,97	28,42
V2 (DxP (239) Yangambi)	23,81	26,87	25,10	23,51	25,82	25,02
V3 (DxP (SMB) Simalungun)	33,44	36,00	33,14	27,46	28,34	31,67
V4 (DxP (LTC) Langkat)	34,48	28,62	21,80	11,97	27,01	24,78
V5 (DxP (718) Yangambi)	22,31	30,65	26,00	30,97	29,15	27,81
Average	28,17	31,82	26,14	24,11	27,46	27,54

Some oil palm varieties did not show a significant effect on total leaf area. This indicates that although there are genetic differences between these varieties, other factors such as environmental conditions, nutrient availability, and agronomic practices may play a larger role in determining the plant's leaf area. Variations in photosynthesis ability or light utilization efficiency in each variety do not always directly correlate with the total leaf area produced, so even though there are variety differences, total leaf area is not significantly affected. This suggests that total leaf area is a morphological characteristic of each oil palm variety, with each variety having a different total leaf area. This is consistent with the statement by Welsh (1981) who stated that genetic variation is caused by the inheritance of traits/genetics as well as environmental factors. The total area is not only influenced by the variety (genetics) and fertilization treatment of the plants but can also be affected by other environmental factors, such as the amount of water the plants receive and sunlight. As Darwis & Wachjar (2014) stated, water's function as a provider of turgor for cells is to assist cells in maintaining their shape and in the opening and closing of stomata in plants. This turgor process also aids cells in division and enlargement.

3.2 Root Weight Wet (g)

The analysis of variance results show that the variety treatment, potassium fertilizer dose treatment, and the interaction between both treatments had no significant effect on wet root weight. The average wet root weight for the variety treatment, potassium fertilizer dose treatment, and their interaction at 6 months after planting (MAP) can be seen in Table 3.

Table 3. Average Root Weight Wet with Variety Treatment and Potassium Fertilizer Dosage (g)

Varieties	Dose of Potassium Fertilizer					Average
	K0	K1	K2	K3	K4	
	............................(g)............................					
V1 (DxP (540-B) AVROS)	30,00	47,33	30,67	34,33	28,33	34,13
V2 (DxP (239) Yangambi)	34,67	19,67	34,00	20,67	21,33	26,07
V3 (DxP (SMB) Simalungun)	32,00	49,33	36,67	43,33	30,67	38,40
V4 (DxP (LTC) Langkat)	25,33	32,67	24,67	18,00	31,67	26,47
V5 (DxP (718) Yangambi)	33,33	35,33	40,00	42,00	30,33	36,20
Average	31,07	36,87	33,20	31,67	28,47	32,25

The potassium fertilizer dose did not show a significant effect on wet root weight. This indicates that the variation in potassium fertilizer doses applied was not sufficient to cause a significant difference in the wet root weight produced. Other factors, such as environmental conditions, plant species, or interactions with other nutrients, may have a more dominant influence on this parameter compared to the potassium fertilizer dose. According to Aryandhita and Kastono (2021), increasing the potassium fertilizer dose can reduce root growth because it inhibits the absorption of nutrients in the soil, which causes the root weight to decrease with the addition of fertilizer.

Several oil palm varieties have no significant effect on root fresh weight. This is because each oil palm variety has different genetic characteristics, which influence their ability to adapt to environmental conditions. Certain varieties may be superior in absorbing water and nutrients, while others may not show significant differences in root fresh weight. This is consistent with the statement by Satwiko et al. (2013), which states that differences in genetic composition are one of the factors causing variations in plant performance. The genetic programs expressed at different growth phases may manifest in various plant traits, including plant form and function, leading to variability in plant growth. Variations in plant performance due to differences in genetic composition are always possible, even if the plant materials used come from the same species.

3.3 Shoot Weight Wet (g)

The analysis of variance results show that the variety treatment and the interaction between both treatments had a significant effect on wet shoot weight, while the potassium fertilizer dose treatment had no significant effect on wet shoot weight. The average wet shoot weight for the variety treatment at 6 months after planting (MAP) can be seen in Tables 4-6.

Table 4. Average Wet Weight of Shoots (g) Age 6 Months After Planting with Variety Treatment

Varieties	Shoot Weight Wet (g)
V1 (DxP (540-B) AVROS)	179,53 abc
V2 (DxP (239) Yangambi)	146,27 c
V3 (DxP (SMB) Simalungun)	229,93 ab
V4 (DxP (LTC) Langkat)	156,87 c
V5 (DxP (718) Yangambi)	227,13 a
Average	187,95

Note: Numbers followed by the same notation in the same column are not significantly different according to the DMRT test at the 5% level.

Table 5. Average Wet Weight of Shoots (g) Age 6 Months After Planting with Potassium Fertilizer Treatment

Dosage of Potassium Fertilizer	Shoot Weight Wet (g)
K0 (no potassium fertilizer)	178,27
K1 (25% of the recommended fertilizer dose)	225,80
K2 (50% of the recommended fertilizer dose)	195,13
K3 (75% of the recommended fertilizer dose)	178,67
K4 (100% of the recommended fertilizer dose)	161,87
Average	187,95

Table 6. Average Wet Weight of Shoots (g) Age 6 Months After Planting with Variety Interaction Treatment and Potassium Fertilizer Dosage

Treatment	Shoot Weight Wet (g)
V1 K0	135 efghi
V1 K1	272,67 abc

V1 K2	161 cdefghi
V1 K3	195,67 abcdefgh
V1 K4	133,33 fghi
V2 K0	232 abcdefg
V2 K1	118,67 fghi
V2 K2	161 cdefghi
V2 K3	106 hi
V2 K4	113,67 ghi
V3 K0	156,33 cdefghi
V3 K1	325,67 a
V3 K2	288,33 ab
V3 K3	233,33 abcdef
V3 K4	146 defghi
V4 K0	158 cdefghi
V4 K1	225,67 abcdefg
V4 K2	148,67 cdefghi
V4 K3	97 i
V4 K4	155 cdefghi
V5 K0	210 abcdefgh
V5 K1	186,33 bcdefgh
V5 K2	216,67 abcdefgh
V5 K3	261,33 abcd
V5 K4	261,33
Rerata	187,95

Note: Numbers followed by the same notation in the same column are not significantly different according to the DMRT test at the 5% level.

The wet weight of the plant is also related to the amount of water absorbed, which contributes to the increase in wet shoot weight in several oil palm varieties. This is in line with the statement by Salisbury and Ross (1995), who mentioned that the wet weight of a plant is closely related to the amount of water absorbed, as water is a compound required in large quantities by all plant organs. The water content in plant tissues can fluctuate or be unstable, depending on factors such as plant age and environmental conditions. Therefore, variation in the amount of water absorbed, influenced by physical conditions and environmental climate, plays a significant role in determining the wet shoot weight of plants, including oil palm, which can affect productivity and growth.

The application of potassium fertilizer had no significant effect on the wet weight of the shoot. Increasing the potassium fertilizer dosage in this study could reduce the wet weight of the shoot. This is because applying potassium fertilizer in excessive doses can cause phytotoxicity, where an excessive concentration of potassium disrupts the ionic balance within the plant. This can inhibit the absorption of water and other nutrients, thereby reducing canopy growth and its fresh weight. According to Prastya et al. (2016), plants require sufficient and balanced nutrients. When nutrients are provided in excessive or insufficient doses, the fresh weight of the plant decreases. A deficiency or excess of nutrients applied to plants results in ineffective photosynthesis, reducing the amount of photosynthate produced and decreasing the photosynthate translocated within the plant. A balanced availability of nutrients in the soil allows for proper plant growth and production.

In contrast to single treatments, the interaction between potassium fertilizer and various oil palm varieties showed a significant effect on shoot wet weight. This suggests that the plant's response to potassium fertilizer is not only influenced by the dose applied but also by the genetic characteristics of the oil palm variety itself. Some varieties may show a greater increase in wet shoot weight when given potassium fertilizer, while others may be less responsive. The application of potassium fertilizer can enhance photosynthesis efficiency, tissue formation, and biomass accumulation in the shoot, but its effectiveness greatly depends on the genetic interaction of the variety with the available nutrients. Therefore, selecting the appropriate variety and providing the correct potassium fertilizer dose can optimize the growth and productivity of oil palm shoots. This is consistent with Saputra's (2015) statement that the interaction between potassium fertilizer and environmental factors such as soil moisture and water availability also influences the effectiveness of the fertilizer in increasing shoot wet weight. Plants growing under optimal conditions with good water availability show a more significant increase in wet shoot weight.

3.4 Root Volume (ml)

The analysis of variance results show that the variety treatment had a significant effect on root volume, while the potassium fertilizer dose treatment and the interaction between both treatments had no significant effect on root volume. The average root volume for the variety treatment at 6 months after planting (MAP) can be seen in Table 7.

Table 7. Average Root Volume with Variety Treatment and Potassium Fertilizer Dosage (g)

Varieties	Dose of Potassium Fertilizer					Average
	K0	K1	K2	K3	K4	
	................................(ml).............................					
V1 (DxP (540-B) AVROS)	91,7	138,3	78,3	95,0	86,7	98,0 abc
V2 (DxP (239) Yangambi)	103,3	63,3	71,7	65,0	50,0	70,7 d
V3 (DxP (SMB) Simalungun)	83,3	148,3	130,0	126,7	88,3	115,3 a
V4 (DxP (LTC) Langkat)	80,0	76,7	75,0	60,0	100,0	78,3 cd
V5 (DxP (718) Yangambi)	100,0	103,3	100,0	123,3	106,7	106,7 d
Average	91,7	106,0	91,0	94,0	86,3	93,8

Note: Numbers followed by the same notation in the same column are not significantly different according to the DMRT test at the 5% level.

Some oil palm varieties showed a significant effect on root volume. This indicates that genetic differences between varieties influence the plant's ability to develop its root system. Certain varieties may have characteristics that support the growth of longer, thicker, or more branched roots, resulting in a larger root volume compared to other varieties. This difference may also be influenced by the physiological adaptation of each variety to environmental conditions and nutrient availability in the soil. According to Sa`diyah et al. (2013), variations between varieties and their traits are generally influenced by their genetics. A high heritability estimate indicates that the environmental influence on trait inheritance is very small. This suggests that these variables are largely influenced by genetic factors because heritability, in the broad sense, is the proportion of genetic variance to phenotypic variance. This is supported by Buana et al. (2019), who stated that a plant variety is a group of plants of a particular species or type characterized by plant shape, plant growth, flowers, leaves, seeds, and the expression of genetic characteristics or combinations of genotypes that can distinguish it from the same species or type by at least one determining trait.

4. CONCLUSION

DxP (SMB) Simalungun is the best variety compared to the others based on total leaf area, wet root weight, wet shoot weight, and root volume, while the best potassium fertilizer dose is K1 (25% of the recommended fertilizer dose). The most efficient interaction between several oil palm varieties and potassium fertilizer dose is V1K1 (DxP (540-B) AVROS and 25% of the recommended fertilizer dose), which resulted in 272.67 grams for the wet shoot weight parameter.

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