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Response of Nutrient Levels of Oil Palm Leaves (*Elaeis guineensis* Jacq.) to Polyhalite and KCl Fertilizers Application in Dystrudepts Soil

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ABSTRACT

Oil palm (*Elaeis guineensis*) is a significant plantation crop extensively cultivated in Indonesia, particularly in the Riau region, where it is often grown on marginal lands, such as typical dystrudepts. Low soil pH and limited water-holding capacity necessitating effective fertilization management strategies characterize typic Dystrudepts. One approach to address these challenges is the application of slow-release fertilizers. Polyhalite, a mineral fertilizer, contains slow-release nutrients including potassium (K), calcium (Ca), magnesium (Mg), and sulfur (S). Given that oil palm plants have a high demand for potassium to support their growth and productivity, providing substantial quantities of readily available potassium fertilizers, such as potassium chloride (KCl) is essential. The synergistic application of polyhalite and KCl is anticipated to enhance plant nutrient absorption, thereby improving leaf nutrient levels. This study aims to evaluate the effects of Polyhalite fertilizer, both alone and in combination with KCl fertilizer, on the leaf nutrient levels of oil palm plants. A Completely Randomized Design (CRD) was employed, consisting of five treatment factors: Control (NPK), Polyhalite at 25% combined with KCl at 75%, Polyhalite at 50% combined with KCl at 50%, Polyhalite at 75% combined with KCl at 25%, and Polyhalite at 100%. Each treatment was replicated three times, resulting in 60 plants across four plants per treatment. The data collected from the research will be analyzed using Analysis of Variance (ANOVA), followed by the 5% Duncan's New Multiple Range Test (DNMRT). The findings indicate that the application of Polyhalite at 75% in combination with KCl at 25% significantly increased the levels of potassium, calcium, and magnesium in the leaves of the oil palm plants.

Keywords: Dystrudepts, KCl, Leaf Nutrient Levels, Oil Palm, Polyhalite

1. INTRODUCTION

Oil palm (*Elaeis guineensis* Jacq.) is a major plantation crop in Indonesia, playing a strategic role in palm oil production (Hidayat et al., 2003). The community widely practices the utilization of marginal land for oil palm cultivation. Herlin (2021) reported that the area of oil palm plantations in the province reached 3.49 million hectares. One example of marginal land that is frequently used is Dystrudepts land.

Dystrudepts land is a type of soil classified under the Inceptisol order, characterized by moderate soil development, low pH, and low Cation Exchange Capacity (CEC) (Survey Staff, 2022). Sudjadi and Effendi (1991) also noted that Dystrudepts soil has a low nutrient availability, necessitating effective fertilization management to enhance the growth and production of oil palm plants.

The utilisation of slow-release fertilisers represents a potential solution for managing dystrudepts land. One such fertiliser is the polyhalite compound fertiliser. Polyhalite is a natural mineral fertiliser that contains potassium (14% K2O), calcium (17% CaO), magnesium (6% MgO) and sulphur (48% SO3) (Yermiyahu et al., 2017).

Potassium is one of the essential nutrients required by plants for growth and production. The nature of polyhalite fertilizer, which is slow-release and has a K2O nutrient content of 14%, is thought to be unable to meet the need for potassium elements in oil palm plants. Therefore, it is necessary to supplement this fertilizer with other potassium fertilizers, one of which is potassium chloride (KCl) fertilizer. (Amry et al., 2019). It is anticipated that applying polyhalite fertiliser in conjunction with KCl will facilitate the release of nutrients that plants can absorb, thereby enhancing leaf nutrient levels. It is crucial to ascertain leaf nutrient levels, as they offer insight into the nutritional status of plants in comparison to other plant organs (Marschner, 2012). Leaf nutrient levels can also be employed as an indicator to monitor the nutritional status of plants, whether in an optimal or suboptimal condition, and to assess the efficacy of fertilisation for oil palm plants, thereby increasing yields (Manorama et al., 2021). The concentration of nutrients in leaves can be quantified using the Leaf Sampling Unit (LSU) method (Rahmawati and Santoso, 2017).

The findings of Sutopo & Aji's (2020) study indicated that the application of 2,125 kg of Polyhalite + 1,875 kg of urea + 1,562.5 kg of SP36 per hectare per harvest season was capable of enhancing the Mg content of Siamese Orange leaves (0.37%) in comparison to the utilisation of ZK fertiliser. However, this treatment did not result in any discernible impact on the S nutrient content in the leaves. Furthermore, the administration of 150% polyhalite was observed to increase the K nutrient content in pomelo leaves by 9.40% in comparison to the control treatment of 300 kg/ha MOP at the Balitjestro Batu experimental garden (Suntari et al., 2020). In light of the aforementioned description, the author is interested in examining the impact of Polyhalite and KCl fertiliser application on leaf nutrient levels in oil palm plants cultivated on Typic Dystrudepts soil. The findings of this study will inform recommendations regarding the optimal application rate of Polyalite fertilizer in conjunction with KCl fertilizer, with the aim of enhancing the nutrient content of oil palm leaves cultivated in Typic Dystrudepts soil. It is anticipated that the findings of this study will provide a foundation for technical recommendations regarding the optimal fertilisation practices to enhance oil palm productivity and ensure the sustained availability of nutrients on marginal lands exhibiting analogous characteristics.

2. RESEARCH METHOD

2.1. Time and Place

This research was conducted on smallholder oil palm plantations in

Petapahan Village, Tapung District, Kampar Regency, Riau Province, with coordinates 0° 35' 39.612" N and 101° 0' 12.5568" E. Leaf nutrient content analysis was performed at the Central Plantation Services Laboratory in Pekanbaru, Riau. The study was carried out over six months, from October 2023 to March 2024.

2.2. Tools and Materials

The materials used in this study were 7-year-old oil palm plants, Urea fertilizer, Rock Phosphate (RP) fertilizer, Polyhalite fertilizer, KCl fertilizer and materials for leaf nutrient content analysis. The tools used in this study were egrek, rice envelopes, stationery, documentation tools, Spectrophotometer, Atomic Absorption Spectrophotometer (AAS) and other laboratory equipment.

2.3. Research Method

This study used a non-factorial completely randomized design (CRD) method, where this study consisted of 5 levels, namely:

Control (NPK) (3.3 kg/plant), Polyhalite 25% (2 kg/plant) + KCl 75% (1.4 kg/plant), Polyhalite 50% (4.1 kg/plant) + KCl 50% (1 kg/plant), Polyhalite 75% (6.1 kg/plant) + KCl 25% (0.5 kg/plant), Polyhalite 100% (8.1 kg/plant).

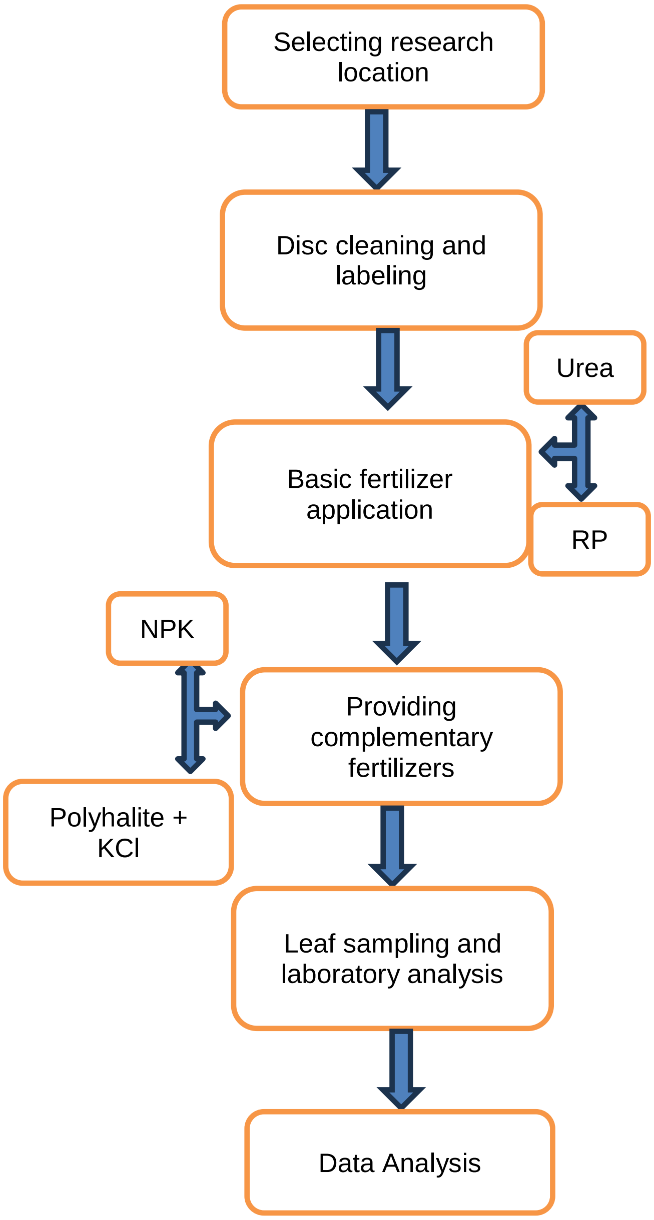

Figure 1. Research Flow Diagram

Each treatment was repeated three (3) times, so that 15 experimental units were obtained with each experimental unit consisting of 4 plants so that the total plants used in this study were 60 plants..

The data obtained were analyzed using statistical software. Analysis of variance (ANOVA) was conducted to determine the effect of fertilizer treatment on the level of solubility and nutrient leaching. Further testing using Duncan's Multiple Range Test (DMRT) was conducted at a 95% confidence level using the SAS 9.0 application to determine significant differences between treatments.

2.4. Research Design

The flow of this research can be seen in Figure 1.

3. RESULT AND DISCUSSION

3.1 Potassium Nutrient Levels in Oil Palm Plants

Based on data from Table 1, the highest potassium nutrient levels were found in the Control (NPK) treatment at 0.85% and the lowest in the 100% Polyhalite treatment at 0.78%. The potassium nutrient levels in oil palm leaves were classified as optimum in all treatments based on the criteria (Nazari, 2020).

Table 1. Potassium nutrient content (%) in oil palm leaves applied with Polyhalite and a combination with KCl fertilizer

Treatment	Potassium nutrient content	Criteria
Control (NPK)	0.85 ± 0.024 a	Optimum
Polyhalite 25% + KCl 75%	0.82 ± 0.010 ab	Optimum
Polyhalite 50% + KCl 50%	0.78 ± 0.025 b	Optimum
Polyhalite 75% + KCl 25%	0.80 ± 0.017a	Optimum
Polyhalite 100%	0.78 ± 0.006 b	Optimum

Notes: Numbers followed by the same lowercase letter are not significantly different according to the DNMRT test at the 5% level. Leaf nutrient content criteria (Nazari, 2020)

The high potassium nutrient levels in the control treatment were due to the fast-release nature of NPK fertilizer so that potassium nutrients from fertilizers were available more quickly in the soil and absorbed more quickly by plants, while Polyhalite was slow-release where potassium nutrients would be released gradually so that they would be absorbed by the roots gradually. Kering et al. (2013), Yusup et al. (2023) and Awaludin et al. (2021) said that NPK fertilizer provides nutrients in a form that is more easily dissolved and available more quickly in the soil so that it is accessed by plants more quickly.

The results of the study by Sihaan et al. (2023) showed that the provision of NPK fertilizer with soil processing affected the K levels in the leaves and were in optimum conditions. The presence of Calcium (Ca) and Magnesium (Mg) content in Polyhalite fertilizer causes competition for nutrient absorption with Potassium so that it can reduce Potassium levels in oil palm leaves (Marschner, 2012).

3.2 Calcium Nutrient Levels in Oil Palm Plants

Based on data from Table 2. the highest Calcium nutrient content in oil palm leaves was found in the 50% Polyhalite + 50% KCl treatment of 0.82% and the lowest in the 100% Polyhalite treatment of 0.65%. According to the criteria (Nazari, 2020) the Calcium nutrient content in the Control, 25% Polyhalite + 75% KCl, 50% Polyhalite + 50% KCl and 75% Polyhalite + 25% KCl treatments were classified as optimum while in the 100% Polyhalite treatment it was classified as low.

Potassium from KCl plays a role in regulating osmotic balance in plants, including the distribution of cations such as Calcium (Ca) to plant tissues, so that it can increase the translocation of Calcium (Ca) in the xylem and improve the distribution of Calcium (Ca) in leaf tissue (White and Broadley, 2001, Saito and Uozumi, 2020).

Table 2. Calcium nutrient content (%) in oil palm leaves applied with Polyhalite and a combination with KCl fertilizer

Treatment	Calcium nutrient content	Criteria
Control (NPK)	0.80 ± 0.033 a	Optimum
Polyhalite 25% + KCl 75%	0.80 ± 0.024 a	Optimum
Polyhalite 50% + KCl 50%	0.82 ± 0.035 a	Optimum
Polyhalite 75% + KCl 25%	0.81 ± 0.023 a	Optimum
Polyhalite 100%	0.65 ± 0.030 a	Minimal

Notes: Numbers followed by the same lowercase letter are not significantly different according to the DNMRT test at the 5% level. Leaf nutrient content criteria (Nazari, 2020)

The Calcium (Ca) content is 17% (CaO) in Polyhalite which is released slowly and also in bound form so that it is absorbed more slowly by plants, besides that there is competence with other nutrients such as Magnesium which results in the Calcium (Ca) nutrient content in the treatment Low 100% polyhalite (Vale and Girotto, 2022).

3.3 Magnesium Nutrient Levels in Oil Palm Plants

Based on the data in Table 3. the lowest Magnesium nutrient content in oil palm leaves was in the Control treatment of 0.18% and the highest was in the 100% Polyhalite treatment. The Magnesium nutrient content in oil palm leaves was relatively low in the Control, 25% Polyhalite + 75% KCl, and 50% Polyhalite + 50% KCl treatments, while the 75% Polyhalite + 25% KCl and 100% Polyhalite treatments were classified as optimum (Nazari, 2020).

Polyhalite fertilizer contains Magnesium (Mg) and is released slowly, tends to be more efficient in providing nutrients so that they can be absorbed by plants. Sutopo and Aji (2020) stated that giving 2.125 kg/ha/one harvest season of Polyhalite can increase the Mg content in lime leaves to 0.37%.

Table 3. Magnesium nutrient content (%) in oil palm leaves applied with Polyhalite and a combination with KCl fertilizer

Treatment	Magnesium nutrient content	Criteria
Control (NPK)	0.18 ± 0.009 c	Minimum
Polyhalite 25% + KCl 75%	0.21 ± 0.012 bc	Minimum
Polyhalite 50% + KCl 50%	0.23 ± 0.003 ab	Minimum
Polyhalite 75% + KCl 25%	0.25 ± 0.010 a	Optimum
Polyhalite 100%	0.26 ± 0.013 a	Optimum

Notes: Numbers followed by the same lowercase letter are not significantly different according to the DNMRT test at the 5% level. Leaf nutrient content criteria (Nazari, 2020)

The administration of NPK slow-release fertilizer in the study of Sembiring et al. (2020) showed that the chlorophyll content of corn leaves increased due to the administration of slow-release NPK fertilizer and dolomite, which was thought to be caused by the increase in Mg content in leaves. This is in line with the results of the study which showed that the administration of Polyhalite slow-release fertilizer increased Mg levels in leaves.

The administration of high doses of KCl also causes low levels of Magnesium nutrients in leaves, this is indicated by the higher the dose of KCl fertilizer given, the lower the Magnesium nutrient content in oil palm leaves. This is due to the presence of ionic competence in the rhizosphere zone (Wahyuni and Manurung, 2020). Marschner (2012) also said that Potassium and Magnesium are absorbed through the same transport mechanism in the roots because both are divalent cations.

3.4 Sulfur Nutrient Levels in Oil Palm Plants

Based on data from Table 4. The highest Sulfur nutrient content in oil palm leaves was in the Control treatment at 0.24% and the lowest in the Polyhalite 75% + KCl 25% treatment at 0.22%. According to (Nazari, 2020) the sulfur nutrient content was classified as deficient in all treatments. The high Sulfur nutrient content in the Control treatment is thought to be due to the presence of Nitrogen (N) and Phosphorus (P) nutrients from NPK fertilizer which are essential macro elements needed for plant growth. Fulfillment of Nitrogen and Phosphorus nutrient levels results in better root growth so that it can absorb Sulfur in the form of SO42- in the soil. Marschner (2012) said that increased sulfur absorption occurs if the plant's needs for other macro nutrients are met. Havlin et al. (2013) also said that the sulfur available in the soil is absorbed by plants if nutrients such as Nitrogen, Phosphorus and Potassium are sufficient.

Table 4. Sulfur nutrient content (%) in oil palm leaves applied with Polyhalite and a combination with KCl fertilizer

Treatment	Sulfur nutrient content	Criteria
Control (NPK)	0.24 ± 0.004 a	Deficiency
Polyhalite 25% + KCl 75%	0.23 ± 0.012 a	Deficiency
Polyhalite 50% + KCl 50%	0.23 ± 0.001 a	Deficiency
Polyhalite 75% + KCl 25%	0.22 ± 0.005 a	Deficiency
Polyhalite 100%	0.23 ± 0.012 a	Deficiency

Notes: Numbers followed by the same lowercase letter are not significantly different according to the DNMRT test at the 5% level. Leaf nutrient content criteria (Nazari, 2020).

The sulfur nutrient content in all treatments that included deficiency is suspected to be caused by the characteristics of Typic Dystrudepts soil, which has a sandy texture and low water retention capacity, leading to nutrient leaching. As a result, nutrients have not been absorbed by the plants before being washed away. This is consistent with the literature by Blum et al. (2013), which states that sulfur in the form of sulfate is susceptible to leaching, especially in soils with high rainfall.

4. CONCLUSION

The findings of the study indicate that the application of Polyhalite in conjunction with KCl fertilizer did not result in a notable impact on the concentrations of potassium, calcium, and sulfur nutrients in oil palm leaves. However, it did lead to a discernible alteration in the magnesium nutrient levels.

The combination of 75% polyhalite and 25% KCl proved to be the most effective in increasing leaf nutrient levels, as compared to the control treatment..

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