

Analysis Study of Soil Phosphorus Availability on the Growth of Oil Palm Seedlings (*Elaeis guineensis* Jacq.) with the Application of Liquid Fertilizer and Guano Fertilizer (Bat Manure) in Main-Nursery

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Article Info

Article history:

Received : Feb 05, 2024

Revised : Mar 19, 2024

Accepted : Apr 29, 2024

Keywords:

Oil Palm;

P available;

Oil Palm Plant Nursery;

Organic Fertilizer.

ABSTRACT

Guano fertilizer is a fertilizer derived from bat dung which is organic fertilizer, and contains a lot of P elements that can increase plant growth both vegetatively and generatively. The purpose of this study was to determine the effect of the application of Banana Stem POC and Guano fertilizer (Bat Manure) on soil P availability and growth of oil palm seedlings in the Main-Nursery. The experimental design used was a factorial Randomized Group Design with three replications. The treatments were arranged in four levels each of Banana Stem POC (C0 = Control, C1 = 1.5 ml/l water/Polybeg, C2 = 3 ml/l water/Polybeg, C3 = 4.5 ml/l water/Polybeg) and Guano Fertilizer (K0 = Control, K1 = 200 g/Polybeg, K2 = 400 g/Polybeg, K3 = 600 g/Polybeg). Banana stem is an agricultural waste that can be used as a useful product because it contains potential compounds, while Bat guano fertilizer has several advantages, namely it can stay longer in soil tissue, increase soil productivity and provide food for plants. These results show that the application of Banana Stem POC and Guano Fertilizer can increase the growth of plant height, stem diameter, leaf area and P available.

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1. INTRODUCTION

Oil palm (*Elaeis guineensis* Jacq.) is a very important plantation crop. This is because of the several types of plants that produce oil, oil palm is the plant that produces the greatest economic value. Besides producing vegetable oil in the form of Crude Palm Oil (CPO), Indonesia is the largest palm oil producing country in the world. In addition, oil palm has the largest economic value per hectare in the world. The oil palm plantation subsector plays a significant role in the Indonesian economy and is the main commodity that generates income for the Indonesian people ¹. The area of oil palm plantations in Indonesia is increasing, reaching 2,193,720 ha in 2016 with a production

¹ Rayani, 2023 n.d.

of 7,037,640 tons, and 2,424,545 ha in 2017 with a production of 7,841,947 tons. Therefore, the increase in area is highly dependent on planting media, watering and fertilization ².

Oil palm independent smallholders often face the problem of poor quality seedlings, which exhibit low growth capacity. While nutrients are essential for the growing medium, the availability of nutrients affects the growth of the overlying plants. Fertilizers are usually used to add nutrients to the growing medium ³.

Crop fertilization consists of organic and inorganic fertilizers. Continuous application of inorganic fertilizers to crops damages the soil and reduces the amount of soil biology. As a result, the nutrients in the soil are not balanced. Therefore, organic fertilization is necessary. ⁴ defines organic fertilizer as POC and solid organic fertilizer. POC is a solution fertilizer that contains more than one nutrient and is made from the decay of organic matter such as plants, animal manure, and humans. The advantage of POC is that it is more easily absorbed by plants because the elements have decomposed. Plants not only absorb nutrients through their roots, but also through their leaves.

In an effort to increase seedling growth yields, organic fertilizers can be used alone or in combination with other chemical fertilizers. The combination of organic and inorganic fertilizers at certain doses needs to be studied further, but the use of inorganic fertilizers needs to be reduced because at this time the price of chemical fertilizers is expensive and can have a negative effect on the soil if used continuously ⁵.

Banana is one of the most important crops in the world due to its rapid growth, high nutritional capacity, economic value, and ease of transportation ⁶. The banana plant, which belongs to the Musaceae family, is native to the Southeast Asian region between Malaysia and Indonesia. About 120 countries in the world grow bananas, which produce about 86 tons of plant waste per hectare, and are an abundant natural resource in tropical and subtropical countries around the world ⁷.

One type of organic fertilizer that can be used is banana stem POC. ^{8, 9} explained that banana stem POC contains 1.80% N, 2.02% P, and 0.05% K. POC functions during the vegetative growth period of plants, helping the availability of soil phosphorus (P) during the flowering process and fruit formation.

But dung fertilizer, or guano, can be used to fertilize organically. According to ¹⁰, "guano" is the term used to describe the dense natural piles of feces and urine from birds or bats collected from caves where populations of these animals live and breed. Guano, which comes from limestone cave dwellings, has the best mineral and nutrient content. It has many micro and macro minerals, as well as high natural nitrogen and phosphorus content. The nitrogen content is 4.28 percent, phosphorus is 1.89 percent, and potassium is 0.46 percent ¹¹.

Guano fertilizer is a fertilizer derived from bat droppings that have settled for a long time in caves and have been mixed with soil and decomposing bacteria. It contains 7.5 percent nitrogen, 8.1 percent phosphorus, and 2.7 percent potassium, in addition to all the microelements that seedlings need. Swallow droppings contain 50.46% C-organic, 11.24% N/total, and a C/N ratio of 4.49. The pH is 7.97, containing 1.59% phosphorus, 2.17% potassium, 0.30% calcium, and 0.01% magnesium. It also contains 5% N, 1.7% P, and 1.59% K [8]. Phosphate rock, also known as phosphate rock (RP), is a fertilizer containing 27% phosphate (P₂O₅). It should be used at the beginning of growth or as a base fertilizer and before flowering ¹².

² Lidar *et al.* 2022

³ Mukti Paderma *et al.* 2021a

⁴ Mukti Paderma *et al.* 2021b

⁵ Syarif & Syarif n.d.-a

⁶ J., Basri, S. K., *et al.* 2023

⁷ J., Basri, S. K., *et al.* 2023

⁸ Lidar *et al.* 2022

⁹ Mukti Paderma *et al.* 2021a

¹⁰ Syarif & Syarif n.d.-a

¹¹ Syarif & Syarif n.d.-b

¹² Syah, Ginting & Parwati n.d.

2. METHOD

2.1 Description of research location

The field experiment was conducted in Dalu X village, Tanjung Morawa sub-district, Deli Serdang district, North Sumatra province. North Sumatra, and the oil palm seedlings used were 6 months old. The experimental land in Dalu X Village has a flat land with an altitude of ± 25 meters above sea level. The experimental land area in Dalu X Village is ± 0.5 ha. with coordinates 3°34'00 "N 98°48'42 "E 12 m.

2.2 Research methods

This study was designed using a factorial Randomized Group Design with 3 replications. The treatment given was the application of Banana Stem Liquid Organic Fertilizer, namely C0 = control (*without application*), C1 = 20 ml/l water, C2 = 30 ml/l water, and C3 = 40 ml/l water. While the application of Guano fertilizer (*bat droppings*) is K0 = Control (*without application*), K1 = 12.5 g/polybag, K2 = 25 g/polybag and K3 = 37.5 g/polybag.

Banana stem liquid organic fertilizer is given by dissolving it first in water, then sprinkled as much as 1 l/polybag on the oil palm seedling soil with a polybag capacity of 5 kg of soil. Meanwhile, fertilizer derived from bat dung (*Guano*) is applied directly after the permentation period is complete. The finished Guano fertilizer is marked by the temperature of the soil that is no longer hot and the smell of pungent is reduced or disappeared, then the fertilizer is ready to be applied. Banana stem POC and Guano fertilizer were applied separately and at different application times. Banana stem POC was applied 1 week after the Guano fertilizer was applied.

2.3 Soil sampling, measurement and analysis

In this study, soil analysis before treatment was carried out by taking soil samples in each treatment as much as 500 g, then from the soil samples available P (Bray method with a flamefotometer).

Soil sampling is done by taking rhizosphere soil, where this soil is the portion of the soil that is directly affected by plant roots. Soil samples that have been taken both before and after the application of the two treatments are then taken to the soil laboratory of the Agricultural Instrument Standardization Agency (BSIP).

Banana stem POC fertilizer analyzed were pH H₂O, organic C (Walkley & Black Method), total N (Kjeldhal Method), total P (25% HCl Extract with spectrophotometer), and K-total (25% HCl Extract with flamefotometer). While the Guano fertilizers analyzed were total N (Kjeldhal Method), total P (25% HCl Extract with spectrophotometer), and K-total (25% HCl Extract with flamefotometer).

The effect of Banana Stem POC and Guano fertilizer on soil P availability in oil palm nurseries in Main-Nursary was tested using ANOVA and further test using LSD test at the 5% level if the treatment given had a significant effect on soil chemical properties.

3. RESULTS AND DISCUSSION

The research results of the treatment given to oil palm seedlings (*Elaeis guinensis* Jacq.) on the observation of P-Available and the growth of oil palm seedlings can be explained below.

3.1 P-Available in Soil (%)

The content of available phosphorus in the soil at the age of 12 MST seedlings, the results of the analysis show that banana stem liquid organic fertilizer does not affect the availability of available P in the soil at the age of 12 MST. However, the application of Guano fertilizer can affect the available P in the soil. This can be seen in Table 1 below.

Table 1. Average P Available Soil (ppm) in Banana Stem POC and Guano Fertilizer (Bat Dung) Treatment at 12 WAP

Treatment	Guano Fertilizer (Bat Manure)				Average
	K ₀	K ₁	K ₂	K ₃	
Banana Stem POC	-----ppm-----				
C ₀	15.60	16.25	17.15	17.85	16.71
C ₁	15.65	16.35	17.26	17.95	16.80
C ₂	15.70	16.50	17.45	18.05	16.93
C ₃	15.70	16.51	17.50	18.10	16.95
Average	15.66 a	16.40 ab	17.34 b	17.99 bc	

Notes: Numbers in the same row followed by different notations indicate significantly different at the 5% level based on the LSD Test.

Table 2. Results of the analysis of the content of N, P and K elements in Guano fertilizer and Banana Stem POC

No	Type of Analysis	Guano Fertilizer	Banana Stem POC
1	Nitrogen (%)	4,37	2,47
2	P2O5 (%)	25,21	1,57
3	K2O (%)	2,34	0,61

Source: Soil Science Laboratory, Faculty of Agriculture, UISU Medan

Based on the results of the analysis shown in Table 1. in accordance with the results of the analysis of Guano fertilizer (bat dung) that fertilizer derived from bat dung contains a lot of P (25.21%). This happens allegedly because bats eat fruits, and fruit requires P in the mass of plant fruit growth so that automatically the dung produced by bats contains a lot of P, this can be seen in Table 2. This is in accordance with the opinion that the availability of P in the soil is closely related to soil pH.

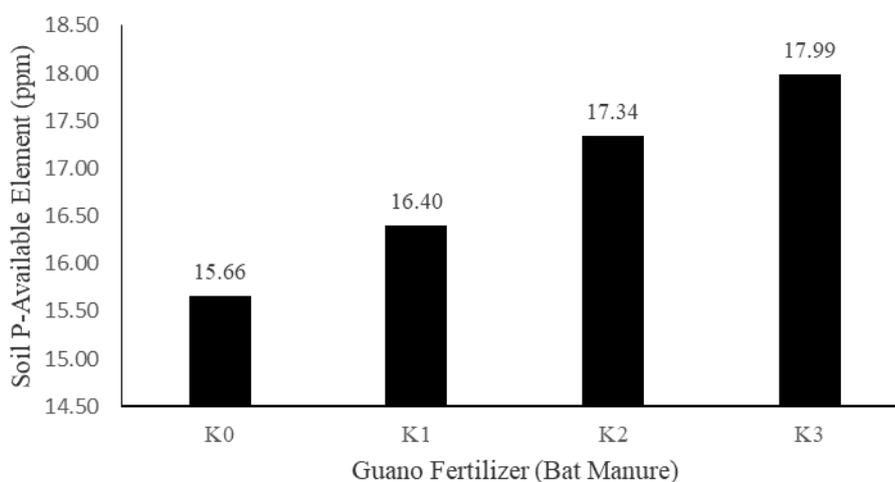
**Figure 1.** P-Available Element in the Soil of Oil Palm Seedlings in Main-Nursary

Figure 1 above shows that the higher the dose given, the higher the level of available P in the soil of oil palm seedlings in the Main-Nursary at the age of 12 weeks after planting. The highest available P content is found at a dose of 37.5 gr/polybeg (K3) which has an available P content of 17.99 ppm. These results are in accordance with the results of research¹³ showing that guano has a positive effect in increasing the availability of phosphorus nutrients in the soil. This increase can occur through two mechanisms, namely directly and indirectly. while the indirect effect is through the release of P from mineral complexes and soil adsorption complexes. Organic matter can increase the availability of phosphorus in the soil, this is what causes the available P content to increase. This is in accordance with what was stated by Guano is used as a fertilizer to improve soil conditions and provide nutrients for plants, and to increase soil organic matter content and improve soil physical properties, especially soil structure and porosity so that the amount of nutrients needed by plants is more available.

3.2 Plant Height (cm)

In the observation of plant height, it is known that the application of banana stem POC and Guano fertilizer can affect the plant height of oil palm seedlings. This can be seen in Table 3 below.

Table 3. Height of Oil Palm Seedlings (cm) in the Treatment of Banana Stem POC and Guano Fertilizer at the Age of 12 MST

Treatment	Guano Fertilizer (Bat Manure)				Average
	K ₀	K ₁	K ₂	K ₃	
Banana Stem POC	-----cm-----				
C ₀	7.23 e	17.32 c	23.85 ab	17.90 c	16.58 a
C ₁	18.60 c	23.80 ab	16.83 dc	25.83 a	21.27 ab
C ₂	17.65 c	17.65 c	22.92 b	25.88 ab	21,03 ab
C ₃	19.30 c	22.30 b	23.87 ab	19.78 c	21,31 b
Average	15.70 a	20.27 ab	21,87 ab	22,35 b	

¹³ Purba *et al.* n.d.

Notes: Numbers in the same row followed by different notations indicate significantly different at the 5% level based on the LSD Test.

Table 1 shows that the application of banana stem POC actually caused greater growth of oil palm seedlings at 12 mst. The highest result was achieved in treatment C3 (45 ml/liter of water/polybag), which reached 21.31 cm. This was significantly different from treatment C0 (no fertilizer), which reached 16.58 cm, and not different from treatment C1 (15 ml/liter of water/polybag), which reached 21.27 cm, and treatment C2 (30 ml/liter of water/polybag) which was 21.03 cm. This is in accordance with the results of research proposed by ¹⁴ showing that the height increase of oil palm seedlings due to the application of banana stem POC at various concentrations is significantly different. Liquid organic fertilizer (POC) is a plant fertilizer derived from organic materials and is liquid in form which is used by sprinkling it on the planting media. POC is easier to use because it absorbs quickly and can be used directly without damaging plants ¹⁵.

All treatments using guano fertilizer showed a significant increase in the size of oil palm seedlings at 12 mst. Treatment K3 achieved the highest guano fertilizer application rate with 600 g/polybag, which was the same as treatment K0 (no fertilizer), which reached 16.75 cm; treatment K2 (400 g/polybag) reached 22.25 cm, and treatment K1 (200 g/polybag) reached 21.08 cm. This is in line with showing that Guano fertilizer shows its effect on the plant height of oil palm seedlings. In contrast, ¹⁶ showed that the application of bat dung compost (guano) did not significantly affect the height of oil palm seedlings in the Main Nursery on ultisol, but the two single factors significantly affected it.

Both treatments significantly increased the plant height of oil palm seedlings at the age of 12 mst. Treatment C1K3, which used POC 15 ml/liter of water per polybag and guano fertilizer 600 g per polybag, reached the highest plant height of 26.33 cm, while treatment C0K0, which was without fertilizer, reached the lowest plant height of 8.33 cm. This is in accordance with the results of the analysis of Banana Stem POC and guano compost that has been carried out, that guano compost has a high N and medium P nutrient content (Table 2), so that guano compost can meet the nutrient needs of seedlings ¹⁷. Likewise, the use of POC can improve the physical, chemical, and biological properties of the soil. In addition, it can reduce the use of inorganic fertilizers ¹⁸.

3.3 Stem Diameter (cm)

The results showed that the treatment of banana stem liquid organic fertilizer and guano fertilizer significantly increased the stem diameter of oil palm seedlings at the age of 12 weeks after planting. However, the interaction of the two treatment factors had no significant impact on the increase in stem diameter at the age of 12 weeks after planting. These results can be seen in Table 3 below.

Table 4. Stem Diameter of Oil Palm Seedlings (cm) in the Treatment of Banana Stem POC and Guano Fertilizer at 12 weeks of age.

Treatment	Guano Fertilizer (Bat Manure)				Average
	K ₀	K ₁	K ₂	K ₃	
Banana Stem POC	-----cm-----				
C ₀	12.55	21.23	29.37	22.02	21.29 b
C ₁	23.02	27.27	30.17	32.80	28.32 a
C ₂	26.87	27.05	27.48	22.40	25.95 ab
C ₃	22.23	25.03	29.75	35.92	28.23 ab
Average	21.17 a	25.15 ab	29.19 b	28.29 bc	

Notes: Numbers in the same row followed by different notations indicate significantly different at the 5% level based on the LSD Test.

In Table 4, it can be seen that the application of Banana Stem Liquid Organic Fertilizer (POC) really increased the stem diameter of oil palm seedlings at the age of 12 weeks after planting. Treatment C1 reached the highest size of 28.32 cm (15 ml/liter of water/polybag), in contrast to treatment C0 (without fertilizer) which was only 21.29 cm. C3 treatment reached a size of 28.23 cm and C2 treatment reached a stem diameter size of 25.95 cm (30 ml/liter of water/polybag).

¹⁴ Mukti Paderma *et al.* 2021b

¹⁵ J., Basri, S. K., *et al.* 2023

¹⁶ Syarif & Syarif n.d.-b

¹⁷ Syarif & Syarif n.d.-a

¹⁸ Basri *et al.* 2023

According to one of the macro nutrients that can support the growth of stem diameter is phosphorus. The results of this study are in line with ¹⁹ which shows that the application of Banana Stem POC has an effect on the stem diameter of oil palm seedlings (*Elaeis guineensis* Jacq.).

The results showed that there was an effect of guano fertilizer on the diameter of the trunk of oil palm seedlings (*Elaeis guineensis* Jacq.). Treatment K2 (400 g/polibag) reached the highest diameter of 29.19 cm, which was different from treatment K0 (without fertilizer), which reached 21.17 cm and treatment K1 (200 g/polibag) reached 25.15 cm, while treatment K3 (600 g/polibag) reached 28.29 cm. According to ²⁰ Guano fertilizer given can increase P-available in the soil because guano fertilizer has a very high P-available content. This fact shows that guano has a positive effect on the availability of phosphorus nutrients in the soil. This is in line with that the provision of guano fertilizer has met the need for nutrients in plants for vegetative growth such as plant growth, stems and leaves, so that it will increase growth in leaves which will affect leaf area.

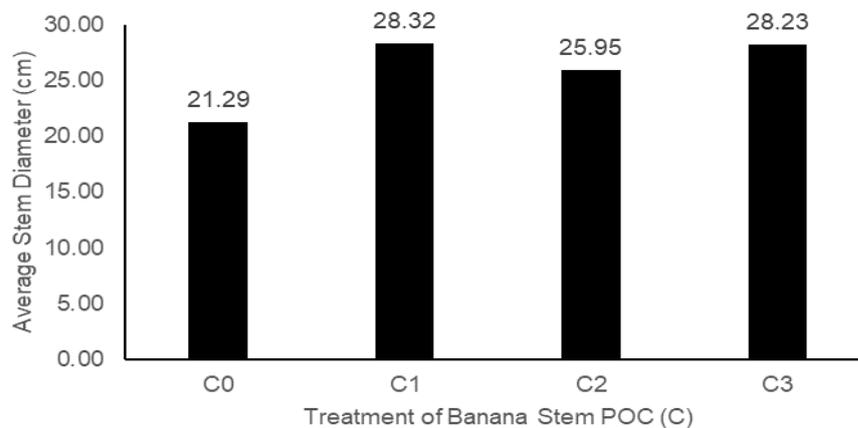


Figure 2. Stem Diameter (cm) of Oil Palm (*Elaeis guineensis* Jacq.) Seedlings in Response to Banana Stem POC.

Figure 2 shows that the provision of Banana Stem POC has different results at each dose given, although it does not provide a significant difference in the observation of stem diameter. This is in line with ²¹, where according to him this is thought to be because the provision of POC has not been able to provide the nutrients needed by oil palm seedlings so that vegetative plant growth such as the increase in stem diameter is not significant.

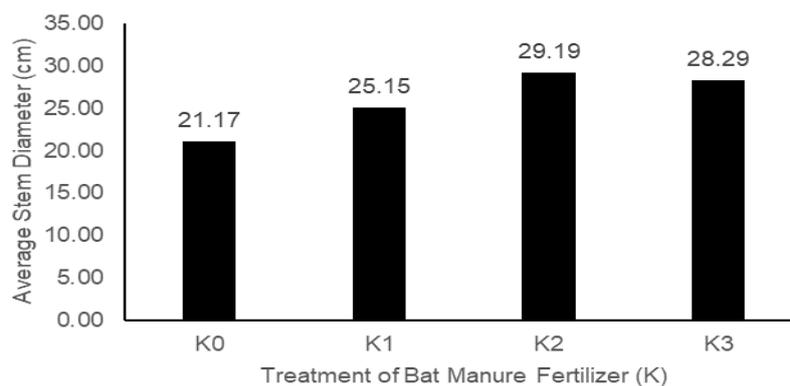


Figure 3. Trunk Diameter (cm) of Oil Palm (*Elaeis guineensis* Jacq.) Seedlings in Response to the Application of Bat Manure (Guano) Fertilizer.

Based on the research results shown in (Figure 3) above, it can be seen that the higher the dose of Guano fertilizer on oil palm seedlings, the higher the stem diameter of oil palm seedlings. It can be seen that the K2 treatment (400 g/polybeg) has the largest diameter of 29.19 cm. While the

¹⁹ Safi'i, Berliana & Zulkifli n.d.

²⁰ Syah *et al.* n.d.

²¹ Bahar *et al.* 2022

increase in the dose of Guano fertilizer in the K3 treatment (600 g/polybeg) actually decreased, namely 28.29 cm, so it can be seen that the appropriate dose to increase the stem diameter of oil palm seedlings is K2 (400 g/polybeg). The results of this study are in line with research that the provision of guano as much as 0.5 kg per polybag, the diameter of oil palm seedlings increased and was significantly different from the diameter of seedlings in the treatment without guano. This shows that by giving guano, the developmental response of oil palm seedlings is getting better. Furthermore, with the higher addition of guano up to 1.5 kg per hectare, the diameter of the seedlings relatively did not increase anymore and was not different from the diameter of the seedlings in the 0.5 kg per polybag treatment.

3.4 Leaf Area (cm²)

The results of the analysis showed that at the age of 12 weeks after planting, the increase in the number of leaves of oil palm seedlings was not influenced by the treatment of banana stem liquid organic fertilizer (POC) and guano fertilizer. This can be seen in Table 4 below.

Table 5. Leaf Area of Oil Palm Seedlings (cm²) in the Treatment of Banana Stem POC and Guano Fertilizer at 12 weeks of age.

Treatment	Guano Fertilizer (Bat Manure)				Average
	K ₀	K ₁	K ₂	K ₃	
POC Batang Pisang	-----cm ² -----				
C ₀	5.10 d	9.02 c	14.13 ab	14.00 ab	10.56 b
C ₁	8.21 c	13.65 ab	10.82 bc	15.71 a	12.10 ab
C ₂	12.90 b	14.15 ab	14.20 a	14.14 a	13.85 a
C ₃	15.05 a	14.25 a	14.26 a	11.60 bc	13.79 ab
Average	10.32 b	12.77 ab	13.35 ab	13.86 a	

Notes: Numbers in the same row followed by different notations indicate significantly different at the 5% level based on the LSD Test.

In Table 5, it can be seen that the application of liquid organic fertilizer on banana stems actually increased the leaf area of oil palm seedlings at 12 mst. Treatment C2 reached the highest area of 13.85 cm² (with 30 ml/liter of water/polybag), different from treatment C0 (without fertilizer), which reached 10.56 cm², and not different from treatment C1 (15 ml/liter of water/polybag), which reached 12.10 cm². This is in line with the results of research ²² which shows that the application of Liquid Organic Fertilizer has a significant effect on the leaf area of oil palm seedlings. According to ²³ Liquid organic fertilizer (POC) is more easily absorbed by plants because the elements contained in it have been decomposed. Plants absorb nutrients mainly through the roots, but also through the leaves so there is a benefit if liquid fertilizer is not only given around the plant, but also around the leaves.

The guano fertilizer application process also increased the leaf area of oil palm seedlings at 12 mst. The K3 treatment reached the highest application rate (600 g/polybag) at 13.86 cm², which was different from the K0 treatment (no fertilizer) at 10.32 cm², and the K1 treatment (200 g/polybag) at 12.77 cm² and the K2 treatment (400 g/polybag) at 13.35 cm². The results of this study are in line with ²⁴ the provision of guano fertilizer has met the needs of nutrients in plants for vegetative growth such as plant growth, stems and leaves, so that it will increase growth in leaves.

The combination of treatments can increase the leaf area of oil palm seedlings at 12 mst. The P1G3 treatment, which used POC 15 ml/liter of water per polybag and 600 kg of guano fertilizer per polybag achieved the highest leaf area of 15.74 cm². While the P0G0 treatment without fertilizer reached the lowest leaf area of 5.24 cm². In accordance with the results of research ²⁵, that the combination of treatments can affect the leaf area of oil palm seedlings in the Main-Nursary. This happens because Banana Pith (*Musca paradisiaca*) has many bud eyes in which there are gibberellins and cytokinins so that it can invite other microorganisms to come. Banana Stem (*Musca paradisiaca*) contains several microorganisms that play a good role in soil fertilization ²⁶. Meanwhile, according to ²⁷, banana pith contains N 2.2 ppm Fe 0.09 ppm, and Mg 800 ppm, and also contains microbial decomposition of organic matter, these decomposing microbes are located

²² Safi'i, Berliana & Zulkifli n.d.

²³ Guna *et al.* 2024

²⁴ Purba *et al.* n.d.

²⁵ Safi'i, Berliana & Zulkifli n.d.

²⁶ Bahar *et al.* 2022

²⁷ Bahar *et al.* 2022

on the outer and inner banana pith, the types of microorganisms identified in banana pith include *Bacillus* sp, *Aeromonas* sp, *Aspergillus*, Phosphate solubilizing microbes and cellulosic microbes that can be used as liquid fertilizers. which will affect leaf area.

4. CONCLUSION

Fertilizer derived from bat dung (guano fertilizer) has a significant effect on the availability of P in the soil, but has no significant effect on the application of banana stem liquid organic fertilizer (POC). The highest content of P-available element in the soil is found in K3 treatment (37.5 g/polybeg) which is 17.99 ppm. The analysis of fertilizer derived from bat dung (guano fertilizer) contains 25.21% P-Available element. In addition to the N element, the P element is also very important in plant vegetative growth. The application of liquid organic fertilizer (POC) made from banana stems and fertilizer derived from bat droppings (guano fertilizer) can affect the growth of oil palm seedlings in Main-Nursary such as plant height (cm), stem diameter (cm) and leaf area (cm²). The best combination is known to be in the C1K3 treatment (20 ml/l POC water and 37.5 g/polybeg Guano fertilizer) producing the best plant height (cm) and leaf area (cm²) of 25.83 cm (plant height) and 15.71 cm² (leaf area).

Based on this conclusion, I suggest that in the future researchers who research organic fertilizers should continue to develop this research, so that later the perfect research results can be applied, and can benefit farmers in the future. So as not to depend on inorganic fertilizers (chemical fertilizers).

ACKNOWLEDGEMENTS

Thank you to the people/farmers of Dalu X Village, Tanjung Morawa Sub-district, Deli Serdang District, Prov. North Sumatra for providing land for my research and assisting me in maintaining the oil palm seedlings during my research.

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