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EFFECTS OF UREA AND ORGANIC FERTILIZER TREATMENTS ON OIL PALM (*ELAEIS GUINEENSIS* JACQ.) SEEDLING GROWTH IN THE PRE-NURSERY

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Abstract

The purpose of this study was to determine the effect of urea fertilizer and organic manure derived from goat manure on the growth of oil palm seedlings in the pre-nursery stage. The research was conducted using a factorial Randomized Complete Block Design (RCBD) consisting of two factors. The first factor was urea fertilizer treatment with three levels: U0 = control, U1 = 3 g/polybag, and U2 = 6 g/polybag. The second factor was the dose of goat manure (K) with three levels: K1 = control, K2 = 200 g/polybag, and K3 = 400 g/polybag. The interaction between urea and goat manure doses had a significant effect on plant height, stem diameter, number of leaves, leaf length, leaf width, and leaf area.

Keywords: Urea fertilizer, goat manure, and oil palm seedlings

INTRODUCTION

Palm oil is Indonesia's flagship crop in international trade. It has significant competitiveness in the global market because palm oil production is concentrated in only a few countries. Oil palm plants also have high nutritional value and can be utilized as a food source, as well as a source of biodiesel fuel (Sakti & Rosmawaty, 2022). To enhance the growth of oil palm seedlings in the pre-nursery stage, the application of goat manure can be beneficial. Goat manure improves the physical properties of the soil, making it looser, which enhances root growth and development. Additionally, the organic matter in goat manure increases the availability of nutrients for plants. Since goat manure is a solid fertilizer, it must undergo a decomposition process before plants can absorb its nutrients. Soil fertility is largely determined by its physical, chemical, and biological properties. The physical properties of soil influence both its chemical and biological fertility. Therefore, efforts to improve soil physical properties should also aim to enhance its chemical properties by applying organic matter, such as manure (Walida et al., 2020). Increasing the growth of oil palm seedlings can also be achieved by applying urea fertilizer. Urea fertilizer is a nitrogen-containing fertilizer that can be quickly absorbed by plants. It is a chemical fertilizer with a high nitrogen (N) content, ranging from 45% to 46%.

Soetrisno (2002) explains that in the tropics, nitrogen (N) is the most deficient element, followed by phosphorus (P) and sulfur (S), while the more soluble elements

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include calcium (Ca), magnesium (Mg), potassium (K), and sulfur (S). Most soils, especially those used for food crops, are overexploited, leading to a decrease in nutrient content due to the high nitrogen uptake for vegetative growth and the lack of organic matter returning nitrogen to the soil. Nitrogen deficiency causes stunted plant growth, resulting in a weak appearance, pale yellow leaves, and poor yield quality. Nasution *et al*. (2019) found that applying urea fertilizer at a dose of 4 g/polybag can enhance the growth of oil palm seedlings in the pre-nursery stage. Similarly, research by Harahap et al. (2021) showed that applying urea fertilizer at a dose of 3 g/polybag resulted in the best plant height and leaf area for oil palm seedlings during the pre-nursery period. Goat manure contains organic matter that provides nutrients for plants through the decomposition process. This process occurs gradually, releasing simple organic compounds that support plant growth. Since goat manure has low moisture content, it decomposes easily. Liquid organic fertilizer can also be produced from goat feces, commonly known as bioculture or biourine (goat urine). In both bioculture and biourine, an activator known as EM4 is used, as it contains *Azotobacter* sp., *Lactobacillus* sp., yeast, photosynthetic bacteria, and cellulose-degrading fungi. The advantage of EM4 is its ability to accelerate the fermentation of organic matter, making nutrients more readily available for plant absorption (Hadisuswito, 2012). Research by Rasyid *et al*. (2017) reported that the application of goat manure at a dose of 30 tons/ha (150 g/polybag) can enhance the growth of oil palm seedlings in the pre-nursery stage. Furthermore, research by Juliana et al. (2018) stated that applying goat manure at a dose of 350 g/polybag can further improve seedling growth in the pre-nursery stage.

RESEARCH MATERIALS AND METHODS

Study Area. This research was conducted at Jl. Klambir V, Sunggal District, Deli Serdang Regency, at an altitude of approximately 32 meters above sea level. The study was carried out from May to August 2023.

Research Tools and Materials. The materials used in this study included oil palm sprouts of the Marihat variety, obtained from the Pematang Siantar-Medan Plantation Research Center located at Jl. Brigadier General Katamso No. 81, Medan. Other materials included 5 kg polybags (15 cm × 23 cm), water, urea fertilizer, goat manure, and topsoil. The tools used in this research were a hoe, bucket, measuring tape, tembilang (a traditional planting tool), sieve, wooden board, zinc plate for name tags, nails, ruler, measuring cup, black/white paint, and wooden sticks to make planting holes. Additionally, stationery and notebooks were used for data recording.

Research Methods. This study employed a factorial Randomized Block Design (RBD) consisting of two factors: (1) Urea fertilizer application, with three levels: U0 = 0 g/polybag, U1 = 3 g/polybag and U2 = 6 g/polybag; (2) Goat manure application, with three levels: K1 = control (0 g/polybag), K2 = 200 g/polybag and K3 = 400 g/polybag. All treatments were repeated three times.

Shade Construction. To protect the oil palm seedlings from direct sunlight, a shade structure measuring 4 meters in length and 3 meters in width was constructed, with a height of 2 meters. The shade was made of paranet with a 75% sunlight intensity reduction.

Fertilizer Application**.** Goat manure was applied during polybag filling according to the designated treatment levels: K1 = 0 g/polybag, K2 = 200 g/polybag and K3 = 400 g/polybag, while Urea fertilizer was applied according to the treatment doses: U0 = 0 g/polybag, U1 = 3 g/polybag, U2 = 6 g/polybag.

Urea fertilizer was distributed evenly along the edge of the polybags. Fertilization was conducted every two weeks, starting when the oil palm seedlings were one month old, and discontinued once the seedlings reached three months of age. Observations were conducted starting at four weeks after planting (WAP).

RESEARCH RESULTS AND DISCUSSION

Plant Height (cm).

The average plant height at 4, 6, 8, 10, and 12 weeks after planting (WAP) as affected by urea fertilizer and goat manure treatments, along with the mean difference test results, is presented in Table 1.

Table 1. Average Plant Height (cm) as Affected by Urea Fertilizer and Goat Manure Treatments

Observations	Treatments	K_1	K_2	K_3	Mean
4 WAP	U_0	9,01	8,90	9,22	9,04a
	U_1	9,64	11,21	11,31	10,72b
	U_2	10,77	10,58	11,22	10,86b
	Mean	9,81	10,23	10,59	
6 WAP	U_0	10,94	13,22	14,44	12,87a
	U_1	13,67	15,39	15,89	14,98b
	U_2	15,44	17,56	18,61	17,20c
	Mean	13,35a	15,39b	16,31b	
8 WAP	U_0	13,73a	16,89b	19,33c	16,65a
	U_1	18,33bc	18,52c	20,94d	19,27b
	U_2	19,89cd	21,00d	24,36e	21,75c
	Mean	17,32a	18,80b	21,54c	
10 WAP	U_0	15,53a	18,07b	21,27cd	18,29a
	U_1	19,80c	22,13d	24,60e	22,18b
	U_2	21,72d	24,97e	30,19f	25,63c
	Mean	19,02a	21,72b	25,35c	
12 WAP	U_0	16,60a	20,73b	24,33d	20,56a
	U_1	22,40c	25,10d	27,00e	24,83b
	U_2	23,96d	27,80e	33,33f	28,36c

	Mean	20,99a	24,54b	28,22c	

Note: Numbers followed by the same letter in the same treatment column are significantly different based on the LSD test at a 5% significance level (α = 5%)

The relationship between urea fertilizer and the height of oil palm seedlings at 12 WAP under various doses of goat manure can be seen in Figure 1.

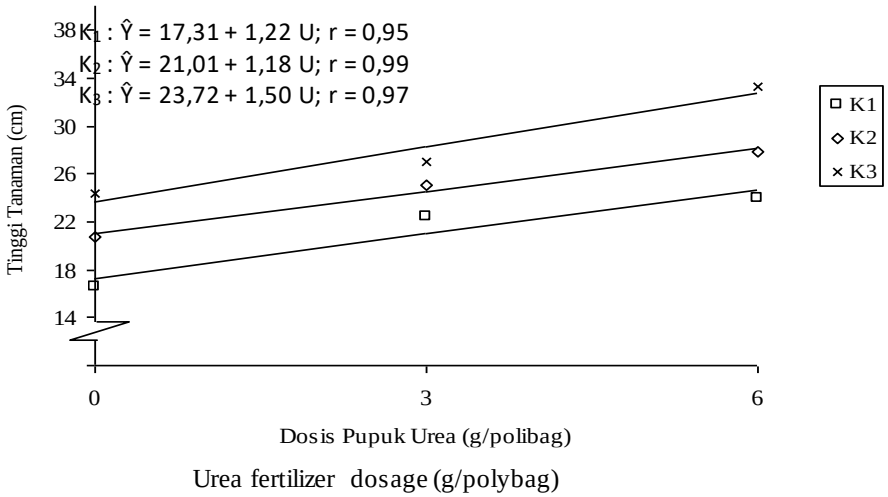

Figure 1. Response Curve of the Interaction Effect of Urea Fertilizer and Goat Manure on Plant Height at 12 Weeks After Planting

From Figure 1, it can be seen that the height growth of oil palm seedlings was better when urea fertilizer was combined with goat manure at a dose of 400 g/polybag (K3), resulting in a seedling height of 33.33 cm. The application of urea fertilizer combined with K1 had an r-value of 0.95, the combination with K2 had an r-value of 0.99, and the combination with K3 had an r-value of 0.97.

An adequate supply of nitrogen accelerates cell division, which leads to cell growth and elongation. The expansion of cells in each plant organ further enlarges the plant's stem, roots, and leaves. This growth rate increases with a higher nitrogen supply (Hardjadi, 2006). Nitrogen is an essential nutrient required for vegetative growth.

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Stem Diameter (mm).

The average stem diameter as affected by urea fertilizer and goat manure application is presented in Table 2..

Table 2. Average Stem Diameter (mm) as Affected by Urea Fertilizer and Goat Manure Application

Observations	Treatments	K_1	K_2	K_3	Mean
4 WAP	U_0	3,22	3,00	3,33	3,19a
	U_1	3,89	4,11	4,33	4,11b
	U_2	4,22	4,22	5,00	4,48c

	Mean	3,78a	3,78a	4,22b	
6 WAP	U_0	3,33	4,00	4,22	3,85a
	U_1	4,78	5,11	5,33	5,07b
	U_2	5,11	5,22	6,11	5,48b
	Mean	4,41a	4,78b	5,22c	
8 WAP	U_0	3,56	4,44	5,44	4,48a
	U_1	5,11	5,78	6,67	5,85b
	U_2	5,67	6,11	7,44	6,41c
	Mean	4,78a	5,44b	6,52c	
10 WAP	U_0	3,33a	4,73b	5,53c	4,53a
	U_1	5,13bc	5,67c	6,53d	5,78b
	U_2	5,67c	6,13d	7,87e	6,56c
	Mean	4,71a	5,51b	6,64c	
12 WAP	U_0	3,27a	4,93b	5,67cd	4,62a
	U_1	5,40bc	6,00d	6,80e	6,07b
	U_2	6,00d	7,00e	8,07f	7,02c
	Mean	4,89a	5,98b	6,84c	

Note: Numbers followed by the same letter in the same treatment column are significantly different based on the LSD test at a 5% significance level ($\alpha = 5\%$)

The effect of urea fertilizer application on the stem diameter of oil palm seedlings at 12 WAP under various doses of goat manure is shown in Figure 2.

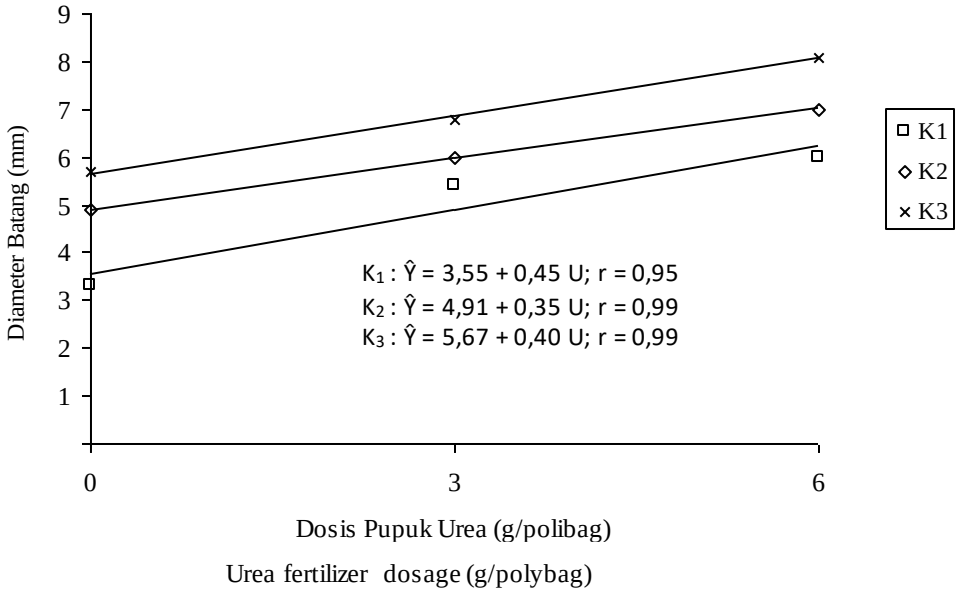

Figure 2. Response Curve of the Interaction Effect of Urea Fertilizer and Goat Manure on Stem Diameter at 12 Weeks After Planting.

From Figure 2, it can be seen that the stem diameter growth of oil palm seedlings was better with a high application of urea fertilizer combined with goat manure at a dose of 400 g/polybag (K3), resulting in a stem diameter of 8.07 mm. The application of urea fertilizer combined with K1 had an r-value of 0.95, while the combination with K2 had an r-value of 0.99, and the combination with K3 had an r-value of 0.99.

Number of Leaves (Blades)

The average number of leaves resulting from the application of urea fertilizer and goat manure is presented in Table 3.

Table 3. The Average Number of Leaves (Blades) Due to the Application of Urea Fertilizer and Goat Manure

Observations	Treatments	K_1	K_2	K_3	Mean
4 MST	U_0	1,78	2,00	2,11	1,96
	U_1	2,11	2,11	2,00	2,07
	U_2	2,00	2,22	2,00	2,07
	Mean	1,96	2,11	2,04	
6 MST	U_0	2,11	2,22	2,56	2,30a
	U_1	2,44	2,67	2,67	2,59b
	U_2	2,56	3,00	3,00	2,85c
	Mean	2,37a	2,63b	2,74b	
8 MST	U_0	2,67	3,00	3,00	2,89a
	U_1	2,89	3,11	3,22	3,07a
	U_2	3,22	3,44	3,89	3,52b
	Mean	2,93a	3,19b	3,37b	
10 MST	U_0	3,20a	3,27a	3,93b	3,47
	U_1	3,27a	3,93b	3,93b	3,71
	U_2	4,00b	4,00b	4,33c	4,11
	Mean	3,49	3,73	4,07	
12 MST	U_0	3,27	3,47	4,00	3,58a
	U_1	3,40	3,93	4,13	3,82b
	U_2	4,20	4,47	5,00	4,56c
	Mean	3,62a	3,96b	4,38c	

Note: Numbers followed by the same letter in the same treatment column are significantly different based on the LSD test at a 5% significance level ($\alpha = 5\%$)

The effect of urea fertilizer application on the number of leaves of oil palm seedlings at 10 weeks after planting (WAP) with various doses of goat manure is shown in Figure 3.

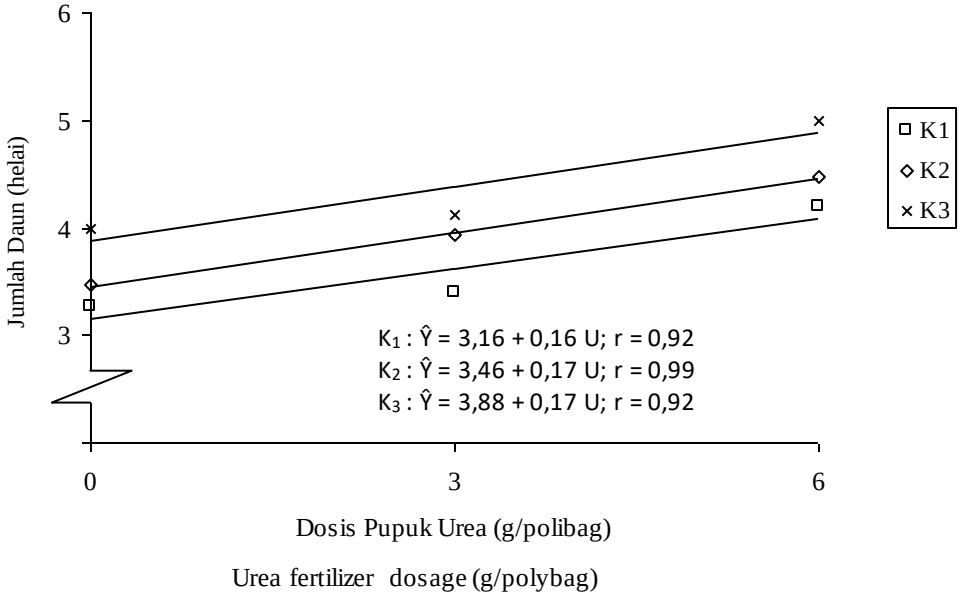

Figure 3. Response Curve of the Interaction Effect of Urea Fertilizer and Goat Manure on the Number of Leaves at 10 Weeks After Planting

From Figure 3, it can be seen that the number of leaves in oil palm seedlings increased with a high dose of urea fertilizer combined with goat manure at a dose of 400 g/polybag (K3), resulting in an average of 4.33 leaves per seedling. The application of urea fertilizer combined with K1 had an r-value of 0.92, while the combination with K2 had an r-value of 0.99, and the combination with K3 had an r-value of 0.92.

These macromolecular compounds are produced through photosynthesis, which generates assimilates. The assimilates formed are then translocated to support the development of new plant organs. The more efficient the photosynthesis process, the greater the assimilate production, leading to faster new organ formation.

Leaf development requires a substantial supply of nitrogen, which can be provided by urea fertilizer. The vegetative growth of oil palm seedlings in the nursery is closely related to nitrogen availability. However, nitrogen fertilizers must be applied at an appropriate dosage, as excessive nutrients can disrupt plant growth and development (Harahap et al., 2019).

Leaf Length (cm)

The average leaf length resulting from the application of urea fertilizer and goat manure is presented in Table 4.

Table 4. The Average Leaf Length (cm) Due to the Application of Urea Fertilizer and Goat Manure

Observations	Treatments	K_1	K_2	K_3	Mean
4 WAP	U_0	6,50	7,11	7,89	7,17a
	U_1	7,97	9,44	9,49	8,97b
	U_2	9,06	8,96	9,44	9,15b
	Mean	7,84a	8,50ab	8,94b	
6 WAP	U_0	7,99	10,50	11,28	9,92a
	U_1	11,28	12,00	13,28	12,19b
	U_2	12,79	13,56	16,51	14,29c
	Mean	10,69a	12,02b	13,69c	
8 WAP	U_0	10,11a	12,41b	15,72de	12,75a
	U_1	14,67cd	15,12d	16,86e	15,55b
	U_2	13,72bc	16,61e	20,36f	16,90c
	Mean	12,83a	14,71b	17,64c	
10 WAP	U_0	12,00a	14,73b	18,07d	14,93a
	U_1	14,37b	16,60c	18,50d	16,49b
	U_2	16,53c	19,93e	24,73f	20,40c
	Mean	14,30a	17,09b	20,43c	
12 WAP	U_0	13,13a	16,47c	20,93e	16,84a
	U_1	15,17b	18,67d	22,07f	18,63b
	U_2	18,55d	22,73f	27,80g	23,03c
	Mean	15,62a	19,29b	23,60c	

Note: Numbers followed by the same letter in the same treatment column are significantly different based on the LSD test at a 5% significance level ($\alpha = 5\%$)

The effect of urea fertilizer application on the leaf length of oil palm seedlings at 12 weeks after planting (WAP) with various doses of goat manure is shown in Figure 4.

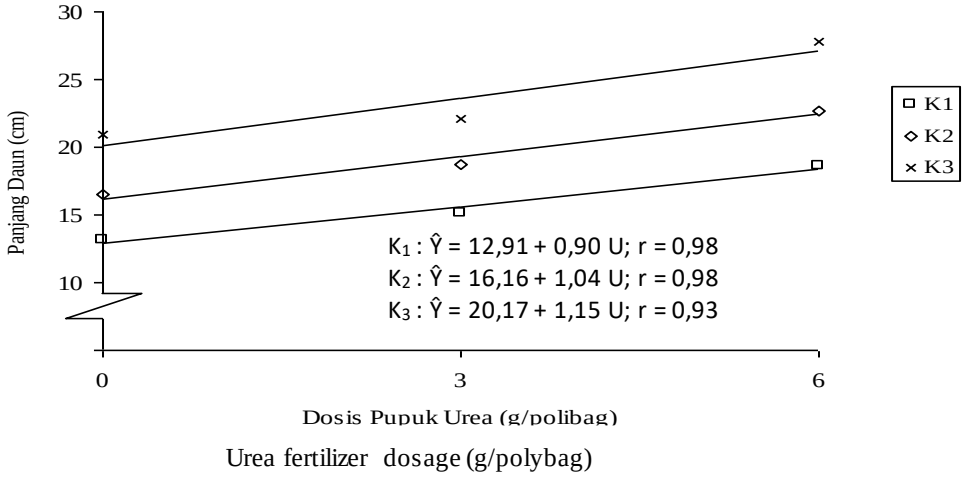

Figure 4. Response Curve of the Effect of Goat Manure on Leaf Length at 12 Weeks After Planting

From Figure 4, it can be seen that the leaf length of oil palm seedlings was greater with a high dose of urea fertilizer combined with goat manure at a dose of 400 g/polybag (K3), resulting in a leaf length of 27.80 cm. The application of urea fertilizer combined with K1 had an r-value of 0.98, while the combination with K2 had an r-value of 0.98, and the combination with K3 had an r-value of 0.93.

Leaf Width (cm).

The average leaf width as affected by urea fertilizer and goat manure application is presented in Table 5..

Table 5. Average Leaf Width (cm) as Affected by Urea Fertilizer and Goat Manure Application

Observations	Treatments	K_1	K_2	K_3	Mean
4 WAP	U_0	2,57	3,06	3,24	2,96a
	U_1	3,03	3,16	3,28	3,16ab
	U_2	3,16	3,30	3,59	3,35b
	Mean	2,92a	3,17b	3,37b	
6 WAP	U_0	3,01	3,53	4,14	3,56a
	U_1	3,59	3,80	4,50	3,96b
	U_2	3,89	4,24	4,81	4,31c
	Mean	3,50a	3,86b	4,49c	
8 WAP	U_0	3,44a	4,16b	4,57bcd	4,06a
	U_1	4,23bc	4,59cd	5,18e	4,67b
	U_2	4,44bcd	4,79d	5,63e	4,96c
	Mean	4,04a	4,51b	5,13c	
10 WAP	U_0	3,71a	4,35b	5,05d	4,37a
	U_1	4,47b	4,74c	5,51e	4,91b
	U_2	4,82cd	5,64e	6,38f	5,61c
	Mean	4,33a	4,91b	5,65c	
12 WAP	U_0	3,87a	4,61b	5,42b	4,63a
	U_1	4,80c	5,06c	5,92d	5,26b
	U_2	5,07e	6,00e	6,87f	5,98c
	Mean	4,58a	5,22b	6,07c	

Note: Numbers followed by the same letter in the same treatment column are significantly different based on the LSD test at a 5% significance level ($\alpha = 5\%$)

The effect of urea fertilizer application on the leaf width of oil palm seedlings at 12 WAP under various doses of goat manure is shown in Figure 5.

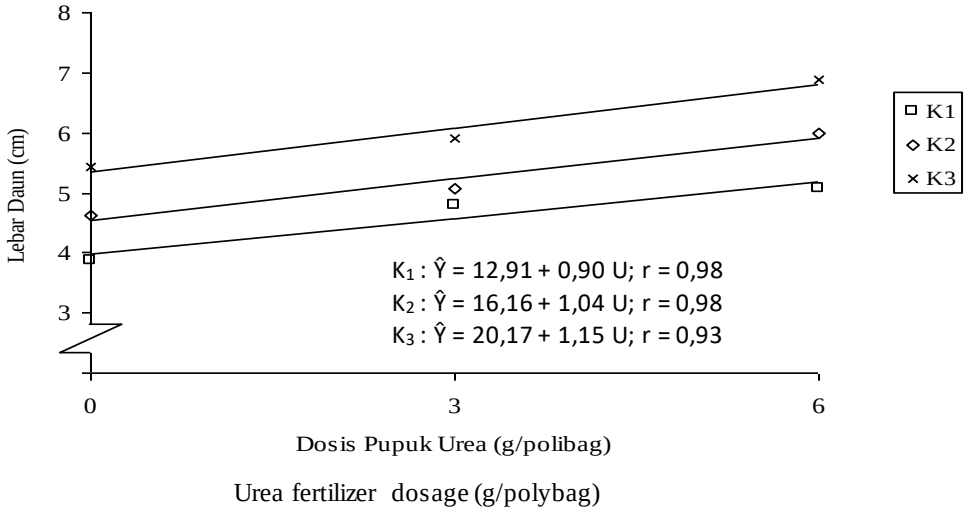

Figure 5. Response Curve of the Interaction Effect of Urea Fertilizer and Goat Manure on Leaf Width at 12 Weeks After Planting.

From Figure 5, it can be seen that the leaf width growth of oil palm seedlings was greater when urea fertilizer was combined with goat manure at a dose of 400 g/polybag (K3), resulting in a leaf width of 6.87 cm. The application of urea fertilizer combined with K1 had an r-value of 0.98, the combination with K2 had an r-value of 0.98, and the combination with K3 had an r-value of 0.93.

Mean Leaf Area (cm²)

The average leaf area resulting from urea fertilizer and goat manure treatment is presented in Table 6.

Table 6. Mean Leaf Area (cm²) as Affected by Urea Fertilizer and Goat Manure Treatments)

Observations	Treatments	K_1	K_2	K_3	Mean
4 WAP	U_0	9,52	12,47	14,61	12,20a
	U_1	13,81	16,96	17,82	16,20b
	U_2	16,37	16,76	19,44	17,52b
	Mean	13,24a	15,40b	17,29b	
6 WAP	U_0	13,69	21,13	26,45	20,42a
	U_1	23,02	26,07	33,89	27,66b
	U_2	28,39	32,79	45,26	35,48c
	Mean	21,70a	26,67b	35,20c	
8 WAP	U_0	19,86a	29,36b	40,95d	30,06a
	U_1	35,38c	39,57cd	49,66e	41,54b
	U_2	34,83c	45,34de	65,32f	48,50c

	Mean	30,02a	38,09b	51,98c	
10 WAP	U_0	25,35a	36,53b	51,93d	37,94a
	U_1	36,59b	44,85c	58,14e	46,53b
	U_2	45,43c	64,08f	90,01g	66,51c
	Mean	35,79a	48,49b	66,70c	
12 WAP	U_0	28,99a	43,23b	64,60d	45,60a
	U_1	41,51b	53,83c	74,46e	56,60b
	U_2	53,56c	77,75f	108,92g	80,07c
	Mean	41,35a	58,27b	82,66c	

Note: Numbers followed by the same letter in the same treatment column are significantly different based on the LSD test at a 5% significance level ($\alpha = 5\%$)

The effect of urea fertilizer application on the leaf area of 12-week-old oil palm seedlings with different doses of goat manure is shown in Figure 6.

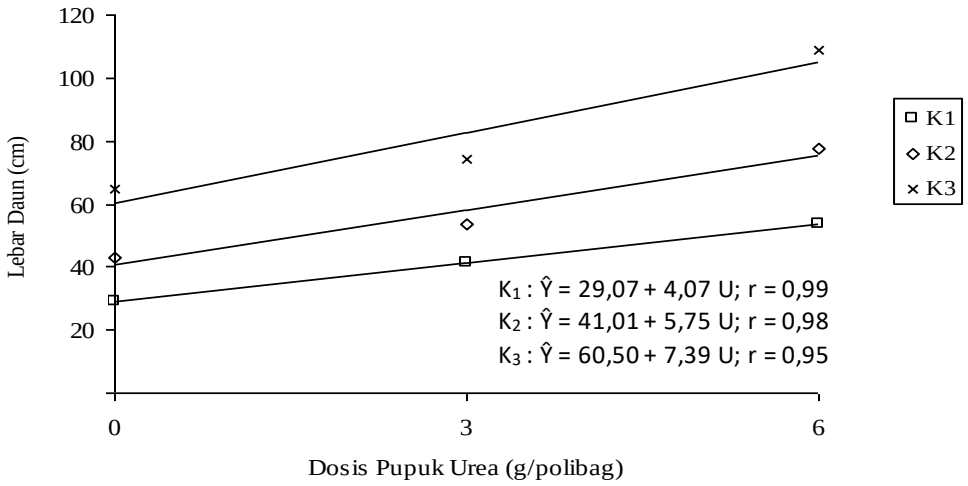

Figure 6. Response Curve of the Interaction Effect of Urea Fertilizer and Goat Manure on Leaf Area at 12 Weeks After Planting

From Figure 6, it can be observed that the application of urea fertilizer combined with K1 resulted in an r-value of 0.99, the application of urea fertilizer combined with K2 yielded an r-value of 0.98, and the application of urea fertilizer combined with K3 produced an r-value of 0.95.

The application of goat manure can improve soil physical properties by retaining water and forming micro- and macro-pores in the soil, thereby increasing the availability of both macronutrients and micronutrients. Additionally, it enhances the presence of microorganisms in the soil, making the planting medium in polybags more friable.The application of goat manure enhances the availability of nitrogen (N), phosphorus (P), and potassium (K) in plants, which subsequently promotes the growth of oil palm seedlings. Hanafiah (2005) stated that nitrogen plays a role in stimulating overall plant growth, synthesizing amino acids and proteins, stimulating

vegetative growth (leaf greenness, leaf length, and leaf width), and promoting vegetative stem growth (height and stem size). Phosphorus (P) is involved in energy transport within plant metabolism, stimulates flowering and fruit formation, promotes root development, enhances seed formation, stimulates cell division, and strengthens plant tissue. Potassium (K) is essential for photosynthesis, the transport of assimilates, enzyme and mineral activity, and water uptake. It also improves plant resistance to diseases, increases soil cation exchange capacity (CEC), and forms complexes with toxic metal ions such as aluminum, iron, and manganese.

A study by Rasyid *et al.* (2017) reported that goat manure contains 2.58% nitrogen (N), 1.81% phosphorus pentoxide (P_2O_5), 5.59% potassium oxide (K_2O), and 58.24% organic carbon (C). The study also found that goat manure provided the best results for oil palm seedlings compared to chicken manure, cow manure, and rice straw. These previous findings support the results of this study, reinforcing the potential of goat manure application in the pre-nursery stage to enhance the vegetative growth of oil palm seedlings.

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CONCLUSIONS AND SUGGESTIONS

Conclusion

The interaction between urea fertilizer and goat manure doses had a significant effect on plant height, stem diameter, number of leaves, leaf length, leaf width, and leaf area. The best treatment was the U2K3 treatment combination.

Suggestion

Further research should be conducted by increasing the doses of urea fertilizer and goat manure, as the optimum dose for enhancing the vegetative growth of oil palm seedlings in the pre-nursery has not yet been reached.

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