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COMPARATIVE ANALYSIS OF TM5 FERTILIZER COSTS USING MANUAL AND *Emdek Tractor METHOD* IN DIVISION 4 OF KANDISTA REGIONAL SIAK PSM 5 PLANTATION PT. IVOMAS TUNGGAL

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Abstract

Fertilization is one of the maintenance activities that plays an important role in increasing the productivity of oil palm plants, but it is also the largest cost component in plantation management. The development of mechanization through the use of EMDEK *tractors* is expected to increase operational efficiency, so a study is needed regarding the cost comparison between manual and mechanical fertilization methods. This study aims to analyze the comparative costs of fertilizing mature plants (TM5) using manual methods and mechanical methods (EMDEK *tractors*) in Division IV of the Kandista PSM 5 Plantation of PT Ivomas Tunggal Regional Siak. The study was conducted from May–August 2026 using a comparative descriptive method. The research sample consisted of six blocks, namely three manual fertilization blocks and three mechanical fertilization blocks. Primary data were obtained through field observations and interviews, while secondary data were obtained from company administrative documents. Data analysis began with the Shapiro–Wilk normality test, then continued with *an independent sample t-test* at a significance level of 5%. The results of the study showed that the average cost of manual fertilization was Rp2,830,710 per hectare or Rp20,922 per tree , while the average cost of fertilization using an EMDEK *tractor was* Rp9,636,062 per hectare or Rp71,811 per tree . The largest cost component in the manual method was the cost of purchasing fertilizer, while in the EMDEK method it was dominated by the cost of TRC2 fuel. The results of the normality test showed that the data were normally distributed ($p>0.05$), thus fulfilling the assumptions for the *t -test* . The *independent sample t-test* produced a significance value of 0.004 ($p<0.05$), which indicated that there was a significant difference in fertilization costs between the manual method and the EMDEK *tractor* . Thus, the manual fertilization method had lower costs than the mechanical method at the research location.

Keywords: oil palm, fertilization costs, manual fertilization, EMDEK *tractor , t- test* .

INTRODUCTION

Fertilization is a cultivation activity aimed at meeting the nutrient needs of plants to support the growth and productivity of oil palms. Fertilization can be done manually or mechanized for both mature and immature plants, with the method chosen depending on the topography of the land (Siahaan & Tarigan, 2023). Manual fertilization is generally applied to areas with terrain that is difficult to reach with mechanical equipment, while mechanical fertilization is more effective on flat to slightly undulating land with a slope of around 0–5°. The success of fertilization is determined not only by the application method, but also by the application of good fertilizer management principles through the 5T concept : correct type, correct dose, correct time, correct method, and correct target. The application of these principles must refer to the company's standard operating procedures. Determination of fertilizer type and dosage is based on soil and leaf analysis results, application time takes into account rainfall conditions, while the method and target of fertilization are directed so that fertilizer is applied to areas and plants that truly require additional nutrients, thereby increasing the efficiency of fertilizer utilization (Mirasari & Ripa, 2023). Manual fertilization is a conventional method that involves spreading fertilizer directly around the plant disc using human labor. This method offers the advantage of flexibility in adjusting the dosage for each plant, but requires a longer implementation time and relatively higher labor costs than mechanical methods (Siahaan & Tarigan, 2023). In contrast, the use of Electronic Mechanical Dispenser Equipment (EMDEK) or

fertilizer spreaders allows for more even fertilizer distribution, improves dosage accuracy, reduces fertilizer loss during application, and reduces labor requirements, potentially increasing operational efficiency of fertilization (Iv & Vi, 2025). At the Kandista PSM 5 Plantation of PT Ivomas Tunggal Regional Siak, manual and mechanical fertilization methods using EMDEK tractors have been applied simultaneously to mature crops. This situation provides an opportunity to evaluate the differences in implementation effectiveness and cost efficiency of the two methods. The research results are expected to provide a basis for determining a more optimal fertilization system for oil palm plantation management.

THEORETICAL BASIS

Oil Palm Plants

Oil palm (*Elaeis guineensis* Jacq.) is a tropical plantation crop with the highest vegetable oil productivity compared to other oil-producing crops. This high productivity makes oil palm a strategic commodity that plays a vital role in the Indonesian economy. Plant growth and productivity are influenced by agroclimatic conditions, such as rainfall, temperature, soil type, and the application of appropriate cultivation techniques, including fertilization.

Fertilizing Oil Palm Plants

Fertilization is the addition of nutrients to maintain soil fertility and meet plant nutritional needs, thereby increasing vegetative growth, fresh fruit bunch (FFB) productivity, and palm oil quality. Fertilization effectiveness must adhere to the **5T principle** : correct type, correct dosage, correct timing, correct method, and correct target. Considering that fertilization costs can account for 30–60% of crop maintenance costs, efficient fertilizer management is a crucial factor in increasing productivity and reducing production costs (Ii & Teori, 2020; Roosmawati et al., 2024).

Oil Palm Fertilization Methods

Fertilization on oil palm plantations is generally carried out using two methods: manual and mechanical. Manual fertilization involves direct spreading of fertilizer using labor, making it more suitable for hilly, peaty lands, or areas with limited access. Conversely, mechanical fertilization using tractors or *fertilizer spreaders* can increase labor efficiency, speed up application times, produce more even fertilizer distribution, and reduce operational costs in large areas with flat topography (Khalida et al., 2019; Fertilization Mechanization, 2023).

Effectiveness and Efficiency of Fertilization

The effectiveness and efficiency of fertilization are influenced by various factors, including land topography, soil conditions, rainfall, fertilizer type, labor skills, and the operator's ability to operate and calibrate equipment. Mechanical fertilization is generally more efficient on flat areas with good road access because it can reduce labor requirements by 30–50%, while manual fertilization is more effective on land with difficult topography. Therefore, the choice of fertilization method must be adjusted to field conditions to achieve both cost efficiency and effective nutrient absorption (Siahaan & Tarigan, 2023; Prasetyo & Abadi, 2022).

RESEARCH METHODS

This research was conducted in May–August 2026 in the Producing Plants (TM5) area of Division 4 of the Kandista PSM 5 Plantation of PT Ivomas Tunggal Regional Siak. The research location was chosen purposively because it applies two fertilization methods, namely manual fertilization and mechanical fertilization using an EMDEK tractor, thus allowing for a comparative analysis of the effectiveness and cost efficiency of both methods. The research population included the entire TM5 area that uses both fertilization systems, while the research sample consisted of six blocks, namely three manual fertilization blocks (Block I30, I31, and I32) and three mechanical fertilization blocks (Block H29, H30, and H31). The research began with the licensing process with the company, then continued with field observations to identify the fertilization process, land conditions, fertilizer dosage, application time, and work systems for each method. Next, research instruments were prepared in the form of observation sheets and operational data recording formats that included iteration, fertilizer dosage, work duration, fuel consumption, labor costs, operational costs, and equipment depreciation costs. Primary data were obtained through direct observation and interviews with division assistants, maintenance foremen, EMDEK tractor

operators, and manual fertilization workers, while secondary data were obtained from company administrative documents related to fertilization operational costs.

The collected data were analyzed using comparative descriptive analysis to compare the effectiveness and cost efficiency of manual and mechanical fertilization methods. Prior to hypothesis testing, the data were tested for normality using the Shapiro–Wilk test, which is suitable for small to medium-sized samples. Data were declared normally distributed if the p-value > 0.05, while a p-value ≤ 0.05 indicated the data were not normally distributed. Furthermore, the difference in fertilization costs between the two methods was analyzed using an *independent sample t-test* at a significance level of 5% to determine whether there was a statistically significant difference between manual fertilization and fertilization using the EMDEK tractor. The results of the analysis were then interpreted by linking the research findings to the concept of plantation mechanization, fertilization effectiveness, and cost efficiency as a basis for compiling research conclusions and recommendations.

RESEARCH RESULT

Fertilization Cost Summary

A summary is a summary of all existing data with the aim of makes it easy to find out the overall data .

Table 1. Planned and Actual Costs for Manual Fertilization Methods

Manual					
Recapitulation	**Year**			**Total**	**Average**
	2023	**2024**	**2025**		
Purchase Fertilizer	513,388,053.34	425,112,842.04	376,891,241.65	1,315,392,137.03	438,464,046
Wages Fertilization	104,313,344	71,649,608	55,831,802	231,794,754.00	77,264,918
Loading Fee Fertilizer	2,177,724	2,177,724	2,177,724	6,533,172.00	2,177,724
Total	619,879,121.34	498,940,174.04	434,900,767.65	1,553,720,063.03	2,830,710
Land area (Ha)	182.96	182.96	182.96	549	183
Amount Main Point	24,950.00	25,555.00	23,758.00	74,263	135
Price/Pkk (Rp)	24,845	19,524	18,305	62,674	20,922

Table 1 shows the components of manual fertilization costs, which consist of fertilizer purchase costs, fertilization labor wages, and fertilizer loading costs in Division IV. Based on the analysis, fertilizer purchase costs are the largest cost component compared to other cost components. The total cost of manual fertilization on TM5 yielding crops reached Rp1,553,720,063.03, with an average cost of Rp2,830,710 per hectare or Rp20,922 per tree. These results indicate that fertilizer requirements are the dominant factor influencing the amount of manual fertilization costs compared to other operational costs.

Table 2. Plan And Realization Cost Fertilization Method *Tractor* Emdek

Manual					
Recapitulation	**Year**			**Total**	**Average**
	2023	**2024**	**2025**		
Purchase Fertilizer	677,519,327.96	490,271,104.38	354,480,907.10	1,522,271,339	507,423,780
Wages Operator	61,758,060	1,000,003,586	951,994,038	2,013,755,684	671,251,895
Cost Fuel TRC2	690,843,138	629,792,775	638,783,297	1,959,419,210	653,139,737
Total	1,430,120,526	2,120,067,465	1,945,258,242	5,495,446,233	9,636,062
Land area (Ha)	190	190.10	190.10	570	190
Principal Amount	25,556	26,060.00	24,910.00	76,526	134
Price/Pkk (Rp)	55,960	81,353	78,091	215,405	71,811

Table 2 shows the cost components of fertilization using an EMDEK tractor, which include fertilizer purchase costs, operator wages, and TRC2 fuel costs in Division IV. Based on the analysis results, TRC2 fuel costs are the largest cost component compared to other operational cost components. Overall, the total cost of fertilization using an EMDEK tractor on TM5 yielding crops is IDR 5,495,446,233, with an average cost of IDR 9,636,062 per hectare or IDR 71,811 per tree. These results indicate that the use of mechanization requires relatively high operational costs, especially those originating from fuel consumption as the main component in the implementation of fertilization.

Descriptive Statistics

Descriptive statistics were used to provide an overview of the fertilizer costs for each research method. The parameters presented include the number of samples (*N), the* mean , the *standard deviation* , and the *standard error of the mean* . The descriptive statistics for the fertilizer costs for the manual and EMDEK methods are presented in Table 3.

Table 3. Descriptive Statistics

	Fertilization	N	Mean	Standard Deviation	Std. Mean Error
Cost	Manual	3	517906687.6667	93936384.35475	54234196.79391
	Emdek	3	1831815411.0000	358690188.86476	207089877.09675

costs for emdek and manual (1,831,815,411.00 > 517,906,687.67) with a relatively high difference that the average fertilization costs for emdek are higher than manual .

Normality Test

Normality testing was performed using the Shapiro–Wilk test, which is suitable for data with small to medium sample sizes. This test aims to determine whether the data is normally distributed before further statistical analysis is performed. Data are considered normally distributed if the significance value (*p-value*) is > 0.05, while a significance value ≤ 0.05 indicates that the data is not normally distributed (Budiyono, 2013). The results of the normality test are presented in Table 4.

Table 4. Results of Data Normality Test

		Kolmogorov-Smirnov [a]			Shapiro- Wilk		
	Fertilization	Statistics	df	Sig.	Statistics	df	Sig.
Cost	Manual	.247	3	.	.969	3	.664
	Emdek	.291	3	.	.925	3	.470

The results of the normality test show that the manual fertilization and EMDEK cost data are normally distributed, with significance values of 0.664 and 0.470, respectively ($p > 0.05$). Therefore, the data meets the normality assumption so that it can be continued with the *independent sample t-test* . Decision making in the *t- test* is based on the significance value, namely if $p > 0.05$ then H_0 is accepted and H_1 is rejected, whereas if $p \leq 0.05$ then H_0 is rejected and H_1 is accepted.

Partial Significance Test (t-Test)

Table 5. Partial Test Results (t-Test)

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Cost	Equal variance es assum ed	5,213	.084	-6,138	4	.004	-1313908723.33333	214073737.99191	-1908272705.33235	-719544741.33431
	Equal variance es not assum ed			-6,138	2,273	.019	-1313908723.33333	214073737.99191	-2136678978.66172	-491138468.00495

Levene's Test F value shows a significance value of 0.084 > 0.05, meaning that the data variance between the two groups is similar (homogeneous). Therefore, the analysis refers to the *Equal variances assumed row.* Furthermore, the significance value of *Equal variances assumed* is 0.004 < 0.05. This means that H0 is rejected and H1 is accepted, so that a significant difference was found between manual and Emdek fertilization costs with an average difference *(mean difference)* of -1,313,908,723.33.

CONCLUSION

Based on the research results, it can be concluded that the cost of fertilization on productive plants (TM5) with the manual method is Rp2,830,710 per hectare or Rp20,922 per tree . Meanwhile, the cost of fertilization using the EMDEK tractor reaches Rp9,636,062 per hectare or Rp71,811 per tree . The results of the statistical analysis show that there is a significant difference between the cost of fertilization using the manual method and the EMDEK tractor method on productive plants (TM5) in Division IV of the Kandista PSM 5 Plantation of PT Ivomas Tunggal Regional Siak. Thus, the manual fertilization method produces lower costs than the fertilization method using the EMDEK tractor at the research location.

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