INTERNATIONAL JOURNAL OF SOCIAL SCIENCE, EDUCATIONAL, ECONOMICS, AGRICULTURE RESEARCH AND TECHNOLOGY (IJSET) | ISSN (E): 2827-766X
Website: https://ijset.org/ | Volumes 5 No. 8 (2026)

THE EFFECT OF HARVEST FREQUENCY AND LABOR EFFICIENCY ON THE PRODUCTIVITY OF OIL PALM (*Elaeis guineensis)* Jacq.) PALM CO REGIONAL 1 RAMBUTAN GARDEN, AFDELING VIII SEI PRIOK VILLAGE

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Received: 02/06/2026 | **Revised** : 11/06/2026 | **Accepted:** 23/06/2026 | **Published** :04/07/2026

Abstract
Palm oil productivity is the main indicator of successful plantation management in producing optimal fresh fruit bunches (FFB). This study aims to analyze the effect of harvest frequency and labor efficiency on oil palm productivity at Palm Co Regional 1 Rambutan Plantation, Afdeling VIII. This study uses a quantitative approach with descriptive and associative methods based on production theory. Secondary data for the period 2021–2025 totaling 60 observations were analyzed using multiple linear regression with the help of SPSS through the classical assumption test, t-test, F-test, and coefficient of determination. The results showed that harvest frequency had no significant effect on productivity (sig. 0.482), while labor efficiency had a positive and significant effect (sig. 0.000). Simultaneously, both variables had a significant effect on productivity with an F-count of 65.748 and an R^2 of 0.698. This finding confirms that increasing productivity is more effective through increasing labor efficiency through training, supervision, and continuous evaluation of harvester performance.

Keywords: labor efficiency, harvest frequency, oil palm, productivity.

INTRODUCTION

Oil palm (*Elaeis guineensis Jacq.*) is a strategic plantation commodity that plays a vital role in the Indonesian economy. This commodity not only contributes significantly to the country's foreign exchange earnings but also plays a role in employment and supports regional economic development through the production, processing, and export of its derivative products. Indonesia is even listed as the world's largest palm oil producer, contributing more than 50% to global palm oil production (Central Bureau of Statistics, 2023).

The success of the palm oil industry is determined not only by the size of the planted area but also by the level of productivity generated by each plantation. Productivity is a key indicator of a plantation's ability to produce fresh fruit bunches (FFB) per unit area. High productivity reflects the efficient use of production factors, both technically and managerially. In this context, palm oil productivity is influenced by various interrelated factors, such as plant genetics, plant age, environmental conditions, and the implementation of appropriate cultivation and harvest management. Optimal plantation management, including harvesting activities and efficient labor utilization, is a crucial factor in increasing palm oil production (Corley & Tinker, 2016; Pahan, 2021).

One important aspect of harvest management is harvest frequency. A harvest frequency that aligns with the established rotation allows fruit to be harvested at optimal ripeness, thus maximizing FFB production. Conversely, an inappropriate or too low harvest frequency can lead to harvest delays, increased losses, and decreased quality and quantity of production. Furthermore, labor efficiency is also a crucial factor in harvesting activities, as an efficient workforce is able to complete work within timeframes, operational standards, and expected productivity levels. Harahap and Munir (2022) stated that labor efficiency positively influences oil palm plantation productivity, making labor management a crucial aspect of the plantation production system.

PalmCo Regional 1 Rambutan Plantation, specifically Afdeling VIII, Sei Priok Village, is one of the production units contributing to the company's production targets. Based on production data for the 2021–2025 period, palm oil productivity in this unit fluctuates from year to year. This change indicates that productivity is influenced not only by plant biology and environmental conditions, but also by operational management factors in the field, particularly in terms of harvest frequency and labor efficiency.

However, based on previous literature reviews, most studies have focused on the influence of labor on oil palm harvest productivity, while studies that simultaneously integrate harvest frequency as an indicator of harvest management and labor efficiency into plantation productivity are still relatively limited, particularly at the division level in plantation companies. This limitation indicates a research gap that requires further exploration to provide a more comprehensive picture of the factors influencing oil palm productivity at the operational level. Therefore, this study was conducted to analyze the effect of harvest frequency and labor efficiency on oil palm productivity at PalmCo Regional 1 Rambutan Plantation Afdeling VIII, with the hope of contributing to the development of more effective and efficient harvest management in the oil palm plantation sector.

THEORETICAL BASIS

Palm oil

Oil palm (*Elaeis guineensis Jacq.*) is a strategic plantation commodity that plays a vital role in the Indonesian economy. This commodity not only provides foreign exchange but also contributes significantly to employment and regional economic development. Indonesia is currently the world's largest palm oil producer, contributing over 50% of global production (Central Statistics Agency, 2023). According to Corley and Tinker (2016), oil palms have a high productivity rate compared to other vegetable oil crops due to their physiological efficiency in photosynthesis in tropical climates. Plant productivity is not only determined by genetic factors but is also greatly influenced by environmental conditions and proper cultivation and harvest management. In general, the primary product of oil palm is fresh fruit bunches (FFB), which are then processed into crude palm oil (*CPO*) and palm *kernel oil (PKO*). Therefore, successful production depends heavily on the quality of plantation management, from maintenance to harvest (Pahan, 2021).

Palm Oil Productivity

Productivity is a measure of the efficiency of a production process in producing output from a given input. In the oil palm plantation sector, productivity is generally expressed in tons of fresh fruit bunches (FFB) per hectare per year (Mankiw, 2021). According to Corley and Tinker (2016), oil palm productivity is influenced by the plant's ability to produce female flowers that develop into fruit bunches and the effectiveness of plantation management. Technical factors such as harvest time, crop rotation, and labor quality significantly determine actual production results in the field. Pahan (2021) emphasized that oil palm productivity is the result of the interaction between plant, environmental, and plantation management factors. Therefore, even if the plant has high genetic potential, productivity can decline if harvest management is not optimal.

Harvest Management

Harvest management is a series of activities aimed at harvesting fresh fruit bunches (FFB) at an optimal ripeness level to achieve maximum yields in terms of both quantity and quality. This includes managing harvest rotations, determining fruit ripeness criteria, harvesting techniques, and labor management (Lubis, 2021). According to Pahan (2021), errors in harvest management, such as late harvesting or harvesting unripe fruit, can cause losses, reduce oil yields, and reduce overall plantation productivity. Therefore, good harvest management is crucial for maintaining efficient palm oil production.

Harvest Frequency

Harvest frequency is the number of harvests carried out within a specific period, related to the crop rotation in a plantation area. The ideal harvest frequency aims to ensure that all fresh fruit bunches (FFB) are harvested at the correct level of ripeness (Lubis, 2021). Theoretically, harvest frequency is related to time efficiency in the production system. Irregular harvests can cause overripe fruit, increase uncollected loose fruit, and reduce production quality (Fauzi et al., 2022). Corley and Tinker (2016) explain that late harvests can reduce bunch quality and increase yield losses. Therefore, appropriate harvest frequency is crucial for maintaining stable production and productivity of oil palm plantations. Previous research by Maulidah et al. (2025) and Ginting & Sembiring (2024) also showed that crop rotation according to company standards has a positive effect on increasing oil palm plantation productivity.

Labor Efficiency

Labor efficiency is the ability of workers to produce maximum output with optimal use of time and resources. In oil palm plantations, labor efficiency is measured by the number of fresh fruit bunches (FFB) harvested per working day (HK) (Mangoensoekarjo & Semangun, 2022). According to Mankiw (2021), labor is one of the main production factors that determines output in a production process. The higher the quality and skills of the workforce, the higher the resulting productivity. Becker (1993), through Human Capital Theory, states that investment in training, education, and work experience can improve labor skills. In the context of oil palm harvesting, skilled labor can increase work speed, harvest accuracy, and reduce yield losses Furthermore, labor efficiency is also influenced by work systems, motivation, experience, and field supervision. An efficient workforce will directly contribute to increased plantation productivity (Harahap & Munir, 2022).

RESEARCH METHODS

This study uses a quantitative approach with descriptive and associative methods to analyze the effect of harvest frequency and labor efficiency on oil palm productivity. The descriptive method is used to describe the conditions of the research variables, while the associative method is used to statistically test the relationship and influence between variables using multiple linear regression (Sugiyono, 2022). The study was conducted at PALM CO Regional 1 Rambutan Plantation, Afdeling VIII, Sei Priok Village, Tebing Tinggi District, Serdang Bedagai Regency, North Sumatra. This location was selected purposively because it is one of the representative centers of oil palm production. The study was conducted from February to May 2026 using secondary data from the 2021–2025 period.

The population in this study was all data on FFB production, harvest frequency, and labor efficiency in Afdeling VIII PALM CO Regional 1 Rambutan Plantation during the study period. The research sample consisted of 60 monthly time series observations covering the variables of harvest frequency, labor efficiency, and oil palm productivity. The sampling technique used a purposive sampling method based on documentation data, namely the selection of available secondary data that is in accordance with the needs of the research variables (Sugiyono, 2020). The data used is secondary data obtained from internal company reports, including data on fresh fruit bunches (FFB) production, harvested area, harvest frequency, and labor efficiency, supported by literature from relevant books and scientific journals. Data collection techniques were conducted through documentation, namely the collection of data already available in company archives and other written sources that support the research analysis.

Data analysis used multiple linear regression to examine the effect of harvest frequency (X_1) and labor efficiency (X_2) on oil palm productivity (Y). Prior to the regression analysis, classical assumption tests were conducted, including normality, multicollinearity, and heteroscedasticity tests, to ensure the model met the BLUE (Best Linear Unbiased Estimator) criteria. Hypothesis testing was conducted using the t-test for partial effects, the F-test for simultaneous effects, and the coefficient of determination (R^2) to determine the ability of the independent variables to explain the dependent variable. All data processing was performed using SPSS software (Sugiyono, 2020).

RESEARCH RESULT

Data Normality

The results of the normality test using Kolmogorov-Smirnov can be seen in the following table:

Table 1. Data Normality Results

One-Sample Kolmogorov-Smirnov Test		
		Unstandardized Residual
N		60
Normal Parameters [a, b]	Mean	.0000000
	Standard Deviation	246.38267457
Most Extreme Differences	Absolute	.110
	Positive	.110
	Negative	- .070
Test Statistics		.110
Asymp. Sig. (2- tailed)		.069 [c]

Based on the results of the Kolmogorov-Smirnov test in Table 4.2, the Asymp. Sig. (2-tailed) value is 0.069. This value is greater than the 0.05 significance level (0.069 > 0.05), so it can be concluded that the residual data in the regression model is normally distributed. This indicates that the research model has met the normality assumption. In addition, the average residual value of 0.0000000 indicates that the prediction error between the actual and predicted values of oil palm productivity is relatively balanced, with no systematic tendency to overestimate or underestimate the model. According to Ghozali (2021), the normality test aims to ensure whether the residuals in the regression model are normally distributed, as this is one of the important requirements in linear regression analysis. By fulfilling this normality assumption, the analysis of the relationship between harvest frequency (X_1) and labor efficiency (X_2) on oil palm productivity (Y) can be carried out using multiple linear regression in a more valid and statistically reliable manner.

Multicollinearity

In this study, the multicollinearity test was conducted by looking at the Tolerance and Variance Inflation Factor (VIF) values for each independent variable, namely, Harvest Frequency (X_1) and Labor Efficiency (X_2).
The basis for making decisions regarding multicollinearity testing is:

1. If the Tolerance value > 0.10 and the VIF value < 10, then multicollinearity does not occur.
2. If the Tolerance value is < 0.10 and the VIF value is > 10, then multicollinearity occurs.

The results of the multicollinearity test can be seen in the following table.

Table 2. Multicollinearity Results

Coefficients [a]								
Model		Unstandardized Coefficients		Standardize d Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance ce	VIF
1	(Constant)	411,110	297,023		1,384	.172		
	X1	- 27,962	39,471	- .067	- .708	.482	.586	1,707
	X2	11,262	1,356	.790	8,303	.000	.586	1,707

Based on the test results in Table 4.X, the harvest frequency (X_1) and labor efficiency (X_2) variables each have a tolerance value of 0.586 and a VIF value of 1.707. The tolerance values for both variables are greater than 0.10 and the VIF values are less than 10, so it can be concluded that the regression model does not experience multicollinearity. This indicates that harvest frequency and labor efficiency do not have a very strong relationship with each other, so both are still able to contribute different information in explaining variations in oil palm productivity. Conceptually, harvest frequency is related to the timing and intensity of harvesting, while labor efficiency is related to the ability of the workforce to produce optimal harvest output. According to Ghozali (2021), the absence of multicollinearity indicates that the independent variables in the model can more accurately explain their influence on the dependent variable. Thus, this regression model has met the classical assumptions and is suitable for further analysis.

Heteroscedasticity

In this study, heteroscedasticity testing was conducted using the Scatterplot method, namely by observing the distribution pattern of points between the predicted value of the dependent variable (Standardized Predicted Value/ZPRED) and the residual value (Studentized Residual/SRESID). The basis for decision-making in the heteroscedasticity test through the Scatterplot graph is:

1. If the points are spread randomly above and below the number 0 on the Y axis and do not form a particular pattern (such as a wavy, widening or narrowing pattern), then the regression model does not experience heteroscedasticity.

2. If the points form a certain clear pattern, such as forming a regular, tapered or widening pattern, then the regression model experiences symptoms of heteroscedasticity.

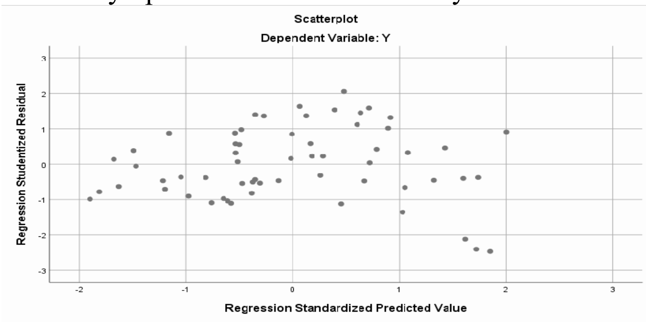

Figure 1. Heteroscedasticity Results

Based on the results of the heteroscedasticity test using a scatterplot, the residual points are randomly distributed around the zero line and do not form a specific pattern. This indicates that the residual variance is constant, thus the regression model does not experience heteroscedasticity.

Thus, it can be concluded that the model has a relatively stable error rate at each observation level, both under low and high productivity conditions. According to Ghozali (2021), the random distribution pattern in the scatterplot indicates that the homoscedasticity assumption is met, making the regression model suitable for further analysis because it produces efficient and unbiased estimates.

Autocorrelation

In this study, the data used are annual/monthly data on oil palm harvesting and productivity activities in Afdeling VIII PalmCo Regional 1 Kebun Rambutan, so autocorrelation testing is needed to ensure that each observation period has independent errors. Autocorrelation testing is carried out using the Durbin-Watson (DW Test) method found in the SPSS multiple linear regression results. The basis for making decisions for the Durbin-Watson test is as follows:

1. The DW value is between the upper limit (dU) and 4-dU, indicating that there is no autocorrelation.
2. The DW value is smaller than the lower limit (dL), indicating the presence of positive autocorrelation.
3. The DW value is greater than 4-dL, indicating the presence of negative autocorrelation.

Table 3. Autocorrelation Test Results

Model Summary [b]					
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.835 [a]	.698	.687	250.66791	.982

Based on the Durbin-Watson test in Table 4.X, a value of 0.982 was obtained, which is smaller than the lower limit (1.514), thus indicating the presence of positive autocorrelation in the research model.
This indicates a correlation between palm oil productivity data across time periods, which is understandable given the influence of plant biology, climate conditions, and sustainable plantation management practices. Nevertheless, the model can still be used for further analysis by considering the characteristics of time series data.

Simple Linear Regression Analysis

Multiple linear regression analysis is used to determine the relationship and magnitude of influence between two or more independent variables on one dependent variable. In this study, multiple linear regression analysis is used to determine the effect of harvest frequency (X_1) and labor efficiency (X_2) on oil palm productivity (Y) in Afdeling VIII PalmCo Regional 1 Kebun Rambutan . Based on the results of multiple linear regression analysis using SPSS, an equation was obtained that shows the relationship between harvest frequency (X_1) and labor efficiency (X_2) on oil palm productivity (Y). The constant value of 411.110 means that when the variables X_1 and X_2 are considered constant or have a value of zero, then theoretically productivity is at 411.110 units. However, this constant value does not reflect actual conditions in the field, as in the practice of oil palm plantations, conditions without harvesting or labor are impossible. This value is more mathematical in nature and serves as a starting point for regression models. Furthermore, oil palm productivity is also influenced by other factors such as plant age, seed quality, soil conditions, rainfall, fertilization, and pest and disease control. This aligns with the Cobb-Douglas theory, which states that production output is the result of a combination of various input factors.

Hypothesis Testing

Partial Significance Test (t-Test)

The t-test was used to determine the partial effect of each independent variable on oil palm productivity. The results of the t-test based on SPSS output can be seen in the following table.

Table 4. Results of Partial Significance Test (t-Test)

Variables	Coefficient	t-count	Sig.	Decision
Frequency Harvest (X_1)	-27,962	-0.708	0.482	No significant
Efficiency Power Work (X_2)	11,262	8,303	0.000	Significant

The Effect of Harvest Frequency on Oil Palm Productivity (H_1)

Based on the results of the partial test (t-test), the harvest frequency variable (X_1) has a regression coefficient of -27.962 with a t-value of -0.708 and a significance level of 0.482. This significance value is greater than 0.05 (0.482 > 0.05), so it can be concluded that harvest frequency does not significantly influence oil palm productivity. Thus, the first hypothesis (H_1) is rejected. The insignificant effect of harvest frequency indicates that changes in the number of harvesting activities within a certain period do not have a significant impact on productivity at the research location. Theoretically, harvest frequency is related to the accuracy of the timeliness of harvesting FFB (Fruit Fruit Bunch) so as to minimize yield losses. However, the results of the study indicate that in Afdeling VIII, harvest frequency has been at a relatively stable level according to operational standards, so that its addition no longer provides a significant increase in productivity. Furthermore, harvest frequency does not directly influence production formation, but only regulates the process of harvesting the results that are already available on the tree. Production is more influenced by pre-harvest factors such as plant age, nutrient availability, and climatic conditions. A negative coefficient also indicates operational adjustments in the field, where increased harvest frequency is carried out under conditions of declining production, thus failing to significantly increase output.

The Effect of Labor Efficiency on Palm Oil Productivity (H_2)

The partial test results (t-test) show that the labor efficiency variable (X_2) has a regression coefficient of 11.262 with a t-value of 8.303 and a significance level of 0.000. Since the significance value is less than 0.05 (0.000 < 0.05), it can be concluded that labor efficiency has a positive and significant effect on oil palm productivity. Thus, the second hypothesis (H_2) is accepted. These results indicate that labor efficiency is an important factor in increasing oil palm productivity. An efficient workforce is able to produce higher harvest output through optimal use of working time, increased work speed, and reduced yield losses. In harvesting activities, labor plays a direct role in determining the number of FFBs that are successfully harvested, so changes in the level of labor efficiency will have a direct impact on plantation productivity. In addition, the skills and experience of the workforce are also determining factors in efficiency. Skilled harvesters are able to select ripe fruit correctly, minimize cutting errors, and speed up the harvesting process. The labor efficiency variable is also the most dominant variable in this study, indicated by a higher beta coefficient value compared to the harvest frequency variable, so that changes in productivity are explained more by labor factors.

Simultaneous Significance Test (F-Test)

Simultaneous influence testing was conducted to determine whether the harvest frequency (X_1) and labor efficiency (X_2) variables were able to explain changes in oil palm productivity (Y) in Afdeling VIII PalmCo Regional 1 Kebun Rambutan. Based on the results of the simultaneous test (F test), the following results were obtained:

Table 5. Results of Simultaneous Significance Test (F-Test)

Model	F-count	Sig.
Regression	65,748	0.000

Based on the analysis results, the F-count value was 65.748 with a significance level of 0.000, which is less than 0.05 (0.000 < 0.05). This indicates that harvest frequency (X_1) and labor efficiency (X_2) simultaneously have a significant effect on oil palm productivity (Y). Thus, changes in productivity are not influenced by a single factor, but are the result of a combination of the two variables. These results indicate that oil palm productivity is influenced by the interaction between the accuracy of harvest frequency management and the ability of the workforce to carry out harvesting activities efficiently. Therefore, optimal harvest management requires synergy between harvest timing management and the quality of human resources in the field.

Coefficient of Determination (R^2)

The coefficient of determination is used to determine the ability of independent variables to explain variations in changes in oil palm productivity.

Table 6. Coefficient of Determination (R^2)

Model Summary [b]					
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.835 [a]	.698	.687	250.66791	.982

Based on the results of the coefficient of determination test, an R Square value of 0.698 was obtained, indicating that harvest frequency and labor efficiency were able to explain 69.8% of the variation in oil palm productivity. This indicates that the research model has quite strong explanatory power, where most of the productivity changes in Afdeling VIII can be explained by the harvest management variables studied. Meanwhile, 30.2% of the productivity variation was influenced by factors outside the model, such as plant age, fertilization, rainfall, soil conditions, seed quality, and pest and disease control. These results also indicate that both variables simultaneously significantly influenced productivity, although harvest frequency was not significantly affected partially. Thus, increasing palm oil productivity is more effectively done through increasing labor efficiency as a dominant factor, accompanied by managing harvest frequency according to operational standards and support from other agronomic factors.

DISCUSSION

The Effect of Harvest Frequency on Oil Palm Productivity

The results of multiple linear regression analysis showed that harvest frequency (X_1) did not significantly affect oil palm productivity, with a regression coefficient of -27.962, a t-value of -0.708, and a significance level of 0.482 (>0.05). This indicates that changes in harvest frequency have not been able to provide a significant impact on FFB productivity in Afdeling VIII PALM CO Regional I Rambutan Plantation. Theoretically, harvest frequency plays a role in regulating harvest timing, not in determining production volume, because oil palm production is more influenced by plant biological factors such as age, fertilization, and environmental conditions (Corley & Tinker, 2016; Pahan, 2021). Harvest frequency is more important in maintaining yield quality and reducing harvesting losses than in directly increasing output (Fauzi et al., 2022). The insignificant effect of harvest frequency is also suspected because harvesting activities have been carried out according to company operational standards, resulting in relatively small variations in frequency. This condition means that changes in harvest frequency do not have a strong enough statistical impact on productivity variations. Furthermore, in the concept of a production function, output is the result of a combination of various production inputs, not just a single factor (Mankiw, 2021).

The Effect of Labor Efficiency on Palm Oil Productivity

The results of the study indicate that labor efficiency (X_2) has a positive and significant effect on oil palm productivity, with a regression coefficient of 11.262, a t-value of 8.303, and a significance level of 0.000 (<0.05). This indicates that increasing labor efficiency will increase oil palm productivity Theoretically, labor is a key production factor that directly impacts output (Mankiw, 2021). This is also supported by Human Capital Theory, which states that improving the skills, experience, and training of the workforce will increase productivity (Becker, 1993). In oil palm harvesting activities, an efficient workforce can increase the number of fresh fruit bunches

(FFB) harvested, speed up the work process, and minimize yield losses (Corley & Tinker, 2016). The Standardized Beta value of 0.790 indicates that labor efficiency is the most dominant variable in this study, compared to the harvest frequency variable.

The Effect of Harvest Frequency and Labor Efficiency on Oil Palm Productivity

The results of the simultaneous test showed an F-count value of 65.748 with a significance of 0.000 (<0.05), which means that harvest frequency and labor efficiency together have a significant effect on oil palm productivity. Theoretically, this aligns with the production function concept that output is the result of a combination of various input factors (Mankiw, 2021). In the context of oil palm plantations, harvest frequency plays a role in the timely harvesting of the crop, while labor efficiency determines the ability to achieve the harvest in the field (Pahan, 2021). The coefficient of determination (R^2) value of 0.698 shows that 69.8% of the variation in productivity can be explained by these two variables, while the remaining 30.2% is influenced by other factors such as plant age, fertilization, rainfall, soil conditions, and environmental factors (Corley & Tinker, 2016).

CONCLUSION

Based on the research results, partial harvest frequency does not have a significant effect on oil palm productivity in Afdeling VIII PALM CO Regional I Kebun Rambutan (sig. 0.482 > 0.05), so that changes in harvest frequency have not been able to significantly increase productivity and play a greater role in maintaining quality and reducing yield losses. Meanwhile, labor efficiency has a positive and significant effect on productivity (sig. 0.000 < 0.05), which indicates that the more efficient the labor, the higher the oil palm productivity, with this variable being the most dominant factor. Simultaneously, harvest frequency and labor efficiency have a significant effect on oil palm productivity (sig. 0.000 < 0.05) with an explanatory power of 69.8%, while the remainder is influenced by other factors outside the model.

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