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Factors Affecting the Productivity of Oil Palm *Elaeis guineensis* Jacq at PTPN IV Regional II Gunung Bayu Plantation

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Abstract

Oil palm is a strategic plantation commodity that is the main source of world vegetable oil and serves as the backbone of foreign exchange in Indonesia's agricultural sector. This study analyzes the factors that influence oil palm productivity at PTPN IV Regional II Gunung Bayu Plantation, Simalungun Regency. The research uses a quantitative approach with multiple linear regression supported by SPSS. The data comprises primary data obtained from field observations and secondary data from the company over a period of five years. The results indicate that, partially, rainfall, plant age, fertilizer use, pesticide use, and labor have a significant effect on productivity. Among these, plant age is the most dominant variable. Collectively, all variables have a significant effect, and the regression model is suitable. The R-squared value shows the model explains 68.9% of the variation. The number of plants does not significantly affect productivity. Interestingly, the use of fertilizers and pesticides negatively affects productivity. Labor, however, has a significant positive effect on oil palm yields. The strength of this study lies in the use of monthly time series data over 60 periods, which produces a predictive model with high accuracy, thereby providing a more comprehensive and dynamic picture than studies based on annual data. In conclusion, integrated management of production factors is necessary to increase plantation productivity sustainably. These results are highly relevant for oil palm plantation management.

Keywords: Fertilizer, Labor, Multiple Linear Regression, Plant Age, Pesticide

1. Introduction

Oil palm (*Elaeis guineensis* Jacq.) is one of Indonesia's primary plantation commodities, possessing high economic value and playing a crucial role in the national agricultural sector. This crop produces crude palm oil (CPO) and palm kernel oil (PKO), which are widely used in the food, cosmetics, and biodiesel industries. Oil palm plantations in Indonesia cover approximately 15.435 million hectares, with annual fresh fruit bunch (FFB) production reaching 46.986 million tons (Central Bureau of Statistics, 2023). The success of this production is heavily influenced by environmental, biological, and cultivation factors such as planting material, rainfall, fertilization, and labor.

In practice, several oil palm plantation companies still struggle of consistently meet FFB production targets. This situation is also observed at the Gunung Bayu Plantation of PTPN IV Regional II, where production realization in recent years has not met the established targets. For example, from 2021 to 2025, the Gunung Bayu Plantation produced 147,621,280 kg in 2021 and 129,898,230 kg in 2025. This discrepancy indicates a gap between potential crop productivity and actual yields in the field, which impacts the efficiency and sustainability of the plantation business.

These problems are likely influenced by internal and external production factors. Internal factors include suboptimal labor management, fertilization, and plant maintenance, while external factors include climate conditions, rainfall, and pest and disease attacks. Production management plays a crucial role in coordinating all these factors to ensure effective and productive cultivation activities meet established targets in the field.

Theoretically, oil palm plantation productivity is the result of the interaction of mutually influencing technical and non-technical factors. Previous research has generally focused on production factors in general or on a national

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scale, without examining them specifically at the company level. Studies analyzing the factors influencing productivity at specific plantations, particularly at the Gunung Bayu Plantation of PTPN IV Regional II, remain very limited. According to Tuty et al. (2021), their analysis of factors affecting oil palm (*Elaeis guineensis* Jacq.) in Afdeling 1 Kebun Bah Birong Ulu PT used multiple linear regression. The results showed that, simultaneously, fertilizer factors, plant age, labor, and herbicides significantly affected oil palm production, with an F-Count value (310.535) > t-table (3.38) and a significance value of 0.00 < α (0.05). This research gap highlights the need for more in-depth studies to identify the key factors influencing oil palm productivity at the plantation level. A comprehensive understanding is necessary to formulate targeted and sustainable production improvement strategies. Therefore, this research is crucial to provide a basis for evaluating and improving plantation management systems.

This study aims to identify and analyze factors influencing oil palm productivity at the Gunung Bayu Plantation of PTPN IV Regional II and assess the influence of each factor on production results. The results are expected to serve as evaluation material for management decision-making, particularly regarding land management, labor, fertilization, and plant maintenance. Furthermore, this study is expected to provide scientific references for the study of oil palm production factors at the company level.

2. Material and Methods

This research was conducted at PT. Perkebunan Nusantara IV Regional II Kebun Gunung Bayu, located approximately 48 meters above sea level in Simalungun Regency, North Sumatra, with coordinates N: 3°5'0" N - 3°15'0" N and E: 99°19'50" E - 99°28'00" E, in May 2026. This research uses a quantitative method with a field survey approach and secondary data analysis to determine the factors that influence oil palm productivity. The data used consists of primary data obtained through direct observation in the field and documentation, as well as secondary data obtained from the company during the last five years.

The secondary data are monthly data from January 2021 to December 2025, covering palm oil production, rainfall, number of mature plants, average plant age, fertilizer use, pesticide use, and labor. Based on this period, the number of observations analyzed was 60 (5 years × 12 months = 60 observations). Therefore, the unit of analysis in this study is the monthly aggregate data from Gunung Bayu Plantation, processed as time series data.

The research variables consist of the dependent variable, namely oil palm productivity, while the independent variables include rainfall (X1), number of plants (X2), plant age (X3), fertilization (X4), pesticide use (X5), and labor (X6). Specifically for the plant age variable, the value used in each observation is calculated based on the average age of productive plants in the same block in the Gunung Bayu Plantation, updated monthly to reflect increases in plant age and changes in the composition of productive plants in the field.

Data analysis used multiple linear regression with the help of SPSS version 26 to determine the effect of independent variables on productivity, both simultaneously and partially. Testing was carried out through classical assumption tests, which include normality, multicollinearity, heteroscedasticity, and autocorrelation tests using the Durbin-Watson test, and continued with the coefficient of determination (R^2) test, t-test, and F-test at a significance level of 5%, with the help of SPSS version 26. The results of the study are expected to serve as a basis for evaluation in plantation management so that oil palm productivity can increase optimally and sustainably.

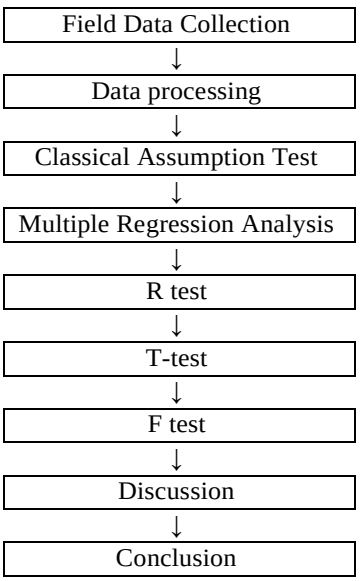


Figure 1. Research flow diagram

3. Results and Discussion

3.1. Overview of Research Location

Gunung Bayu is a business unit of PT Perkebunan Nusantara IV (PTPN IV) Regional II, which operates in the palm oil plantation and processing sector in Indonesia. Located in Bosar, in Maligas District, Simalungun Regency, North Sumatra, this unit plays a vital role in the company's palm oil production chain. Its main product is Fresh Fruit Bunches (FFB), which the company processes into Crude Palm Oil (CPO) at a palm oil processing plant integrated with the plantation.

Gunung Bayu focuses not only on production but also on various productivity improvement programs, such as replanting and rejuvenating oil palm trees. These programs aim to replace aging plants to maintain optimal productivity. Additionally, the plantation implements sustainability initiatives, including environmental management, tree

planting, and corporate social responsibility (CSR) activities, demonstrating its commitment to environmental conservation and community development (Nasution, 2023).

Geographically, Gunung Bayu Plantation is located in Bosar. The oil palm plantation is located in Maligas and Bandar District, Simalungun Regency, at an altitude of about 48 meters above sea level, with coordinates 3°05'0"–3°15'0" N and 99°19'50"–99°28'00" N. This plantation is about 150 km from Medan and 49 km from Pematangsiantar. The topography is generally flat to hilly, with dominant yellowish-brown and dark brown podzolic soils suitable for oil palm cultivation.

The plantation's working area covers two districts and is surrounded by approximately 34 villages, which are divided into nine divisions, from 10 to 9 since the reorganization in 2015. The oil palm plantation area consists of various planting age groups spread across several blocks and divisions, forming the basis for management and production planning at Gunung Bayu Plantation, PTPN IV Regional II.

The largest area of oil palm plantations occurred in the 2018 planting year, at 500 ha, or 53.36% of the total land area. The smallest area was in the 2016 planting year, at 46 ha. The total land area observed was 937 ha, with 127,478 trees and an average density of 136 trees per hectare. The relatively uniform density indicates that plantation management follows technical cultivation standards and supports optimal crop productivity.

The production results of mature oil palm plantations at the Afdeling 1 Office of the Gunung Bayu Plantation are as follows (Table 2). Table 2 shows that palm oil production increased in 2022, but then tended to decline until 2025. This fluctuation is thought to be influenced by factors such as rainfall, the number and age of mature trees, fertilizer and pesticide use, and labor. Therefore, further analysis is needed to determine how these factors affect palm oil productivity at the Gunung Bayu Plantation.

Table 1. Area of Oil Palm Plantation in Gunung Bayu Plantation in 2025

No.	Planting Year	Area (Ha)	Principal Amount	Average Trees/Hectare
1	2005	78	7,381	95
2	2006	136	17,036	125
3	2016	46	6,360	138
4	2017	177	25,738	145
5	2018	500	70,963	142
6	**Amount**	**937**	**127,478**	**136**

Source: Gunung Bayu Garden

Table 2. Productivity Data for the Last 5 Years

No.	Year	Total Production (Kg)	Area (ha)	Productivity (Ton/ha)
1	2021	147,621,280	6,901	21,391
2	2022	151,398,150	6,772	22,356
3	2023	146,886,780	6,795	21,617
4	2024	142,185,260	6,193	22,959
5	2025	129,898,230	5,994	21,671

3.2. Research Results and Discussion: Factors Affecting Productivity at PT. Perkebunan Nusantara IV Regional II, Gunung Bayu Plantation

3.2.1. Descriptive statistics

Descriptive statistics is a data analysis method used to describe or summarize research data for easier understanding. This analysis is not intended to test hypotheses, but rather to provide a general overview of the data's characteristics, including minimum and maximum values, mean, and standard deviation.

This study used a sample of 60 respondents. Data from these 60 respondents were processed using SPSS to obtain an overview of each research variable. The descriptive statistical results were used to identify trends in data values and distributions for each variable.

Table 3. Descriptive Statistical Test Results

Variables	N	Minimum	Maximum	Means	Standard Deviation
Rainfall	60	7	366	153.75	77,422
Number of Plants	60	5,486	6,193	5,884.4	286,786
Plant Age	60	1	16	9.05	3,998
Fertilizer Use	60	42,056.42	235,176.06	137,216,016	64,852,5625
Pesticide Use	60	24.25	145.5	65,056	421,533
Labor	60	496	911	656.3	155,624
Productivity	60	4,026,890	16,061,340	11,966,495	2,782,929,073
Valid N values (based on list)	60				

3.2.2. Normality Test

The normality test aims to determine whether the dependent and independent variables in a regression model are normally distributed (Ghozali, 2020). This test uses the Kolmogorov-Smirnov test with a significance level of 0.05. The results of the normality test are presented in the following table:

Table 4. Normality Test Results

Method	Important Values	Information
Kolmogorov–Smirnov	0.057	Normally distributed data

Source: Data processed by SPSS 26, 2025

The results of the Kolmogorov-Smirnov normality test show an Asymp. Sig. (2-tailed) value of 0.057, which is greater than 0.05. This result indicates that the data in this study are normally distributed.

3.2.3. Multicollinearity Test

The multicollinearity test aims to determine the existence of a perfect linear relationship between independent variables in a regression model (Ghozali, 2020). This test is performed by checking whether tolerance> 0.10 and VIF < 10 to ensure the absence of multicollinearity. The results of the multicollinearity test are presented in the following table.

Table 5. Multicollinearity Test Results

Variables	Tolerance	VIF	Information
Rainfall	0.705	1,418	No multicollinearity was found.
Number of Plants	0.232	4,304	No multicollinearity was found.
Plant Age	0.674	1,484	No multicollinearity was found.
Fertilizer Use	0.273	3,665	No multicollinearity was found.
Pesticide Use	0.652	1,535	No multicollinearity was found.
Labor	0.325	3,074	No multicollinearity was found.

Source: Data processed by SPSS 26, 2025

Based on the multicollinearity test results, all independent variables in this study had tolerance values > 0.10 and VIF < 10, indicating that the regression model did not exhibit multicollinearity. This indicates that each independent variable does not have a strong linear relationship with the other variables.

The variables Rainfall (X1), Plant Age (X3), and Pesticide Use (X5) each have tolerance values of 0.705, 0.674, and 0.652, with VIFs of 1.418, 1.484, and 1.535, respectively, so they are all free from multicollinearity. These results indicate that the three variables do not influence each other excessively in the regression model.

Meanwhile, the variables Number of Plants (X2), Fertilizer Use (X4), and Labor (X6) also showed tolerance values of 0.232, 0.273, and 0.325, respectively, with VIFs of 4.304, 3.665, and 3.074, respectively, which are still within normal limits. Thus, all independent variables in this study are suitable for use in regression analysis because there are no multicollinearity problems.

3.2.4. Heteroscedasticity Test

The heteroscedasticity test aims to determine whether there is an imbalance in the residual variance in the regression model (Ghozali, 2020). This test uses a scatterplot graph and the Glejser test. The results of the heteroscedasticity test are presented as follows:

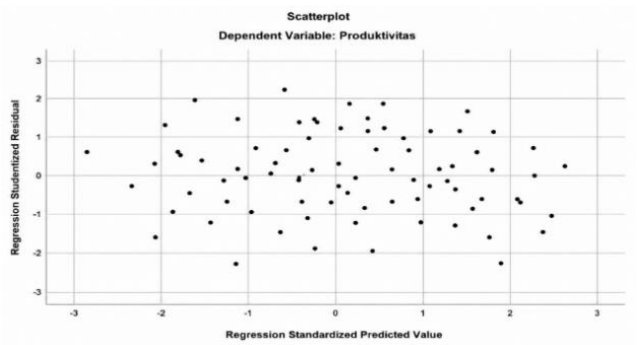


Figure 2. Scatterplot Test Results. Source: Data processed in SPSS 26, 2025

The results of the heteroscedasticity test using a scatterplot show that the residual points are randomly distributed around the zero line on the Y-axis and do not form a specific pattern. This indicates that residual variance is constant; thus, the regression model in this study does not exhibit heteroscedasticity.

The Glejser test regresses the absolute value of the residual against the independent variable to determine the presence or absence of heteroscedasticity. With a significance level of 5%, if the Sig. value is > 0.05, heteroscedasticity is absent, while if the Sig. value is < 0.05, heteroscedasticity is present. This test is used to strengthen the results of the scatterplot analysis.

Based on the results of the heteroscedasticity test using the Glejser method in Table 6, it was found that all independent variables, namely rainfall (X_1), number of plants (X_2), plant age (X_3), fertilizer use (X_4), pesticide use (X_5), and labor (X_6), had a significance value greater than 0.05, which was in the range of 0.121 to 0.707. This indicates that there is no significant relationship between the independent variables and the absolute value of the residual, so it can be concluded that the regression model does not experience heteroscedasticity problems. Thus, the assumption of homoscedasticity is met, and the regression model is suitable for further analysis.

Table 6. **Glejser Test**

Variables	t value	Signature.	Information
Rainfall (X_1)	-1,231	0.224	No heteroscedasticity detected.
Number of Plants (X_2)	0.378	0.707	No heteroscedasticity detected.
Plant Age (X_3)	0.756	0.453	No heteroscedasticity detected.
Fertilizer Use (X_4)	-0.439	0.663	No heteroscedasticity detected.
Pesticide Use (X_5)	1,157	0.253	No heteroscedasticity detected.
Labor Force (X_6)	1,578	0.121	No heteroscedasticity detected.

Source: Data processed in SPSS 26, 2025

3.2.5. Autocorrelation Test

The autocorrelation test aims to determine whether there is a correlation between confounding variables in a given period and the previous period (Ghozali, 2020). This study used the Durbin- Watson test. The results of the autocorrelation test are presented in the following table:

Table 7. Autocorrelation Test Results i

Statistics	Mark
Durbin–Watson (DW)	2,301
dL	1.15
dU	1.75
Decision	No autocorrelation occurs.

Source: Data processed in SPSS 26, 2025

Based on the results of the autocorrelation test using the Durbin–Watson test, we obtained a value of 2.301, with dL value of 1.15 and dU = 1.75 at the 5% significance level of 5%, with the number of independent variables. The Durbin–Watson value is in the range of $dU < DW < 4 - dU$ ($1.75 < 2.301 < 2.25$), so it can be concluded that the regression model does not experience autocorrelation problems. Thus, the residuals in the model are independent and meet the classical assumption of being free from autocorrelation, so the regression model is suitable for further analysis.

3.2.6. Multiple Linear Regression Test

Multiple linear regression tests determine the influence and relationship between several independent variables and the dependent variable (Sugiyono, 2022). In this study, the analysis determined the direction and magnitude of the influence of rainfall (X1), number of plants (X2), plant age (X3), fertilizer use (X4), pesticide use (X5), and labor (X6) on productivity (Y). The results of the multiple linear regression test are presented in the following table (Table 8).

Based on the results of the multiple linear regression test in the table above, this study has an equation that can be explained as follows:

Y = 14,203,271,773 + 4,447,481X_1 - 962,510X_2 + 274,431,990X_3 - 0.096X_4 - 250,170X_5 + 3,875,534X_6

Table 8. Multiple Linear Regression Test Results

Variables	Unit	Regression Coefficient (B)	t value	Signature.	Information
Constant		14,203,271.77	2,357	0.022	Important
Rainfall (X_1) mm/year)	mm/year	4,447.48	2,201	0.032	Important
Number of Plants (X_2)	trees/ha)	-962.51	-1.013	0.316	Not Significant
Plant Age (X_3, years)	year	274,431.99	6,854	0	Important
Fertilizer Use (X_4)	Kg/ha	-0.096	-2,465	0.017	Important
Pesticide Use (X_5)	Liter/ha	-250.17	-2,581	0.013	Important
Labor Force (X_6)	HOK	3,875.53	2,618	0.012	Important

Source: Data processed by SPSS 26, 2025

The constant value of 14,203,271.773 indicates that if all independent variables (Rainfall, Number of Plants, Plant Age, Fertilizer Use, Pesticide Use, and Labor) are set to zero or assumed constant, then productivity is estimated at that value. This describes the initial productivity condition without the influence of any independent variables in the model.

The regression coefficients show that Rainfall (X_1) and Plant Age (X_3) have a positive relationship to productivity, amounting to 4,447.481 and 274,431.990, respectively. This means that increasing these two variables increases productivity, assuming the other variables remain constant. Furthermore, Labor (X_6) also has a positive relationship with productivity, amounting to 3,875.534.

Meanwhile, the Number of Plants (X_2), Fertilizer Use (X_4), and Pesticide Use (X_5) showed a negative

relationship with productivity, with values of -962.510, -0.096, and -250.170, respectively. This result shows that an increase in these three variables is followed by a decrease in productivity when other variables are held constant.

3.2.7. Hypothesis Testing

3.2.7.1. Partial Test (t-Test)

Table 9. Partial Test Results (t-Test)

Variables	Regression Coefficient (B)	t value	Signature.	Information
Constant	14,203,271.77	2,357	0.022	Important
Rainfall (X_1)	4,447.48	2,201	0.032	Important
Number of Plants (X_2)	-962.51	-1.013	0.316	Not Significant
Plant Age (X_3)	274,431.99	6,854	0	Important
Fertilizer Use (X_4)	-0.096	-2,465	0.017	Important
Pesticide Use (X_5)	-250.17	-2,581	0.013	Important
Labor Force (X_6)	3,875.53	2,618	0.012	Important

Source: Data processed by SPSS 26, 2025

The results of partial testing in this study are as follows:

1. Rainfall (X_1) on Productivity (Y).

The t-test results show that rainfall (X_1) has a positive and significant relationship with oil palm productivity, with a calculated t-value of 2.201 > t-table 2.006 and a significance level of 0.032 < 0.05. These results indicate that increased rainfall is associated with increased oil palm productivity at the study site. Adequate rainfall supports the availability of water, which plants need for physiological processes such as photosynthesis, flower formation, and fresh fruit bunch (FFB) development. Conversely, conditions of air deficiency are often accompanied by decreased plant growth and productivity. This phenomenon is also seen in field data, where productivity tends to be higher during periods with sufficient rainfall compared to drier periods.

These findings align with research by (Ningsih, 2021) and (Harahap, 2025), which demonstrated a significant relationship between rainfall and oil palm productivity. Air temperature is an environmental factor closely related to plant growth and development, so that variations can follow variations in rainfall in productivity. Furthermore, optimal rainfall is generally associated with better nutrient uptake by plants, ultimately supporting higher productivity. However, these results show a statistical relationship and do not directly prove a causal link between rainfall and oil palm productivity.

2. Number of Plants (X_2) to Productivity (Y)

The t-test results show that the number of plants (X_2) does not have a significant relationship with oil palm productivity, with a calculated t-value of -1.013 < t-table 2.006 and a significance level of 0.316 > 0.05. These results indicate that variations in the number of plants at the study site are not significantly related to changes in productivity. This suggests that productivity is determined not only by the number of plants but also by other factors such as plant age, the condition of the producing plants, and the cultivation management applied. In the field, it was found that some blocks with fewer plants actually had higher productivity because they were in the optimal production phase and received better care. This finding is in line with research by Prasetio et al. (2023), which showed that labor and plantation management factors have a stronger relationship with productivity than the number of plants. In addition, excessive plant density can increase competition for nutrients, water, and light, so it does not always correlate with increased productivity.

3. Plant Age (X_3) on Productivity (Y).

The t-test results show that plant age (X_3) has a positive and significant relationship with oil palm productivity, with a calculated t value of 6.854 > t-table 2.006 and a significance level of 0.000 < 0.05. These results indicate that variations in plant age are significantly related to changes in oil palm productivity at the research location. Plant age has the strongest relationship with productivity in this model, indicating that differences in plant growth phases relate to differences in production levels. Oil palm plants aged 9–14 years are generally in the optimum productive phase, so they tend to have a higher number and weight of fresh fruit bunches (FFB) than younger or older plants.

This finding is in line with research by Nadeak et al. (2019) and Fikri et al. (2023), which showed a significant relationship between plant age and oil palm productivity. Each plant growth phase has distinct physiological characteristics related to the plant's ability to produce fresh fruit bunches. In the mature phase, root system and crown development are generally optimal, which is associated with better water and nutrient absorption capacity. However, the results of this study show a statistical relationship between plant age and productivity and therefore cannot be interpreted as evidence of a direct causal relationship.

4. Fertilizer Use (X_4) on Productivity (Y)

The t-test results show that fertilizer use (X_4) has a negative and significant relationship with oil palm productivity, with a calculated t-value of -2.465 and a significance level of 0.017 < 0.05. The fertilizer use variable in this study was measured based on the amount of

fertilizer applied in kilograms per hectare per month (kg/ha/month). The negative regression coefficient indicates that, in this study's data, increased fertilizer use is associated with decreased oil palm productivity. However, this relationship cannot be interpreted as evidence that increased fertilizer use directly causes decreased productivity.

This negative relationship likely reflects field-level operational conditions, where higher fertilizer applications are often applied to crop blocks with lower productivity or those requiring better growing conditions. Furthermore, variations in land characteristics, soil fertility status, nutrient uptake efficiency, and plantation management practices not fully captured in the research model may also be associated with crop productivity. Therefore, the results of this study indicate a statistical association between fertilizer use and oil palm productivity, so their interpretation should be done with caution without inferring a direct causal relationship (Artashevi, 2026).

5. Pesticide Use (X_5) on Productivity (Y)

The t-test results indicate that pesticide use (X_5) has a negative and significant relationship with oil palm productivity, with a calculated t-value of -2.581 and a significance of 0.013 (<0.05). The pesticide use variable in this study was measured based on the amount of pesticide use in liters per hectare per month (L/ha/month). The negative coefficient indicates that higher pesticide use is associated with lower oil palm productivity in the research data. This finding indicates a statistical association between pesticide use and productivity, but cannot be interpreted as a direct causal relationship. This relationship may occur because pesticide use tends to be higher in areas experiencing more severe pest or disease attacks, resulting in relatively lower crop productivity. In addition, other factors such as land conditions, the level of plant pest attacks, plant age, and plantation management practices that are not all included in the model may also be related to productivity. Therefore, the results of this study should be interpreted as a statistical relationship between pesticide use and oil palm productivity, not as evidence that pesticide use directly causes decreased productivity (Junianta, 2025).

6. Labor (X_6) to Productivity (Y)

The t-test results indicate that labor (X_6) has a positive and significant relationship with oil palm productivity, with a calculated t value of 2.618 > t table 2.006 and a significance level of 0.012 < 0.05. The labor variable in this study was measured based on the number of workers involved in oil palm farming activities. A positive coefficient indicates that as the number of workers increases, productivity increases in the research data. This finding indicates a statistical relationship between labor and productivity, but cannot be interpreted as a direct causal relationship. This relationship may occur because plantations with more labor tend to be able to carry out maintenance, harvesting, and transportation activities more optimally so that the observed productivity is relatively higher. In addition, other factors such as land area, plant age, level of technology application, worker skills, and plantation management that are not fully included in the model may also be related to productivity. The results of this study are in line with the findings of Nunyai (2023) and Firmansyah (2025), which show a positive relationship between labor and palm oil production performance. Therefore, these results should be interpreted as a statistical relationship between labor and palm oil productivity, not as evidence that increased labor directly causes increased productivity.

3.2.7.2. Simultaneous Test (F Test)

According to Ghozali (2020), the F test is used to determine the simultaneous relationship of independent variables to the dependent variable with a significance level of 0.05. The decision-making criteria are: if the significance value is <0.05 and Fcount > Ftable, then all independent variables are related to the dependent variable. If the significance value is >0.05 and Fcount < Ftable, then there is no relationship. In this study, the number of independent variables (k) is 6, and the number of samples (n) is 60, so df1 = 5 and df2 = 53. Based on these values, the F-table at a significance level of 5% is 2.389. This value is used as a reference in testing the simultaneous relationship of independent variables to oil palm productivity.

Table 10. Simultaneous Test Results (F Test)

F count	F Table (α=0.05)	df	Signature.
19.56	± 2.28	6	0.000

Source: Data processed by SPSS 26, 2025

Based on the results of the simultaneous test (F Test) in Table 9, the calculated F value was obtained at 19.560 with a significance value of 0.000. The calculated F value is greater than the F table value of 2.28, so it can be concluded that the variables Rainfall (X_1), Number of Plants (X_2), Plant Age (X_3), Fertilizer Use (X_4), Pesticide Use (X_5), and Labor (X_6) simultaneously have a significant relationship to Productivity (Y). These results indicate that all independent variables together can explain variations in oil palm productivity, so the regression model used is worthy of further analysis (Ningsih, 2020).

3.2.8. Coefficient of Determination Test

The coefficient of determination (R^2) measures the model's ability to explain variation in the dependent variable, with values ranging from 0 to 1. An R^2 value close to 1 indicates that the independent variable can explain almost all of the variation in the dependent variable. In contrast, a small value indicates limited explanatory power

of the model (Ghozali, 2020). The results of the coefficient of determination (R^2) test in this study are presented in the following table:

Table 11. Results of the Determination Coefficient

Statistics	Mark
R	0.83
R Squared (R^2)	0.689
Adjusted R Squared	0.654
Standard Error of Estimate	1,009,239.94

Source: Data processed by SPSS 26, 2025

Based on the coefficient of determination test (R^2), the R-squared value was 0.689, or 68.9%. This shows that the variables Rainfall (X_1), Number of Plants (X_2), Age of Plants (X_3), Use of Fertilizer (X_4), Use of Pesticides (X_5), and Labor (X_6) were able to explain the variation in Productivity (Y) by 68.9%. In comparison, other variables outside the research model explained the remaining 31.1%.

3.3. The Relationship between Rainfall, Number of Plants, Plant Age, Fertilizer Use, Pesticide Use, and Labor on Oil Palm Productivity

This shows that the calculated F value is greater than the F table value (19.560 > 2.28). Furthermore, a significance value of 0.000 is obtained, which is less than 0.05 (0.000 < 0.05). Therefore, it can be concluded that the variables Rainfall (X_1), Number of Plants (X_2), Age of Plants (X_3), Use of Fertilizer (X_4), Use of Pesticides (X_5), and Labor (X_6) simultaneously or collectively have a positive and significant relationship to Productivity (Y).

These findings indicate that oil palm productivity is the result of the interaction of various interrelated production and environmental factors. In oil palm cultivation systems, productivity is not determined by a single factor. However, it is influenced by a combination of agroclimatic factors, plant characteristics, the use of production facilities, and human resource management. Rainfall plays a role in meeting plant water needs, which are necessary to support physiological and metabolic processes. The number of plants is related to the level of plant population in an area, which can affect land use efficiency. Plant age is related to the growth phase and the ability of the plant to produce fresh fruit bunches (FFB). Meanwhile, the use of fertilizers and pesticides is part of plant maintenance efforts to maintain nutrient availability and control plant pests. Furthermore, labor plays a role in supporting plantation operations, from maintenance to harvest.

Although partial test results indicate that not all variables significantly affect productivity, simultaneous test results indicate that these variables collectively explain variations in oil palm productivity. This result suggests that increasing productivity requires a comprehensive and integrated management approach across all production factors. Optimal productivity will be more easily achieved if each production factor is managed associatively according to the needs of the crop and local environmental conditions (Wulan, 2023).

The results of this study align with those of Nubun (2022), which stated that production factors simultaneously influence palm oil production. This study demonstrates that the success of oil palm plantations is not determined by a single production factor, but rather by the accumulation of various factors that support each other in the production process. This finding reinforces the need of manage all available production factors in an integrated way. Research by Saidi & Suryani (2021) also explains that a combination of internal and external factors, including plant characteristics, use of production inputs, environmental conditions, and plantation management, influences oil palm productivity. Therefore, efforts to increase oil palm productivity cannot be achieved by improving only one aspect; they must be carried out through comprehensive management of the factors that influence the production process. Therefore, the synergy between climate factors, plant biology, use of production facilities, and labor management is a crucial aspect in supporting sustainable increases in oil palm productivity.



Figure 2 Workforce management documentation

4. Conclusion

Based on the research findings on factors influencing oil palm productivity at PTPN IV Regional II Gunung Bayu Plantation, the following conclusions can be drawn: All variables studied, including rainfall, number of plants, plant age, fertilizer use, pesticide use, and labor, collectively have a significant relationship with oil palm productivity. This regression model explained 68.9% of the variation in productivity. Plant age is the most dominant factor and has a significant positive influence, with plants in the optimal productive phase (9–14 years) producing the highest yields.

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