Vol. 6, No. 6, June 2025
E-ISSN:2723 – 6692
P-ISSN:2723– 6595
http://jiss.publikasiindonesia.id/

Determinants of Oil Palm Production (Case Study in Pauhranap Village, Peranap District, Indragiri Hulu Regency)

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KEYWORDS
Oil palm production; fertilizer; land area; seedlings; pesticides; sustainable agriculture

ABSTRACT
This study examines the factors influencing oil palm production in Pauhranap Village, Peranap District, Indragiri Hulu Regency. Using a quantitative approach, data were collected from 45 farmers and analyzed using multiple linear regression. The results indicate that fertilizer use and the number of seedlings have a significant positive effect on oil palm production, while land area does not show a significant impact. Pesticide use also contributes positively to production but to a lesser extent. Based on these findings, recommendations include the adoption of precision fertilization techniques, ideal planting density management, and the use of environmentally friendly bio-pesticides. Additionally, local governments should enhance extension programs and promote modern agricultural technology adoption. This study provides insights for policymakers, farmers, and academics to improve oil palm productivity sustainably.

Introduction

Oil palm (Elaeis guineensis) is one of the strategic plantation commodities that makes a significant contribution to the Indonesian economy. Palm oil is used in a variety of industries, from food to biofuels. Since it began to be cultivated commercially, palm oil has developed into Indonesia's main export product. In 2018, the export value of palm oil reached USD 28.1 billion or equivalent to 393.4 trillion rupiah (Zayanti et al., 2023).

Indonesia is the world's largest producer of palm oil, with most of its production centered in Sumatra and Kalimantan (Chiriacò Bellotta M. Jusić J. & Perugini L., 2022). One of the main producing regions is Riau Province, which in 2021 contributed more than 8.6 million tons of palm oil production (Central Statistics Agency, 2022). Despite its great potential and a supportive climate, palm oil productivity in Riau still faces various challenges (Chew Ng C. Y, 2021). One of the main challenges faced is climate change affecting crop growth patterns, as well as infrastructure limitations affecting crop distribution. The following is the data on palm oil production in Indonesia by province for the period 2018-2021:

Table 1 DataProduction of Oil Palm Plants in Indonesia

Province	Palm oil production from the most (thousand tons)			
	2018	2019	2020	2021

Riau	**8496**	**9512**	**9984,3**	**8629,1**
Central Kalimantan	7230,2	7664,8	7685,8	8629,9
North Sumatra	5737,3	5647,3	5776,8	5310,9
West Kalimantan	3086,9	5235,3	5471,4	5835,9
South Sumatra	3793,6	4049,2	4267	3062,4
East Kalimantan	37686,5	3988,9	3823,2	3808,7
Jambi	2691,3	2884,4	3022,6	2575,1
South Kalimantan	1464,2	1665,4	1561,1	1212,8
West Sumatra	1248,3	1253,4	1312,3	1352

Source: Central Statistics Agency 2021

Riau Province is one of the largest palm oil production centers in Indonesia. With a supportive tropical climate and vast plantation land, Riau has become the center of national oil palm development. Based on data from the Central Statistics Agency (BPS), palm oil production in Riau Province reached 8.6 million tons in 2021, making it the province with the most palm oil production in Indonesia (Guntoro et al., 2022).

Indragiri Hulu Regency, one of the districts in Riau, has great potential in oil palm development. Palm oil production in the district reached 232,844 tons in 2022, showing considerable stability in recent years. However, there are still several challenges in terms of optimizing land management and production, especially in certain villages in this district, one of which is Pauhranap Village in Peranap District. The following is data on oil palm production in Indragiri Hulu Regency and other districts in Riau:

Table 2 Total People's Oil Palm Production in Riau Province by Regency/City in 2020-2022

Regency/City	Palm oil production (Ton)		
	2020	2021	2022
Kuantan Singingi	161095	162817	435299
Indragiri Hulu	229785	230849	232844
Indragiri Hilir	268882	269138	269138
Pelalawan	450082	444265	477610
Siak	430374	429352	556783
Kampar	572714	551754	568122
Rokan Hulu	689931	695985	695965
Bengkalis	262292	238064	240228
Rokan Hilir	512533	512530	512529
Pekanbaru	9500	83238	47170
Dumai	82544	83283	84291

Source : Riau Central Statistics Agency in 2022 figures

Indragiri Hulu Regency, Pauhranap Village reflects the problems faced by oil palm farmers in this area. Even though the land area owned is quite large, farmers in Pauhranap Village are often unable to maximize their production potential. One of the main determinants of low productivity is the use of suboptimal fertilizers, where many farmers still rely on traditional methods. The use

of appropriate and measurable fertilizers can increase crop yields, but in Pauhran Village, difficulties in determining the appropriate dosage and type of fertilizer are a challenge for farmers.

In addition to the use of fertilizers, the available land area also affects the scale of production. Although some farmers own large tracts of land, the productivity produced is not always optimal without good land management and the application of modern agricultural technology. Traditional cultivation techniques in Pauhranap Village result in lower productivity per hectare than other areas that have adopted modern technology.

Pesticide management also plays an important role in maintaining crop yields. Pest and disease attacks can damage oil palm plants if not handled properly. In Pauhrana Village, pesticide use is often unmeasured and poorly monitored, which not only negatively impacts land quality, but also decreases production in the long run. Therefore, a more effective approach is needed in the use of pesticides to maintain the balance of the ecosystem and increase crop yields.

Based on the description above, this study is focused on "Determination of Oil Palm Production in Pauhranap Village, Peranap District, Indragiri Hulu Regency".

This study aims to analyze the factors that affect oil palm production in Pauhranap Village, Peranap District, Indragiri Hulu Regency, with a focus on fertilizer use, land area, number of seeds, and pesticide use. The results of this research are expected to provide benefits to various parties, including farmers, local governments, and academics. For smallholders, this study can provide insights into more effective and efficient management of oil palm plantations, especially in the use of fertilizers and pesticides. For local governments, the findings of this research can be considered in formulating policies that support the oil palm plantation sector in the region. Meanwhile, for academics, this research can be an additional reference in the study of factors that affect palm oil productivity in rural areas.

Materials and Methods

This research was conducted in Pauhranap Village, Peranap District, Indragiri Hulu Regency, Riau Province, in 2024, with the research population covering all oil palm farmers who make plantations as their main livelihood. The sample was determined using the Slovin formula with an error rate of 15%, resulting in 45 respondents. Data collection was carried out through questionnaires that included variables in the amount of fertilizer, land area, number of seeds, and pesticide use, as well as in-depth interviews to gain a more detailed understanding. The validity and reliability of the instruments were tested using construct validity and Cronbach's Alpha, with values greater than 0.70 to ensure data consistency. The analysis techniques used included descriptive analysis to describe the variables affecting oil palm production as well as multiple linear regression to measure the relationship between independent variables and oil palm production, with regression equations involving the amount of fertilizer (X_1), land area (X_2), number of seedlings (X_3), and pesticides (X_4).

Before regression analysis is performed, classical assumption tests such as multicollinearity, heteroscedasticity, and normality tests are applied to ensure the regression model meets the statistical requirements. The bound variable in this study is oil palm production measured in kilograms per farmer, while the independent variables include the amount of fertilizer, land area, number of seeds, and pesticides. Previous studies have shown that land area and fertilizer use have a significant influence on oil palm productivity, while the number of seeds and pesticides also plays an important role in increasing crop yields (Yanita & Suandi, 2021). Thus, this study aims to understand the extent to which these factors affect oil palm production in Pauhrana Village, so that

it can provide recommendations for farmers, local governments, and academics in increasing the productivity of oil palm plantations in the region.

Results and Discussions

The location of this research is in Pauhranap Village, Peranap District, Indragiri Hulu Regency, which has a strong agricultural base, especially in oil palm cultivation. Historically, the village developed under the influence of the native Malay community as well as a transmigration program. Geographical and demographic analysis shows that the village has a population of 3,985 people, with the majority of the population working as oil palm farmers. The main economic activities are centered on the agricultural sector, supported by facilities such as markets, health centers, and educational institutions that play a role in improving people's welfare. The study also examined the characteristics of respondents, including age, education level, and farming experience that affect agricultural productivity. In addition, the existence of religious, health, and educational institutions also shape the social structure of the village

Descriptive Analysis and Variable Correlation

In analyzing the data, the first step is to conduct a descriptive analysis to provide an overview of the variables involved in this study. Based on the data obtained, the average oil palm production per farmer in Pauhranap Village is 3,176.07 kg per farmer, with a standard deviation of 591.39 kg. This indicates moderate variation in oil palm production levels between smallholders, which may be influenced by a variety of factors, both internal (such as cultivation techniques) and external (such as climate or access to agricultural inputs).

In the independent variables, the number of seedlings was recorded as 2,997.80 stems, while the average amount of fertilizer used by farmers was 303.49 kg. The correlation results showed a positive and significant relationship between the number of seedlings and oil palm production with a Pearson correlation value of $r = 0.928$ ($p < 0.01$), which indicates that the more seedlings planted, the higher the yield that can be obtained. These findings are consistent with the Cobb-Douglas Production Function theory (Coelli et al., 2005), which states that production inputs such as seeds and fertilizers play an important role in increasing production output. A significant positive correlation between the amount of fertilizer and oil palm production ($r = 0.359$, $p < 0.01$) is also in line with the theory that proper fertilizer application can increase agricultural yields, but this correlation is weaker compared to the number of seedlings. In contrast, the variables of land area ($r = 0.092$) and pesticide use ($r = 0.157$) showed an insignificant correlation with oil palm production. This shows that although land area and pesticides have a relationship with productivity, the impact is not as large as the variable of seeds and fertilizers. This indicates that other non-input factors may play a greater role in determining oil palm productivity levels, such as the quality of plantation management and crop maintenance.

Classical Assumption Test and Model Validity

Normality

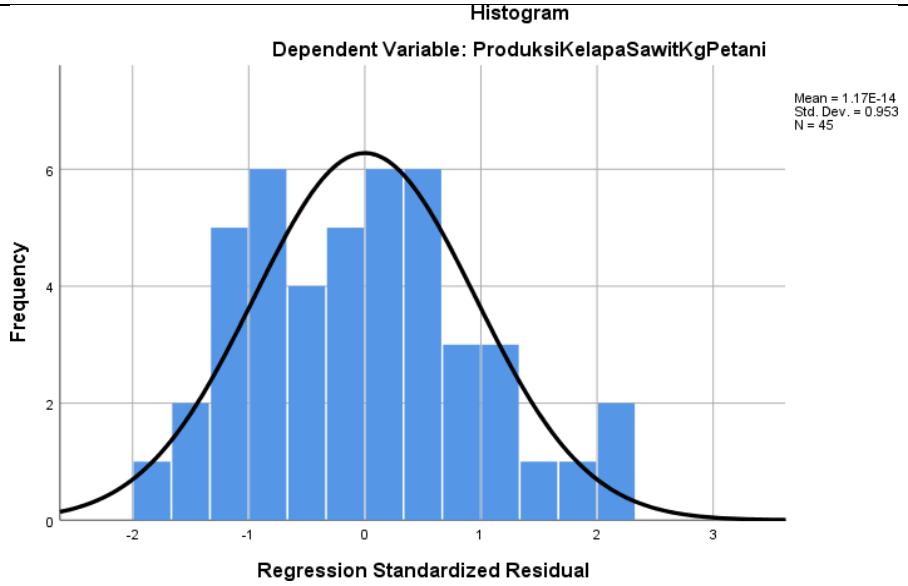

Figure 2 Normality Test Results

The residual normality test showed that the residual data was normally distributed ($p > 0.05$), which met the basic assumptions of parametric statistics and supported the validity of the regression analysis results (Field, 2018).

Multicollinearity

In regression analysis, multicollinearity refers to the presence of a very high correlation between two or more independent variables, which can lead to inaccuracies in the estimation of regression coefficients and reduce the reliability of the model. Therefore, it is important to examine the multicollinearity between the independent variables used in the regression model.

Based on the results of the multicollinearity test shown in the Collinearity Statistics Table, the values of Tolerance and Variance Inflation Factor (VIF) for each independent variable in the model can be seen:

Table 3 Collinearity Statistics

	Tolerance	VIVID
Number of Fertilizers (X1)	0,973579	1,027138
Land Area (X2)	0,972379	1,028405
Number of Seedlings (X3)	0,987842	1,012308
Pesticides (X4)	0,984875	1,015357

Source: Processed Data, 2025

Based on the results in the table above, all independent variables in the regression model show a Tolerance value greater than 0.1 and a VIF value that is much smaller than 10. This shows that there is no significant multicollinearity between the independent variables in this model. Therefore, it can be concluded that this regression model is free from multicollinearity problems, so the resulting regression coefficient estimation is reliable.

Heteroscedasticity

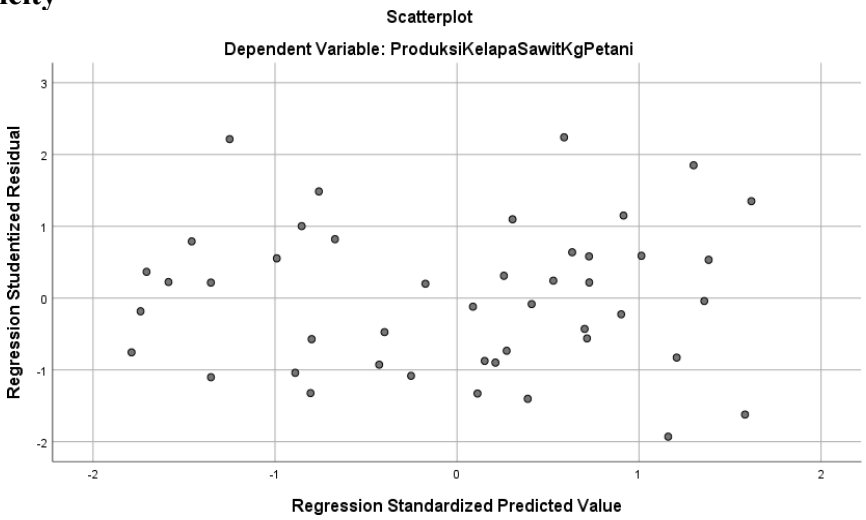

Figure 3 Results of the Hetroscedasticity Test

Heteroscedasticity tests were performed to check for residual variance inhomogeneity in the regression model. The test results showed that the residual pattern was randomly dispersed on the scatterplot, which means there were no heteroscedasticity issues in this model. This indicates that the residual variance is consistent across the range of predictive values, and that this regression model meets the assumption of homogeneity, so that the results of the regression analysis can be considered valid and reliable to make conclusions.

Multiple Linear Regression Results Table 4 Multiple Linear Regression Results

Model	B	Beta	t	Mr.
Constant	961.842		27.018	0.000
Total Fertilizer (Kg)	1.930	0.356	27.478	0.000
Land Area (Ha)	3.684	0.017	1.324	0.193
Number of Seedlings (Stems)	0.509	0.920	71.588	0.000
Pesticides (Liters)	1.490	0.065	5.089	0.000

Source: Processed Data, 2025

Based on the results of multiple linear regression presented in Table 3, the influence of independent variables on oil palm production can be analyzed. First, the variable amount of fertilizer shows a coefficient of 1,930, which means that every additional 1 kg of fertilizer used will increase oil palm production by 1,930 kg per farmer. This is reinforced by a very low significance value (p = 0.000), which suggests that the use of fertilizers has a very significant influence on increasing palm oil production. Therefore, it can be concluded that the amount of fertilizer is a very influential factor in supporting the success of oil palm production.

Furthermore, the land area variable has a coefficient of 3.684, which shows a positive relationship between land area and oil palm production. However, despite the positive coefficient, the significance value (p = 0.193) was greater than 0.05, indicating that land area did not significantly affect oil palm production in this study. This shows that although in theory more land

can increase production, the influence of land area in this study is not strong enough to be statistically significant.

The variable number of seedlings also showed a very significant influence on oil palm production, with a coefficient of 0.509. This means that every additional 1 seedling planted can increase oil palm production by 0.509 kg per farmer. A very low significance value (p = 0.000) indicates that the number of seedlings has a very significant influence on the increase in oil palm production. This underscores the importance of the role of seed numbers in increasing oil palm production.

Finally, the pesticide use variable showed a coefficient of 1,490, which means that every additional 1 liter of pesticide used can increase oil palm production by 1,490 kg per farmer. Although the coefficient is smaller compared to the amount of fertilizer and the number of seedlings, the very low significance value (p = 0.000) suggests that the use of pesticides still has a significant influence on oil palm production. Thus, although their contribution is slightly smaller, pesticides still play an important role in increasing production yields.

Overall, the results of this multiple linear regression show that the amount of fertilizer, the number of seedlings, and pesticides have a significant influence on oil palm production, while land area does not have a significant influence in the context of this study. The resulting regression model can be used to estimate oil palm production based on these factors, with regression equations:

$$Y = 961{,}842 + 1{,}930X_1 + 3{,}684X_2 + 0.509X_3 + 1{,}490X_4$$

Where:

- **Y** = Oil palm production (Kg/Farmers)
- **X_1** = Amount of Fertilizer (kg)
- **X_2** = Land Area (Ha)
- **X_3** = Number of Seedlings (Stems)
- **X_4** = Pesticide (Liter)

Effect of Fertilizer Amount (X_1)

Based on the results of regression analysis, the amount of fertilizer had a significant effect on oil palm production ($\beta = 0.356$; $p < 0.001$). Every 1 kg increase in fertilizer increases oil palm production by 1.93 kg. These findings support the theory of the Law of Diminishing Returns (Mankiw, 2020), which states that in the increasing returns phase, the addition of inputs, such as fertilizer, can increase output. Research by Bindraban et al. (2021) revealed that fertilizers, especially NPK, have a vital role in increasing photosynthesis and the formation of oil palm fruit bunches. However, overuse of fertilizers in the long term can lead to nutrient leaching and soil degradation (Zhang et al., 2022). In Pauhranap Village, the average fertilizer use is 303.49 kg/farmer, which is still below the FAO-recommended environmental risk threshold (2023) of 500 kg/Ha/year. Therefore, farmers should adopt precision fertilization techniques based on soil analysis to increase the efficiency of fertilizer use without damaging the ecosystem.

Effect of Number of Seedlings (X_3)

The number of seedlings has a dominant influence on oil palm production ($\beta = 0.920$; $p < 0.001$), where each additional one seedling increases production by 0.509 kg. This high beta coefficient supports the theory of Agricultural Intensification (Evenson & Gollin, 2003), which suggests the importance of optimal crop density to achieve high productivity. However, these

results need to be considered through the lens of superior seed selection theory (Slingerland et al., 2022), which shows that Dura x Pisifera (DxP) oil palm seedlings can produce 25–30 tons of FFB/Ha/year if managed properly (MPOB, 2021). However, seedling densities of more than 143 stems/Ha, as found in the sample average (2,997.80 stems/Ha), risk causing nutrient and light competition. Therefore, it is necessary to carry out pruning and thinning so that long-term results remain optimal (Corley & Tinker, 2015). A practical recommendation is socialization about the ideal planting distance (8–9 meters between trees) to prevent overcrowding.

Effects of Pesticides (X_4)

Pesticides have a positive effect on palm oil production ($\beta = 0.065$; $p < 0.001$), with a contribution of 1.49 kg/liter. This finding is in accordance with the principles of Integrated Pest Management (IPM) (Pimentel, 2019), which states that the rational use of pesticides can reduce yield losses due to pest attacks, such as Oryctes rhinoceros (horn beetle) by up to 20–30%. However, Altieri (2018) in Agroecology and Sustainable Food Systems warns about the risk of pest resistance and biodiversity disruption if pesticides are used in a monoculture. In Pauhranap Village, the average pesticide use is 54.84 liters/farmer, which is still below the threshold set by the Ministry of Agriculture (2023) which is 100 liters/Ha/year. One of the solutions that can be adopted is the replacement of chemical pesticides with environmentally friendly Beauveria bassiana-based bio-pesticides (Nurjanah et al., 2020).

Insignificance of Land Area (X_2)

Land area does not have a significant effect on oil palm production ($\beta = 0.017$; $p = 0.193$). This is contrary to the theory of Economies of Scale (Samuelson & Nordhaus, 2020) which states that the larger the land area, the more efficient the management and production produced. However, this phenomenon can be explained through the theory of Inverse Farm Size-Productivity Relationship (Barrett et al., 2020), which shows that farmers with small land (<10 Ha) tend to manage land intensively, using family labor, so that productivity per hectare can be higher. In Pauhranap Village, the average land area is 5.49 hectares, which has reached the optimal scale for traditional management. The study of Otsuka et al. (2016) also shows that smallholders in Southeast Asia are more efficient in the allocation of inputs compared to large landowners. Therefore, the right policy is a cooperative-based land consolidation program to increase economic scale without reducing the intensity of management.

Conclusion

Based on the analysis conducted, the use of fertilizers and pesticides has been proven to have a positive effect on oil palm production in Pauhranap Village, while land area does not show a significant influence, and the number of seedlings is the dominant factor in production. Therefore, several recommendations are given, including advising farmers to implement precision fertilization techniques, maintain an ideal planting density, and use environmentally friendly bio-pesticides. The local government is expected to enhance extension programs, develop a seed traceability system, and promote the adoption of modern agricultural technologies. Meanwhile, academics can use this research as a reference for further studies on oil palm productivity and the impact of agricultural technology. Thus, this study is expected to contribute to increasing oil palm productivity in Pauhranap and support more efficient and sustainable policies in the plantation sector.

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