The Effect of Guano Organic Fertilizer on Fresh Fruit Bunch Production of Oil Palm on Marginal Land at PT. Sawitmas Nugraha Perdana

Marianus Sitepu, Hanifah Mutia Z. N. Amrul, Kurniawan Sinaga

Abstract

The application of organic fertilizer in oil palm plantations can gradually improve soil fertility and yield. Guano organic fertilizer is derived from the droppings of bats or seabirds and contains essential macronutrients such as N, P, and K in natural proportions, which is why it is widely used as a source of organic nutrients in crop cultivation. This study was conducted at the estate of PT. Sawitmas Nugraha Perdana, located in Sampit, East Kotawaringin Regency, Central Kalimantan Province, Indonesia. Both primary and secondary data were collected from 2020 to 2024, with the secondary data consisting of fresh fruit bunch (FFB) production records. The correlation analysis showed a positive and significant relationship between guano fertilizer application and oil palm production, indicating that oil palm production tends to increase with the application of guano fertilizer.

Keywords: *guano fertilizer, plant age, fresh fruit bunch (FFB)*

Marianus Sitepu[1]
[1]Master of Agricultural Science, Universitas Pembangunan Panca Budi
e-mail: marianussitepu@mahasiswa.pancabudi.ac.id

Hanifah Mutia Z. N. Amrul, Kurniawan Sinaga
[2,3]Master of Agricultural Science, Universitas Pembangunan Panca Budi
e-mail: hanifahmutia@dosen.pancabudi.ac.id, kurniawansinaga@dosen.pancabudi.ac.id
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Introduction

The productivity of oil palm is higher than that of other vegetable-oil-producing crops, which is why this commodity continues to be developed, including on sub-optimal land. However, such expansion often faces the constraint of declining soil fertility, particularly on marginal land. According to [1], the success of oil palm production depends heavily on soil condition and the availability of balanced nutrients.

Marginal sandy soils are characterized by a coarse texture, low organic-matter content, low cation-exchange capacity, and limited water-holding capacity. These conditions cause nutrients to be easily leached, so they are not available to plants in optimal amounts. Sandy soils therefore require specific treatment in the form of added organic matter and fertilization strategies capable of improving the soil's physical, chemical, and biological properties. The use of organic matter can increase the efficiency of inorganic fertilizers by enhancing nutrient retention and soil microbial activity. Organic fertilizer can thus serve as a potential alternative in oil palm fertilization systems on marginal land [2].

Guano organic fertilizer is one natural source of organic matter. Derived from the droppings of bats or seabirds, it is known for its relatively high nitrogen and phosphorus content. Guano fertilizer is regarded as having strong potential for application to oil palm cultivated on sandy soils.

Guano is the term used to describe the dense accumulation of droppings and urine from birds or bats collected from the caves in which these animal populations live and breed. Guano originating from limestone caves has the best mineral and nutrient content. It contains numerous micro- and macro-minerals as well as high levels of natural nitrogen and phosphorus. Research has shown that the nutrient content of composted bat droppings is N 4.89% (very high), P 1.65% (very high), K 1.89% (very high), with a C/N ratio of 5 (low) [3].

Several studies have reported the benefits of applying organic fertilizer to oil palm, particularly in improving soil fertility and plant growth. The application of organic fertilizer in oil palm plantations can gradually increase soil organic-matter content and yield [4].

Literature Review

The productivity of oil palm is higher than that of other vegetable-oil-producing crops, which is why this commodity continues to be developed, including on sub-optimal land. However, such expansion often faces the constraint of declining soil fertility, particularly on marginal land. According to [1], the success of oil palm production depends heavily on soil condition and the availability of balanced nutrients.

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Research Methodology

This study was conducted at the estate of PT. Sawitmas Nugraha Perdana, located in Sampit, East Kotawaringin Regency, Central Kalimantan Province, Indonesia. Primary and secondary data were collected from 2020 to 2024 across different planting years, namely 2007, 2014, and 2015. The study employed a quantitative and qualitative descriptive method (descriptive analysis). The analytical methods used were multiple regression analysis and regression correlation. The effects of the guano fertilizer and plant age variables on FFB production were analyzed using the following equation:

$$Y = a_1x_1 + b_2x_2 + E$$

Before regression analysis was carried out, the data were first tested for normality. Where the data were normally distributed, the analysis proceeded with a Pearson correlation test to determine the relationships among guano fertilizer application, plant age, and oil palm FFB production. Data analysis was performed using SPSS v.26

Results

Multiple linear regression analysis was conducted to determine whether the plant-age and guano-fertilizer variables affected FFB production at PT. Sawitmas Nugraha Perdana.

Table 1. Correlation between guano fertilizer, plant age, and FFB production

Correlations		**Guano fertilizer**	**Plant age**	**Production (kg/ha)**
Guano fertilizer	Pearson Correlation	1	.000	.464
	Sig. (2-tailed)		1.000	.010
	N	30	30	30
Plant age	Pearson Correlation	.000	1	.472

	Sig. (2-tailed)	1.000		.008
	N	30	30	30
Production (kg/ha)	Pearson Correlation	.464	.472	1
	Sig. (2-tailed)	.010	.008	
	N	30	30	30

The correlation coefficient (R) indicates that the combined relationship of the plant-age and guano-fertilizer variables with FFB production is 66% (moderately strong). The coefficient of determination (R^2) shows that 43.8% of the variation in FFB production can be explained by variation in plant age and guano fertilizer, while the remaining 56.2% may be influenced by other variables not accounted for by the model.

A correlation coefficient of r = 0.464 with a significance of p = 0.010 (p < 0.05) indicates a positive and significant relationship between guano fertilizer application and oil palm production, meaning that production tends to increase with guano application. This positive relationship suggests that organic fertilization can improve soil fertility and the efficiency of nutrient uptake. Guano is an organic fertilizer rich in nitrogen (N), phosphorus (P), and potassium (K), which play important roles in the vegetative and generative growth of plants. Nitrogen supports flower and fruit formation, while potassium enhances fruit filling and bunch quality. Increasing the availability of these nutrients improves photosynthesis and the translocation of assimilates to reproductive organs, thereby increasing FFB production. This is consistent with the agronomic principle that appropriate fertilization can sustainably increase crop productivity.

Plant age was positively and significantly correlated with oil palm production, as shown in Table 1, with a correlation coefficient of r = 0.472 (moderate correlation) and a significance value of p = 0.008 (p < 0.05). This means that as plant age increases (within the productive age range), production tends to rise. Physiologically, oil palm has an optimal productive phase at a certain age. During this phase, the root system, canopy area, and photosynthetic efficiency are at their peak, resulting in higher production. The peak production period for oil palm is between 9 and 18 years of age, after which production begins to decline [14].

A correlation value of r = 0.000 with p = 1.000 indicates that there is no relationship between guano fertilizer and plant age, meaning that fertilizer application is not influenced by plant age. This is consistent with field practice, where the fertilization treatment is applied independently of plant age.

Table 2. Model summary of the effect of guano fertilizer and plant age on FFB production

Model	R	R Square	Adjusted R Square
1	.662[a]	.438	.396

a. Predictors: (Constant), plant age, guano fertilizer

Based on Table 2, the regression analysis shows the relationship between guano fertilizer and plant age and oil palm fresh fruit bunch (FFB) production. The multiple

correlation coefficient (R) of 0.662 indicates a fairly strong relationship between the independent variables and FFB production.

The R Square (R^2) value of 0.438 shows that 43.8% of the variation in FFB production can be explained by guano fertilizer and plant age, while the remaining 56.2% is influenced by other factors not included in the model, such as soil condition, rainfall, plant variety, cultivation techniques, water availability, and pest and disease control. Guano fertilizer contains macronutrients such as nitrogen (N), phosphorus (P), and potassium (K), as well as micronutrients important for plant growth. Nitrogen contributes to chlorophyll formation and vegetative growth, while phosphorus supports flower and fruit formation. Guano fertilizer contains 2–6% total nitrogen, 1.5–10% available phosphoric acid, and 1.5–10% soluble potassium [15]. The concentrations of N, P, and K in bat guano meet the 5% N–P–K composition established as the criterion for a material to qualify as a fertilizer [7].

Based on the model summary, the coefficient of determination of 0.438 indicates that 43.8% of production is influenced by guano fertilizer and planting year. However, other factors—such as environmental conditions, cultivation techniques, water availability, and pest and disease control—also affect productivity.

Table 3. ANOVA of the effect of guano fertilizer and plant age on FFB production

ANOVA[a]		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	309848283.315	2	154924141.658	10.516	.000[b]
	Residual	397784189.385	27	14732747.755		
	Total	707632472.700	29			

a. Dependent Variable: production (kg/ha)

b. Predictors: (Constant), plant age, guano fertilizer

Guano fertilizer had a significance value of 0.003 ($p < 0.05$), indicating a positive and significant effect on FFB production. Plants treated with guano fertilizer showed an average increase in FFB production of 4,506 kg/ha compared with those without guano fertilizer. Guano fertilizer improves the physical, chemical, and biological properties of soil. The organic matter in guano can enhance the soil's ability to retain water and nutrients [11], making nutrient uptake by the roots more efficient; it also acts as an ameliorant on the marginal sandy soil where the study was conducted. These improvements in soil condition contribute to increased oil palm productivity.

Plant age had a significance value of 0.003 ($p < 0.05$), showing a positive and significant effect on FFB production. For each one-year increase in age within the productive range, production increased by 598 kg/ha. Plant age was thus also shown to have a real effect on FFB production. In oil palm, increasing plant age until it reaches the optimal productive phase enhances the plant's capacity to produce fruit bunches. Older plants have a more developed root system and higher photosynthetic capacity, enabling them to supply more assimilates for fruit formation. Nevertheless, the increase in production associated with plant age typically continues only until the optimal productive age is reached, after which it tends to decline in trees that are too old.

Conclusion

The correlation analysis shows a positive and significant relationship between guano fertilizer application and oil palm production, indicating that oil palm production tends to increase with the application of guano fertilizer.

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