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# COMPARATIVE ANALYSIS OF OIL PALM PRODUCTION, COSTS, AND INCOME WITH AND WITHOUT CASTRATION AT KENCANA SARI ESTATE, LAHAT REGENCY, INDONESIA

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## ABSTRACT

**Background:** Castration is a cultivation practice in which all male and female inflorescences are removed from immature oil palms so that photosynthates are redirected toward vegetative growth. However, this practice increases maintenance costs, so its economic benefits need to be evaluated. This study aimed to compare the production and economic performance of oil palm blocks with and without castration.

**Methods:** The study was conducted at the Kencana Sari Estate, PT PP London Sumatra Indonesia Tbk, in Lahat Regency, Indonesia. The location was selected purposively because the plantation practices intensive oil palm cultivation, including castration. The study used a survey method with a comparative quantitative approach involving one castrated block and one non-castrated block. Data on production, production costs, and income were analyzed using an independent-samples t-test.

**Results:** The results showed that the castrated block had significantly higher production than the non-castrated block ($p < 0.05$), whereas production costs and income did not differ significantly ($p > 0.05$). These findings indicate that castration increased production but did not significantly increase income.

**Conclusion:** The non-significant results for costs and income should be interpreted as insufficient statistical evidence within the one-year observation period, not as evidence that castration does not affect income.

**Keywords:** Production costs; Castration; Oil palm; Revenue

## 1 INTRODUCTION

Oil palm (*Elaeis guineensis*) is a strategic plantation commodity for the Indonesian economy. According to preliminary data from the Directorate General of Plantations [1], the national oil palm area in 2025 reached 16.83 million hectares,

with crude palm oil (CPO) production totaling 46.55 million metric tons. However, national productivity stood at only 3.61 metric tons of CPO per hectare of mature area, far below the potential yield of 6 metric tons per hectare [2]. The same report attributes this low productivity to the use of uncertified seeds and the large number of old and damaged palms. Consequently, efforts to increase productivity are focused on replanting old, damaged, or unproductive palms with high-quality seeds. Monzon et al. [3] reported that the average yields of large and smallholder plantations have reached only 62% and 53% of the attainable yield, respectively. They estimate that closing this yield gap through improved agronomic management, coupled with limited expansion of cultivated areas outside vulnerable ecosystems, could save approximately 2.6 million hectares of forest and peatland compared with continuing historical trends.

One maintenance practice for immature oil palms that helps prepare them for their first harvest is castration, also known as ablation [4]. Castration involves removing all male and female inflorescences and any developing fruit bunches so that nutrients are redirected to support the palm's vegetative growth [5]. This practice generally begins 12–18 months after planting and is repeated every 1–2 months until the palms are approximately 24 months old [5,6]. Removing early inflorescences prevents the formation of small, uneconomical bunches and allows nutrients to be used to strengthen the canopy and roots and to improve the drought tolerance of young palms [6,7]. Castrated palms are sturdier and grow more evenly, and they produce larger, more uniform fruit bunches [6]. Rodríguez Rivera et al. [8] reported that early ablation of interspecific OxG hybrid oil palms (*Elaeis oleifera* × *E. guineensis*) increased leaf area and raised annual bunch yield to 4,9 metric tons per hectare, compared with 2,3 metric tons per hectare without ablation. Similarly, Pratama 2026 [4], found that blocks with seven castration cycles produced 18,57 metric tons per hectare in the first year of harvest, compared with 13,26 metric tons per hectare in blocks with four cycles.

Studies on oil palm castration have so far focused mainly on its technical and agronomic aspects. Roosmawati et al. [5] and Hasibuan & Surbakti [9] calculated the costs of castration without linking them to changes in production and income; Sirait et al. [6] tested the performance of castration tools; and Aditya 2018 [10] discussed the technical management of castration in the field. Other studies have highlighted growth responses and fruit bunch yields [4,8], as well as the effects of castration on pest infestation [11]. The economic effects of castration, specifically the variations in production, production costs, and income between castrated and non-castrated palms on big estates, have not been thoroughly examined. However, this data is required as an empirical foundation for plantation management to decide whether to continue or increase castration. Therefore, this study aimed to compare the production, production costs, and income of oil palm blocks with and without castration at the Kencana Sari Estate, PT PP London Sumatra Indonesia Tbk, Lahat Regency.

## 2 MATERIAL AND METHODS

### 2.1 Time and Location of the Study

This study was conducted from June through November 2026 at the Kencana Sari Estate of PT PP London Sumatra Indonesia Tbk, located in Hamlet VI, Bungamas Village, East Kikim Subdistrict, Lahat Regency, South Sumatra Province, Indonesia. The location was selected purposively because the plantation practices intensive oil palm cultivation, including castration.

### 2.2 Data Collection Methods

This study used a survey method with a comparative quantitative approach. All data were secondary data from the records and reports of PT PP London Sumatra Indonesia Tbk, covering fresh fruit bunch (FFB) production, production costs, revenue, and income. The study population consisted of two oil palm blocks of 13,85 ha each at the Kencana Sari Estate, one castrated and one non-castrated. Details of both blocks are shown in Table 1.

**Table 1: Selection criteria for oil palm blocks with and without castration**

| No | Criteria | Castrated | Non-castrated |
|---|---|---|---|
| 1 | Land area (ha) | 13,85 | 13,85 |
| 2 | Number of trees | 143 | 143 |
| 3 | Variety | BLRS | BLRS |
| 4 | Age of the plant | 5 | 5 |
| 5 | Soil type | Ultisol | Ultisol |
| 6 | Topography | Undulating | Undulating |
| 7 | Plant spacing | 9 x 9 x 9 | 9 x 9 x 9 |

Source: Data PT. PP. London Sumatra Indonesia Tbk (2026)

### 2.3 Data Analysis Methods

The data obtained from the company's records were processed through tabulation, calculations, and statistical analysis. Before the means were compared, the data were tested for normality using the Shapiro–Wilk test and for homogeneity of variances using Levene's test. Because both assumptions were met, differences in mean production, production costs, and income between the castrated and non-castrated blocks were tested using an independent-samples t-test, with significance at p<0,05. Data were processed using Microsoft Excel and IBM SPSS Statistics version 31.

## 3 RESULTS AND DISCUSSION

### 3.1 Overview of the Research Site

The study site was located in Hamlet VI, Bungamas Village, East Kikim Subdistrict, Lahat Regency. The village covers 35,29 $km^2$ and consists of five hamlets. It is about 12 km from the subdistrict capital and 15 km from the capital of Lahat Regency, and it can be reached by road using public or private transportation. Suka Makmur Village has a population of 1.459, most of whom work in the oil palm plantation sector. Public facilities in the village include a mosque, a community health post, a satellite health center, a village office, a borehole well, a public school, and a madrasah (Islamic school).

### 3.2 Company Overview

The Kencana Sari Estate of PT PP London Sumatra Indonesia Tbk covers 1.772,96 ha, divided into three divisions and 77 blocks (73 mature and 4 immature). Planting years range from 1997 to 2021. The plantation is surrounded by 10 villages and lies within two subdistricts, Gumay Talang and East Kikim. All plantation facilities are located in one central area. Under the company's Best Management Practices (BMP), key crop maintenance measures include a replanting program and quality standards for achieving high yields. Land preparation follows a standard procedure that depends on soil type: on peat soils, it involves constructing field drains, CECT, chambering, and compaction; on mineral soils, it involves laying out planting rows and tilling the soil in 2-meter-wide strips. The company selects high-quality seedlings that are 12 to 18 months old.

### 3.3 Fresh Fruit Bunch Production with and without Castration

The castrated block produced 140,785 metric tons of fresh fruit bunches (FFB) per year, or 10,165 metric tons per hectare per year, whereas the non-castrated block produced 59,947 metric tons per year, or 4,328 metric tons per hectare per year (Table 2). The difference in production between the two blocks was 80,838 metric tons per year, or 5,837 metric tons per hectare per year. In other words, the productivity of the castrated block was 2,35 times that of the non-castrated block, or 134,85%.

**Table 2: FFB Production in Blocks with and without Castration**

| Description | Castrated | Non-castrated | Difference | Change (%) |
|---|---|---|---|---|
| Block area (ha) | 13,85 | 13,85 | 0,00 | 0,00 |
| FFB Production (ton/block/year) | 140,785 | 59,947 | 80,838 | 134,85 |
| Productivity (ton/ha/year) | 10,165 | 4,328 | 5,837 | 134,85 |

Source: Data PT. PP. London Sumatra Indonesia Tbk (2026) Note: The percentage change is calculated relative to the non-castrated

The t-test results (Table 3) showed a t-value of 2,20 with 22 degrees of freedom (df) and a two-tailed p-value of 0,039. Because p < 0,05, FFB production was significantly higher in the castrated block than in the non-castrated block

**Table 3: Results of the independent-samples t-test for fresh fruit bunch (FFB) production**

| | t | df | Sig. (Two-Sided p) |
|---|---|---|---|
| Equal variances assumed | 2,200 | 22 | 0,039 |
| Equal variances not assumed | 2,200 | 17,787 | 0,041 |

Source: Results of data analysis using SPSS 31.0 (2026)

The higher yield of the castrated block is consistent with the physiological effects of castration. Removing male and female inflorescences and developing bunches during the immature phase redirects the nutrients that would otherwise form small, uneconomical bunches toward vegetative growth [5,6]. These nutrients support canopy and root growth [7], producing sturdier palms that grow more evenly and produce larger, more uniform bunches once they mature [6].

This stronger vegetative growth during the immature phase therefore gives the palms greater production capacity in the mature phase [4].

The higher production of the castrated block was consistent with previous findings. Rodríguez Rivera et al. [8] reported that early ablation of OxG hybrid oil palms raised annual bunch yield to 4,9 metric tons per hectare, compared with 2,3 metric tons per hectare without ablation. This ratio of about 2,1 is close to the 2,35-fold difference observed in this study. In Indonesia, Pratama 2026 [4] likewise found higher first-year yields in blocks with seven castration cycles than in blocks with four. The consistent direction of these findings reinforces the notion that castration plays an important role in determining palm productivity during the early years of harvest.

### 3.4 Production Costs with and without Castration

Production costs in this study consisted of fixed and variable costs. Fixed costs do not change with production volume; in this study, they consisted only of equipment depreciation, calculated from the initial value and economic life of each item. Variable costs, which change with the intensity of maintenance and production activities, included the costs of castration, fertilizer, herbicides, and labor. Fixed costs were the same for both blocks, at IDR 32.568.000 per block per year, because both used the same types of equipment and the same basis for calculating depreciation (Table 4). The largest components of fixed costs were the depreciation of the sprayer (26,53%), brush cutter (23,58%), and wheelbarrow (22,11%), with the remainder coming from the pole sickle, hoe, harvesting chisel, and machete. Because fixed costs were identical, any difference in total production costs between the blocks came entirely from variable costs.

**Table 4: Fixed costs (equipment depreciation) with and without castration**

| No | Components | Castrated (IDR/block/year) | Non-castrated (IDR/block/year) | Difference (IDR/block/year) | Percentage (%) |
|---|---|---|---|---|---|
| 1 | Harvesting chisel | 1.872.000 | 1.872.000 | 0 | 5,75 |
| 2 | Pole sickle | 3.120.000 | 3.120.000 | 0 | 9,58 |
| 3 | Machete | 1.872.000 | 1.872.000 | 0 | 5,75 |
| 4 | Hoe | 2.184.000 | 2.184.000 | 0 | 6,71 |
| 5 | Sprayer | 8.640.000 | 8.640.000 | 0 | 26,53 |
| 6 | Wheelbarrow | 7.200.000 | 7.200.000 | 0 | 22,11 |
| 7 | Brush cutter | 7.680.000 | 7.680.000 | 0 | 23,58 |
| Total | | 32.568.000 | 32.568.000 | 0 | 100,00 |

Source: Data PT. PP. London Sumatra Indonesia Tbk (2026) Note: Percentage (%) of total fixed costs

Variable costs in the castrated block were IDR 121.381.264 per year, IDR 18.280.360 (17,73%) higher than in the non-castrated block (IDR 103.100.904; Table 5). Because the costs of fertilizer (IDR 43.766.360) and herbicides (IDR 2.413.744) were the same in both blocks, the difference came entirely from two components: castration (IDR 15.818.920) and additional labor (IDR 2.461.440). The castration cost was IDR 1.142.160 per hectare per year, or 10,28% of the castrated block's total production costs.

**Table 5: Variable costs with and without castration**

| No | Components | Castrated (IDR/block/year) | Non-castrated (IDR/block/year) | Difference (IDR/block/year) | Percentage (%) |
|---|---|---|---|---|---|
| 1 | Castration | 15.818.920 | 0 | 15.818.920 | – |
| 2 | Fertilizer | 43.766.360 | 43.766.360 | 0 | 0,00 |
| 3 | Herbicides | 2.413.744 | 2.413.744 | 0 | 0,00 |
| 4 | Labor | 59.382.240 | 56.920.800 | 2.461.440 | 4,32 |
| Total | | 121.381.264 | 103.100.904 | 18.280.360 | 17,73 |

Source: Data PT. PP. London Sumatra Indonesia Tbk (2026)

Note: Percentage (%) was calculated relative to the non-castrated block. (–) sign indicates that the value could not be calculated because the reference value was zero.

In both blocks, labor was the largest variable cost component (48,92% in the castrated block and 55,21% in the non-castrated block), followed by fertilizer (36,06% and 42,45%, respectively). This cost structure is consistent with Riyanto et al. [12], who identified fertilization as one of the largest components of oil palm plantation maintenance costs, primarily because its implementation is highly labor-dependent. Labor availability was also a major constraint on increasing production on large plantations [13]. In the castrated block, labor costs increased by only 4.32%, far less than the increase in production (134,85%). As a result, the labor cost per kilogram of FFB was IDR 421,79 in the castrated block, less than half the cost in the non-castrated block (IDR 949,52).

**Table 6: Total production costs with and without castration**

| Components | Castrated | Non-castrated | Difference | Change (%) |
|---|---|---|---|---|
| Fixed costs (IDR/block/year) | 32.568.000 | 32.568.000 | 0 | 0,00 |
| Variable costs (IDR/block/year) | 121.381.264 | 103.100.904 | 18.280.360 | 17,73 |
| Total production costs (IDR/block/year) | 153.949.264 | 135.668.904 | 18.280.360 | 13,47 |

Source: Data PT. PP. London Sumatra Indonesia Tbk (2026)

Overall, total production costs in the castrated block were IDR 153.949.264 per year, IDR 18.280.360 (13,47%) higher than in the non-castrated block, which was IDR 135.668.904 (Table 6). Per hectare, this difference was approximately IDR 1,32 million per year. Variable costs dominated the cost structure, accounting for 78,84% of total costs in the castrated block and 75,99% in the non-castrated block. The independent-samples t-test on production costs (Table 7) showed a t-value of 1,775 with 22 degrees of freedom (df), and production costs did not differ significantly between the castrated and non-castrated blocks.

**Table 7: Results of the independent samples t-test for production costs**

| | t | df | Sig. (Two-Sided p) |
|---|---|---|---|
| Equal variances assumed | 1,775 | 22 | 0,090 |
| Equal variances not assumed | 1,775 | 20,728 | 0,091 |

Source: Results of data analysis using SPSS 31.0 (2026)

### 3.5 Revenue and Income with and without Castration

Revenue is the product of the quantity of fresh fruit bunches (FFB) produced and their selling price, whereas income is revenue minus total production costs [14]. FFB was valued at the same selling price in both blocks, IDR 3.300/kg, so the difference in revenue reflects only the difference in production. Annual revenue was IDR 464.590.500 for the castrated block and IDR 197.825.100 for the non-castrated block (Table 8). This difference of IDR 266.765.400 means that revenue in the castrated block was 134,85%, matching the percentage increase in production. After total production costs were deducted, income was IDR 310.641.236 in the castrated block and IDR 62.156.196 in the non-castrated block, a difference of IDR 248.485.040. The income of the castrated block was therefore about five times that of the non-castrated block (399,78%).

**Table 8: Revenue and Income with and without Castration**

| Components | Castrated | Non-castrated | Difference | Change (%) |
|---|---|---|---|---|
| FFB production (ton/block/year) | 140.785 | 59.947 | 80.838 | 134,85 |
| FFB selling price (IDR/kg) | 3.300 | 3.300 | 0 | 0,00 |
| Revenue (IDR/block/year) | 464.590.500 | 197.825.100 | 266.765.400 | 134,85 |
| Total production costs (IDR/block/year) | 153.949.264 | 135.668.904 | 18.280.360 | 13,47 |
| Income (IDR/block/year) | 310.641.236 | 62.156.196 | 248.485.040 | 399,78 |

Source: Data PT. PP. London Sumatra Indonesia Tbk (2026), Note: The change (%) was calculated relative to the non-castrated block

The difference in income resulted from relatively small additional costs accompanied by much larger additional revenue. Additional costs of IDR 18.280.360 generated additional revenue of IDR 266.765.400, so 93,15% of the additional revenue became additional income. This indicates that, in the castrated block, increased production was the main driver of income, while the additional costs of castration offset only a small portion of that benefit. Although the

difference in income was descriptively very large, the independent-samples t-test (Table 9) showed a t-value of 1,265 with 22 degrees of freedom and a two-tailed p-value of 0,219. The difference in income between the castrated and non-castrated blocks was therefore not statistically significant at the 5% level, whether equal or unequal variances were assumed.

**Table 9: Results of the independent-samples t-test for income**

| | t | df | Sig. (Two-Sided p) |
|---|---|---|---|
| Equal variances assumed | 1,265 | 22 | 0,219 |
| Equal variances not assumed | 1,265 | 20,115 | 0,220 |

Source: Results of data analysis using SPSS 31.0 (2026)

The discrepancy between the size of the descriptive difference and the t-test result can be explained by the high month-to-month variability in income (Table 8). Income is the difference between two fluctuating components: revenue, which depends on production and price, and costs, whose realization is not always consistent. Monthly FFB production fluctuates because of water stress and endogenous yield cycles [3], and revenue is further affected by changing FFB prices [15]. With only 12 monthly observations per block, such variability reduces the statistical power of the test to detect differences. In addition, because the observations come from one block per group, they are repeated measurements and not independent replicates, which limits generalization. A p-value also does not measure the magnitude or importance of an effect, so decisions should not rest solely on whether it crosses a threshold [16].

## 4 CONCLUSION

Castration of oil palms significantly increased fresh fruit bunch production at the 5% significance level. Production in the castrated block was 134,85% higher than in the non-castrated block (p = 0,039). Total production costs in the castrated block were 13,47% higher, mainly because of castration costs, but this difference was not statistically significant (p = 0.090). Income in the castrated block was 399,78% higher, but this difference was also not statistically significant (p = 0,219), probably because of large variability among monthly observations and their limited number. The non-significant results for costs and income should be interpreted as insufficient statistical evidence within the one-year observation period, not as evidence that castration does not affect income. Further research over a longer period and with more blocks and plantations is needed to test the economic impact of castration more conclusively.

## STATEMENTS ON COMPLIANCE WITH ETHICAL STANDARDS

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### *Disclosure of conflict of interest*

The authors declare no conflicts of interest.

### *Statement of informed consent*

Written informed consent was obtained from all participants.

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