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Impact of El Niño on the Productivity and Income of Conventional and Organic Oil Palm Farmers at Penawar Tama, Tulang Bawang Regency

Siti Ghalika Permata Suri Almega[1], Zainal Abidin[1,✉], Yaktiworo Indriani[1], Ktut Murniati[1], Fembriarti Erry Prasmatiwi[1]

[1] Department of Agribusiness, Faculty of Agriculture, University of Lampung, Bandar Lampung, INDONESIA.

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Corresponding Author:
✉ zainal.abidin@fp.unila.ac.id
(Zainal Abidin)

ABSTRACT

Extreme weather condition such as El Niño phenomenon potentially result in great effect on farm production. This study aims to analyze the effect of El Niño on the productivity and income of organic and conventional oil palm farming. The research was conducted in Penawar Tama Subdistrict, Tulang Bawang Regency, during March–April 2024, using a survey involving 56 oil palm farmers. Data were analyzed using paired sample t-test, Wilcoxon Signed Rank, Mann-Whitney test, and described qualitatively. Results indicate that El Niño phenomenon had significant negative impacts on productivity, revenue, and farmer income, as evidenced by the premature fruit drop under extreme drought conditions. Specifically, oil palm productivity declined by 19.14% for organic farm, and by 20.46% for conventional farm. The income of organic oil palm farmers fell by 61.70% (equivalent to 7,400,446.44 IDR/ha), and that of conventional farmers declined by 127.09% (equivalent to 5,048,508.01 IDR/ha). The paired sample t-test and Wilcoxon Signed Rank test revealed significant differences in productivity, total costs, Fresh Fruit Bunch (FFB) prices, revenue, and income before and during El Niño phenomenon, with significance values of less than 0.05. The Mann-Whitney test showed significant differences in productivity, total costs, revenue, and income between organic and conventional oil palm farming during the El Niño. However, no significant difference was found in FFB selling prices.

1. INTRODUCTION

The plantation subsector is one of the key contributors to the agricultural sector in Indonesia. It ranks first among agricultural subsectors in terms of contribution to the Agriculture, Forestry, and Fisheries sector, accounting for 30.97 percent of the total contribution. In addition, the plantation subsector contributed 3.88 percent to Indonesia's total Gross Domestic Product (GDP) in 2023 (Badan Pusat Statistik, 2024).

Oil palm (*Elaeis guineensis* Jacq.) is one of the leading commodities within the plantation sector. This is evidenced by Indonesia's position as the world's largest producer and exporter of palm oil, with the largest supporting production areas located in the provinces of Sumatra. One of the major oil palm-producing regions in Lampung Province is Tulang Bawang Regency. However, in recent years, oil palm productivity in Indonesia has shown fluctuating trends. According to statistical data from the Direktorat Jenderal Perkebunan (2024), the productivity of smallholder oil palm plantations increased by 20 kg/ha in 2022, but subsequently declined by 95 kg/ha in 2023. In 2024, productivity slightly increased again, but only by 6 kg/ha. Smallholder oil palm productivity is projected to face increasing challenges in competing with state-owned and private large-scale plantations due to the fertilizer scarcity phenomenon triggered by the Russia–Ukraine conflict. This fertilizer shortage has made it difficult for farmers to access fertilizers as prices have risen significantly, resulting in an imbalance between production costs and selling prices.

To address the fertilizer scarcity issue, farmers have adopted several alternative strategies in managing their oil palm farming operations. One such strategy involves applying cultivation techniques that differ from conventional practices. Several farmers in Tulang Bawang Regency, Lampung Province, have implemented microbe-based organic cultivation techniques using locally sourced fertilizers, thereby reducing their dependency on commercially distributed fertilizers.

In addition to fertilizer scarcity, oil palm farmers have also faced climate change challenges, particularly the El Niño phenomenon and prolonged drought in mid-2023. Badan Meteorologi, Klimatologi dan Geofisika (2023) projected a 50–60 percent probability of El Niño occurrence in March 2023, with its effects beginning to be felt in June 2023 at weak to moderate intensity. This projection was supported by BMKG monitoring results in the third quarter (July–September) of 2023, which indicated a moderate El Niño event that caused drought conditions in several regions of Indonesia. In August 2023, approximately 6,964 hectares of rice fields experienced crop failure (Badan Meteorologi, Klimatologi dan Geofisika, 2024).

The El Niño phenomenon resulted in reduced rainfall across several regions of Indonesia during the 2023 dry season. This is evidenced by the significant decline in extreme rainfall in Tulang Bawang Regency in 2023, as illustrated in Figure 1.

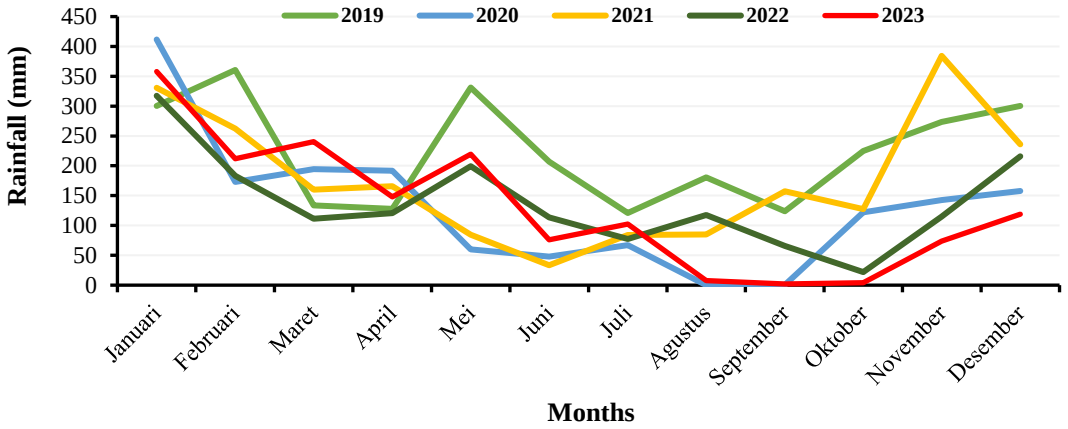

Figure 1. Average annual rainfall (mm) in Tulang Bawang Regency period 2019–2023. (Source: BPS Provinsi Lampung, 2024)

Lampung Province experienced a decline in rainfall in 2023 compared to previous years. The lowest rainfall levels were recorded in August, September, and October 2023, with monthly rainfall below 100 mm. This indicates that rainfall during those months was significantly lower than the normal average rainfall, which typically ranges from 200–400 mm per month. According to Christian *et al*. (2023), the ideal rainfall for oil palm growth is approximately 1,300–2,500 mm per year, provided that the annual water deficit does not exceed 250 mm. Such an extreme decline in rainfall may lead to drought conditions that adversely affect harvest quality and may even result in crop failure. Although the dry season may increase oil palm extraction rates, excessive drought raises the risk of crop failure due to water stress experienced by the plants.

The El Niño phenomenon has become a global issue due to the substantial losses it causes across various sectors, particularly agriculture. The current El Niño event has significantly affected farmers, especially oil palm farmers. The impacts include reduced water availability due to decreased rainfall and prolonged dry seasons, leading to drought conditions.

El Niño conditions may also increase the incidence of pests and plant diseases. Under extreme drought conditions, the populations of natural predators that control oil palm pests and diseases tend to decline, thereby increasing pest and disease outbreaks. Consequently, drought conditions can reduce harvest quality and, in certain cases, result in crop failure. This finding is consistent with Egonyu *et al*. (2022), who reported that pest attacks intensify during drought periods, amplifying their overall impact.

During El Niño conditions, crop maintenance practices in both cultivation systems are adjusted to maintain water availability and minimize plant water stress and excessive evapotranspiration, thereby sustaining optimal productivity. Conventional farmers generally conduct limited pruning of non-productive fronds to reduce excessive evaporation, and the pruned fronds are used as mulch to maintain soil moisture. In contrast, organic farmers maintain weed growth up to 20 cm to preserve soil moisture and protect beneficial microbes from direct sunlight exposure. These practices demonstrate that farmers have implemented cost-effective adaptive strategies to maintain production levels.

Farmers strive to achieve optimal production by utilizing necessary agricultural inputs under both normal and El Niño-affected conditions, depending on the cultivation system adopted. These farming activities incur production costs associated with the production of Fresh Fruit Bunches (FFB). These costs are ultimately reflected in the selling price of FFB, influencing farmers' revenue and income to prevent financial losses. Based on the aforementioned background, this study aims to analyze the impact of the El Niño phenomenon on productivity and income in conventional and organic oil palm farming in Penawar Tama District, Tulang Bawang Regency. This research is expected to provide empirical evidence to farmers regarding differences in productivity and profitability between conventional and organic oil palm farming under both normal and El Niño conditions, as well as serve as a reference for further studies on other aspects of oil palm agribusiness.

2. METHODS

2.1. Research Area

This study was conducted in Penawar Tama District, Tulang Bawang Regency. The research location consisted of two different categories: smallholder plantations applying microbe-based organic cultivation techniques and those applying conventional cultivation techniques. The research site was selected purposively, based on the consideration that Penawar Tama District, Tulang Bawang Regency, has oil palm farmers who implement different cultivation systems. Tulang Bawang Regency is also one of the major oil palm-producing areas with the highest production levels in Lampung Province.

Tulang Bawang Regency is the third-largest regency in terms of plantation area in Lampung Province, following Mesuji Regency and Central Lampung Regency. Penawar Tama District has the largest oil palm plantation area within Tulang Bawang Regency, accounting for 19.6 percent of the total oil palm plantation area in the regency, equivalent to 6,913 hectares (Badan Pusat Statistik, 2024).

2.2. Research Methods

The respondents of this study were independent oil palm smallholders who were not involved in partnership programs, with a total population of 213 farmers. Based on the calculation conducted, a sample of 56 farmers was selected for this study. Using proportional allocation sampling, the respondents were divided into 27 farmers practicing organic cultivation and 29 farmers practicing conventional cultivation.

Figure 2. Map of study area at Penawar Tama District, Tulang Bawang Regency

2.3. Data Collection Methods

This study employed a survey method. A structured questionnaire was used as the primary instrument for data collection. The purposive sampling technique was applied, as the selected samples were required to meet specific criteria, namely oil palm plantations with relatively similar planting years and relatively comparable land areas. The total sample was subsequently classified into two categories: organic oil palm farmers and conventional oil palm farmers. The sample size representing the population of oil palm farmers was determined using the Isaac & Michael (1995) formula.

$$s = \frac{\lambda^2 N.P.Q}{d^2.(N-1).\lambda^2.P.Q} \quad (1)$$

where s is sample size, λ^2 is chi-square value, N is total population, d is margin of error between the sample mean and the population mean (1%, 5%, 10%), P is probability of success (0.5), and Q is probability of failure (0.5)

The data used in this study consisted of primary and secondary data. Primary data were obtained through interviews using a structured questionnaire and direct field observations at the sample plantations. Secondary data included farmers' production and revenue data under normal conditions, as well as supporting data obtained from Badan Meteorologi, Klimatologi, dan Geofisika (BMKG) and Badan Pusat Statistik (BPS).

Data collection was conducted from March to April 2024. The collected data were analyzed using farm productivity analysis, farm income analysis, parametric and non-parametric difference tests (paired sample *t*-test, Wilcoxon Signed Rank test, and Mann–Whitney test), as well as descriptive qualitative analysis.

2.4. Data Analysis Methods

2.4.1. Productivity Analysis

The productivity of oil palm farming was calculated based on observations of Fresh Fruit Bunch (FFB) production, which was estimated in tons per hectare per year using the following formula.

$$Productivity = \frac{Total\ Production\ (ton)}{Area\ (ha)} \quad (2)$$

2.4.2. Income Analysis

Farm income was calculated using farm income analysis. According to Soekartawi (2016), income refers to net income, which is total revenue minus total production costs. The formula for calculating farm income is as follows.

$$\pi = TR - TC \quad (2)$$

$$\pi = Y \times Py - (TFC + TVC) \quad (3)$$

where π is income (IDR·month^{-1}·ha^{-1}), *TR* is total revenue (IDR·month^{-1}·ha^{-1}), *TC* is total cost (IDR·month^{-1}·ha^{-1}), *Y* is total production output (kg·month^{-1}·ha^{-1}), *Py* is selling price (IDR/kg), *TFC* is total fixed cost (IDR·month^{-1}·ha^{-1}), and *TVC* is total variable cost (IDR·month^{-1}·ha^{-1})

2.4.3. Comparative Statistical Analysis

The comparative test analysis was conducted to examine whether there were significant differences in productivity, total costs, selling prices, revenue, and income obtained by organic and conventional oil palm farmers under El Niño conditions compared to normal conditions. The analysis consisted of both parametric and non-parametric tests. This approach was applied because several variables were not normally distributed based on the normality test.

The paired sample *t*-test was used to test the hypothesis of whether there were differences in productivity and income between conventional and organic oil palm farming under El Niño and normal conditions. The decision criteria were as follows:

a. If *t*-calculated ≤ *t*-table or significance value ≥ 0.05, then H_0 is accepted.
b. If *t*-calculated > *t*-table or significance value < 0.05, then H_1 is accepted.

The Wilcoxon Signed Rank Test was applied as a non-parametric test alternative to the paired sample *t*-test when the quantitative data were not normally distributed. This test was used to determine whether there were significant differences in productivity, revenue, and income of organic and conventional oil palm farmers during the 2023–2024 El Niño period compared to the 2022–2023 normal weather conditions.

The Mann–Whitney test was employed as a non-parametric alternative to the independent samples *t*-test. This test was conducted to analyze whether there were significant differences in productivity, revenue, and income between organic and conventional oil palm farmers during the 2023–2024 El Niño period. The decision criteria were as follows

a. If the Asymp. Sig. (2-tailed) value > 0.05, then H_0 is accepted.
b. If the Asymp. Sig. (2-tailed) value < 0.05, then H_1 is accepted.

3. RESULT AND DISCUSSION

3.1. Development of Oil Palm in Tulang Bawang Regency

The development of oil palm plantations in Tulang Bawang Regency has shown positive growth in recent years. This progress has been supported by various stakeholders, including large-scale companies with Domestic Investment schemes and Koperasi Unit Desa (KUD) that actively implement farmer partnership programs, thereby contributing to the development of the smallholder plantation sector.

In 2023, the productivity of oil palm in Tulang Bawang Regency was the highest in Lampung Province, reaching 25.4 quintals per hectare. Furthermore, Tulang Bawang Regency recorded the highest oil palm production in the province, contributing approximately 23 percent to the total oil palm production of Lampung Province. This production performance was significantly supported by Penawar Tama District, which achieved a production output of 23,756 tons, accounting for 40.3 percent of the total oil palm production in Tulang Bawang Regency (Badan Pusat Statistik, 2024).

3.2. Respondent Characteristics

The general characteristics of farmers in this study included age, education level, secondary occupation, farming experience, number of household dependents, land area, and crop conditions. Based on the findings, the majority of both organic and conventional oil palm farmers were still within the productive age range, with an average age of 48 years. Both groups were predominantly junior high school graduates, accounting for 44.64 percent of the respondents. This indicates that farmers have had access to formal education, although the level remains relatively low. Higher levels of education significantly influence farmers' cognitive processes in decision-making and action-taking (Fidiawati *et al*., 2025).

Most respondents identified farming as their primary occupation; however, several farmers had secondary jobs to supplement their income. The majority engaged in off-farm activities, such as trading. In line with Sholeh & Mublihatin (2021), secondary occupations are recommended to increase household income, even though their contribution may be relatively small. The study also found that most farming households had 3–4 family dependents (71.43%), which falls into the moderate category.

Farming experience plays a crucial role in determining farmers' success in managing oil palm cultivation. The results indicate that conventional farmers generally had longer farming experience compared to organic farmers. This condition may limit the acceptance of new agricultural innovations among more experienced farmers, as they tend to be reluctant to adopt new practices due to perceived risks. In contrast, organic farmers, who had relatively less farming experience, were more open to information transfer regarding innovations and new agricultural technologies, demonstrating greater curiosity and willingness to experiment. Farmers with limited farming experience are generally more receptive to innovation, whereas experienced farmers tend to be more resistant to new technologies but are better prepared to manage farming risks (Agatha & Wulandari, 2018).

Based on the respondent selection criteria and research findings, most organic and conventional oil palm farmers had an average land area of 1.1–1.5 hectares (46.43%). Although the land of organic farmers had not yet been officially certified as organic, they cultivated oil palm using 100 percent non-chemical inputs; therefore, they were

classified as organic farmers in this study. Both organic and conventional farmers had oil palm trees aged 8 years, categorized as mature plants (TM 5).

The findings show that organic farmers had fewer trees per hectare compared to conventional farmers. This is because organic farmers applied a planting distance of 9 × 9 meters, resulting in approximately 123–132 trees per hectare. Wider spacing facilitates maintenance and harvesting activities. Additionally, wider spacing allows optimal sunlight absorption by the plants. Consistent with Prasetio *et al*. (2023), planting density does not significantly affect productivity or total Fresh Fruit Bunch (FFB) yield; however, it influences the average bunch weight. The number of trees also affects the amount of fertilizer and other agricultural inputs used.

3.3. Conventional Oil Palm Cultivation

Conventional oil palm cultivation is the most commonly practiced farming technique among oil palm farmers. This cultivation method refers to the use of chemical-based agricultural inputs, such as synthetic fertilizers, pesticides, and herbicides, to support oil palm farming activities. Based on the research findings, conventional oil palm farmers in Penawar Tama District generally applied a planting distance of 8.5–9 meters using a quincunx (mata lima) planting pattern. This spacing resulted in a planting density of approximately 140–150 trees per hectare. The selected density was intended to maintain oil palm productivity while anticipating potential plant population losses due to *Ganoderma* disease during the 25-year planting cycle. According to Cooper *et al*. (2011), Ganoderma is one of the most common oil palm diseases in Sumatra, with plant mortality rates reaching 40–50%.

Since the plantations observed in this study were already in the productive stage, farming activities did not include nursery management but were limited to fertilization, pruning, weed control, pest and disease control, and harvesting. Fertilization is carried out to supply essential nutrients required for plant growth. Based on the guidelines from the Direktorat Jenderal Perkebunan (2014), the recommended fertilizers for mature oil palm (TM category) include Urea, ZA, SP-36, Rock Phosphate, TSP, MOP, empty fruit bunch ash, Kieserite, and dolomite.

Pruning refers to the removal of fronds according to the plant's growth stage to maintain an optimal number of leaves and a clean trunk, thereby facilitating harvesting activities. Weed control is conducted to prevent competition for nutrients, water, and sunlight. It is generally performed either mechanically (weeding) or through the application of herbicides. Pest and disease control is typically carried out using chemical pesticides.

3.4. Organic Oil Palm Cultivation

Organic oil palm cultivation is generally similar to conventional cultivation; however, it does not use any chemical-based agricultural inputs. Most farmers shifted to organic practices due to the increasing price of chemical fertilizers, which are no longer subsidized by the government. Farmers have become aware that the continuous use of chemical fertilizers and pesticides may damage the environment and the natural microorganisms present in their farmland. This condition is reflected in the widespread incidence of basal stem rot (Ganoderma) disease, which is difficult to control and has led to plant mortality and declining production levels. Microbe-Based Cultivation Technology (BBM) is a cultivation technique developed by PT. Ghalli Roelies Indonesia based on research findings. This method relies on the role of beneficial microbes in supplying plant nutrients. Therefore, the use of chemical substances is strictly prohibited, as they may eliminate microbes and other beneficial microorganisms essential for nutrient availability. The BBM technology consists of two main components: agricultural inputs and cultivation practices.

Regarding agricultural inputs, farmers are required to avoid all chemical-based inputs, including agricultural tools and machinery contaminated with chemical residues. This technology can be applied to land previously exposed to chemical inputs, as the land must first undergo a sterilization process using chemical residue neutralizers before BBM implementation. Consequently, the resulting production is classified as organic and may command a higher market price, provided that farmers fully comply with the company's Standard Operating Procedures (SOPs). In general, organic cultivation practices are not substantially different from conventional techniques. Farmers apply a planting distance of 9 × 9 × 9 meters using a square (mata empat) planting pattern. This spacing results in a lower planting density of approximately 123–125 trees per hectare.

The fertilization process in organic oil palm cultivation differs from that in conventional systems. The fertilizer used is microbe-based organic NPK, which fully substitutes chemical NPK fertilizers. Additionally, liquid fertilizers

are sprayed to serve as microbial inoculants and to neutralize residual chemical substances. Pruning is conducted selectively to prevent excessive sunlight from directly reaching the soil surface.

Weed management is carried out mechanically using a grass slasher or through the implementation of the Cattle–Oil Palm Integration System (SISKA). The application of SISKA in organic oil palm plantations under BBM technology is highly feasible and recommended, as it supports sustainable agricultural practices with an optimal stocking rate of two cattle per hectare (Wulandari, 2024). Pest and disease control is performed using biopesticides and herbicides that are free from chemical substances, thereby maintaining microbial activity in nutrient provision.

3.5. Oil Palm Productivity Analysis

Oil palm productivity can be calculated by dividing total production output by the cultivated land area. Greater land area and higher production levels contribute to increased productivity. Based on the research findings, the average production and productivity levels are presented in Table 1. Under normal conditions, the difference in yield between organic and conventional oil palm reached 13,673.88 kg/ha. During the El Niño period, the production and productivity of conventional oil palm decreased by 2,326.68 kg/ha. This decline occurred due to a significant number of fruit set failures caused by extreme drought, which adversely affected overall production. Darlan *et al*. (2016) reported that the 2015 El Niño phenomenon led to a productivity decline of up to 60 percent in the first semester of 2016 in Southern Sumatra.

Table 1. Average production and productivity of organic and conventional oil palm farms in Penawar Tama Districts

Description	Units	El Niño Condition		Normal Condition	
		Organic	Conventional	Organic	Conventional
FFB Selling Price	Rp	1.929,93	1.930,52	2.200,45	2.206,24
Production	Kg/Area	16.712,89	11.601,92	20.381,59	14.389,07
Production	Kg/ha	20.253,17	9.047,53	25.048,10	11.374,22
Annual productivity	Kg/Ha	20.253,17	9.047,53	25.048,10	11.374,22

In organic cultivation, production and productivity also declined by 4,794.93 kg/ha. This substantial decrease was not only due to fruit set failure caused by extreme weather conditions, but also because the microbes applied in the cultivation system require sufficient water availability and soil moisture. The occurrence of the El Niño phenomenon reduced water availability and soil moisture levels, thereby limiting microbial performance and reducing nutrient availability for plant growth. Consistent with these findings, Abubakar *et al*. (2021) reported that the El Niño phenomenon in Malaysia caused water stress and disrupted oil palm growth processes, including slower frond development, increased flower abortion rates, and reduced bunch weight.

In line with Sasmita *et al*. (2009), the average Fresh Fruit Bunch (FFB) production of five-year-old oil palm can reach 22.87 tons/ha/year under favorable environmental conditions and proper farm management practices. Based on the results of this study, the average production in organic cultivation remains within a reasonable range. However, the average production in conventional cultivation is considered relatively low. This is primarily because farmers did not apply fertilizers according to the standard dosage recommended by the Indonesian Oil Palm Research Institute (PPKS), mainly due to high fertilizer prices. According to Maulana *et al*. (2025), the estimated production of Fresh Fruit Bunches (FFB) is influenced by various factors, including environmental carrying capacity and the proper implementation of cultivation stages.

3.6. Farmer Income Analysis

Farm income analysis was conducted by calculating the difference between total costs incurred and total revenue obtained. Based on the results of the income analysis, it was found that the average farm production declined during the El Niño period, leading to a corresponding decrease in average revenue. The results of the farm income analysis are presented in Table 2. The El Niño phenomenon reduced the average revenue of organic oil palm farmers by 14,462,060.22 IDR/ha, while conventional oil palm farmers experienced an average revenue decline of 7,360,637.49 IDR/ha. The income of organic oil palm farmers decrease by 7,400,446.44 IDR/ha or 61.70% (from IDR11,993,532.15

to IDR4,593,085.71), while for conventional oil palm farmers the average income decreased by 5,048,508.01 IDR/ha or 127.09% (from IDR3,972,413.59 to minus 1,076,094.42). During the extreme drought phase, there was a reduction in expenditures such as labor costs; however, this reduction was not sufficient to offset the magnitude of the production decline. This condition is in line with the study by Sahara *et al*. (2024), which found that cocoa farmers' income in Bussu Village declined by 56.29% due to the El Niño phenomenon (from IDR 141,932,000.00 under normal weather conditions to IDR 62,044,000.00 during El Niño).

Table 2. Farm income analysis of organic and conventional oil palm in Penawar Tama District, 2022-2024 (per hectare)

Description	Unit	Organic (IDR)		Conventional (IDR)	
		El Niño Condition	Normal Condition	El Niño Condition	Normal Condition
Revenue					
Oil palm production	kg	20,253.17	25,048.10	9,047.53	11.374.22
Total Revenue	**IDR**	**38,890,750.57**	**53,352,810.78**	**17,482,088.17**	**24,842,725.66**
Total Cost					
I. Cash Costs					
Variable Cost					
Urea fertilizer	kg	-	-	781,838.33	781,838.33
KCL fertilizer	kg	-	-	222,793.65	222,793.65
NPK fertilizer	kg	-	-	1,189,554.46	1,189,554.46
Dolomite fertilizer	kg	-	-	18,497.14	18,497.14
TSP fertilizer	kg	-	-	222,450.67	222,450.67
Manure	kg	320,879.12	320,879.12	-	-
Ghaly organik fertilizer	kg	8,758,681.32	8,758,681.32	-	-
Bio Ghaly fertilizer	kg	283,589.74	283,589.74	-	-
Pesticides		-	-	505,718.86	446,799.87
Paid labor	MD	4,222,060.44	9,190,311.36	6,652,383.33	6,052,892.54
Fix Cost					
Tax	IDR	171,719.27	171,719.27	82,216.47	82,216.47
Total Cash Cost	**IDR**	**13,756,929.89**	**18,725,180.81**	**9,675,452.92**	**9,017,043.14**
II. Imputed Costs					
Variable Costs					
Family Labor	MA	7,772,723.22	10,958,091.58	2,868,064.07	4,248,806.67
Fixed Costs					
Equipment depreciation	IDR	399,741.18	399,741.18	277,298.31	277,298.31
Land rent	IDR	10,000,000.00	10,000,000.00	10,000,000.00	10,000,000.00
Total Imputed Costs	**IDR**	**18,172,464.40**	**21,357,832.76**	**13,145,362.38**	**14,526,104.97**
III. Total Costs	**IDR**	**31,929,394.29**	**40,083,013.56**	**22,820,815.30**	**23,543,148.11**
Income					
Income over Cash Costs	IDR	**24,757,089.91**	**72,197,464.36**	**9,755,818.59**	**15,993,360.30**
Income over Total Costs	IDR	**4,593,085.71**	**11,993,532.15**	**-1,076,094.42**	**3,972,413.59**
R/C over Cash Costs		**2.83**	**2.85**	**1.81**	**2.76**
R/C over Total Costs		**1.22**	**1.33**	**0.77**	**1.06**

Farming is considered profitable if the R/C ratio value is > 1, meaning that every 1 IDR of cost incurred generates revenue of more than 1 IDR. If the R/C ratio value is < 1, farming is considered unprofitable because every 1 IDR of cost incurred generates revenue of less than 1 IDR. If the R/C ratio value = 1, the farming operation is said to break even, as every 1 IDR of cost incurred generates revenue equal to 1 IDR.

Based on the R/C ratio analysis of cash costs, both organic and conventional oil palm farming are considered profitable because the R/C ratio is > 1. This is shown by the R/C ratio over cash costs in organic farming, which is 2.85 under normal weather and 2.83 under El Niño conditions. This means that every 1 IDR spent by farmers generates Rp 2.85 under normal weather and Rp 2.83 during El Niño. Conventional oil palm farming is also considered profitable because the R/C ratio over cash costs is 2.76 under normal conditions and 1.81 during El Niño. This means that every 1 IDR spent by farmers generates Rp 2.76 under normal conditions and Rp 1.81 during El Niño. Thus, the El Niño phenomenon causes a decline in the farming R/C ratio value.

The results of the R/C ratio analysis over total costs show that organic oil palm farming remains profitable, with values of 1.33 and 1.22. However, in conventional oil palm farming, the operation is considered profitable under normal conditions with a value of 1.06 and unprofitable during El Niño conditions because the R/C ratio is < 1, namely 0.77. An R/C ratio value smaller than 1 indicates that every 1 IDR of cost incurred does not generate returns greater than that cost. This can occur due to high land rental cost components and low production yields, causing revenue not to exceed total costs overall. However, revenue in the following year is projected to cover these losses due to the increased ability of the plants to produce fruit as they age.

3.7. Impact of the El Niño Phenomenon on Productivity, Costs, FFB Prices, Revenue and Income

The Wilcoxon Signed Rank difference test analysis was conducted to determine whether there were statistically significant differences in productivity and revenue of organic and conventional oil palm in Penawar Tama Subdistrict under normal conditions and El Niño conditions. The Wilcoxon Signed Rank test was used because the data were not normally distributed. Based on the analysis results (Table 3), there were significant differences in the productivity and revenue of conventional and organic farming under El Niño conditions compared to normal conditions. This is indicated by the Asymp. Sig. (2-tailed) values for the productivity and revenue difference tests, which were less than 0.05. Therefore, it is concluded that there were significant differences in farmers' productivity and revenue under El Niño conditions in 2023 compared with normal conditions in 2022.

Table 3. Results of the Wilcoxon Signed Rank test on productivity and revenue of conventional and organic oil palm farming under normal and El Niño conditions

Description	Mean Rank	Z	Asymp. Sig. (2-tailed)	Interpretation
Productivity	28.50	-6.509	0.000	Significant
Revenue	28.50	-6.509	0.000	Significant

Differences in productivity and revenue may occur due to a decline in production under El Niño conditions, where many fruitlets abort as a result of extreme drought. According to Christian *et al*. (2023), the ideal rainfall for oil palm growth is 1,300–2,500 mm per year, provided there is no water deficit exceeding 250 mm within the year. The analysis results are consistent with the study by Owusu *et al*. (2019), where the El Niño phenomenon adversely affects farmers' agricultural yields—particularly maize production—thereby influencing farmers' income and livelihoods.

A paired sample *t*-test analysis was conducted to determine whether there were statistically significant differences in total costs, fresh fruit bunch (FFB) prices, and farm income of organic and conventional oil palm in Penawar Tama Subdistrict under normal conditions and El Niño conditions. The results of the paired sample *t*-test (Table 4) showed a significant difference in the total costs of organic and conventional oil palm farming between normal and El Niño conditions. This is indicated by the Sig. (2-tailed) value being less than 0.05, namely 0.000. The significant difference can be seen from the reduction in cost components during El Niño conditions, such as labor costs, because the El Niño phenomenon limited farmers' ability to carry out crop maintenance activities such as pruning and weeding to maintain soil moisture and water availability. In addition, production declined during the El Niño phenomenon, so the harvesting labor required under El Niño conditions decreased, leading to lower labor costs.

The selling price of fresh fruit bunches (FFB) during the El Niño season showed a significant difference compared with FFB prices under normal conditions. This was due to the decline in global crude palm oil (CPO) prices throughout 2023, which led to lower FFB selling prices. At the national level, the provincially determined FFB price across Indonesia in 2023 decreased by 13.4% in the 22 oil palm–producing provinces compared with the average FFB

Table 4. Result of the paired sample *t*-test on total costs, FFB prices and farmers income over total costs of conventional and organic oil palm under normal and El Niño conditions

Description	Z	Sig. (2-tailed)	Interpretation
Total costs	7.595	0.000	Significant
Fresh fruit bunch (FFB) prices	111.944	0.000	Significant
Income over total costs	17.385	0.000	Significant

price in 2022 (Amri, 2024). Declining production and lower FFB selling prices under El Niño conditions inevitably caused farmers' revenue and income to decrease. This is indicated by the significant difference between the income of organic and conventional oil palm farmers under normal and El Niño conditions, as shown by the Sig. (2-tailed) value of less than 0.05).

A Mann–Whitney test analysis was conducted to determine whether there were significant differences in productivity, revenue, and income between organic and conventional oil palm farmers during the El Niño phenomenon. This nonparametric analysis was used because the data were not normally distributed. Based on the analysis results presented in Table 5, there were significant differences in productivity, total costs, revenue values, and income (based on total costs and revenue) between organic and conventional farmers under El Niño conditions. This is indicated by the Asymp. Sig. (2-tailed) values being less than 0.05. Differences in productivity may arise from differences in production quantities during El Niño. Organic oil palm productivity was higher than that of conventional oil palm farmers. The productivity differences subsequently led to differences in revenue and income of farmers.

Table 5. Result of the Mann-Whitney on productivity, total costs, FFB Prices, revenue, and income over total costs of conventional and organic oil palm under El Niño conditions

Description	Z	Asymp. Sig. (2-tailed)	Interpretation
Productivity	-6.420	0.000	Significant
Total Costs	-6.321	0.000	Significant
FFB Prices	-0.197	0.844	Not significant
Revenue	-6.420	0.000	Significant
Income over Total Costs	-5.337	0.000	Significant

In addition to productivity, the total cost component in organic oil palm farming differed significantly from that in conventional oil palm farming. This was due to differences in the use of inputs such as fertilizers, pesticides, equipment, and labor, which resulted in different total cost levels between the two cultivation systems. Overall, organic oil palm farming incurred higher total costs than conventional one, amounting to 9,108,578.99 IDR/ha.

The selling price of organic oil palm fresh fruit bunches (FFB) did not differ significantly from that of conventional oil palm FFB. This is indicated by the Asymp. Sig. (2-tailed) value being greater than 0.05. The FFB selling price in both systems did not differ because both organic and conventional farmers sold their oil palm directly to the same processing mill, resulting in similar prices. To date, there are no specific regulations governing organic oil palm commodities nor a dedicated market for organic oil palm; therefore, the value of organic oil palm generally remains similar to that of conventional oil palm.

4. CONCLUSION AND RECOMMENDATIONS

The impact of the El Niño phenomenon is also reflected in the decline in organic oil palm productivity by 19.14%, or 4,794.93 kg/ha, and in conventional cultivation by 20.46%, or 2,326.68 kg/ha, under El Niño conditions. This was caused by reduced production due to the large number of fruitlets aborting during extreme drought. The El Niño phenomenon led to a 61.70% decrease in the income of organic oil palm farmers, equivalent to Rp 7,400,446.44/ha, while the average income of conventional oil palm farmers declined by 127.09%, or Rp 5,048,508.01/ha. The R/C ratio in organic oil palm farming decreased by 0.11, whereas in conventional oil palm farming the R/C ratio declined by 0.29 under El Niño conditions. Farmers need to implement more impactful mitigation measures, such as constructing small water reservoirs or irrigation channels to maintain water availability, as a preventive measure against production losses caused by water stress.

The Wilcoxon Signed Rank test and paired sample *t*-test analyses show that the El Niño phenomenon has a significant impact on productivity, total costs, FFB prices, revenue, and income of both organic and conventional oil palm farmers, with Asymp. Sig. (2-tailed) values less than 0.05. The Mann–Whitney test results also indicate significant differences in productivity, total costs, revenue, and income, with Asymp. Sig. (2-tailed) and Sig. (2-tailed) values below 0.05. However, there was no significant difference in the selling price of organic and conventional oil palm fresh fruit bunches (FFB). This is due to the absence of regulations governing organic oil palm commodities and

the lack of a dedicated market for organic oil palm. The government is therefore considered to need to implement regulations or policies related to price incentives for organic oil palm to create added value. Organic oil palm remains relatively rare in Lampung Province, making it important to conduct further research, such as studies on market prospects and the risks of organic oil palm farming.

AUTHOR CONTRIBUTION STATEMENT

Author	C	M	So	Va	Fo	I	R	D	O	E	Vi	Su	P	Fu
SGPSA	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓		✓	✓
ZA	✓	✓		✓	✓			✓		✓	✓	✓		
YI	✓	✓		✓	✓			✓		✓	✓	✓		
KM	✓	✓		✓						✓		✓		
FEP	✓	✓		✓						✓		✓		

C: Conceptualization
M: Methodology
So: Software
Va: Validation
Fo: Formal Analysis
I: Investigation
D: Data Curation
R: Resources
O: Writing - Original Draft
E: Writing - Review & Editing
Vi: Visualization
Su: Supervision
Fu: Funding Acquisition
P: Project Administration

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