Factors that influence the production of cayenne pepper in the highlands of Temanggung Central Java Indonesia

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Abstract. Temanggung is a region in Central Java, consisting of highlands and mountains. One of the horticultural products cultivated in this region is cayenne pepper. Generally, altitude influences microclimate conditions, which in turn impact cayenne pepper growth and production. Therefore, this study aims to determine the costs and profits of cayenne pepper farming in the Temanggung highlands and the factors that influence the production of these commodities. Sampling was carried out by proportional random sampling of 44 cayenne pepper farmers in Tlogomulyo District. The costs and profits of cayenne pepper farming were calculated mathematically and a multiple linear regression model with the Cobb-Douglas function was used to analyze the factors that influence cayenne pepper production. The results showed that the majority of farmers were aged 31-63 years, junior high school/high school education, 1-5 years of farming experience but there were 2 farmers up to 20 years. The cultivated land area was 100-2000 m2 with an average of 1673 m2. Cayenne pepper farming in the Temanggung highlands requires a cost of Rp. 24,144,332 and provides a profit of Rp. 37,948,817 for a land area of 1,673 m². Factors that significantly influence cayenne pepper production in the highlands of Temanggung are the number of seedlings and labor. Based on these results, for the sustainability of cayenne pepper farming, it is necessary to pay attention to labor both within the family and outside the family.

1 Introduction

In Indonesia, cayenne pepper is an agricultural commodity with high economic value and increasing market demand [1]. Cayenne pepper belongs to the Solanaceae family. It is a short-lived plant with a plant height of up to 1.5 m [2]. Cayenne pepper can grow in subtropical and tropical regions. Cayenne pepper can be grown at various altitudes: lowlands at an altitude of 0–200 meters above sea level, midlands at an altitude of 201–700 meters above sea level, and highlands at an altitude of ≥ 700 meters above sea level. Differences in planting altitude can impact chili pepper growth and production due to differences in climatic conditions such as temperature, humidity, and light intensity [3].

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People commonly use Cayenne Pepper for its flavor and as a seasoning. Cayenne Pepper serves as an agricultural crop for specific populations due to its ease of production and considerable economic value. The duration required for planting is comparatively brief, and the accessibility of diverse technologies, along with the simplicity of their adoption by farmers, serves as a significant incentive for them [4].

The annual production of Cayenne Pepper in Indonesia has varied over time. The Central Statistics Agency (BPS) reported that Cayenne Pepper production in Indonesia was 1.39 million tonnes in 2021. Central Java is Indonesia's second-largest province, accounting for over 13% of the country's production. The subsequent graph illustrates Cayenne Pepper production in Central Java Province from 2019 to 2021.

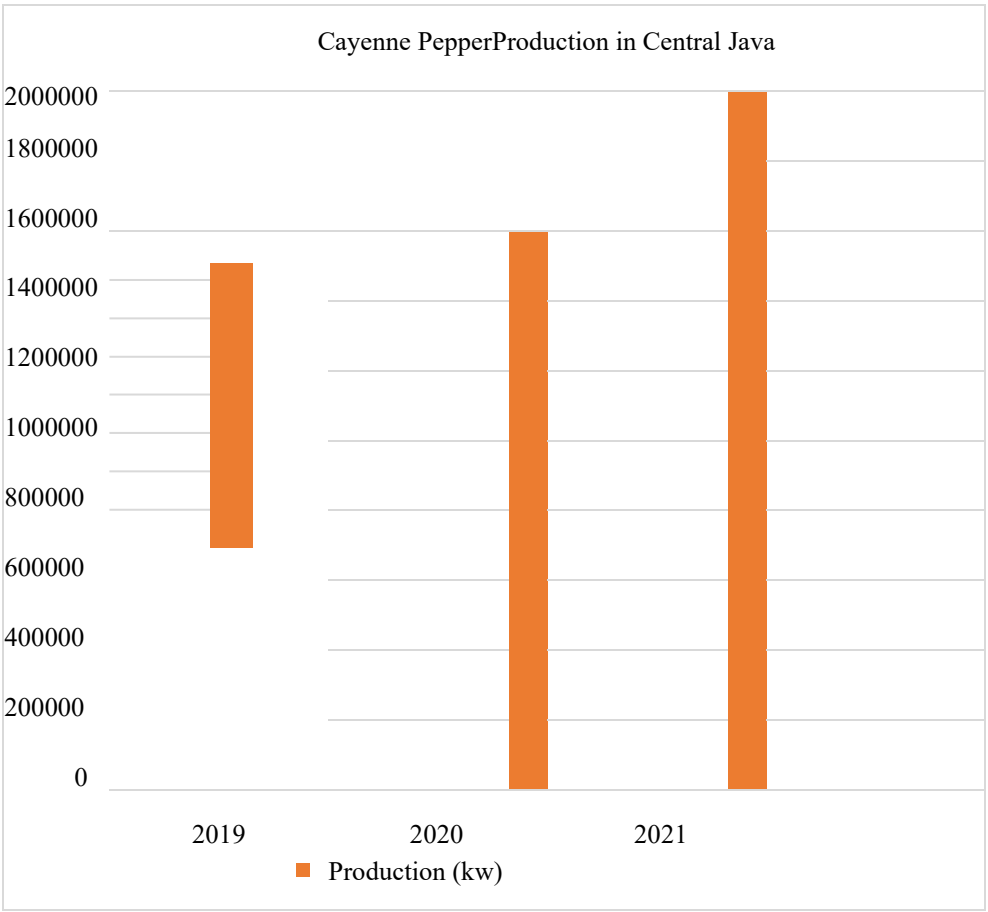

Fig. 1. Cayenne Pepper Production in Central Java Province 2019-2021
Source: Central Statistics Agency of Central Java Province 2019-2021

Figure 1 illustrates that Cayenne Pepper output in Central Java Province rose to 1,487,500 quintals in 2019, 1,590,989 quintals in 2020, and further grew to 1,849,948 quintals in 2021. In 2021, Temanggung Regency ranked among the top regions for Cayenne Pepper production, yielding 26,556 quintals. Temanggung Regency possesses considerable agricultural potential owing to its exceptionally appropriate land for farming.

Temanggung Regency is an agricultural area predominantly inhabited by farmers. It serves as the center for Cayenne Pepper farming, with a planted area of 60,956 hectares,

sufficiently satisfying the community's demand for this commodity. Table 1 displays the output of Cayenne Pepper in Temanggung Regency from 2020 to 2021.

Table 1. Cayenne Pepper Production by District (tonne) in Temanggung in 2020 and 2021

District	2020		2021	
	Area (Ha)	Production (tonne)	Area (Ha)	Production (tonne)
Parakan	93,00	1.153,50	272,00	2.626,30
Kledung	250,00	1.726,10	261,00	1.700,20
Bansari	73,00	1704,00	183,00	1.553,30
Bulu	261,00	1.465,60	229,00	1.202,64
Temanggung	254,00	2.749,50	141,50	1.216,40
Tlogomulyo	381,00	2.674,60	286,00	1.877,10
Tembarak	72,00	1475,50	114,00	799,90
Selopampang	34,00	329,00	76,00	470,30
Kranggan	57,00	619,00	83,00	791,20
Pringsurat	19,00	187,50	15,00	133,40
Kaloran	140,00	1.009,00	167,00	1.175,10
Kandangan	88,00	533,40	39,00	346,30
Kedu	116,00	1.284,50	137,00	754,20
Ngadirejo	434,00	3.336,00	562,00	3.615,70
Jumo	47,00	274,90	55,00	329,00
Gemawang	69,00	961,00	65,00	691,50
Candiroto	65,00	345,30	114,00	491,20
Bejen	-	-	-	-
Tretep	52,00	834,80	92,00	463,20
Wonoboyo	117,00	728,40	83,00	564,00

Source: Central Statistics Agency of Temanggung Regency

Table 1 exhibits the level of Cayenne Pepperproduction in Temanggung Regency, which comprises 20 districts, including Tlogomulyo. In 2020, Tlogomulyo District emerged as one of the leading regions for Cayenne Pepper production in Temanggung. Several previous studies in the Temanggung highlands focused on tobacco commodities, because the region is the production center for this commodity, so it is necessary to analyze the production of cayenne pepper, which is one of the horticultural commodities in the region.

In 2021, the amount of land dedicated to Cayenne Pepper farming diminished, leading to a reduction in output. The fall in Cayenne Pepper production could result from several circumstances, adversely affecting the economic income of the farmers. Accordingly, it is essential to comprehend the factors affecting Cayenne Pepper production in Temanggung, to ascertain the underlying reasons for the issues encountered. The results of this study can be used as information for farmers regarding inputs that can determine the amount of cayenne pepper production in the highlands.

2 Research Method

This research employed a quantitative approach. This method enabled researchers to gain an accurate understanding of the issue examined. This study was conducted in Tlogomulyo Village, Tlogomulyo District, as this region possesses the largest chili production area and the highest chili output levels within the district**.**

2.1 Sampling

The observational results disclosed that the total population of farmers growing Cayenne Pepper within each category was 147 people. Rangkuti [5] stated that when the population is approximately 100 people, a sample of 30% should be selected. Consequently, the sample size for this study comprised 30% of the entire population of Cayenne Pepper farmers, amounting to 147 individuals, resulting in a total of 44 farmers selected. Sampling within each farmer group was conducted through the proportional random sampling method, employing the proportionate allocation formula as outlined as follows:

$$ni = \frac{Ni}{N} \times n \quad \text{……(1)}$$

Description:
ni : Number of samples by strata
n : Total number of samples
Ni : Population size
N : Total population

The sample calculation using the proportional random sampling formula is as follows:

Tani Utomo : $\frac{23}{147} \times 44 = 7$

Harapan Satu : $\frac{26}{147} \times 44 = 8$

Harapan Dua : $\frac{50}{147} \times 44 = 15$

Berkah 9 : $\frac{48}{147} \times 44 = 14$

The sample was derived from the proportional allocation formula for the research population, comprising 7 participants from the Tani Utomo Farmer Group, 8 respondents from the Harapan Satu Farmer Group, 15 respondents from the Harapan Dua Farmer Group, and 14 respondents from the Berkah 9 Farmer Group.

2.2 Cost Analysis, Revenue Analysis, and Profit Analysis

Cost analysis was adopted to determine how much farmers incurred during the production, with the following formula :

$$TC = TIC + TEC \quad \text{……(2)}$$

Description:
TC : Total costs (IDR)
TIC : Total implicit costs (IDR)
TEC : Total explicit costs (IDR)

Revenue analysis was employed to identify the amount of revenue for Cayenne Pepperfarmers, using the following formula:

$$TR = P \times Q \quad \text{……(3)}$$

Description:
TR : Total revenue (IDR)
P : Price (IDR)
Q : Total production (IDR)

The income analysis defined the amount of farmer income from Cayenne Pepper farming, which can be formulated as follows :

$$I = TR - TEC \quad \ldots\ldots(4)$$

Description:
I : Income (IDR)
TR : Total revenue (IDR)
TEC : Total explicit costs (IDR)

Profit analysis was utilized to determine the amount of profit farmers made from farming bird's eye chili, formulated as follows :

$$\pi = I - TIC \quad \ldots\ldots(5)$$

Description:
π : Profit (IDR)
I : Income (IDR)
TIC : Total implicit costs (IDR)

2.3 Analysis of Factors Affecting Chili Production

This study employed multiple linear regression analysis utilizing the Cobb-Douglas function [6] to assess the impact of various factors on Cayenne Pepper production in Tlogomulyo Village, focusing on the relationship between the dependent variable, Cayenne Pepper production, and the independent variables.

$$LnY(= Lna + b_1 LnX_1 + b_2 LnX_2 + b_3 LnX_3 + b_4 LnX_4 + b_5 LnX_5 + b_6 LnX_6 + b_7 LnX_7 + e$$

Description:
Y : Cayenne Pepper production (kg)
X_1 : Land area (m^2)
X_2 : Seed (stem)
X_3 : Organic fertilizer (kg)
X_4 : Chemical fertilizer (kg)
X_5 : Solid pesticides (kg)
X_6 : Liquid pesticide (L)
X_7 : Labor (HKO)
a : Constant
b : Regression coefficient
e : Error term

The analysis of the coefficient of determination (R^2) was performed to determine the extent to which the independent variables (X) collectively contribute to the dependent variable (Y) [7] :

$$R^2 = \frac{ESS}{TSS} \quad \ldots\ldots(6)$$

Description:
ESS : Explained sum of squares (Regression sum of squares)
TSS : Total sum of squares
Determination test criteria:
If the coefficient of determination (R^2) is close to 1, the independent variable (X) can explain the effect on the dependent variable (Y).

If the coefficient of determination (R^2) is close to 0, the independent variable (X) cannot explain the dependent variable (Y).

The **F test** assessed the impact of independent variables (X), specifically land area, seeds, fertilizer, pesticides, and labor, on the dependent variable (Y). The F test was delineated by the subsequent formula [7]:

$$F_{count} = \frac{\frac{R^2}{(k-1)}}{\frac{(1-R^2)}{(n-k)}} \quad \text{.....(7)}$$

Description:
R^2 : Coefficient of determination
k : Number of independent variables
n : Number of observations or samples
with the hypothesis:
H0: $b_1 = b_2 \ldots b_7 = 0$, the independent variables together do not have a significant effect on the dependent variable.
H1: $b_1 \neq b_2 \ldots b_7 \neq 0$, the independent variables together have a significant effect on the dependent variable.

With a significance level of α,
If the significance value is greater than α, H0 is rejected and H1 is accepted, meaning that the independent variables (X) collectively have a significant effect on the dependent variable (Y).
If the significance value is less than α, H0 is accepted and H1 is rejected, indicating that the dependent variables (X) collectively have no effect or are non-significant on the dependent variable (Y).

As stated by Ghozali [8], the t-test, also known as a partial test, can help determine if the independent variable has a significant partial effect on the dependent variable. The t-test can be executed utilizing the following formula:

$$t_{count} = \frac{bi}{Se\ (bi)} \quad \text{.....(8)}$$

Description:
bi : Regression coefficient
Se : Standard error of the regression coefficient
With hypothesis:
H_0 : (b1, b2, …b7) = 0, the independent variable does not have a partial significant effect on the dependent variable.
H_1 : (b1, b2, …b7) ≠ 0, the independent variable has a partial and significant effect on the dependent variable.

With a significance level of α,
If the significance value is greater than α, H0 is rejected and H1 is accepted, signifying that the independent variable (X) has a partial significant effect on the dependent variable (Y).
If the significance value is less than α, H0 is accepted and H1 is rejected, denoting that the independent variable (X) has no partial effect on the dependent variable (Y).

3 Results And Discussion

3.1 Farmer Profile

The age of farmers is a critical factor in farming, as it affects performance, physical strength, and endurance —all of which are essential for the success of Cayenne Pepper farming in Tlogomulyo Village. The average age of participating farmers was 46 years. The predominant age group of farmers was 53–63 years, comprising 14 individuals, accounting for 31.8%. Consequently, Cayenne Pepper farmers in Tlogomulyo Village fell within the productive age bracket of 15 to 65 years. Andayani [9] asserted that farmers of productive age exhibit superior performance and effectiveness compared to their non-productive counterparts.

A farmer's level of education significantly influences his attitudes toward information and technology. An elevated level of education correlates with an increased acquisition of information and knowledge. This educational attainment can also impact farmers' farming decisions. In Tlogomulyo Village, 17 Cayenne Pepper farmers attained primary education, representing 38.6%, with many pursuing further education. A total of 25 farmers have completed junior high school (56.8%) and high school (56.8%). Meanwhile, two farmers obtained a college education (4.6%).

Farmers planting Cayenne Pepper necessitate adequate experience to attain their objectives. Most farmers have been conducting bird's-eye chili farming for five years. The majority of farmers (24, constituting 54.5%) possessed one to five years of experience in farming bird's eye chili. Meanwhile, 13 farmers (29.6%) hold six to ten years of experience in farming bird's eye chili. Five farmers (11.3%) had 11–15 years of expertise in farming bird's eye chili, while two farmers (4.6%) exhibited 16–20 years of experience in the same endeavor. Veteran farmers possessed greater familiarity with land conditions, pests, and illnesses that commonly affected Cayenne Pepper plants.

Land is an essential element in bird's-eye chili farming. The average land area possessed by Cayenne Pepper farmers in Tlogomulyo Village was 1,673 m². A significant number of farmers possessed land ranging from 1,100 to 2,000 m², specifically 21 farmers, constituting 47.7%. Among farmers with land ranging from 100 to 1,000 m², there were 13 individuals, covering 29.5% of the total. In the subsequent land area category of 2100–3000 m², there were nine farmers, representing 20.5% of the total. One farmer had a land area of 3,100–4,000 m², representing 2.3% of the total land area.

3.2 Cost Analysis, Revenue Analysis, and Profit Analysis

3.2.1 Farming Costs

Farming costs encompass all expenses spent by farmers during the Cayenne Pepper production. Cayenne Pepper production in Tlogomulyo Village required eight months for a single planting season between 2022 and 2023. The details of Cayenne Pepperfarming costs in Tlogomulyo Village are as follows:

Table 2. Costs of Cayenne PepperFarming in Tlogomulyo Village During the 2022-2023 Planting Season

Description	Costs (IDR)
Explicit Costs	
Production Infrastructure Costs	11,672,728
Equipment Depreciation Costs	807,762
Outside Family Labor Costs	7,037,046
Other Costs	33,737
Total Explicit Cost	**19,551,273**
Implicit Costs	
Land Rental Costs	1,673,000
Employee Interest Costs	552,019
Equity Investment Costs	2,368,040
Total Implicit Cost	**4,593,059**
Total Cost	**24,144,332**

3.2.2 Revenue

Revenue was derived from the sale of products generated through the production of bird's eye chili. To determine the revenue, the selling price per unit of the product must be calculated and then multiplied by the total production for the season.

Table 3. Revenue of Cayenne Pepper Farmers in Tlogomulyo Village During the 2022-2023 Planting Season

Harvest Time	Harvest (Kg)	Price (IDR)	Revenue (IDR)
1st Harvest	5.27	27,188.63	143,284.09
2nd Harvest	9.27	31,693.14	293,795.45
3rd Harvest	14.74	37,893.95	558,556.82
4th Harvest	20.01	40,067.47	801,750.00
5th Harvest	26.11	45,609.05	1,190,852.27
6th Harvest	31.10	46,426.12	1,144,852.27
7th Harvest	36.83	41,470.95	1,527,375.00
8th Harvest	46.56	37,237.87	1,733,795.45
9th Harvest	51.22	39,537.87	2,025,102.27
10th Harvest	56.20	40,668.88	2,285,590.91
11th Harvest	64.23	43,416.59	2,788,647.00
12th Harvest	72.10	44,921.20	3,238,818.18
13th Harvest	78.86	45,917.39	3,621,045.45
14th Harvest	82.20	48,689.17	4,002,250.00
15th Harvest	84.78	49,219.10	4,172,795.45
16th Harvest	83.28	51,683.12	4,304,170.45
17th Harvest	79.57	50,718.35	4,035,659.09
18th Harvest	73.36	52,079.56	3,820,556.82
19th Harvest	67.16	51,494.90	3,458,397.37
20th Harvest	64.07	55,253.13	3,540,068.18
21st Harvest	58.80	53,976.31	3,173,806.82
22nd Harvest	56.22	51,033.28	2,869,090.91
23rd Harvest	49.89	45,972.05	2,293,545.45
24th Harvest	43.09	37,354.43	1,609,602.27

25th Harvest	36.89	34,027.58	1,255,227.27
26th Harvest	29.77	21,273.11	633,875.00
27th Harvest	23.02	18,649.68	429,488.86
28th Harvest	17.95	18,063.45	324,238.93
29th Harvest	12.65	16,134.57	204,102.27
30th Harvest	8.66	15,550.86	134,670.45
31st Harvest	4.78	19,196.94	86,493.91
32nd Harvest	2.84	13,628.36	38,704.55
33rd Harvest	1.58	16,477.27	26,034.09
34th Harvest	0.68	19,652.41	13,363.64
35th Harvest	0.25	18,584.72	4,568.18
Total	**1.479,41**		**62,093,149**

3.2.3 Income and Profit

Income was the value derived from revenue subtracted by the explicit costs associated with Cayenne Pepper farming. It enabled the researchers to ascertain the income generated from Cayenne Pepper farming in Tlogomulyo Village. Meanwhile, profit denotes the value derived from revenue, subtracting implicit costs. This analysis examined the average income and profit from Cayenne Pepper farming in Tlogomulyo Village.

Table 4. Income and Profit of Cayenne PepperFarmers in Tlogomulyo Village During the 2022-2023 Planting Season

Description	
Revenue (IDR)	62,093,149
Explicit Costs (IDR)	19,551,273
Income (IDR)	**42,541,876**
Implicit Costs (IDR)	4,593,059
Profit (IDR)	**37,948,817**

3.3 Analysis of Production Factors

Factors affecting the Cayenne Pepper farming in Tlogomulyo Village were land area (X1), seeds (X2), organic fertilizer (X3), chemical fertilizer (X4), solid pesticides (X5), liquid pesticides (X6), and labor (X7). The contributing factors were examined using Cobb-Douglas analysis, which utilized data collected via questionnaires during interviews, subsequently organized in Microsoft Excel, and analyzed using SPSS software. The analyzed results established a multiple linear regression to identify the factors affecting the production of Cayenne Pepperin Tlogomulyo Village.

Table 5. Regression Results of Factors Affecting Cayenne PepperProduction in Tlogomulyo Village During the 2022-2023 Planting Season

Variable	Coefficient	t-count	sig
Constants	1.594	2.819	0.008
Land Area	0.166	1.037	0.307
Seedlings	**0.426*** **	**3.183**	**0.003**
Organic Fertilizer	0.013	0.199	0.843
Chemical Fertilizer	0.039	0.413	0.682
Solid Pesticides	-0.122	-1.200	0.238
Liquid Pesticides	-0.048	-0.626	0.535

Labor	**0.279****	**2.100**	**0.043**
R²	**0.840**		
f-count	**33.158**		**0.000**

Description: **: has a significant effect on α 5%
***: has a significant effect on α 1%

3.3.1 Analysis of the Determination Coefficient Test (R²)

The extent of the impact of independent factors, including land area, seeds, organic and chemical fertilizers, labor, and solid and liquid pesticides, on the dependent variable (Cayenne Pepper production) was assessed by the analysis of the coefficient of determination, computed using SPSS software, generating a value of 0.840. It signifies that 84% of the Cayenne Pepper output could be attributed to independent factors, including land area, seeds, organic and chemical fertilizers, solid and liquid insecticides, and labor. The residual 16% could be assigned to variables excluded from the model, including local climate, farming experience, and the educational background of farmers.

3.3.2 F test

The F-test analysis assessed the simultaneous impact of independent variables, encompassing land area, seeds, organic fertilizer, chemical fertilizer, solid pesticides, liquid pesticides, and labor, on the dependent variable, Cayenne Pepper production. This test was evaluated by comparing the estimated F-value with the F-table or by assessing their respective probabilities. The computed F-value, as displayed in Table 5, was 33.158. It is evident from the comparison of the probabilities, which was 0.000, and was less than α 5%. Land area, seeds, organic fertilizer, chemical fertilizer, solid pesticide, liquid pesticide, and labor collectively exerted a substantial influence on Cayenne Pepper production at a 95% confidence level.

3.3.3 T test

The significance value for **land area** was 0.307, exceeding alpha. Consequently, H0 is accepted, whereas H1 is rejected, signifying that the land area variable exerted no influence on Cayenne Pepper production. The extent of land utilized for farming Cayenne Pepper did not consistently influence the yield; both minimal and maximal production were contingent upon the farmer's land management practices.

The significance value for **seeds** was 0.003, below the alpha level of 1%. Consequently, H0 is rejected and H1 is accepted, signaling that the seed variable exerted a significant impact on Cayenne Pepper production at a 99% confidence level. The correlation for the seed variable was 0.426, demonstrating that a 1% rise in seeds can enhance Cayenne Pepperproduction by 0.426%.

The significance value of **organic fertilizer** was 0.843, which surpassed the alpha value. Therefore, H0 is accepted, whereas H1 is rejected. It indicates that the organic fertilizer variable exhibited no partial influence on Cayenne Pepperproduction. The application of this organic fertilizer did not adhere to the suggested instructions [10]. The organic fertilizer employed was inadequate in maturity, as it had not undergone complete decomposition, evidenced by its dark black color, lack of stickiness, and loose texture [11].

The significance value of the **chemical fertilizer** was 0.682, exceeding the alpha value. Consequently, H0 is accepted, whereas H1 is rejected. The chemical fertilizer variable had no substantial influence on Cayenne Pepper production. Excessive use of chemical fertilizers

would result in residues firmly adhering to soil particles. The deficiency of organic matter in the soil might result in the rapid leaching of fertilizer by water due to flooding or excessive moisture. The dry season could end in drought, leading to insufficient fertilizer availability for plant roots [12].

The significance value for **solid pesticides** was 0.238, exceeding the alpha value. Consequently, H0 is accepted, while H1 is rejected. The solid pesticide variable imposed no substantial influence on Cayenne Pepper production. Excessive pesticide application or the use of substandard sprayers could lead to significant issues, including compromised plant health, waste generation, plant resistance, and environmental contamination, ultimately hindering the growth of Cayenne Pepper plants [13].

The significance value for **liquid pesticides** was 0.535, beyond the alpha value. Hence, H0 is accepted, while H1 is rejected, suggesting that liquid pesticides displayed no partial influence on the Cayenne Pepperyield.

One thing that is indispensable in cayenne pepper cultivation is labor. Each type of cayenne pepper farming activity requires a different amount of labor; it all depends on the time required. Harvesting takes longer than nursery work [14]. The significance value for **labor** was 0.043, below the 5% alpha level. In that case, Ho is rejected, and H1 is accepted, signifying that labor had a substantial impact on Cayenne Pepperproduction at the 95% confidence level. The regression coefficient for the labor variable was 0.279, implying that a 1% rise in labor resulted in a 0.279% upsurge in Cayenne Pepper production.

4 Conclusions and Suggestions

A single-season Cayenne pepper farm in Temanggung regency, covering 1,673 m², incurred a total cost of IDR 24,144,332 and generated revenue of IDR 62,093,149. Farmers attained an income of IDR 42,541,876 and a profit of IDR 37,948,817. The primary factors affecting Cayenne pepper output in Temanggung were the quantity of seedlings and the availability of labor. Cayenne pepper farming in Temanggung possesses significant economic potential, enabling farmers to enhance chili yields by meticulously assessing and optimizing the utilization of production resources in accordance with Standard Operating Procedures (SOP), including the application of organic fertilizers, chemical fertilizers, solid pesticides, and liquid pesticides to augment Cayenne pepper output.

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