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TECHNICAL EFFICIENCY ANALYSIS OF CAYENNE PEPPER (CAPSICUM FRUTESCENS L.) FARMING IN PERMATA INTAN DISTRICT OF MURUNG RAYA REGENCY, INDONESIA

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ABSTRACT
Cayenne pepper commodity farming has good and promising prospects because it can increase farmers' income. The production of a commodity is influenced by whether or not it is efficient in the allocation of input use and whether there is technical inefficiency problems related to the managerial capabilities of farmers. This study aims to analyze the effect of the use of production factors on maximum production, the level of technical efficiency, and the factors that cause technical inefficiency in cayenne pepper (*Capsicum frutescens L.*) farming in Permata Intan District, Murung Raya Regency. The results of the analysis showed that the production factor of land area, NPK fertilizer, and the use of plastic mulch had a significant effect on the level of = 0.01 while labor had a significant effect on the level of = 0.05 while the production factor of the number of seeds and pesticides had no significant effect on business production. Cayenne pepper farming is technically inefficient as seen from the average technical efficiency value achieved by respondent farmers of 0.398. The age factor did not significantly affect technical inefficiency, on the other hand, the formal education factor and the activeness of farmers in participating in the counseling had a significant effect on the technical inefficiency of cayenne pepper farming in Permata Intan District, Murung Raya Regency.

KEY WORDS
Production factors, efficiency, technical, cayenne pepper.

Cayenne pepper is one type of vegetable that has an important meaning in the household and state economy. This commodity farming business has bright and promising prospects because it can support efforts to increase farmers' income, alleviate poverty, expand job opportunities, although the price of chili in the market often rises and falls quite sharply, but the interest of farmers to plant chili never subsides.

Cayenne pepper production in 2020 in Central Kalimantan Province has increased by 2,596 kw. This increase was due to an increase in productivity of 5.10 kw/ha (BPS Central Kalimantan Province, 2021).

Murung Raya Regency is one of the regencies in Central Kalimantan Province where the harvested area of cayenne pepper compared to 2019, there was a decrease of 40 ha in 2020, so the production of cayenne pepper decreased by 1,687 kW in 2020. Permata Intan District is one of the sub-districts that have a high productivity level, the highest cayenne pepper after Laung Tuhup District in Murung Raya Regency. Based on the development of cayenne pepper harvested area, Permata Intan District occupies the 6th position in 2019 with a production of 449 kw. However, in 2020 the harvested area of cayenne pepper in Permata Intan District occupies the 3rd position with a production of 280 kw from a harvested area of 7 ha (BPS Murung Raya Regency, 2021).

Efforts to increase production cannot rely on efforts to increase land area but need to be focused on efforts to increase productivity. Productivity can be increased through increased farming efficiency and technological innovation.

The production of a commodity is influenced by whether or not it is efficient in the allocation of input use and whether there is technical inefficiency problems related to the managerial capabilities of farmers. The managerial capacity of farmers is important in farming activities because it will affect farmers' decision making in allocating production inputs.

This study aims to analyze: (1) the effect of the use of production factors on maximum production; (2) the level of technical efficiency of farming; and (3) the factors that cause technical inefficiency in cayenne pepper (*Capsicum frutescens L.*) farming in Permata Intan District, Murung Raya Regency.

The benefits of this study: (1) as a consideration for farmers in using production factors in cultivating cayenne pepper (*Capsicum frutescens L.*) in Permata Intan District, Murung Raya Regency; (2) as material for information and consideration for the local government of Murung Raya Regency in taking policies on the development of cayenne pepper production; and (3) as a forum for the development and application of knowledge obtained by students as a suggestion for the dedication of the academic community.

METHODS OF RESEARCH

This research was conducted in Permata Intan District, Murung Raya Regency. The research was carried out from January to April 2022. In this study the data used were primary data obtained by direct observation to the research location and conducting direct interviews with respondents. In addition, secondary data is needed to support primary data obtained from literature studies, related institutions or agencies. This research was conducted using *purposive sampling method*, to the District of Permata Intan. Taking into account the highest productivity of cayenne pepper after Laung Tuhup District in 2020. The total population is the number of farmers who are still active in cayenne pepper farming in the sub-district. The sample of farmers obtained as many as 80 farmers.

To analyze the first objective, namely to analyze the use of production factors for the maximum production of cayenne pepper, using a production function of *Cobb-Douglas*, with a *stochastic frontier* with the *maximum likelihood estimated* (MLE) method (Coelli *at al*., 1998):

$$Ln\ Y = {}_0 + \beta_1 \ln X_1 + \beta_2 \ln X_2 + \beta_3 \ln X_3 + \beta_4 \ln X_4 + {}_5 \ln X_5 + \beta_6 \ln X_6 + v_i - u_i \quad (1)$$

Where:

Y: total production of cayenne pepper (kg);
X_1: land area (ha);
X_2: number of seeds (kg);
X_3: total NPK fertilizer (kg);
X_4: number of pesticides (liters);
X_5: number of workers (HOK);
X_6: number of *dummy* use of plastic mulch (d_1= 1 farmer who use plastic mulch, d_1= 0 for farmers who do not use plastic mulch);
β0: coefficient constant;
$\beta_1, \beta_2, \beta_3, \beta_4, \beta_5, \beta_6$: production factor regression coefficient;
v_i-u_i: *error term* (v_i is *noise effect*, u_i is inefficiency effect technical model).

The second objective is the level of technical efficiency of cayenne pepper (*Capsicum frutescens* L.) can be measured using the formula:

$$TE_i = \frac{Y_i}{Y_i^*} \quad (2)$$

Where:

TE_i: technical efficiency achieved by the i-th observation;
Y_i: actual output of cayenne pepper (kg);
Y_i^*: output limit (potential) chili cayenne.

The third objective is the factors that cause technical inefficiency in cayenne pepper (*Capsicum frutescens L.*) farming mathematically:

$$u_i = \delta_0 + \delta_1 Z_1 + \delta_2 Z_2 + \delta_3 Z_3 + \delta_4 Z_4 \quad (3)$$

Where:

ui: effect of technical inefficiency;

δ0: constant;

*δ1, δ2, δ3, δ4:*coefficient estimator inefficiency;

Z_1: farmer's age (years);

Z_2: Farmer's education (years);

Z_3: dummy of active participation in extension activities (d_2= 1 actively participates in extension activities, d_2= 0 does not actively participate in extension activities).

$$LR = -2\left[Ln\left\{\frac{L(H_0)}{L(H_1)}\right\}\right] = -2\{Ln[L(H_0)] - Ln[L(H_1)]\} \quad (4)$$

Test criteria with 95% confidence level or = 0.05:

- LR one-sided error > X^2restriction i (Palm Code table) then reject H0;
- LR one-sided error < X^2restriction (Palm Code table) then accept $H_{0,}$ where LR test is used to detect whether there are cases of inefficiency in the field.

$$\text{tcount} = \frac{b_i}{Se(b_i)} \quad (5)$$

Where:

b_i: regression coefficient of the i-th independent variable;

$Se(b_1)$: standard error of the estimated i-th regression.

Hypothesis:

- $H_{0:}$ $b_i = 0$;
- $H_{1:}$ b_i 0.

If t-count $_{\leq}$ t_{table} (nk-1: /2) then it is decided to accept the null hypothesis (H_0) which means that the independent variable (X_i) has no significant effect on the dependent variable (Y).other hand, if $t_{count} > t_{table}$ (n k-1: /2), it is decided to reject the null hypothesis or accept H_1 which means that the independent variable (X_i) has a significant effect on the dependent variable (Y). The T-test is a significance test that is carried out individually or more often referred to as a partial data analysis process.

RESULTS AND DISCUSSION

The MLE method is used to describe the relationship between the production maximum that can be achieved with the use of existing production factors. The initial production factors that are thought to influence the production of cayenne pepper are land area, use of seeds, NPK fertilizers, pesticides, labor, and plastic mulch. The results of estimating the *Cobb-Douglas* using the MLE (*Maximum Likelihood Estimation*) method can be seen in Table 1.

Table 1 – Estimating production function *Cobb-Douglas* using the MLE method

Input variable	Coefficient	t-count
Intercept	4,842	7,225
Land area (X_1)	0,979	6,185***
Seeds (X_2)	-0,163	-0,955
NPK fertilizer (X_3)	1,363	8,458***
Pesticides (X_4)	-0,194	-0,230
Family labor (X_5)	0,278	1,386*
Plastic mulch (X_6)	0,770	4,907***
Sigma-squared	0,225	
Gamma (γ)	0,999	74,50***
Log-likelihood OLS	-0,588	
Log-likelihood MLE	-0,504	
LR test of the one-sided error	16,846**	

*Note: *** significant at level = 1%, ** significant at level = 5%, * Significant at level = 10%.*

From the results, the value of the LR ratio is 16.846 greater than the value of the palm code table with a restriction of 5 and at the level = 5% of 8.671. Because the value of LR > the critical value of X^2, then H_0 is rejected and H_1 is accepted. It can be concluded that in the field of cayenne pepper farming in Permata Intan District there are cases of technical inefficiency.

The *sigma-square* 0.225 is small enough so that the *error term* for inefficiency in cayenne pepper farming is normally distributed. While the gamma value (γ) of 0.999 is close to 1, indicating that the *error term* mostly comes from the effects of technical inefficiency, not from *noise* such as climate, weather, and pests. The gamma value can be interpreted that 99% of the observed variation in farmer production is caused by technical inefficiency and the remaining 1% is caused by external factors not observed in this study.

The *log likelihood* using the MLE method (-0.504) > the *log likelihood* using the OLS method (-0.588), means that the data on the production function using the MLE method is good and in accordance with the conditions in the field.

Land (X_1). Land use has a positive and significant effect at the 99% confidence level on the maximum production of cayenne pepper. The t_{-hit} value for the land area is 6.185 > the t-count value is 2.380 with a positive coefficient value of 0.979. Meaning, if there is an increase in land use by 1% it will increase the maximum production of cayenne pepper by 0.97%. Considering the land area of chili farming respondents in Permata Intan District is not so wide ranging from 0.1 Ha to 0.38 Ha. Thus, it is possible for respondent farmers to increase the area of cayenne pepper cultivation.

Seeds (X_2). The seeds have a t-count -0.995 < t_{table} , where the coefficient value is negative - 0.163, meaning that if there is an increase in the use of seeds by 1% it can reduce the production of cayenne pepper by -0.173%. This means that if more seeds are planted on the land than the normal distance, it will automatically narrow this will cause competition for nutrients in plants, it will also increase pest and disease attacks caused by high humidity around the plant. In chili cultivation, seeds have a very important role, seed quality is one of the factors that will affect chili production.

NPK fertilizer (X_3). NPK fertilizer has no significant effect at the 99% level where the results of t-count 8,458 > t_{table} 2,380, with a coefficient value of 1,363. This means that if there is an increase in the use of fertilizer by 1%, it will increase production by 1,363. This is presumably the use of NPK fertilizer used by respondent farmers as recommended.

Pesticides (X_4). Pesticide input t-count -0.230 < t_{table} 90% confidence level is 1.294 so it has no significant effect on cayenne pepper production, and the negative coefficient value is -0.194. This shows that the addition of 10% pesticide will reduce the production of cayenne pepper by 0.194%. It is suspected that the use of pesticides, be it insecticides, bactericides, and fungicides are still not as recommended.

Labor (X_5). The t-count of the workforce is 1.386 > the t_{table} with a 90% confidence level, which is 1.294. That is, the workforce has a real influence on the production of cayenne pepper. The value of the labor coefficient has a positive value of 0.278 which means that if there is an increase in the use of labor by 10%, it can increase the production of cayenne pepper by 0.278%. The use of labor in farming is a very important factor, considering that the production process on the land is carried out by workers.

Dummy Use of Mulch (X_6). The use of mulch with a t-count 4.907 > t_{table} with a 99% confidence level of 2.380 means that the use of mulch in cayenne pepper farming has a significant effect on the production of cayenne pepper. Wherewith a positive coefficient of 0,770 means that the addition of 1% use of mulch in the production of cayenne pepper can increase the maximum production by 0,770%. The use of polyethylene mulch technology (black silver plastic mulch) has begun to be widely adopted by farmers in the cultivation of chili plants (*Capsicum annuum L.*). Polyethylene mulch is widely used for vegetable production and can increase the production of red chili plants.

Technical Efficiency Analysis of Cayenne Pepper Farming Cayenne pepper farming is said to be technically efficient if it is able to produce a number of outputs using a smaller number of inputs or is able to produce maximum output from the use of a certain number of inputs. The advantage of the stochastic frontier approach is that apart from producing predictive parameters that affect production, it can also determine the level of technical efficiency of each farmer, as well as identify factors that affect technical efficiency.

Table 2 – Distribution of the technical efficiency index of respondent farmers in cayenne pepper farming

index technical efficiency	Number of farmers (person)	Percentage (%)
0,10 ≤ TE ≤ 0,30	30	37,5
0,31 ≤ TE ≤ 0,50	31	40
0,51 ≤ TE ≤ 0,69	12	20
0,70 ≤ TE ≤ 0,99	7	0,07
Jumlah	80	
Average	0,398	
Maximum	0,994	
Minimum	0,110	

Source: Primary data processing (2022).

From Table 2, it can be seen that the efficiency per individual respondent. The average efficiency index value is 0.398 and the maximum is 0.994 while the minimum index is 0.110. Thus, the technical efficiency of the model, on average, each respondent farmer has the opportunity to be able to increase efficiency results to the maximum. Table 3 shows that the respondent farmers show that 73 people or 91.25 percent of the distribution of the efficiency index are classified as inefficient in their farming business. The technical efficiency index value is categorized as efficient at 0.70 (Kumbhakar and Lovell, 2000).

The average value of technical efficiency in the model shows that on average the respondent farmers still have the opportunity to obtain higher yields to achieve maximum yields as obtained by the most technically efficient farmers. In the short term, the average cayenne pepper farmers in the research area have the opportunity to increase their production by 59.9% (1- (0.398/0.994)) by applying the most technically efficient production inputs, skills, and cultivation technology of farmers.

By using the efficiency index criterion of 0.7 as the efficiency limit, only 8.75% of the total farmers whose farming business is classified as efficient. While the remaining 91.25 farmers have a low level of efficiency (efficiency value < 0.70) or their farming activities are classified as inefficient. The average respondent farmer in the research area is not yet technically efficient, so if farmers want to improve the technical efficiency of their farming business, the way to do it is to add production inputs that have a significant effect on production and pay attention to factors that affect technical efficiency which are the source The source of the cause of inefficiency. This is reinforced by the gamma value of 0.999 which indicates that the *error term* only comes from the effect of inefficiency and not from noise.

Sources of Technical Inefficiency in Cayenne Pepper Farming where the inefficiency function is determined by other factors other than inputs related to the managerial aspects of farmers. The factors that are thought to affect the level of technical efficiency of curly red chili farming in the study are: the age of the farmer, the level of education of the farmer, and the *dummy* following the extension. The estimation results of this inefficiency function are simultaneous results that are processed together with the production function using the *Cobb-Douglas* with the MLE method. The inefficiency effect is the *error term* of the modeled production function.

Table 3 – Estimation of the effect of technical inefficiency on the *stochastic frontier* cayenne pepper farming

Variable	Value of coefficient	t-ratio
Constant	0,283	0,604
Age of farmer (Z_1)	0,259	3,276**
Farmer's education (Z_2)	-0,290	-1,357*
Activity in extension Z_3)	-0,227	-1,401*

*Note: *** significant at level = 1%, ** significant at level = 5%, * significant at level =10%.*

Farmer's age factor (Z_1). The estimation results of the technical inefficiency effect model show that the age factor with t-count 3,276 > t_{table} 2,380 at the 99% confidence level gives a real or positive effect on the technical inefficiency of cayenne pepper farming. The coefficient value is positive at 0.259. A positive sign indicates that the older the farmer, the more technical inefficiency in his farming business can be increased by 2.59%, meaning that the older the farmer the less efficient he is in running his farming business. This is in accordance with the assumption that the older the farmer, the lower his working ability and technical ability and a negative impact on technical efficiency.

Farmer Education Factor (Z_2). The education factor is one of the important factors in causing technical inefficiency in farming, where in Table 4, it can be seen that the t-count > t_{table} 1.293 with a 90% confidence level, this means that the education factor has a negative effect on technical inefficiency. With a negative coefficient of -0.290, which means that if there is an increase in education by 1 year, it will reduce the technical inefficiency factor by 0.290% in farming. Higher education can encourage farmers to apply farming technology more proportionally using production inputs.

Dummy Activity in Following Counseling (Z_4). The extension factor is one of the causes of technical inefficiency in farming, from Table 4 shows that the extension has a negative value on the technical inefficiency factor. Where the value of t-count 1.401 > t_{table} 1.293 90% confidence. The coefficient is -0.227, which means that an increase in the frequency of counseling by 10% will cause a decrease in the level of technical inefficiency of 0.227%. Counseling plays an important role in farmers' farming, because there is a lot of information that can be obtained in this activity, such as good cultivation techniques including how to control pests and diseases, fertilization methods, and harvest and post-harvest techniques.

CONCLUSION

Cayenne pepper production in Permata Intan District shows that the factors that have a significant effect are land area, fertilizer, labor, and use of mulch. Meanwhile, other factors such as seeds and pesticides had no significant effect on the production of cayenne pepper.

The average cayenne pepper farmers in Permata Intan District are not technically efficient with an average technical efficiency distribution index of 0.384, while the minimum efficiency index is 0.110 and the maximum index is 0.994. This figure explains that 99.4% of respondent farmers are technically inefficient. Opportunities to improve technical efficiency are still large through improving production factors that affect technical efficiency.

The factor causing the technical inefficiency of cayenne pepper is due to the education and activeness of farmers in participating in counseling, while the age factor has no significant effect on technical inefficiency in cayenne pepper farming in Permata Intan District.

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