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Efisiensi Produksi Usahatani Ubi Kayu dengan Pendekatan *Stockhastic Frontier* di Provinsi Lampung

Production Efficiency of Cassava Farming Using Stochastic Frontier Approach in Lampung Province

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ABSTRACT

This study aimed to analyze the production efficiency of cassava farming consisting of technical, economic, and price efficiency and cassava farmer's income in Lampung Province. This research was conducted in Central Lampung Regency as a cassava production center in Lampung Province using a survey method. Determining the number of samples using stratified random sampling to obtain a total sample of 100 farmers. Data collection was carried out in August 2020. The production function and the stochastic frontier production cost function were used to analyze the production efficiency level. Farming income was analyzed using the R/C ratio. The results showed that cassava farming was technically inefficient, with the influencing factors being variable land area (X1), seeds (X2), urea fertilizer (X4), pesticides (X8), and labor (X9). Cassava farming has been very efficient economically, and prices with factors that affect economic efficiency are the variable price of seeds/kg (X2), price of NPk/kg (X3), price of Urea/kg (X4), price of SP36/kg (X5), price of Pesticide/kg (X8), price of labor/kg (X9). The income of cassava farming on total costs is IDR 13.959.551,45 per ha with an R/C ratio of 2,35, so cassava farming is profitable for cultivation.

Keywords: *price efficiency, economic efficiency, and technical efficiency*

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INTRODUCTION

Lampung Province is one of Indonesia's cassava production center provinces (Mardliyah and Supriyadi, 2018; Haryono *et al*., 2021). In recent years cassava production in Lampung Province has continued to decline (Thamrin *et al*., 2013; Robert Asnawi, 2016). Declined production was due to the shrinking land area and the fluctuating and low cassava prices (Rosanti *et al*., 2018; Damanhuri *et al*., 2017; Nugraha *et al*., 2015). This result in the continued decrease of farmer interest to grow cassava plants and choose to plant other crops (Nadeak, 2019; Yantu & Kalaba, 2013). Variable land area is the most responsive variable to cassava production (Anggraini *et al*., 2016; Afinah & Rahayu, 2018). Then, the low selling price of cassava will lead to low income for cassava farmers and not comparable with the production costs of cassava farming so cassava farming is inefficient (Indah, Zakaria and Prasmatiwi, 2015).

Efforts to increase cassava production in Lampung Province need to be carried out by increasing production efficiency in cassava farming in Lampung Province. Increased production efficiency in terms of the use of inputs used by farmers. The inputs are used in accordance with government recommendations or have even exceeded government recommendations. The input variables that farmers use are land area, seeds, urea fertilizer, NPK fertilizer, SP36 fertilizer, KCl fertilizer, organic fertilizer, pesticides, and labor (Thamrin, Novita and Hardianto, 2015).

In addition to increasing the efficiency of farming inputs, the most important thing in developing food crop commodities, in this case cassava, is through efforts to increase farm income. Increasing farm income in the short term can be achieved through the use of production facilities in accordance with recommendations, in the medium term by increasing the planting area, and using essential production factors, and in the long term by using the development of farming technology (Zakaria *et al.*, 2020). The optimal use of production factors will provide maximum profit and production efficiency (Zakaria *et al*., 2019)

Research on production efficiency especially on cassava in Lampung Province is interesting to study. As a region with the highest cassava production in Indonesia, research on the efficiency of cassava production using the Stochastic Frontier approach has never been carried out. Several studies on cassava in Lampung Province include research on the analysis of cassava competitiveness (Rosanti *et al*., 2018), cassava marketing efficiency analysis (Anggraini, Hasyim and Situmorang, 2010), the competitiveness of cassava commodities by internalizing transaction costs (Zulkarnain *et al*., 2021), institutional model engineering of cassava partnership (Zakaria *et al*., 2022) and research on the competitive advantage of cassava against corn and soybeans in Lampung Province (Asnawi and Mejaya, 2016). Research on the technical efficiency of cassava production in Lampung Province with the stochastic frontier analysis approach has been carried out by Mardhiah and Suhartini (2020), however, this study did not use primary data as a research database but instead used raw data from the 2017 Palawija Farming Cost Structure Survey. Mardhiah and Suhartin (2020) did not analyze cassava farming income as done in this study. This research is essential to consider that cassava production in Lampung Province tends to decrease every year, so it is very important to study the efficiency of cassava production to increase efficiency and productivity of cassava. This study aimed to analyze production efficiency included technical, economic, and price efficiency, as well as analyze cassava farmer's income in Lampung Province.

RESEARCH METHODS

Research methods. The research was conducted using a survey method. This method is used to collect data on a large scale; the data studied is data from samples taken from a population.

Location and Time. This research was conducted in Central Lampung district using a survey method. The location selection was chosen purposively with the consideration that Central Lampung Regency is a cassava production center in Lampung Province. Data collection was carried out in August 2020.

Sampling and data collection methods. Determining the number of samples using stratified random sampling to obtain a total sample of 100 farmers. The data used in this study are primary data and secondary data. Primary data were obtained from direct interviews with respondent farmers using a questionnaire. Secondary data was obtained from institutions, related agencies, and the internet related to research.

Data analysis method. This study measures production efficiency, which consists of technical efficiency, economic efficiency and price (allocative). Farming is categorized as economically efficient if the agricultural business achieves technical efficiency and price efficiency. The research analysis tool uses the form of the Cobb-Douglass frontier production function and uses the Frontier 4.1 application. Mathematically the Cobb-Douglass frontier production function estimator model and technical inefficiency models in cassava farming in Lampung Province using the MLE (Maximum Likelihood Estimation) method in this study can be written as follows:

Ln Y = In *b*0 + b1 lnX1 + b2 InX2 + b3 InX3 + … + b9 InX9 + b1 InZ1 + … +
b2 InZ2 + b3 InZ3 + b4 InZ4 + ei + Ui (1)

Note:

Y	= cassava production (kg)
b0	= Intercept
b1,b2…bn	= Estimator variable parameter/regression coefficient
X1	= Land area (ha)
X2	= Seeds (kg)
X3	= NPK Fertilizer (kg)
X4	= Urea Fertilizer (kg)
X5	= SP36 Fertilizer (kg)
X6	= KCl Fertilizer (kg)
X7	= Organic Fertilizer (kg)
X8	= Pesticide (gba)
X9	= Labor (HOK)
Z1	= Farmer's age (years)
Z2	= Level of farmer's formal education (years)
Z3	= Farming experience (years)
Z4	= Agriculture extension participation
ei	= Error due to random factors
Ui	= Technical inefficiency factor

The technical efficiency score is in the range of 0 to 1. If the technical efficiency of cassava farming is 1, then the farming business is technically efficient by 100%. However, several studies state that a farming business is said to be quite efficient if it has a technical efficiency value of >0.7 and is categorized as inefficient if it has a technical efficiency value of ≤0.7.

The technical efficiency method used in this study refers to the technical inefficiency effect model developed by Battese and Coelli (1995). The variable ui used to measure the effect of technical inefficiency is assumed to be independent and normally distributed with N(μit,σ2). To determine the value of the distribution parameter (ui), the effect of technical inefficiency on cassava farming in this study used the following formula:

ui = δ0 + δ1Z1 + δ2Z2 + δ3Z3 + δ4Z4 + Ɛi (2)

Note:

Ui = inefficiency effect
δ = expected coefficient value, where δ1 is assumed to be >0, while δ2, δ3, and δ4 presumably <0
Z1 = farmer's age (years)
Z2 = farmer's formal education level (years)
Z3 = farming experience
Z4 = agriculture extension participation
Ɛi = random error term, which is assumed to be independent and its distribution normal truncated with N(0,σ2)

The positive coefficient value will have a positive effect on the value of technical inefficiency. So, if the coefficient value is positive and the greater the coefficient value, the value of technical inefficiency will also be greater, so farming becomes inefficient. Meanwhile, a negative coefficient value will negatively affect the value of technical inefficiency and vice versa will positively affect the level of technical efficiency. A negative coefficient value means that the greater the coefficient value, the smaller the level of technical inefficiency so that the level of technical efficiency of farming will increase.

Economic efficiency is obtained by using the parameter estimation of the cost function. The function of the overall economic efficiency estimation model can be written as follows:

Ln Ci= In b0+b1 InX1+b2 InX2+b3 InX3 +…+ b9lnX9 + Ui (3)

Note:
Ci = Total cost of production (Rp)
X1 = Land rental price (Rp/ha)
X2 = Seedling price (Rp/kg)
X3 = NPK fertilizer price (Rp/kg)
X4 = Price of urea fertilizer (Rp/kg)
X5 = SP36 fertilizer price (Rp/kg)
X6 = Price of KCl fertilizer (Rp/kg)
X7 = Price of organic fertilizer (Rp/kg)
X8 = Pesticide price (Rp/kg)
X9 = Labor price (Rp/kg)
b = regression coefficient
ui = error

The results obtained from the frontier 4.1 application with the cost function model are Cost Efficiency means to obtain economic efficiency use the formula:

$$EE=\frac{1}{CE} \quad (4)$$

Note :
EE = Economic efficiency
CE = Cost efficiency

Analysis of price efficiency or allocative efficiency is obtained from the results of calculating economic efficiency divided by technical efficiency written by the formula:

$$EA=\frac{EE}{ET} \quad (5)$$

Note:
EA = Allocative efficiency
EE = Economic efficiency
ET = Technical efficiency

Farming Income Analysis. Income analysis is calculated to determine profit that farmers can get from cassava farming, to calculate income using the following formula:

$$\pi = TR-TC \quad (6)$$

$$\pi = (Y.Py) - (X.Px) \quad (7)$$

Note:
Π = Farmer's income
TR = Total Revenue (Rp)
TC = Total Cost (Rp)

Y = Output (kg)
Py = output price (Rp)
X = Input (kg)
Px = Input Price (Rp)

R/C calculations are carried out to determine the feasibility of farming carried out by farmers. If the results of the calculation of R/C <1 then cassava farming is not profitable to do, R/C = 1 then break even farming and R/C > 1 then farming is profitable to do, the formula used is:

$$R/C = \frac{TR}{TC} \quad (8)$$

Note:
R/C = Revenue and cost ratio
TR = Total Revenue (Rp)
TC = Total Cost (Rp)

RESULTS AND DISCUSSION

Characteristics of Cassava Farmers Respondents. The characteristics of cassava farmers are a description of the character and values that develop from an individual that can differentiate them from the others. Characteristics of farmers consist of age, education level, farming experience, number of family members, land area, and side jobs. The farmers in this study were cassava farmers in Central Lampung Regency. Economically productive age can mean that in general the level of willingness, enthusiasm and ability to develop farming tend to be higher and have great responsibility for their business, because in reality their fate is determined by themselves. The average age of the respondent farmers in the Terusan Nunyai district, Central Lampung is 46 years old. The distribution of respondent farmers by age group (productive and non-productive age) in the productive age group (16–60 years) with a percentage of 89 %. Most of the farmers have elementary school education level. The average number of family dependents is 3 people. The education level of farmers will affect the mindset of farmers in acting for the progress of their farming (Manyamsari, 2014; Dewi *et al.*, 2017).

The average area of cassava farmers' land is 1.29 hectares. The smaller the area of land cultivated by cassava farmers, the smaller the production obtained so that it will have an impact on the level of income received by cassava farmers. Some of the respondents (28.21%) of cassava farmers had 21-30 years of farming experience with an average of 24 years of cassava farming experience. Farming experience will affect the cultivation of cassava farming (Subagiyo & Charisnalia, 2019; Asmarantaka & Zainuddin, 2017).

Production Efficiency of Cassava Farming. Production efficiency of cassava farming consists of technical, economic and price efficiency. Technical efficiency is a way to see whether cassava farming is technically efficient or not. In addition, from this study it can be seen the level of technical efficiency of cassava. Completion of the MLE method was carried out using the Frontier 4.1 application by estimating the Stochastic Frontier production function of cassava farming with nine independent variables. The MLE equation model is said to be good if the results of the MLE log likelihood value are greater than the OLS. Table 1 shows the MLE log likelihood value of -52.2836 while the OLS log likelihood value is -61.6114 which means that the MLE log likelihood value is greater, so the model used is correct and can be continued for interpretation of the results.

Table 1. Estimation of the production function of the stochastic frontier of cassava farming

Variable	coefficient	Standard-error	t-
Intercept	6.8608***	0.5964	11.5046
Land area (X_1)	-0.0128***	0.0017	-7.4834
Seeds (X_2)	0.3081**	0.1427	2.1585
NPK (X_3)	0.0019	0.0016	1.1702
Urea (X_4)	0.4073***	0.0950	4.2890
SP36(X_5)	0.0025	0.0019	1.3384
KCl (X_6)	0.0073	0.0111	0.6510
Organic (X_7)	-0.0003	0.0020	-0.1347
Pesticide(X_8)	0.3034***	0.0870	3.4891
Labor(X_9)	0.0057***	0.0020	2.8789
Sigma-squared	0.1667***	0.0234	7.1305
Gamma	0.0277	0.1025	0.2706
OLS likelihood logs	-61.6114		
MLE likelihood logs	-52.2836		
LR-test	18.6556		

Source = Primary Data, processed research results, 2020
Description ** = 95% confidence level (t-table = 1.9833)
*** = 99% confidence level (t-table = 2.6349)

Based on Table 1, it can be seen that the variable land area (X1), urea (X4), pesticides (X8), and labor (X9) have a significant effect at the 99% confidence level, and the seed variable (X2) has a significant effect with a 95% confidence level. Technical efficiency is obtained through an analysis of production inputs using inputs used by farmers. Based on the regression results in Table 1, the frontier production function is as follows:

$$\text{Ln } Y = 6{,}8608 - 0{,}0128 \ln X1 + 0{,}3081 \ln X2 + 0{,}0019 \ln X3 + 0{,}4073 \ln X4 + 0{,}0025 \ln X5 + 0{,}0073 \ln X6 - 0{,}0003 \ln X7 + 0{,}3034\, X8 + 0{,}0057\, X9 \quad (9)$$

Based on Kusnadi *et al*., (2011), the seed variable has a significant effect on production with a confidence level of 95%, this is in line with the results of the analysis of this study, the seed variable has a significant effect of 95% on the production of cassava farming. This means that every addition of cassava seeds by 1 stick will increase the production of cassava farming by 0.3081 kg.

Table 2. Distribution of technical efficiency of cassava farming in Lampung Province

Technical Efficiency	Number of people)	Percentage	Information
<0,70	72.00	72.00	Not yet efficient
0,70 – 0,90	22.00	22.00	Quite efficient
>0,90	6.00	6.00	Very efficient
Amount	100.00	100.00	
Average	0.63		
Minimum	0.47		
Maximum	0.98		

Source: Primary Data, processed research results, 2020

Based on Table 2, cassava farming is not technically efficient and this is in line with Anggraini *et al*., (2016) regarding the analysis of the production efficiency of cassava farming in Central Lampung that the results of the research obtained that the average technical efficiency of farmers was 0.69 and in this study it was 0.63. Compared with other studies, the value of technical efficiency obtained is smaller than the value of technical efficiency in cassava farmers in Cross River State of 0.70 (Nkang and Ele, 2014), and cassava farmers in Central Lampung (Anggraini, Harianto and Anggraeni, 2017).

Table 3. Parameters of alleged technical inefficiency factors in cassava farming in Lampung Province

Variable	Coefficient	Standard error	t-
intercept ($\delta 0$)	6.8608***	0.5964	11.5046
Age (Z_1)	- 0.0254*	0.0138	-1.8361
Education (Z_2)	0.0012	0.0036	0.3436
Farming experience (Z_3)	- 0.0402***	0.0131	-3.0703
Counseling participation (Z_4)	0.0054*	0.0029	1.8604

Source : Primary Data, processed research results, 2020
Description : * = 90% confidence level (t-table = 1,6630)
** = 95% confidence level (t-table = 1,9833)
*** = 99% confidence level (t-table = 2,6349)

Based on the results in Table 3, the variable farming experience has an effect on technical inefficiency of 99%.(Oladeebo and Oluwaranti, 2014). The variables of age and extension participation have a significant effect on technical inefficiency by 90%, while the education variable has no effect on technical inefficiency. The education level of farmers has a negative correlation with the level of technical inefficiency (Maryanto, Sukiyono and Sigit Priyono, 2018). In this study, the education variable had no significant effect on the technical inefficiency of cassava farming.

Based on the results in Table 3, the variable farming experience has an effect on technical inefficiency of 99% (Oladeebo and Oluwaranti, 2014). The variables of age and extension participation have a significant effect on technical inefficiency by 90%, while the education variable has no effect on technical inefficiency. The education level of farmers has a negative correlation with the level of technical inefficiency (Maryanto, Sukiyono and Sigit Priyono, 2018). In this study, the education variable had no significant effect on the technical inefficiency of cassava farming (Table 3). The production cost function equation is carried out to determine the factors that affect production costs and determine the level of economic efficiency of cassava farming. The larger MLE log likelihood value is 55.54 compared to the OLS log likelihood value which is 55.52, so it shows that the equation used in the production cost function equation is correct and can be continued for the interpretation of the analysis results. The results of the estimation of the stochastic frontier production function of cassava farming in Lampung Province are presented in Table 4.

Table 4. The estimation of the production cost function of the stochastic frontier of cassava farming in Lampung Province

Variable	coefficient	St-error	t-
Intercept	3.3579***	0.3212	10.4528
Land rental price/kg (X_1)	-0.0076***	0.0007	-11.4850
Seed price/kg (X_2)	0.3695***	0.0528	6.9939
Price of NPk/kg (X_3)	0.0033***	0.0006	5.4984
Price of Urea/kg (X_4)	0.1530***	0.0315	4.8516
Price SP36/kg(X_5)	0.0015**	0.0006	2.4448
Price of KCl/kg (X_6)	0.0002	0.0037	0.0559
Organic Price/kg (X_7)	-0.0003	0.0006	-0.4906
Pesticide Price/kg(X_8)	0.1067***	0.0266	4.0123
Labor Prices/kg (X_9)	0.0013**	0.0006	2.1140
Sigma-squared	0.0267	0.0192	1.3890

Variable	coefficient	St-error	t-
Gamma	0.4351	0.7906	0.5504
OLS likelihood logs	55.52		
MLE likelihood logs	55.54		
LR-test	0.0431		

Source : Primary Data, processed research results, 2020
Description : ** = 95% confidence level (t-table = 1,99961)
*** = 99% confidence level (t-table = 2,65866)

Based on Table 4, it can be seen that the variable price of land rent/kg (X1), price of seeds/kg (X2), price of NPk/kg (X3), price of urea/kg (X4), and price of pesticides/kg (X8) have a significant effect at the 99% confidence level, the price variable SP36/kg (X5) and labor/kg (X9) had a significant effect of 95%, and the price variable KCl/kg fertilizer (X6) and the price of organic fertilizer/kg (X7) had no significant effect on the economic efficiency of cassava farming. Economic efficiency is obtained through an analysis of production input costs using weighted prices by dividing input variable costs by the amount of production.

Based on Table 5 shows that 79% of farmers belongs to very efficient criteria, which means that cassava farming in Lampung Province are already economically efficient. This is opposite of other study results which state that cassava farming in Lampung is not economically efficient (Saputra, Lestari and Nugraha, 2018). The average achievement of the economic efficiency level of 0.91 indicates that cassava farmers' profits have been maximized, due to the ability of farmers to optimally manage the use and purchase of production factors so as to save production costs incurred.

Table 5. Distribution of economic efficiency of cassava farming in Lampung Province

Price Efficiency	Number (people)	Percentage	Description
<0.70	0	0.00	Not yet efficient
0.70 – 0.90	21.00	21.00	Quite efficient
>0.90	79.00	79.00	Very efficient
Amount	100	100	
Average	0.91		
Minimum	0.80		
Maximum	0.95		

Source : Primary Data, processed research results, 2020

Based on Table 6, the calculation of price efficiency results with an average of 1.00, so it can be concluded that cassava farming is very efficient in price. Cassava farmers have been able to maximize their profits. The distribution of price efficiency levels for cassava farming in Lampung Province in 2019 can be seen in Table 6.

Table 6.The distribution of price efficiency of cassava farming in Lampung Province

Price Efficiency	Number (people)	Percentage	Description
<0.70	0	0.00	Not yet efficient
0.70 – 0.90	0	0.00	Quite efficient
>0.90	100.00	100.00	Very efficient
Amount	100.00	100.00	
Average	1.00		
Minimum	0.96		
Maximum	1.00		

Source : Primary Data, processed research results, 2020

Compared with Anggraini, Harianto, and Anggraeni (2016) regarding the analysis of production efficiency of cassava farming in Central Lampung, it was found the average price efficiency of farmers were only 0.71, meaning that the price efficiency of cassava farming in this study was higher with an average of 1.00.

Cassava Farming Income. The costs used in cassava farming are divided into two, namely cash costs and calculated costs. Cash costs consist of seed costs, NPk fertilizer costs, Urea fertilizer costs, SP36 fertilizer costs, KCl fertilizer costs, organic fertilizer costs, pesticide costs, costs for outside family labor (TKLK), transportation costs, interest loan costs, poktan fees, and land and building tax. The calculated costs consist of the cost of land rent, the cost of Family Labor (TKDK), which costs the same amount as TKLK, the cost of depreciating equipment. The total cash cost of cassava farming per hectare is IDR 5,839,549.21 and the total calculated cost is IDR 4,492,888.97.

The costs that have been used by farmers will have an impact on the profits that farmers will get which is calculated from revenue minus costs, while revenue is obtained from production multiplied by price. The production of cassava produced with a land area of 1 ha is 19,990.16 kg at a price of IDR 1,107.90, so the revenue is IDR 22,147,030.67

Table 7. Receipts, costs, and income of cassava farming in Lampung Province

Description	Cassava farming per 1,29 ha				Per 1 ha
	Unit	Amount	Price (IDR)	Value (IDR)	Value (IDR)
Reception				31,336,666.67	24,291,989.66
Production	Kg	25,787.30	1107.90	28,569,669.56	22,147,030.67
Production cost					
I. Cash Charges					
Seeds	Kg	130.20	7,063.86	919,704.01	712,948.84
NPk fertilizer	Kg	169.25	2,427.51	410,846.09	318,485.34
Urea Fertilizer	Kg	250.00	2,149.78	537,444.44	416,623.60
SP36 fertilizer	Kg	70.44	1,461.11	102,915.56	79,779.51
KCl fertilizer	Kg	74.49	2,934.92	218,616.37	169,470.05
Organic fertilizer	Kg	1,114.60	224.60	250,336.20	194,059.07
Pesticide	Gba	0.04	640.67	354,701.01	274,962.02
TKLK	OK	55.40	64,909.21	3,595,730.91	2,787,388.30
Transportation	Rp			1,020,000.00	790,697.67
Interest Loans	Rp			53,452.38	41,435.95
Poktan dues	Rp			4,444.44	3,445.31
United Nations	Rp			64,827.10	5,0253.57
Total Cash Charges				7,533,018.52	5,839,549.24
II. Calculated Cost					
Land lease	Rp			5,063,492.07	3,925,187.65
TKDK	OK	7.70	64,909.21	499,633.84	387,313.06
Tool Shrinkage	Rp			232,700.87	180,388.27
Total Cost Calculated				5,795,826.78	4,492,888.97
III. Total cost				13,328,845.29	10,332,438.21
Income					
I. Income on Cash Expenses				23,803,648.15	18,452,440.43
II. Revenue on Total Expenses				18,007,821.37	13,959,551.45
R/C on Cash Charges				4.16	4.16

Description	Cassava farming per 1,29 ha				Per 1 ha
	Unit	Amount	Price (IDR)	Value (IDR)	Value (IDR)
R/C Over Total Cost				2.35	2.35

Source : Primary Data, processed research results, 2020

Based on Table 7, the cassava farming income in Lampung Province on cash costs is IDR 18,452,440.43 per ha with an R/C value for cash costs of 4.16. It indicates the use of cassava farming production costs of IDR 1,000.00 will generate revenue of IDR 4,160.00, while the cassava farming income on total costs is IDR 13,959,551.45 per ha with an R/C value of 2.35. It means the use of production costs of IDR 1,000.00 will generate revenue of IDR 2,350.00. The RC value of cassava production in Lampung Province in terms of cash costs and total costs is greater than one, so it can be concluded that cassava farming is profitable to cultivate.

CONCLUSION

Cassava farming in Lampung Province is not yet technically efficient, however; it is very efficient economically and price wise. This gives an understanding that cassava farmers have been able to maximize profits. Factors that influence technical efficiency are farming experience, age and participation in agriculture extension. Increasing the efficiency of cassava farming in Lampung Province can be done through increasing the frequency of agriculture extension. The income of cassava farming on total costs is IDR 13,959,551.45 per ha with an R/C ratio of 2.35 so cassava farming is profitable for cultivation.

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