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Technical Efficiency Analysis of Fertilizer use for Oil Palm Plantations Self-Help Patterns in Muaro Jambi Regency using Methods Data Envelopment Analysis

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Abstract— *This study aims to analyze the level of technical efficiency of fertilizer use, describe the distribution of technical efficiency based on the characteristics of farmers, and analyze the determinant factors that affect the use of fertilizers in smallholder oil palm plantations in Sekernan District, Muaro Jambi Regency. The type of research used is descriptive quantitative research. The analytical method used to calculate the efficiency value of farmers is using the Data Envelopment Analysis (DEA) method with the input approach of Variable Return to Scale assumptions. This research was conducted in two villages, namely Gerunggung Village and Bukit Baling Village in Sekernan District, Muaro Jambi Regency and carried out from June 2022 to July 2022. The results showed that based on DEA analysis there were 9 farmers who farmers.The distribution of farmers' were technically efficient and there were as many as 48 technically inefficient. Technical efficiency based on farmer characteristics is found in farmers who have a land area of 1.5 to 4.5 ha with a percentage of 90 percent, with an age range of 50 to 54 years with a percentage of 33.4 percent, have experience in farming for 9 to 14 years and 27 to 32 years with their respective percentages of 33.4 percent, and the length of education 6 to 8 years of 66.67 percent. Based on the tobit regression analysis, the factors (determinants) that affect the technical efficiency of oil palm farming, the variable FFB price, length of education and farmer's age have a significant value of more than 0.05 or no significant effect on the technical efficiency of fertilizer use. As for the variable price of fertilizer, farming experience, land area has a significance smaller than alpha 0.05 which means it has a significant impact on the technical efficiency of using oil palm fertilizer in Sekernan District, Muaro Jambi Regency. However, simultaneously all independent variables have a significant effect on the confidence level of 0.05.*

Keywords— ***Oil Palm Farming; Technical Efficiency; DEA, DEA VRS; Input Approach; Tobit's Regression.***

I. INTRODUCTION

Jambi province is a center for palm oil production, especially for Indonesia and is in 7th place out of 34 provinces in Indonesia. For Jambi province, the main production center for palm oil is Muaro Jambi Regency. Muaro Jambi Regency is recorded to have oil palm plantations covering an area of 268,873 ha consisting of 105,810 ha of owned plantations, 9,812 ha of state plantations and 153,251 ha of community plantations in 2021 with a production of 268,870 tons of FFB (fresh fruit bunch). This production tends to increase along with the development of oil palm plantation areas in various areas in Muaro Jambi Regency. The increase in the area of oil palm land has resulted in an increase in the interest of farmers who want to know about oil palm. Based on data from the Jambi Province Plantation Service (2021). Muaro Jambi Regency, when viewed from the last 5 years, has experienced fluctuations that tend to increase. The average area of oil palm plantations has increased by 0.5% annually, while production has increased by 0.42%. In the period

2016-2020, the highest productivity was achieved in 2016 with a harvested area of 55,901 ha, production of 189,613 tons with a productivity of 3,374 tons/ha.

Sekernan District is the area with the largest oil palm area in Muaro Jambi Regency with a production area of 27,514 ha, production of 58,010 tons in 2021 and this palm oil production area continues to increase every year. Based on the pre-survey conducted by researchers, oil palm plantations in the research area are mostly managed in a self-help and traditional manner, besides that it is known that many farmers who are not active in active farmer groups result in the management of oil palm farming in Sekernan District being less precise. because it does not have a clear and credible source. This can be seen from the habits of farmers in managing their farming businesses where information and assistance regarding oil palm cultivation is carried out independently and the information obtained is also obtained from looking at the management of other farmers' farms. Another problem is that smallholder plantations are usually also difficult to absorb the latest technology, both because of the lack of capital as well as the knowledge and skills of farmers so that they have smaller opportunities compared to private and state plantations.

Based on observations, it is known that the behavior of farmers in managing their oil palm plantations, especially in the use of fertilizers, is also influenced by the socio-cultural environment of the farmers where most of them are rural communities who in farming are generally still based on traditions that are hereditary, so that changes in farmers are difficult because the mindset of the people (especially the older generation) is still based on habits and is traditional. Making the technical cultivation of oil palm plantations less precise because it does not have a clear and credible source. In addition, in reality in the field, farmers have limited costs in managing their farms so that farmers will consider purchasing fertilizer products at the cheapest prices with relatively the same quality or using fertilizers under the recommendation to reduce production costs. In addition to products, prices and distribution, promotions by marketers often affect the knowledge, perceptions and attitudes of farmers in addition to local agricultural information and extension agents. Another problem is that smallholder plantations are usually also difficult to absorb the latest technology, both because of the lack of capital as well as the knowledge and skills of farmers so that they have smaller opportunities compared to private and state plantations

According to Valiarana and Saptana, (2010) the amount of natural fertilizer use is influenced by the area of agricultural commodities, the level of farming intensification represented by the application of fertilizer doses, land fertility, and regional agro-climatic conditions. Efficient and optimal use of fertilizers can certainly increase the productivity of oil palm plants. The use of the wrong fertilizer can cause inefficiency in the production process. Whereas fertilization is the main factor in calculating production costs because more than 50% of the cost is used for this activity (Hakim, 2007). Good fertilization of oil palm must refer to the maximum effectiveness and efficiency factors (Pahan, 2011). The high price of fertilizer and its limited availability in the market requires more attention to the management of fertilizer use by farmers so that the fertilizer used can be absorbed by plants efficiently and effectively, the need for farmers' knowledge about optimal fertilizer use and the factors that cause a decrease in production in business. Farming is important to produce sustainable palm oil production, so research is needed to analyze the efficiency of fertilizer use by farmers. Therefore, the authors take the title to be observed, namely "Technical Efficiency Analysis of the Use of Self-Help Palm Oil Plantation Fertilizers in Muaro Jambi Regency by Using Data Envelopment Analysis Methods".

II. research methods

This research was conducted in Jambi Province, by taking two sample villages, namely Gerunggung Village and Bukit Baling Village, Sekernan District, Muaro Jambi Regency. The location determination was carried out purposively with the consideration that the area is one of the centers of oil palm plantations in Jambi Province. The research was carried out from June to July 2022. The data collection technique was carried out using observation and interview techniques. The criteria for the sample farmers are independent oil palm farmers. Determination of the sample is done by random sampling. The number of samples taken as many as 57 samples of farmers with the division of 43 farmers in Bukit Baling Village and 14 farmers in Grunggung Village. To determine the performance of the use of production factors, socio-economic factors and oil palm production, qualitative descriptive analysis was used. Meanwhile, quantitative analysis was conducted to analyze the technical efficiency and the influence of the determinants on the technical efficiency of fertilizer use in Sekernan District, Muaro Jambi Regency. The DEA equation used in this study is as follows:

Maximizing the equation function:

Min δ,λ δ

Min δ,λ δ; subject to

$\sum_{i=1}^{n} [\lambda i\, y_{ri} \geq y_{r0}, r=1,2....s]$

$\delta oxjo - \sum_{i=1}^{n} [\lambda i\, x_{ri} \geq 0, j=1,2....m]$

$\sum_{i=1}^{n} [I1' \lambda = 1 ; \lambda i \geq 0,] i=1,2,...,...n$.....(1)

meaning:

δ= scalar

n= jumlah DMU

x= input

y = output

λ=DMU

Equation 1 is the VRSTE of DMU 1 and the DEA program needs to be repeated as many as 57 samples. This study uses an output-oriented BCC model, where the variables used in this study consist of one output (Q), namely the production and 4 inputs (x), namely: NPK fertilizer (X1), urea fertilizer (X2), KCL fertilizer (X3), dolomite fertilizer (X4).

This study uses the BCC model assuming the VRS scale because this model generally produces a better efficiency score than the CRS model. In addition, the VRS model also assumes that the DMU does not or has not operated optimally according to the data to be analyzed by researchers where oil palm farming in the research location is almost impossible to reach the optimal scale. This research is also oriented to input variables, which means that when an inefficient DMU wants to achieve a more efficient level, it is necessary to reduce the proportion of input variables with a fixed level of output. The model used in this study consists of input and output variables. The input variables used were NPK fertilizer, urea fertilizer, KCL fertilizer, dolomite fertilizer, the output variable produced was the level of production.

Furthermore, to answer the third objective whether the determinant factors (fertilizer prices, FFB prices, land area, farming experience, age and education) have an influence on the use of fertilizers on oil palm plantations in the research area, the authors follow the notation Balcombe & Latruffe (2008), where socio-economic factors as independent variables and one dependent factor used the truncated regression model adapted from Tobit's model in Amemiya (1984):

$TEi^* = \beta0 + \beta1X1 + \beta2\ X2 + \beta3\ X3 + \beta4\ X4 + \beta5\ X5 + \beta6\ X6 + \varepsilon$

$TEi = 0$ if $TEi^* \leq 0$; Left sensor ;

$TEi = TEi^*$ if $0 < TEi^* < 1$; uncensored;

$TEi = 1$ if $TEi^* \geq 1$; right sensor……..(2)

Equation 2 is the truncated regression model used in this study with the VRSTE value in the equation obtained from the results of DEA analysis which was further analyzed using six independent variables, namely fertilizer price (X1), FFB price (X2), land area (X3), farmer age (X4), formal education (X5), farming experience (X6) where is a collection of other variables that are not in the model that have an influence on the dependent variable, namely the value of technical efficiency Tei

III. RESULT AND DISCUSSION

CHARACTERISTICS OF RESPONDENT FARMERS

Farmer descriptions in the form of farmer characteristics determine the adoption of oil palm cultivation technology. The characteristics of farmers can be seen in table 2 below:

No	Karakteristik Petani Responden	Average	Presentation
1	Farmer Age (year)	43.56	43.86
2	Experience (year)	15.24	22.81
3	Land Area (ha)	3.86	68.12
4	Education (Year)	8.68	85.40

Source: Primary Data processed 2022

In general, someone at that age already has better knowledge, skills and experience in oil palm farming than those who are under this age range. One's farming experience can be a benchmark for a farmer in understanding and being competent in a farming business. The longer the experience that farmers have, it is expected that the higher the productivity of the farmers, so that the farm is managed better. Good farming experience refers to the length of time the respondent farmers have worked on oil palm farming.

The factor of land area owned by farmers also affects the management of oil palm plantations by farmers. The wider the land they cultivate, the more farmers will use the fertilizer given to plants. Maiangwa et al. 2007; Ugwuja et al. 2011). In addition, the number of plants is influenced by the area of land as well as its relation to production results, the wider the area of land used, the higher the production produced. This is in line with the research of Panjaitan, Edward (2020) where an increase in oil palm area will increase oil palm production by as much and have a significant (significant) effect on oil palm production in Sungai Buluh Village.

A person's intellectual knowledge can be influenced by the length of formal education received, education is fundamental for a person in acquiring the knowledge and skills to do business. Someone who has extensive knowledge will certainly be more careful in determining whether to accept or reject an innovation. Education plays

an important role in agriculture, because it will affect a farmer's decision in farming and determine the amount of production input use. This is in line with the results of this study, according to Agatha, Wulandari in (2018) where farming experience will affect farmers in doing their farming. Farmers who have longer farming experience will have a high level of experience and skills in carrying out their activities in farming so that they are more selective and precise in choosing the type of innovation applied, and are more careful in the decision-making process in carrying out their farming activities, but on the contrary for Less experienced farmers will usually make decisions faster because they will usually take more risks.

3.1 USE OF PRODUCTION FACTORS, AND PRODUCTION RESULTS IN THE RESEARCH AREA

The production response is determined by the use of factors of production. The use of fertilizers in oil palm plantations in the study area, 2022 can be seen in table 3 below:

Table 3. Use of Palm Oil Fertilizer in the Research Area, 2022

No	Use Of Fertilizer	Average
1.	Urea (kg/ha/yr)	539
2.	NPK (kg/ha/yr)	527
3.	Dolomit (kg/ha/yr)	976
4.	KCL (kg/ha/yr)	391

Source: primary data processed 2022

Table 3 explains that the average use of urea fertilizer in the study area is 539 kg/ha/yr, NPK fertilizer is 527 kg/ha/yr, KCL fertilizer is 391 kg/ha/yr, and dolomite fertilizer is 976 kg/ha/year. This shows that the use of fertilizers in Sekernan District is not in accordance with the recommendations where the average use of urea fertilizer for oil palm plants is 600-750 kg/ha/year (Balitbang, 2013). While the recommendations for the use of NPK, KCL and dolomite fertilizers are 643.5 kg/ha/yr, 643.5 kg/ha/yr, 572 kg/ha/yr.

In farming, of course, it requires natural resources, it also requires human resources or also called labor. Labor is used in oil palm farming activities ranging from plant maintenance consisting of spraying and weeding to harvesting and transporting the results The average use of labor in the study area can be seen in Table 4.

Table 4. Employment of Labor by Farmers in Oil Palm Plantations in the Research Area, 2022

Job Desk	TKDK (HOK/ha)	TKLK (HOK/ha)	Jumlah Keseluruhan (HOK/Ha)
Manintanance	2.91	7.68	10.59
Fertilization	2.48	7.00	9.48
Harvesting	45.84	77.76	123.60
Jumlah	51.23	167.68	143.67

Source: Primary Data Processed 2022

Table 4 shows that the use of labor in the family is 51.23 HOK/ha, while the use of labor outside the family is 167.68 HOK/ha. The use of labor in the study uses HOK units (workdays) with the assumption that 1 HOK is equal to 7 hours. It can be seen in table 15 that the largest total use of labor is in harvesting activities, which is 123.6 HOK/ha and followed by maintenance and fertilization of 10.59 HOK/ha and 9.48 HOK/ha. The amount of HOK in this type of work is caused by farmers who still use conventional labor and have not used modern tools for their farming.

Table 5. Distribution of Sample Farmers by Total Production in Oil Palm Plantations in the Research Area, 2022

Production (kg/ha/yr)	**Farmer (People)**	**Presentation (%)**
11.150 – 12.127	12	21.06
12.128 – 13.105	1	1.75
13.106 – 14.083	4	7.02
14.084 – 15.061	14	24.56
15.062 – 16.039	11	19.30
16.040 – 17.017	10	17.54
17.018 – 17.995	5	8.77
Total	**57**	**100**
Average Production kg/ha		14.611 kg/ha

Source: Primary Data Processed 2022

The average FFB production in the study area is 14,018 kg/ha/yr. The level of production is influenced by production factors such as land area, use of seeds, use of fertilizers, medicines, and so on. This is in line with the

results of Susanti's research (2018) that the variables of land area, labor, fertilizer, pesticides, age, farming experience, and farming distance together have a significant effect on Liberika coffee production in Betara District, West Tanjung Jabung Regency. The results of this study are reinforced by the findings of Balitbang, 2008 that the amount of oil palm production is highly dependent on various factors, including soil type, type of seedling, climate and technology applied. Under optimal conditions, palm oil productivity can reach 20-25 tons of FFB/ha/year or about 4-5 tons of palm oil.

3.2 Analysis of Determinant Factors Affecting the Use of Fertilizers in Oil Palm Farming Business in Sekernan District

The results of the previous estimation of technical efficiency show that the use of fertilizers on oil palm plantations by farmers is still not efficient and needs to be increased. Therefore, it is necessary to know the socio-economic factors (determinants) that affect the efficiency of oil palm farming in the research area.

To see the factors that influence the use of fertilizers, primary data is used with the independent variables used are the price of fertilizer (X1), the price of fresh fruit bunches (X2), land area (X3), and the age of the farmer (X4), the length of formal education of the farmer (X4). X5), farming experience (X6). Through statistical tests to see how much influence the independent variable has on the technical efficiency of the fertilizer used as the dependent variable (Y). Data processing is carried out using the R-Studio software tool. The results of the Tobit regression test are presented in Table 9 below:

Table 9. Results of Tobit Regression Analysis of Determinant Factors Affecting Technical Efficiency in the Use of Palm Oil Fertilizers in the Research Area

TE	Coef.	Std. Err.	T	P > | t |	[95% Conf.Interval]
Fertilizer Price	-.0000351	.0000307	-1.29		
0.003	-.0001013	.0000112			
TBS Price	.0000446	.000087	0.51	0.635	-
.0001301	.0001881				
Land Area	.0276962	.0075231	0.21	0.007	
.0720166	.0166729				
Age	.0067731	.0033087	2.05	0.576	
.0001306	.0134159				
Education	-.0052421	.0057829	-0.14	0.208	-
.0124337	.0107854				
Experience	-.0036754	.0028527	-0.59	0.004	
.0074025	.0040517				
_cons	.5259521	.2272208	1.96	0.006	-
.0917372	1.063641				
/sigma	.1313184	.0140215			
.1031691	.1594677				
Prob > chi2				0.0378	
Log Likelihood				19.16227	

These factors were estimated using the DEA bootstrap model, namely Tobit regression.

Based on the results of data processing shown in table 9 above, it is known that from a total of 57 observations there are 9 respondent farmers who have an efficiency value of 1 and as many as 48 other respondent farmers have varying efficiency values, which are more than 0 less than 1, so it is classified as a non-performing observation. censored. Based on the value of Prob > chi2 which is used as a simultaneous test in the Tobit regression model above, the probability value for Prob > chi2 is 0.0378 while the value of = 0.05 which means the probability value < means that there is at least one variable that has a significant effect on the model.

The factors that affect the technical efficiency of the use of oil palm fertilizers are, from the six variables there are three independent variables, namely the TBS price variable, length of education and the age of the farmer which has a P-value greater than 0.05. This means that the variable price of TBS, length of education and age of farmers partially does not significantly affect the technical efficiency of fertilizer use.

Meanwhile, the variable price of fertilizer, land area, and farming experience has a significance smaller than alpha 0.05, which means that it has a significant impact on the technical efficiency of using oil palm fertilizer in Sekernan District, Muaro Jambi Regency. However, simultaneously all independent variables have a significant effect on the confidence level of 0.05. The variable coefficient of fertilizer price has a negative value, meaning that the increase in fertilizer prices has the potential to reduce technical efficiency in the research area, however, the price of fertilizer significantly affects the technical efficiency of fertilizer use in the research area because farmers still need fertilizer for their oil palm plantations. Even though fertilizer increases, farmers will still buy fertilizer to help increase their production even though the dose used is not as recommended.

Based on the results of data processing shown in table 19 above, it is known that from a total of 57 observations there are 9 respondent farmers who have an efficiency value of 1 and as many as 48 other respondent farmers have varying efficiency values, which are more than 0 less than 1, so it is classified as a non-performing observation. censored. Based on the value of Prob > chi2 which is used as a simultaneous test in the Tobit regression model above, the probability

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TBS prices have a negative coefficient value, meaning that there is a possibility that TBS prices can reduce technical efficiency in the research area, although not significantly. This is because when the price of TBS increases, farmers will tend to increase the use of fertilizers in the hope that production will increase regardless of whether the use of fertilizers used is optimal or not, even though the addition of fertilizers will not necessarily increase production yields as expected by farmers.

Land area has a positive value, meaning that the increase in land area will affect technical efficiency because the wider the land owned by farmers, the more farmers will use fertilizers given to plants. the more used will be as well as its relation to production results, the more land area used, the higher the resulting production. This is in line with the research of Panjaitan, Edward (2020) where an increase in oil palm area will increase oil palm production by as much and have a significant (significant) effect on oil palm production in Sungai Buluh Village.

The age of the farmer is positive, meaning that the age of the farmer has the potential to affect the technical efficiency of fertilizer use in the research area. However, the age of the farmer does not significantly affect the technical efficiency of the use of fertilizers because the age of the farmer does not necessarily indicate a broad knowledge of the farming he does, especially regarding the use of fertilizers. This can be evidenced by, the age range of farmers is almost the same, namely >70% of respondents are included in the same age group as the average age of farmers, which is 44 years or productive age and responsive to wages and new technology and information, but only 8 farmers out of 57 respondent farmers or 14.04% who achieved the value of technical efficiency in the use of inputs in the research area. This is in accordance with Aprilyanti's research (2017) which states that there is no significant effect because the age difference of the respondents is not too far away. Older farmers do not necessarily have better knowledge than younger farmers.

The length of education has a negative sign on technical efficiency, meaning that the level of education can potentially reduce the technical efficiency of fertilizer use in the research area, but not significantly. The length of education of farmers in the research area varies from 0-16 years which includes not attending school, elementary, junior high, high school, and college. The results show that efficient farmers are not in the range of the longest length of education, namely 15-17 years, but farmers who are able to achieve the highest level of technical efficiency are in the range of 0-6 years of education, so it can be interpreted that it does not mean the longer the education received by a person. farmers, the more efficient the use of fertilizers in their farming. The results of this study are in line with Simatupang's research (2019) that the level of formal education of a person does not affect farmers' perceptions of the use of organic fertilizers, because farmers are very easy to obtain information and knowledge through non-formal education such as extension activities or seminars on the use of fertilizers.

The variable coefficient of farmer experience is negative with a level of sig. 0.004 which means that farming experience has the potential to significantly reduce technical efficiency. This is according to Agatha, Wulandari in (2018) where farming experience will affect farmers in doing their farming. Farmers who have longer farming experience will have a high level of experience and skills in carrying out their activities in farming so that they are more selective and precise in choosing the type of innovation applied, and are more careful in the decision-making process in carrying out their farming activities, but on the

contrary for Less experienced farmers will usually make decisions faster because they will usually take more risks.

IV. CONCLUSION

Based on the results of research in Sekernan District, Muaro Jambi Regency, conclusions can be drawn:

1. Oil palm farming in Sekernan sub-district, Muaro Jambi Regency. The oil palms in the study area are still classified as productive age, ranging from 5-15 years. Farming activities in the research area include weeding, fertilizing, and harvesting. The use of fertilizers by farmers has not been in accordance with fertilizer recommendations so that production results have not reached optimal with the average FFB production in the study area of 14, 611 kg/ha/yr.

2. The results of the analysis of the technical efficiency of the DEA (Data Envelopment Analysis) method with the input approach, it is known that the sawadaya pattern oil palm farmers in Sekernan District, Muaro Jambi Regency have not yet achieved technical efficiency.

3. The distribution of farmers' technical efficiency based on farmer characteristics is found in farmers who have a land area of 1.5 to 4.5 ha with a percentage of 90 percent, with an age range of 50 to 54 years with a percentage of 33.40 percent, having farming experience for 9 to 14 years and 27 to 32 years with a percentage of 33.34 percent, and 6-8 years of education, which is 66.67 percent.

4. Based on the Tobit regression analysis, the FFB price, education and farmer's age have no significant effect (source of technical inefficiency) on the technical efficiency of fertilizer use. As for the variable price of fertilizer, land area and farming experience, it significantly affects the technical efficiency of using oil palm fertilizer in Sekernan District, Muaro Jambi Regency. However, simultaneously all independent variables have a significant effect.

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