Technical Efficiency Analysis of Non-Chemical Pesticide Rice Farming in Rejoasri Village, Seputih Raman District

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Abstract. Rejoasri Village, Seputih Raman District, is one of the villages that implements sustainable agricultural practices, namely non-chemical pesticide rice farming that produces rice free of chemical pesticide residue "Berasera". The problem faced in farming is the low productivity of paddy fields so that the level of technical efficiency of rice farming is also low. This will cause economic sustainability to also be low. The objectives of this study are (1) Analyze the factors that affect the production of non-chemical pesticide paddy paddy farming, (2) Analyze the level of technical efficiency of non-chemical pesticide paddy paddy farming, and (3) Analyze the determinants of in-efficiency of non-chemical pesticide paddy paddy farming in Seputih Raman District, Central Lampung Regency. This research will be carried out in Rejoasri Village, Seputih Raman District, Central Lampung Regency. The research sample was taken as many as 30 people. The research data will be analyzed in a qualitative and quantitative descriptive manner. The data will be tabulated, analyzed mathematically, and analyzed statistically according to the research objectives. Itwill be processed using a computer using frontier software version 4.1. The first, second, and third research objectives were analyzed using the stochastic frontier production function approach. The technical efficiency for a farmer ranges from zero to one or the Technical Efficiency (TEi) value is $0 \leq TEi \leq 1$. The results showed that the factors that had a significant effect on the production of non-chemical pesticide rice were the area of agricultural land (X1), organic fertilizer (X4), and vegetable pesticides (X5), while the factors that did not have a significant effect on the production of non-chemical pesticide rice were the Seed variable (X2), the inorganic fertilizer variable (X3), and the rice farming labor variable (X6). The average value of technical efficiency of non-chemical pesticide rice production in the region is 0.8737, which means that the cultivation of non-chemical pesticide rice has been efficient, because the technical efficiency value is with an average of > 0.7000. There are 86.6667% of farmers who have achieved technical efficiency, and as many as 13.3333% of farmers have not achieved technical efficiency in the non-chemical pesticide rice business. Significant factors affecting the technical inefficiency of non-chemical pesticide rice farming are age, education, and experience in non-chemical pesticide rice farming.

Keywords : Efficiency, rice, frontier, technical, non-chemical pesticides

INTRODUCTION

Rice commodities are the main food source for the people of Indonesia. Rice paddy commodities are one of the food crops and are still a priority in agricultural development. Rice as a raw material for milling rice into rice is a staple food, and most of the Indonesian population also uses rice cultivation as a source of income for farmers' households [1] (Kasmin and Kartomo, 2020). The largest rice supply in Lampung Province is supplied by Central Lampung Regency. Rice production data in Lampung Province can be seen in Table 1.

TABLE 1. Rice Production Data in Lampung Province in 2021

Regency/City	Harvest Area (hectare)	Production (tone)	Productivity (ku/hectare)
Lampung Barat	12.303,02	65.432,93	49,31
Tanggamus	22.572,24	130.616,88	54,68
Lampung Selatan	51.178,22	345.033,78	64,54
Lampung Timur	83.568,70	444.283,70	47,55
Lampung Tengah	100.290,55	540.115,25	48,80
Lampung Utara	16.940,92	63.287,40	43,83
Way Kanan	17.403,59	100.178,39	47,25
Tulang Bawang	52.601,29	280.011,59	44,20
Pesawaran	21.260,36	130.475,31	53,34
Pringsewu	21.574,65	135.731,10	56,63
Mesuji	65.020,17	283.879,49	51,79
Tulang Bawang Barat	6.994,69	50.743,98	48,33
Pesisir Barat	12.215,56	60.048,17	51,00
Bandar Lampung	470,07	2.644,85	54,49
Metro	5.179,20	28.879,99	46,74
Lampung	489.573,23	2.661.362,81	50,77

Sumber: Badan Pusat Statistik Provinsi Lampung (2023)

Table 1 shows that Central Lampung Regency is the largest contributor to rice production in Lampung Province with a total of 540,115.25 tons or contributing 20.29%, the second largest production is East Lampung Regency at 16.69%, and the third is South Lampung Regency with 12.96% (BPS, 2023). The rice productivity of Central Lampung district reached 4.88 tons/ha. This shows that rice farming in Central Lampung Regency still has a problem, namely low productivity will cause technical inefficiencies in farming. Technically inefficient farming will affect the income of rice farming. The low productivity of rice is influenced by the use of seeds and fertilizers, Integrated Pest and Disease Control (PHT), as well as the skill factor of farmers in rice farming. This problem in rice farming must be solved by finding a solution, because the low supply of rice will threaten the existence of national food production and security.

The rice production center in Central Lampung Regency is supplied by Seputih Raman District. This area is a rice field area supported by adequate technical irrigation. Rice cultivation is carried out conventionally and semi-organic. One of the groups that encourages semi-organic cultivation is PP Gapsera Sejahtera Mandiri. The semi-organic cultivation system in this sub-district is known for rice paddy cultivation which produces healthy rice that is free of chemical pesticide residues.

1. The types of rice produced vary in quality from medium rice, peremium rice, organic rice, and healthy rice free of chemical pesticides. However, there are no government regulations/regulations regarding healthy rice free of chemical pesticides. One of the farmer groups that produces pesticide-free healthy rice is the Gapsera Sejahtera Mandiri Farmers Association (PP) in Rejosari Village, Seputih Raman District. PP Gapsera Sejahtera Mandiri promotes healthy rice production. In rice cultivation, this group still uses organic fertilizers and chemical fertilizers, but the use of chemical fertilizers has been reduced in number, and does not use chemical pesticides and has not detected residues from 16 non-toxic and chemical pesticide-free items. The rice produced by this group is called "BERASERA" Healthy Rice Free of Chemical Pesticide Residues (PP Gapsera Sejahtera Mandiri, 2021).

The non-chemical pesticide rice cultivation system is a form of sustainable agricultural practice. This responds to the high consumer demand for healthy food and sustainability in environmentally friendly cultivation practices [3] Furthermore [4] also stated that the demand for organic food, especially organic rice, has increased rapidly. To meet the demand for a healthy rice market, the production and productivity of non-chemical pesticide rice in Seputih Raman District must continue to be increased.

The problem of reduced use of chemical inputs will cause the production of non-chemical pesticide rice in the short term to decrease, but with the application of organic fertilizers, rice production will gradually increase. This is because the use of organic fertilizers will be able to improve the soil structure better in the long term. The problem of low production is related to the use of production factors, especially organic fertilizers and inorganic fertilizers. The switch of farmers to organic farming is because it can increase their income. Optimal income if farmers take advantage of production factors is managed efficiently. The use of production factors is the main key to agricultural development because it will have a direct impact on production and business income. Efforts to increase productivity can be made through production efficiency [4].

The low production of rice farmers is caused by the inefficient use of input amounts and production factors, resulting in less than optimal rice yields [5]. Efficiency is an effort to use the smallest input to get the largest production, where this situation can occur if the production process makes an effort if the marginal product value for an input is equal to the input price (Soekartawi, 1990). Efficiency consists of three efficiencies: technical, allocative (price), and economical. Technical efficiency can be obtained through the analysis of the *stochastic frontier production analysis approach* [6] [7] 8] .

Some results show that the technical efficiency score for organic rice farmers has the highest efficiency level (TE = 0.733) compared to conventional rice with chemical input (TE = 0.688). Recommendations for the use of high-quality seeds and organic fertilizers can improve the efficiency of organic rice in Eastern Thailand [9]. The determinants of significant rice technical efficiency are; household income, rice field area and Contrac Farming [10]

Another researcher found that the average technical efficiency of organic rice is high reaching 92% in the dry season and 90% in the rainy season. Technical efficiency is significantly influenced by farming experience, education, training followed, income from other sources, affiliation with organizations, technical services from the Department of Agriculture, and homemade input sources. The results of the study show that farmers must apply organic inputs optimally and continue water management to control weeds [11].

Technical efficiency will encourage increased farmers' income. Increasing production, income, and farmer welfare are indicators of the economic sustainability of rice farming. The sustainability of farming can be assessed from 3 aspects, namely economic, social, and ecological/environmental aspects. In general, the technical efficiency of rice farming is not optimal because it has not been able to produce 100% ET. Research on the technical efficiency of rice has been carried out by other studies, but research examining the technical efficiency of non-chemical pesticide rice has not been conducted. For this reason, it is necessary to carry out various alternatives to good rice farming management and policy recommendations by the government so that rice farming is more efficient. Therefore, this study will focus on technical efficiency analysis in supporting the economic sustainability of non-chemical pesticide rice farming in Seputih Raman District, Central Lampung Regency.

Based on the previous description, the problems can be identified as beirkut: (1) What are the factors that affect the production of non-chemical pesticide paddy rice farming in Seputih Raman District, Central Lampung Regency, (2) What is the level of technical efficiency of non-chemical pesticide paddy farming in Seputih Raman District, Central Lampung Regency, and (3) What are the factors that determine the in-efficiency of non-chemical pesticide paddy farming in Seputih Sub-district Raman, Central Lampung Regency. The objectives of this study are:

1. Analyzing factors affecting the production of non-chemical pesticide paddy rice farming in Seputih Raman District, Central Lampung Regency
2. Analyzing the level of technical efficiency of non-chemical pesticide paddy rice farming in Seputih Raman District, Central Lampung Regency
3. Analyzing the determinants of in-efficiency technical efficiency of non-chemical pesticide rice farming in Seputih Raman District, Central Lampung Regency

METHODS

This research was carried out in Rejoasri Village, Seputih Raman District, Central Lampung Regency. The location was determined *purposively*, considering that: (1) there are 100 farmers who cultivate non-chemical pesticide paddy rice in Central Lampung Regency, (2) Healthy rice sales area, and (3) there is a healthy rice mill that operates continuously, and (4) there is a farmer group that actively develops environmentally friendly paddy rice farming. The research will be carried out for 6-7 months, namely from June to November 2024. The research will involve 2 students of the Food Agribusiness Study Program to conduct a survey at the research site and input research data.

The population of this study is 100 farmers who cultivate non-chemical pesticide paddy rice. The farmer is a member of PP Gapsera in Rejoasri, Seputih Raman District, Central Lampung Regency. Farmers who are active in the cultivation of non-chemical pesticide rice are 30 and all are taken as samples. The sampling method refers to (Nurhidayati, S., et al., 2021) the samples used in the paramatic research are normally distributed, which is a minimum of 30 samples, so that the number of samples used in the study has met the requirements for analysis.

This research is a survey method. The data used in this study is divided into two, namely primary data and secondary data. Primary data was obtained through direct interviews with farmers who cultivate non-chemical pesticide paddy using a questionnaire guide. Secondary data was obtained from various related agencies, namely: the Food Crop Security and Horticulture Office of Central Lampung Regency, PP Gapsera Rejosari Village, BPS Lampung Province, and BPS Central Lampung Regency.

The research data was analyzed in a qualitative and quantitative descriptive manner. The data will be tabulated, analyzed mathematically, and analyzed statistically according to the research objectives. The data will be processed using a computer using frontier software version 4.1.

The purpose of the first study was to analyze using the stochastic frontier production function approach. The stochastic frontier production function model of non-chemical pesticide paddy rice refers to the research [13] ; [14] ; [6] namely:

$$ln\ Yi = \beta 0 + \sum \beta 1 lnX1 + \sum \beta 1 lnX2 + \sum \beta 1 lnX3 + \sum \beta 1 lnX4 + \sum \beta 1 lnX5 + \sum \beta 1 lnX6 + \sum \beta 1 lnX7 + vi - ui \quad \text{……………………………….(3.1)}$$

Keterangan:

Yi : Total production of non-chemical pesticide paddy rice (kg)
X1 : Land (ha)
X2 : Number of seeds (kg)
X3 :An organic fertileizer (kg)
X4 : Organic fertilizer (karung)
X5 : Plant-based pesticides (liter)
X6 : Workforce (HOK)
βj : parameters to be estimated.
vi : random variable assumed N~ (0, δ2V), indicating a factor of errors from the stochastic effect that farmers cannot control.
ui : Random variable a non-negative random that indicates inefficiency Technical of Farming

The purpose of the 2nd research on the level of technical efficiency (*Techinical Efficientcy / TE)* of non-chemical pesticide rice farming was analyzed with the following formula [15]:

$$TE = y_i / y^*_i \quad \text{.....(1)}$$

$$TE = [\ ln\ Yi = \beta 0 + \sum \beta 1 lnX1 + \sum \beta 1 lnX2 + \sum \beta 1 lnX3 + \sum \beta 1 lnX4 + \sum \beta 1 lnX5 + \sum \beta 1 lnX6 + vi - ui] / [ln\ Yi = \beta 0 + \sum \beta 1 lnX1$$

$+\sum \beta 1 lnX2 + \sum \beta 1 lnX3 + \sum \beta 1 lnX4 + \sum \beta 1 lnX5 + \sum \beta 1 lnX6 + vi]$
……..……(2)

Information:
TE : Techinical Efficientcy Non Chemical Pesticide Paddy Rice
yi : Actual production of non-chemical pesticide paddy
y*i : Suspected frontier production obtained from the frontier production function Stochastic Rice Non Chemical Pesticide

The technical efficiency for a farmer ranges from zero to one or the Technical *Efficiency* (TEi) value is $0 \leq TEi \leq 1$. The value of farmers' technical efficiency is categorized as quite efficient if it has a value of > 0.7 (Coelli et al., 1998) in (Ulpah et al., 2018)

The 3rd research objective on the factors affecting the level of technical efficiency (*Techinical Efficientcy / TE)* of non-chemical pesticide paddy rice farming was analyzed with the following formula [17]:

Ui = αo + α1Z1+ α2Z2+ α2Z2+ α3Z3 …..…….(3)

Keterangan:
Ui : Technical inefficiency of non-chemical pesticide rice farming
Z1 : Farmer's age (years)
Z2 : Farmer education (years)
Z3 : Experience in non-pesticide rice farming (Rp/year)

RESULTS AND DISCUSSION

Technical Efficiency Analysis of Non-Pesticide Rice Farming

The technical efficiency of non-chemical pesticide rice farming was statistically analyzed by the stocatis frontier production function approach. Software used with frontier software vers.4.1. The results of the analysis showed that the factors that affected the production of non-chemical pesticide rice were the land area, the use of organic fertilizers, and plant-based pesticides. Meanwhile, factors that do not affect the production of non-chemical pesticide rice are; the use of rice seeds, the use of organic fertilizers, and the number of rice farming workers. The results of the analysis of the esterism of the production function *of Cobb-Douglas stochastic frontier* non-chemical pesticide rice can be seen in the following table:

TABLE 2. Esthimization of cobb-douglas stochastic frontier rice production function non chemical pesticides

Variabel	Koefisien	Standard-error	t-hitung
Intersep	8,782	0,986	8,903***
X1 (Land)	0,932	0,206	4,516***
X2 (Seed)	-0,0137	0,147	0,093 ns
X3 (On organic fertilizer)	0,00187	0,00518	0,362 ns
X4 (Organik fertilizer)	0,00784	0,00542	1,446*
X5 (Non-chemical pesticides)	0,0459	0,00315	14,537***
X6 (Workforce	-0,0000476	0,185	0,00025 ns

Z1 (Age)	-0,01259	0,00597	-2,1083**
Z2 (Education)	-0,0793	0,00998	7,9717***
Z3 (Experience in non-chemical pesticide rice farming)	0,0574	0,04154	1,3836*
Sigma-squared	0,0480	0,0195	2,463**
Gamma	0,999	0,0000	25888531,00***
Log Likehood Function	19,069		
LR test	29,069		

Information:
* Significant at real level: 0.10
** Significant at real level: 0.05
*** Significant at real level: 0.01

Table 1 shows that the sigma-squared value (σ^2) is 0.0480. The low sigma-squared (σ^2) value indicates that the error term inefficiency (ui) is normally distributed. The gamma value () is 0.999 which is the ratio between the deviation of technical inefficiency (ui) to the deviation that may be caused by a random variable (vi). Statistically, the gamma value of 0.0288 shows that 99.99% of the residual variation in the model comes from inefficiency in the rice production process (ui) and the rest (1.01%) is caused by random error in measurement (vi) (noise).γ

The results of the analysis of the production function showed that the value *of the log likelihood function* estimated by the MLE method (19.069) was greater than that of the *log likelihood function* estimated by the OLS method (14.495), which showed that the production function with the MLE method showed good results and could represent field conditions.

The LR test of the one-sided rror with number of reactions = 5 of the *stochastic frontier* rice production function model was 29.069. The results of the analysis showed that from each non-chemical pesticide rice production factor, the estimated production function model of the stochastic frontier was:

The land area variable (X1) had a significant effect on the production of non-chemical pesticide rice at a real level of 0.01. The value of the variable regression coefficient of land area X1 of 0.9325 is a positive sign in accordance with expectations, meaning that an increase in land area of 1 percent will lead to an increase in non-chemical pesticide rice production by 0.9325 percent. Thus, it can be concluded that the larger the rice farming land will affect the production of non-chemical pesticide rice. In the large research area, the area owned in rice farming on an average scale is 0.25 ha. An alternative that can be done is farmers in this research area, some of whom are entitled to receive zakat, meaning that land ownership for rice farming is relatively narrow (0-0.25 ha), so it can be rented to farmers with a large area of land.

The Seed variable (X2) did not have a significant effect on the production of non-chemical pesticide rice at a real level of 0.10. The value of the variable regression coefficient of land area of -0.0137 is marked negative as expected, meaning that an increase in land area of 1 percent will cause a decrease in rice production without chemical pesticides by 0.0137%. This research is in line with (Kerdsriserm, et al., 2018) farmers must use high-quality seeds to increase efficiency, for this reason it is recommended that respondent farmers use good quality seeds. The types of varieties used in rice farming in the research area are the Ciliwung and Sintanur varieties.

The variable The use of inorganic fertilizer (X3) did not have a significant effect on the production of non-chemical pesticide rice at a real level of 0.01. The value of the variable regression coefficient of inorganic fertilizer use of 0.18779 is a positive sign in accordance with expectations, meaning that an increase in the use of inorganic fertilizers by 1 percent will cause an increase in the production of non-chemical pesticide rice by 0.18779 percent. The use of inorganic fertilizers in the study area is still used by farmers in chemical non-pesticide rice farming, but

the amount of use has decreased by more than 50% of the standard use of the amount of levels and doses used. This is done by farmers in an effort to implement environmentally friendly agriculture.

The variable of organic fertilizer use (X4) had a significant effect on the production of non-chemical pesticide rice at a real level of 0.10. The value of the variable regression coefficient of X4 organic fertilizer use of 0.00784 is a positive sign in accordance with expectations, meaning that an increase in the use of organic fertilizer by 1 percent will cause an increase in the production of non-chemical pesticide rice by 0.00784 percent. Organic fertilizers have a real effect on non-chemical pesticide rice cultivation, because the use of organic fertilizers is highly recommended for substitution/substitution of inorganic fertilizers in rice farming. The use of organic fertilizers has benefits in improving soil structure, providing organic matter in the soil, and can maintain a friendly environmental ecosystem. This research is in line with the research of [9] which states that farmers should use high-quality seeds and organic fertilizers to improve efficiency.

The variable of the use of vegetable pesticides (X5) had a significant effect on the production of non-chemical pesticide rice at a real level of 0.01. The value of the variable regression coefficient of the use of plant-based pesticides (X5) of 0.04590 is a positive sign in accordance with expectations, meaning that an increase in the use of plant-based pesticides by 1 percent will cause an increase in the production of non-chemical pesticide rice by 0.04590 percent.

The variable of labor use (X6) did not have a significant effect on the production of non-chemical pesticide rice at a real level of 0.10. The value of the variable regression coefficient of labor use (X6) of -0.00047 is marked as negative not in accordance with expectations, meaning that an increase in labor use of 1 percent will cause a decrease in the production of non-chemical pesticide rice by 0.00047 percent.

Technical Efficiency Level of Non-Chemical Pesticide Rice Farming

The technical efficiency (TE) of each farmer in the cultivation of non-chemical pesticide rice with the *cobb-douglas stohcatis frontier function approach* can be seen in the following table:

TABLE 3. Results of Technical Efficiency Analysis of Farmers in Non-Pesticide Rice Farming

Efficiency level	TE	%
< 0,70	4	13,3333
≥0,70	26	86,6667
Total	30	
Minimum	0.5472	
Average	0,8737	
Maximum	0,9997	

Table 1 shows that the average value of the technical efficiency of non-chemical pesticide rice production in the region is 0.8737, which means that the cultivation of non-chemical pesticide rice has been efficient in the research area. This is in line with the research of [17] ; [18]; [19] who stated that to achieve cassava, corn, and rice farming is efficient if the technical efficiency value is > with an average of 0.7000. However, not all respondent farmers in the study area have achieved technical efficiency. There are 86.6667% of farmers who have achieved technical efficiency, and as many as 13.3333% of farmers have not achieved technical efficiency in the non-chemical pesticide rice business.

Factors affecting Technical Inefficiencies

The results of the estimation of significant factors affecting the technical inefficiency of non-chemical pesticide rice farming are age, education, and experience of non-chemical pesticide rice farming. Signs of the parameters of the alleged analysis results that are appropriate and not as expected. The regression coefficients are marked negative

and positive. The farmer age variable had a significant effect on the technical inefficiency of non-chemical pesticide rice farming at a real level of 0.10. This research is in line with the research of [17]; [19] that education has a real effect on the technical infringement of corn and cassava farming in Lampung Province.

The farmer education variable had a significant effect on the technical inefficiency of non-chemical pesticide rice farming at a real level of 0.05. This research is in line with the research of [17]; [19]; [18] that education has a real effect on the technical infectiation of corn farming in Abuja, Nigeria, rice, and cassava in Lampung Province. Furthermore, [11] technical efficiency is significantly influenced by education. The results of the study show that farmers must apply organic inputs optimally and continue water management to control weeds (Lambert, 2022).

The farmer experience variable (Z3) had a significant effect on the technical inefficiency of non-chemical pesticide rice farming at a real level of 0.01. This research is in line with the research of [17]; [19] that farming experience has a real effect on the technical differentiation of corn farming in Abuja, Nigeria and cassava in Lampung Province. Other researchers also [11] also stated that farming experience has a significant effect on technical inefficiencies. Past experiences, both success and failure, are a source of information for farmers in rice farming, the application of rice technology innovations, and decision-making on rice farming. The longer the farming experience, the more information sources that can be used in farming management.

CONCLUSIONS

Based on the results and discussion, it can be concluded that: (1) The factors that had a significant effect on the production of non-chemical pesticide rice were the area of agricultural land (X1), organic fertilizer (X4), and vegetable pesticides (X5), while the factors that did not have a significant effect on the production of non-chemical pesticide rice were the seed variable (X2), the inorganic fertilizer variable (X3), and the rice farming labor variable (X6), (2) The average value of technical efficiency of non-chemical pesticide rice production in the region is 0.8737, which means that the cultivation of non-chemical pesticide rice has been efficient, because the technical efficiency value is with an average > 0.7000. However, not all respondent farmers in the study area have achieved technical efficiency. There are 86.6667% of farmers who have achieved technical efficiency, and as many as 13.3333% of farmers have not achieved technical efficiency in the non-chemical pesticide rice business, and (3) Significant factors affecting the technical inefficiency of non-chemical pesticide rice farming are age, education, and experience in non-chemical pesticide rice farming.

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