AMERICAN-EURASIAN JOURNAL OF SUSTAINABLE AGRICULTURE
ISSN: 1995-0748, EISSN: 1998-1074
2016, volume(10), issue(5): pages (21-27)
Published Online 23 October 2016 in http://www.aensiweb.com/AEJSA/

Analysis of The Technical Efficiency Of Organic Rice In Tasikmalaya Regency Indonesia

[1,2]Candra Nuraini, [3]Dwidjono H. Darwanto, [3]Masyhuri, [3]Jamhari

[1]Ph.D Student of Agribusiness Management, Faculty of Agriculture, Universitas Gajah Mada, Yogyakarta, Indonesia
[2]Lecturer of Departemen of Agribusiness, Faculty of Agriculture, Universitas Siliwangi, Tasikmalaya, Indonesia
[3]Lecturer of Departemen of Agribusiness, Fakulty of Agriculture, Universitas Gajah Mada, Yogyakarta, Indonesia

Received 12 July 2016; Accepted 20 October 2016

Address For Correspondence:
Candra Nuraini, Ph.D Student of Agribusiness Management, Faculty of Agriculture, Universitas Gajah Mada, Yogyakarta, Indonesia
Tel: +6281235000232; E-mail: candranuraini12@gmail.com

ABSTRACT

This study aims at analyzing farmer's level of technical efficiency in the use of factors of production and the factors affecting the level of technical inefficiency. It was conducted in Tasikmalaya Regency as a centre for organic rice in Indonesia with both national and international certifications. The sample of the study was 117 people selected by a multistage random sampling. The data used were both primary and secondary data. The data analysis was carried out by the computer program Frontier 4.1 with a Cobb-Douglas stochastic frontier model. The results of the study show that the variables that partially had significant effect on organic rice production were land size, seeds, and labors, while the variables that did not have significant effect on organic rice production were manure, liquid fertilizer, and vegetable pesticide. The mean value of technical efficiency among organic rice farmers was 0.89, meaning that the current organic rice production is inefficient yet but the remaining 11% is an opportunity to increase the production. The variables with significant effect on the inefficient production were farmers' experience and status. The variables of age, education, and family members did not have significant effect.

KEY WORDS
Organic rice, stochastic frontier, technical efficiency, inefficiency

INTRODUCTION

Organic agriculture plays an important role to preserve the number of plant and animal species that exist in environmental area. According to International Federation of Organic Agriculture Movements (IFOAM), organic agriculture is "a production system that sustains the health of soils, ecosystems and people. It relies on ecological processes, biodiversity and cycles adapted to local conditions, rather than the use of inputs with adverse effects. Organic Agriculture combines tradition, innovation and science to benefit the shared environment and promote fair relationships and a good quality of life for all involved." [7]

Organic farming is one of the sustainable farming systems. The objectives of organic farming are to stabilize and increase production crops in a sustainable manner by improving soil fertility, environmental sustainability, and ecosystem biodiversity conservation [6]. Organic farming will also increase the nutrient values of product and reduce pesticide residues within it [14]. Even it allows the higher price of crops in market [9].

One of the commodities cultivated by using the organic farming system is organic rice. One of the regions that have successfully developed the organic rice farming is Tasikmalaya Regency with areas of 120,245 Ha and most organic rices were exported with amount of 580,323 kg until 2014. The export was carried out to the United States of America, Malaysia, Singapore, Germany, Belgium, Italy, Dubai, and Netherlands. This shows that organic rice has a high competitive value at the international level. In the tight competition at global level, it is necessary to maintain such competitive position and competitive excellence. This can be done by enhancing both efficiency and effectiveness in a sustainable manner.

However, farmers faced many problems related to technical/technological aspect, financial capital, difficult access to market and information, institutional constraints, and unaffirmative government policies. For example, in relation to the technical/technological aspect, farmers generally have insufficient understanding and knowledge about the ways to allocate the factors of production. According to Ellis [5] and Sumaryanto et al. [15], efficiency in the rice farming can be caused by technical inefficiency, so that the maximum productivity rate cannot be achieved; it means that each unit of the input bundles cannot produce maximum production.

In daily practice, farmers' orientation in a relatively homogenous area and ecosystem is to pursue technical efficiency through the efforts of maximizing the productivity. Meanwhile, Coelli, et al. [4] argued that the factors that increase productivity are: (1) technological change, (2) increase in the technical efficiency, and (3) economies of scale. New technologies can move the production curve up and affect the increase of productivity with combined inputs. Thus, to increase the organic rice production and productivity, it is necessary to manage the factors of production to be efficient technically using the production frontier function.

Ogundari and Ojo [12] said that the technical efficiency is a farming capacity to produce a maximum output from the use of input bundle. Allocative efficiency is a farming capacity to use the inputs with an optimal proportion at the constant prices of factors of production and production technologies. Such combination of technical efficiency and allocative efficiency becomes economic efficiency.

To estimate the level of efficiency, the stochastic frontier functions that were more widely introduced by Aigner, Lovell and Schmidt [1] and Meeusen and Van den Broeck [12] was used. Coelli et al. [4] argued that production frontier is a production function that describes a maximum production that can be achieved from each use of certain input. If a farming activity is at the point of the frontier production function, it means that the farming is technically efficient. If the frontier profit function was known, the technical inefficiency can be estimated by a comparison of relative actual position and the frontier. Inefficiency is a main problem in farming activity, because it will affect the farming productivity. Many studies on efficiency were conducted in a variety of commodities.

A study conducted by Murniati, et al., [11] on the technical efficiency of organic rice in rainfed rice land showed that the level of technical efficiency that could be achieved by farmers varied, ranging from 0.423 to 0.999, with a mean value of 0.836. It means that the farming was technically efficient but still allow the farmers to increase crop production up to 16.39% through better management. The study also found out that education, experience in the organic rice farming, age, frequency in attending extension, and farmers' perception on climate change significantly affected to reduce technical inefficiency.

A study conducted by Rahman [13] showed that in order to examine the technical efficiency of rice farming in Bangladesh, a Cobb-Douglas stochastic production function approach was used. The results of the study showed that the level of technical efficiency was 0.84. The variables that affected the factors of production included land size, labors, seeds, fertilizers, manure, ox strength, and irrigation cost. Meanwhile, the variables that affected inefficiency included age, education, experience, extension contact (as dummy), and land size. Finally, the variables with negative effect on technical inefficiency included age, experience, extention contact, and land size.

From the results of previous studies, it can be concluded that the sources of inefficiency that affected the technical efficiency were land ownership status, education, rice farming experience, extention contact, infrastructure, soil fertility, income outside of agricultural sector, age, frequence to attend extension, farmers' perception of climate change, land fragmentation, and access to micro finance. In this study, the variable of farmers' certification and non-certification status was added. Difference in farmers' status leds to different management practices in the farming application.

Backman, et.al. [2] said that The measurement of efficiency needs the determination of factors that influence the overall efficiency. The approach that is commonly used to do this is the determination of inefficiency index (considered as the dependent variable), and then regress the dependent variable against a set of explanatory variables that are considered to affect the efficiency levels.

Based on the explanation above, the study aims at analyzing the level of technical efficiency in organic rice farming in the use of factors of production and the factors affecting the level of technical inefficiency.

MATERIAL AND METHODS

The study was conducted with samples selected by a purposive sampling technique in Tasikmalaya Regency as one of the organic rice centers in Indonesia with both international certification from Institute for Marketecologi (IMO) and the Indonesian Organic Farming Certification (INOFICE). It was also focused on Farmers Group *Simpatik* as the certified organic rice farmers association and the main producers of organic rice.

Population in the study consisted of farmers in organic rice farming with certification and non-certification status (in a conversion period). The sample of the study was selected by using a multistage random sampling technique and the number was determined using a Solvin formula i.e. 117 farmers, consisting of 90 people with certification status and 27 people with non-certification status.

The data used were primary and secondary data. The former was collected through interviews, while the latter was collected from the relevant instances such as the Subdepartment of Agriculture, the Central Bureau of Statistics, the Farmers Group *Simpatik*, and agricultural extension office. The data were analyzed by an analysis method using the stochastic frontier production function with translog model using an empirical equation as follows:

$$lnY = \beta_0 + \sum_{j=1}^{6} \beta_j lnX_j + \frac{1}{2}\sum_{j=1}^{6}\sum_{k=1}^{6} \beta_{jk} lnX_j lnX_j + (v - u)$$

Description:
Y = production (kg)
X_1 = land area (ha)
X_2 = seed (kg)
X_3 = manure (kg)
X_4 = liquid fertilizer (liters)
X_5 = vegetable pesticides (liters)
X_6 = Labor (manday)
v = random variables related to external factors
u = random variables related to internal factors or effect of inefficiency

The function of technical inefficiency is:

$$u_i = \delta_0 + \sum_{m=1}^{5} \delta_m Z_m + \mu$$

Z_m = variables that explain the effects of inefficiencies with the variable name:
Z_1 = age of farmers (years)
Z_2 = education of farmers (years)
Z_3 = organic rice farm experience (years)
Z_4 = the number of family members (person)
Z_5 = dummy farmer status, 1 = certified farmers
0 = no certified farmer
u = random variables related to internal factors or effect of inefficiency
μ = random mistake of technical inefficiency

The level of technical efficiency of farming is calculated from the ratio of output observationto output limits, using the formula (Coelli, 1996) [3] :

TE of_i =Yi/Yi*= $\frac{\exp(xi\beta + vi - \mu i)}{\exp(xi\beta + vi)}$ = **exp (-ui)**
TE of_i = E [exp ($-u_i$) | e_i] i = 1,2,3….n

Description :
TE of = technical efficiency of organic farmers-si
Yi = the amount of production of the i-th (Y potential)
Yi * = the amount of production expected in the observation of the i-th E [exp (-ui) | ei]
= the expected value (mean) of u, the condition oi, so 0 ≤ Tei ≤ 1.

RESULTS AND DISCUSSION

1. Analysis of Organic Rice Production Function in Tasikmalaya Regency:

Analysis in the study was carried out using the computer program Frontier 4.1 with a Cobb-Douglas stochastic frontier model with an estimation method of Maximum Likelihood Estimated (MLE). The results of analysis were presented in Table 1.

Table 1: Frontier Production Function in Organic Rice Farming, 2015

Variables	Parameter	Coefficient	Standard-error	T- Ratio
Intercept	β0	8,625	0.613	14.072
Land size (X_1)	β_1	0.899***	0.118	7.627
Seeds (X_2)	β_2	0.155***	0.075	2.069
Manure (X_3)	β_3	0.023	0.028	0.822
Liquid fertilizer (local microorganism) (X_4)	β_4	0.009	0.027	0.359
Vegetable pesticide (X_5)	β_5	0.040	0.041	0.978
Labors (X_6)	β_6	-0.188**	0.111	-1.695
Sigma-squared (σ2s = σ2v+σ2u)		0.254	0.157	1.681
Gamma (γ = σ2u+ σ2s)		0.911	0.055	16.377
log likelihood function		61.691		
LR test of the one-sided error		23.239		
Mean efficiency		0.895		

Source: The primary data were processed, 2015
Where:*** = significant at α = 0.01; ** = significant at α = 0.05
t-Table α 0.0% = 2.6 t-Table α 0.05% = 1.97 , t-Table α 0.10% = 1.65

Table 1 shows that the variable that partially had a significant effect at an error rate of 1% was land size (X_1), that with a significant effect at an error rate of 5% was seeds (X_2), and that with a significant effect at an error rate of 10% was labors. The variables with no significant effect were manure (X_3), liquid fertilizer/ local microorganism (X_4), and vegetable pesticide (X_5).

The parameter value of gamma (γ) was 0.911, which was significant at α = 1%. The gamma (γ) value was a ratio of deviation in technical inefficiency (ui) to deviation that was possibly caused by random factors (vi). Statistically, the value was 0.911, meaning that 91.12 % of the errors in production function was caused by the factors of technical inefficiency. Thus, the errors were not caused by the variables of random errors such as weather effect, disease pest attack, and error in modeling. This explaines that all variations in the organic rice farming production in Tasikmalaya Regency did not occurred incidentally, but caused by the factors of technical inefficiency associated with managerial farming-related problems.

The sigma squared (σ2) value was 0.254. Statistically the value shows that 25.4 per cent of the error variable in the production function indicates a technical efficiency or variation in crop production among farmers due to different technical efficiency, while the remaining 74.6 per cent was caused by both stochastic effect and errors in modeling.

The value of restriction parameter in likelihood ratio test was 23.24. It was higher than a critical value of Kodde and Palem table [8], i.e. 22.53 at a significance level of 1%. It shows that there was the effect of inefficiency in the model that was stochastic in nature, thus describing that the organic rice farming activity was inefficient yet.

Estimation parameter in the Cobb Douglas Stochastic Frontier production showed the elasticity of production for the inputs used. Table 1 indicate that the elasticity of production for land size (X_1) and seed (X_2) significantly affected the organic rice production, while labors (X_6) had negative effect. Meanwhile, the variables of organic fertilizer (X_3), liquid fertilizer (local microorganism) (X_4), and vegetable pesticide did not had significant effect.

Land Size (X_1):

Coefficient value in the variable of land size was 0.93. The variable had a positive significant effect on organic rice production at a confidence level of 99%. The coefficient value showed that the elasticity of production for land size used was 0.93. It means that the addition of 1% land size and other inputs are constant can increase the organic rice production in the site of the study for 0.93%.

This condition explains that the land size of organic rice farming was positively correlated with the harvest size of rice plant, thus affecting the increase of rice production. This can be done by the addition of land areas for organic rice farming through opening new lands or converting from the lands for conventional farming to those for organic farming. The effort was pursued by the Government through several programs to achieve the goals of *Go Organic* national program.

Seeds (X_2):

The coefficient value of seed number (X_2) was 0.202. The variable had a positive significant effect on the organic rice production at a confidence level of 99%. The value of seeds showed that the elasticity of production for seeds used was 0.93. It means that the addition of 1% seeds and other inputs are constant can increase the rice production for 0.202%. The condition explains that seeds number in organic rice farming was positively correlated with the number of rice plant shoots, thus affecting the increase of organic rice production.

Organic fertilizer (X_3):

The coefficient value of organic fertilizer (X_3) was 0.021. The variable had a positive significant effect on organic rice production. The coefficient value shows that the elasticity of production for organic fertilizer used was 0.021. It means that the addition of 1% organic fertilizer and other inputs are constant can increase organic rice production in the site of study for 0.021 %. It shows that the addition of organic matters will also increase fertility, thus increasing the growth of rice plant. The increased growth of plant can increase the crop production.

Liquid fertilizer (X_4):

The coefficient value of liquid fertilizer (local microorganism) (X_4) was 0.017. The variable had a positive significant effect on organic rice production. The coefficient value shows that the elasticity of production for liquid fertilizer used was 0.017. It means that the addition of 1% liquid fertilizer and other inputs are constant can increase organic rice production in the site of the study for 0.017 %.

Liquid fertilizer/local microorganism contains micro- and macro-nutrients as well as bacteria with potential to decay organic matters in soil, as the stimulator of plant growth, and pest and disease control. Thus, the larger the addition of local microorganism, the higher the stimulator of plant growth, thus increasing the corp production.

Vegetable pesticide (X_5):

The coefficient value of vegetable pesticide (X_5) was 0.056. The variable had a positive but not significant effect on organic rice production. The coefficient value shows that the elasticity of production for vegetable pesticide used was 0.056. It means that the addition of 1% vegetable pesticide and other inputs are constant can increase organic rice production in the site of the study for 0.056 %.

Pest and disease control was done by bio-pesticide and vegetable pesticide. The disease control by bio-pesticide can be carried out using bio-agents, while the vegetable control can be done by vegetable pesticide.

Labors (X_6):

The coefficient value of labors (X_6) was -0.28. The variable had a negative significant effect on organic rice production at a confidence level of 95%. The coefficient value shows that the elasticity of production for labors used was -0.28. This means that the addition of one unit of labor and other inputs are constant can reduce organic rice production in the site of the study for 0.28%.

2. Analysis of Technical Efficiency and Inefficiency:

2.1 Analysis of Technical Efficiency:

T-test was done to examine the level of technical efficiency in the organic rice. The hypotheses proposed were: (a) Ho: There is no difference between average technical efficiency and 1 (equal to 1), and (b) Ha: There is difference between average efficiency and 1 (equal to 1).

The levels of technical efficiency achieved by the organic rice farmers varied, ranging from 0.55-0.97 with mean of 0.89. From the results of t-test, it can be known that the significance value was < 0.05, thus Ho was rejected and Ha was accepted. This means that the organic rice farming activity was technically inefficient. The mean value of 0.89 achieved was inefficient. This shows that the farmers cannot averagely achieve the level of potential production based on the use of the combined production inputs and there is still 11% opportunity for the improvement of organic rice production in Tasikmalaya Regency.

Table 2: Distribution Value Technical Efficiency Organic Rice Growers 2015

Group Technical Efficiency	Technical Efficiency Index	
	Total (n)	Percent (%)
0.5 ≤ TE < 0.6	3	1.28
0.6 ≤ TE < 0.7	5	2.14
0.7 ≤ TE < 0.8	6	2.56
0.8 ≤ TE < 0.9	71	30.34
0.9 ≤ TE < 1.0	149	63.67
Total	234	100
Average	0.89	
Minimum	0.55	
Maximum	0.97	

Source: Primary data, processed in 2015

Table 2. shows that the distribution of the value of technical efficiency, namely: (1) farmers 149 respondents (63.67%) have efficiency values in the range 0.9 to 1, (2) farmers whose efficiency is in the range 0.8 to 0.9 as many as 71 farmers (30.34%), (3) 6 farmers (2.56%) have efficiency values in the range 0.7 to 0.8, (4) 5 farmers (2.14%) have efficiency values at the range of 0.6 to 0.7 and (5) 3 farmers (1.23%) have efficiency

values in the range 0.5 to 0.6. The average value achieved technically efficient of 0.89 with the lowest value of 0.55 and a highest value of 0.97.

2.2 Sources of Technical Inefficiency:

The estimation of technical inefficiency from the production function model can be shown in Table 3.

Table 3: Stochastic Frontier Production Function Model of Technical Inefficiency

Variables	Parameters	Coefficients	Stand Error	t-ratio
Constant	β_0	4.1678	0.2310	1.804
Age of famers	β_1	-0.4893	0.4148	-1.564^{ns}
Education of famers	β_2	-0.5159	0.4693	-1.099^{ns}
Experience	β_3	-1.2336	0.6680	-1.847*
Family members	β_4	0.4537	0.2944	1.541^{ns}
Farmer status	β_5	-1.0205	0.5679	-1.797*

Source: The primary data processed, 2015
Where :*** = significant at α = 0.01; ** = significant at α = 0.05 *=significant at α =0.10
t-Table α 0.0% = 2,6 t-Table α 0.05% = 1,97 , t-Table α 0.10% = 1,65

The factors of inefficiency with negative significant effect on production were experience (Z_3) and farmers status (Z_5) at α = 0.01. It means that the higher the farmer's experience in the farming, the higher the farmer's level of efficiency. With farmer's certification status, the level of efficiency in the farming increased. The condition was the effect of farming management in the organic farming.

Meanwhile, the factors of inefficiency such as age (Z_1) and education (Z_2) had negative and insiginificant effect on the technical inefficiency of farming. In view of age, the older the farmers, the higher the level of efficiency in farming. The condition can be seen in the farmers' age in production. Meanwhile, in view of education, the higher the education achieved by farmers, the higher the level of efficiency of farming. With formal education, the farmers have better capacity to apply new technologies and allocate the existing resources in an optimal manner. Meanwhile, family members had positive but insignificant effect on the technical inefficiency of rice farming. This means that the lower the family members, the higher the level of efficiency in farming. The smaller family members allow the farmers allocating their funds maximally, thus increasing the crop production. The organic rice farming system requires sufficiently large costs to meet the needs for production inputs, particularly for the farmers with short experiences in applying the organic farming system.

Conclusion:

1. The variable that partially had a significant effect at an error rate of 1% was land size (X_1), that with a significant effect at an error rate of 5% was seeds (X_2), and that with a significant effect at an error rate of 10% was labors. The variables with no significant effect were manure (X_3), liquid fertilizer/ local microorganism (X_4), and vegetable pesticide (X_5).
2. The organic rice farming activity was technically inefficient. The mean value of 0.89 achieved was inefficient.
3. The factors of inefficiency with negative significant effect on production were experience (Z_3) and farmers status (Z_5) at α = 0.01. And the factors of inefficiency such as age (Z_1) and education (Z_2) had negative and insiginificant effect on the technical inefficiency of farming.

Suggestion:

The increase of crop production and productivity can be done through the increase of technical efficiency as it still has opportunity to increase the technical efficiency. This can be done by combining some factors of production such as lands, seeds, fertilizers, and labors based on the rules determined or by applying organic farming technology based on standardization. Moreover, the farmers that did not attend the certification program can follow the certification process as one of the ways to implement the better farming management practices based on the organic farming standardization.

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