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Efficiency of organic rice farming in Bantul Regency Special Region of Yogyakarta, Indonesia

*Istiyanti, E., Rahayu, L. and Sriyadi

Departement of Agribusiness, Faculty of Agriculture, Universitas Muhammadiyah Yogyakarta, Jl. Brawijaya, Tamantirto, Kasihan, Bantul, Yogyakarta 55183 Indonesia

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Abstract

The impact of excessive use of chemical fertilizers and pesticides that can disrupt health and environment has encouraged the development of organic cultivation systems. The objectives of the study are to identify the effectiveness of the implementation of the Standard Operational Procedure (SOP) of organic rice. In addition, it also aims to analyze the technical efficiency and the factors that affect the technical inefficiency of organic rice farming. The research was conducted under a survey design located in Bantul, Special Region of Yogyakarta. Census sampling was applied to all organic rice farmers who joined the union farmer group named 'Mitra Pertanian' as the respondents. The Cobb-douglass frontier production function was used to analyze the technical efficiency. The results show that the level of effectiveness of SOP implementation of organic rice farming by farmers was high that equals to 71.26%. Factors production area of land, seed and manure have significant effect on the production of organic rice with positive coefficient, while petroganic fertilizer has significant effect with the negative coefficient. The average level of technical efficiency of organic rice farming in Bantul Regency is 0.71, which means that the organic rice farming in Bantul Regency is efficient enough. To improve the technical efficiency of organic rice farming, farmers are suggested to use more organic fertilizer. Meanwhile, the level of farmers' education shows significant effect on technical inefficiency in the organic rice farming. On the other hand, farmers' age, farming experience and the land status do not significantly affect the technical inefficiency. Therefore, in organic rice farming, it is necessary to increase knowledge and skills through non-formal education rather than that of through formal one.

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Introduction

The rise of food demands has encouraged farmers to increase crop productivity and develop food diversity. Green revolution is one of the successfully-developed alternatives to increase the crop productivity. Unfortunately, humans do not realise that the use of chemical fertilizers and pesticides in the green revolution is less wise to their life. Due to the exploitation of the nature, it then loses its balance which ultimately leads to negative impacts on humans life (Sulistyaningsih, 2012). The use of chemical inputs will decrease soil fertility, decline the biodiversity and increase pest, disease and weed attacks. Public awareness on the risk of the chemical fertilizers and pesticides use towards health and environment has brought the transition of cultivation to organic systems. According to Prihtanti *et al.* (2013), the advantages obtained by implementing the organic farming is to ease the soil processing and to provide the friendly environment.

One of the organic farming products is rice, which becomes Indonesia main staple food. The positive sides of having organic rice compared to non-organic rice is that it doesn't contain any chemical residue, has softer texture and staying fresher for more extended period of time. Besides, the price of organic rice is higher than non-organic rice which means more benefits will be earned by farmers (Andoko, 2005). Therefore, to maximize the production of organic rice, it is important to employ an efficient management.

Efficiency is defined as actual productivity relative towards the maximum potential productivity, Farrel in Coelli *et al.* (1998). Efficiency has two components namely technical efficiency and allocative efficiency. Technical efficiency is farming ability to produce the maximum output from some inputs (input oriented) or farming ability using input as small as possible to produce a certain amount of output (output oriented).

*Corresponding author.
Email: eniistiyanti@umy.ac.id

Organic rice has an important meaning for Indonesia. First, there is a high demand of overseas market for organic rice with higher price. The export of organic rice from Indonesia in 2016 was still under 1,000 tons with the destination countries of the United States, Hong Kong, EU, Malaysia, Singapore and Australia. Second, organic rice can increase Indonesian farmers' income. The results of research in several regions in Indonesia such as Klaten Regency, Cianjur and Sragen indicate that organic rice provides greater benefits in terms of farmers' financial condition. Third, organic rice is safer for health. Fourth, from the side of environmental sustainability, organic rice farming system is able to restore the fertility of paddy fields which can also improve the ecosystem. The organic farming system always utilizes natural resources in a sustainable manner (Mayrowani, 2012).

The total area of organic rice farming in Indonesia is about 5% of the total rice fields or about 630,000 ha with average productivity of 7.8 tons of rice/ha. However, the level of productivity in each region in Indonesia varies. One example, in Kulonprogo Regency, the lowest productivity was 3.3 ton/ha and the highest was 10.6 ton/ha. Most farmers could produce between 6-8 ton/ha (Rusiyah *et al.*, 2012). While the productivity of organic rice in Tasikmalaya Regency was 6.054 ton/ha and which was higher than the conventional rice that was 4.67 ton/ha (Machmuddin *et al.*, 2016). If compared to the productivity level in other countries, in Nepal for instance, the organic rice productivity was 3.15 ton/ha higher than non-organic that was 2.9 ton/ha (Adhikari, 2011). While different conditions occured in the Philippines, where organic rice productivity was 3.25 ton/ha lower than the conventional one which was 3.52 ton/ha (Mendoza, 2004).

Although Indonesia has launched the "go orgnic" program since 2010 and since that various policies have been implemented; however, the development of organic agriculture still faces various problems. The problems include: 1) the considerably low interest of farmers' for organic farming due to market uncertainty, 2) the lack of farmers' understanding about organic farming IFOAM (International Federation of Organic Agricultural Movement) and Indonesia National Standard, 3) the limited organization of organic farming supporters such as farmer groups, organic product certification institutions and 4) the lack of partnerships between farmers and entrepreneurs for the export of organic products (Mayrowani, 2012).

The possibility to increase the organic rice productivity is substantial and the productivity improvement by using technical efficiency is the right choice. The level of technical efficiency of organic rice farming in various regions in Indonesia are varied. In fact, in Sragen, the technical efficiency was of 0.7 (Prayoga, 2010), Tasikmalaya was 0.86 (Machmuddin *et al.*, 2015), and Riau was 0.87 (Bahasoan, 2013). Overall, the level of technical efficiency in organic rice farming is still lower compared to the conventional rice farming which has reached 0.919 (Kusnadi *et al.*, 2011). Thus, it can be concluded that the organic rice farming is not easy to develop widely. This is caused by farmers' lack of knowledge about organic rice (Hossain *et al.*, 2007), and by the insignificant price gap between organic rice and conventional rice at the level of farmers' (Pornpratansombat *et al.*, 2011). In addition, the organic rice farming requires more labors, especially to prepare the organic fertilizers and pesticides.

To address the aforementioned challenges the Standard Operating Procedure-Good Agriculture Practice (SOP-GAP) of organic rice farming is necessary to be implemented for it my also serve as guideline for farmers to produce healthy rice, keep environment sustained and increase their income. The level of SOP-GAP implementation is influenced by internal factors of farmers such as education level, age land area and availability of capital. While the external factors include input and output prices (Sriyadi *et al.*, 2015).

Based on the phenomenon above, this research have three objectives namely: 1) to identify the effectiveness of the implementation of organic agricultural SOP; 2) to analyze the technical efficiency of organic rice farming; and 3) to identify factors causing the sources of technical inefficiency of organic rice farming in Bantul Regency, Special Region of Yogyakarta.

Materials and methods

The research was conducted in Bantul Regency, Special Region of Yogyakarta using descriptive analysis under survey method. Census sampling was applied to all organic rice farmers who joined the union farmer group named '*Mitra Pertanian*' which consisted of 42 farmers including the owners (farmers who own the land and cultivate their own lands), renter (farmers who rent lands by paying rent and cultivate those land by themselves), and tenants (farmers who do not have lands, but cultivate someone's lands with shared harvest system). This farmers group of '*Mitra Pertanian*' has obtained a certification on hygienic rice from the local food safety agency and won the 3rd place in the Special

Region of Yogyakarta Province level. Primary data was collected through Focus Group Discussion (FGD), interview with questionnaire and observation guide.

The first objective is to identify the effectiveness level on the implementation of the Standard Operational Procedure (SOP) in organic rice farming which was measured using the achieved score. The score was obtained from respondents in planting, maintening, harvesting and post-harvest processing. The score has four (4) scales. In analysing the data, SPSS 15 and Frontier 4.1 aplication were used to answer the second and the third objectives. The production function in this study employed the stochastic frontier production function as developed by Coelli *et al.* (1998). Stochastic frontier production function had the Cobb-douglass formula, which was transformed into linear natural logarithm as written in equation 1:

$$LnY = Ln\alpha + \beta 1 LnX1 + \beta 2 LnX2 + \beta 3 LnX3 + \beta 4 LnX4 + \beta 5 LnX5 + (vi\text{-}ui) \quad (1)$$

Where,

Y =	Production of organic rice (kg)
α =	Constants
β1- β5 =	Estimated parameters
X1 =	Land area (m2)
X2 =	Seed (kg)
X3 =	Manure (kg)
X4 =	Petroganic Fertilizer (kg)
X5 =	Labour (days)
(vi-ui) =	error term (inefficiency effect in the model)

Technical efficiency is measured using the formula in equation 2:

$$TE_i = E [\exp (-Ui / € i)] \quad (2)$$

Where : i = 1, 2, 3, ... 42

Farming is categorized as technically efficient if the value of TE> 0.7

Results and discussion

Level of effectiveness on the SOP implementation of organic rice farming

Level of effectiveness of the Standard Operational Procedure (SOP) implementation organic rice farming was measured using score of achievement of respondents in organic rice farming which includes planting process, maintaining, harvesting and post-harvesting. Based on these indicators, the average score acheived and the level of effectiveness of organic rice SOP implementation was obtained.

Table 1. Average score achievement and level of implementation effectiveness standard operating procedure of organic rice farming in Bantul Regency

No	Standard operating procedure	Average score	Effectiveness (%)
1	Seed	3.30	76.77
2	Seed treatment	3.27	75.76
3	Planting	3.42	80.81
4	Fertilization	2.76	58.59
5	Weeding	3.27	75.76
6	Pest control	2.70	56.57
7	Irrigation	3.09	69.70
8	Harvest	3.33	77.78
9	Post-harvest	3.18	72.73
10	Milling	3.30	76.77
11	Sorting and packaging	2.88	62.63
	Average	3.14	71.26

Based on Table 1, it is known that the achieved score on the organic rice SOP implementation is high with score 3.14 out of 4, while the effectiveness of its implementation is 71.26%. This situation is in accordance with the research conducted by Sriyadi *et al.* (2015), who mentions that the majority of organic rice farmers always implement the Standard Operating Procedure-Good Agriculture Practice (SOP-GAP) of organic rice farming, which include land, seeds, fertilizers, pesticides, tools, cultivation, planting, fertilizing, irrigation, pest control, harvesting and post-harvest. Similar results are shown by Sumarsoso *et al.* (2017) who claims that 68.33% of organic rice cultivation farmers was in the high category, 31.66% was in the moderate category and none was in the low category. Of this situation is different from the results of research by Suharni *et al.* (2017) which refute that the application of GAP (Good Agriculture Practices) of shallots in Bantul Regency was low.

Although the effectiveness of the implementation of SOP is high, there are some components in the SOP which is still below the average on the fertilization, pest control, irrigation and sorting and packaging. The dose of fertilizer used by respondents is appropriate but the time of fertilization and the type of fertilizer are not appropriate yet. The suitable fertilization time is between 15-25 days after planting, however, some respondents did the fertilization part less than 15 days after planting. According to fthe SOP, respondents should add organic liquid fertilizer, yet, only few respondents added the liquid fertilizer.

Most respondents have already sorted the rice,

Table 2. Estimation of cobb-douglass production function with frontier approach of organic rice farming in Bantul Regency

No	Parameter	Variable	Coefficient	Standard error	T tes
1	A	Constant	0.8972***	0.2861	3.1360
2	β1	Land	0.7568***	0.0816	9.2776
3	β2	Seed	0.3625*	0.1927	1.8812
4	β3	Manure	0.0150**	0.0064	2.3355
5	β4	Petroganic	-0.0825***	0.0090	-9.1932
6	β5	Labor	-0.0944^{ns}	0.1149	-0.8214
		Sigma-squared	0.3517	0.0687	5.1208
		Gamma	0.9999	$0.299.10^{-7}$	0.346.1
		Log-likelihood MLE	-1.626		0^{8}
		Log-likelihood OLS	-12.919		
		LR test of error	22.585		

Information:

*** : significant effect on α 1%

** : significant effect on α 5%

* : significant effect on α 10%

ns : non significant

however, they have not packaged the rice according to the SOP. The respondents sell the rice to the union farmers groups using sacks with no measurements of packing as stated on the SOP namely 5 kg, 10 kg and 25 kg.

Analysis of production function

The production function used in this study is a stochastic frontier in the form of the cobb-douglass production function. The dependent variable in the production function is organic rice production while the independent variables including the land area, seed, manure, petroganic fertilizer and labour. The average land used for organic rice farming is 968.8 m^2 with an average production of 357.8 kg of rice. Farmers use 4.93 kg of seeds with 'Pandan Wangi' variety. The organic fertilizer used consisted of manure with average use of 212.6 kg and petroganic fertilizer of 83.5 kg. The labour used is their own family members with an average use of 14.19 working days for cultivating, planting, maintaining, harvesting and post-harvesting.

Based on Table 2, the value of gamma in the model is 0.9999, statistically > 0, it means that the production variation in organic rice farming occurs not by chance but it is actually because of the technical inefficiency. The sigma-square (variance) value is 0.3517 and it is significant to be interpreted as production variation contributed by technical inefficiency of 35.17%. The value of log likelihood MLE (-1.62) is higher than log likelihood OLS (-12.919), it means the production function with MLE method is better and by conditions in the field.

The production factors area of land, seed and manure have a positive coefficient and it shows the significant effect on the production of organic rice. It means that if land, seed or manure are added, the production of organic rice will increase. Petroganic fertilizer has a negative coefficient but is responsive to production. It can be interpreted that if the petroganic fertilizer is added, it will have an impact on the decrease of organic rice production. Labour has a negative coefficient and does not affect the production of organic rice. Similar results are shown by Machmuddin *et al.* (2016), who mentioned that land, seed, manure and labour in the family and outside of the family have a positive coefficient and were responsive to the production of organic rice.

Technical efficiency of organic rice farming

The result of technical efficiency analysis using frontier production function model presented in Table 3 shows that the average level of technical efficiency of organic rice farmers in Bantul Regency, was 0.71 and it means that it was efficient because the value was > 0.7 (Coelli *et al.*, 1998). The number of farmers who can achieve technical efficiency level > 0.7 are 26 people. It can be said that more than 60% organic rice farmers are efficient. Farmers whose technique is efficient are those who actively

participates in training organized by the union farmer groups such as training on the manufacture of organic fertilizer.

Table 3. Distribution and level of technical efficiency of organic rice farming in Bantul Regency

Level of technical efficiency	Amaount (person)	Percentage (%)
0.000-0.100	0	0
0.101-0.200	0	0
0.201-0.300	2	4.76
0.301-0.400	2	4.76
0.401-0.500	5	11.90
0.501-0.600	3	7.14
0.601-0.700	4	9.52
0.701-0.800	10	23.81
0.801-0.900	7	16.67
0.901-1.000	9	21.43
Mean technical efficiency	0.7114	
Number of respondents	42	
Minimum value	0.2597	
Maximum value	0.9998	

Organic rice farming in Bantul Regency has higher efficiency than organic rice farming in other areas, such as Sragen Regency which equals to 0.7 (Prayoga, 2010). However, its value is still lower than organic rice farming in Tasikmalaya Regency which was 0.86 (Machmuddin *et al.*, 2016), lower than rice farming of the integrated crop management program in Riau Regency which was 0.87 (Bahasoan, 2013). Moreover, if compare to West Java Province which was 0.742 (Tinaprilla *et al.*, 2013) and five provinces of central rice in Indonesia amountly 0.919 (Kusnadi *et al.*, 2011), the result of this research has lowest level of technical efficiency. This level of technical efficiency is also lower than the technical efficiency of rice farming in some countries such as in Vietnam with 0.816 (Khai and Yabe, 2011), Cambodia with 0.786 (Kea *et al.*, 2016), Pakistan with 0.91 (Abedullah *et al.*, 2007) and Nigeria with 0.77 (Kadiri *et al.*, 2014)

Based on Table 4, it is known that there is a correlation between the level of technical efficiency of organic rice farming and the status of land ownership, land area and the use of organic fertilizer. Twelve out of the 26 farmers who technical efficient are owners. The farmers owners are more technically efficient than those of the renters and tenants. Given the land as the only natural resource owned by farmers, the farmers will manage the land as well as possible.

Table 4. Distribution of technical efficiency level based on land status, land area use of organic fertilizer and level of implementation SOP of organic rice farming in Bantul Regency

Variable	TE < 0.7		TE >0.7	
	Amount (person)	Percentage (%)	Amount (person)	Percentage (%)
Land status:				
Owner	7	43.75	12	46.15
Tenant	4	25.00	7	26.92
Rent	5	31.25	7	26.92
Land area (m^2):				
< 500	2	12.50	4	15.38
500-1000	10	62.50	16	61.53
>1000	4	25.00	6	14.29
Use of organic vertilizer (kg):				
< 200	8	50.00	8	30.76
200-400	5	31.25	9	34.62
>400	3	18.75	9	34.62
Implementation SOP (%)				
< 70	4	25.00	5	19.23
70 – 80	11	68.75	19	73.08
>80	1	6.25	2	7.69

Information : TE = Technical Efficiency

Farmers with rented land try to keep production costs as low as possible because they have already paid a considerably high rent. The tenant does not have the freedom to use the land. The tenant must be are all the production costs, but still has to divide the harvest product with the landowner by a ratio of 1:1 meaning that both landowner and tenant will obtain the same yield.

The land area used for organic rice farming is related to the level of technical efficiency. Out of the 26 efficient farmers, 16 farmers have a land area between 500 and 1,000 m^2. In other words, farmers with land of 500-1,000 m2 are more efficient than farmers with land area < 500 m^2 or > 1,000 m^2. Farmers with moderate land can utilize their land efficiently. The same opinion is state in research by Tinaprilla *et al.* (2013), who affairms that farmers with moderate land is more technically efficient.

Organic rice farming uses organic fertilizer in the form of manure and petroganic. The amount of organic fertilizer used affects the level of technical efficiency. Out of the 26 efficient farmers, 18 farmers use more organic fertilizer (> 200kg). The more organic fertilizer used, the more efficient the technique will be.

The level of SOP implementation of organic rice farming has an effect on the level of the technical efficiency. Of all 80.77% farmers who are technically efficient, the level of the implementation of SOP during their farming is high (> 70%). Provided that there is a tendency of higher level of SOP implementation, organic farming system will also be more technically efficient.

Table 5. The estimates of factors affecting technical inefficiency of organic rice farming in Bantul Regency

Parameter	Variable	Coefficient	Standard error	T test
$\delta 0$	Constants	-0.9190ns	0.9467	-0.9707
$\delta 1$	Level of education	0.6199***	0.2121	2.9224
$\delta 2$	Age of farmer	0.0101^{ns}	0.7173	0.0149
$\delta 3$	Land status	0.1048^{ns}	0.1487	0.7044
$\delta 4$	Farming experience	-0.4021^{ns}	0.7154	-0.5621

Information: *** : significant at α 1%

ns: non significant

The factors to affect in technical inefficiency

The variables suspected to affect the technical inefficiency of organic rice farming in Bantul Regency are farmers' education level, age, farming experience and land status. Based on Table 5, it can be seen that the level of education only significantly affects the level of technical inefficiency of organic rice farming. However, age of farmers, farming experience and land status do not significantly affect the level of technical inefficiency. Of the 16 organic rice farmers technical inefficiency, 44% were 55 years old and 56% were under 55 years old. In other words, organic rice farmers with technical inefficiency in Bantul Regency consist of productive and non-productive farmers. The same situation occurs in rice farming, '*Operasi Pangan Riau Makmur*' in Kampar Regency (Putra and Tarumun, 2012) and semi-organic farming in Cigombong District Bogor Regency (Gultom *et al.*, 2014) where the age of farmers does not affect the level of technical inefficiency. Meanwhile, according to a research conducted by Kusnadi *et al.* (2011), age affect the technical inefficiency with the positive coefficient which means the older the person, is more inefficient the farming is.

The experience of farmers in organic rice farming has negative coefficient value and has no significant effect on the level of technical inefficiency, meaning that longer experience tends to decrease technical inefficiency. Of the 16 organic rice farmers with technical inefficiency, 44% had experience in organic rice farming <10 years and 56% have experienced in it for more than or equal to 10 years. Technical inefficiency can occur in farmers who have a long or recent farming experience. Similarly, in semi-organic farming in Cigombong District Bogor Regency (Gultom *et al.*, 2014), the experience of farming didn't affect the technical inefficiency. Different conditions exist in organic rice farming in Tasikmalaya where experience positively affected technical inefficiency (Machmuddin *et al.*, 2016).

The land status of organic rice farmers, consisting of owners, renters and tenants have positive coefficients but have no significant effect on technical inefficiency. The farmers are technically inefficient in possessing land ownership (44%) and rent and tenant (56%). Although the farmers' land status is different, the method in running the farming is relatively the same because all the farmers become members of the union farmer groups and actively participate in the activities. This situation is different from the study by Kusnadi *et al.* (2011), who stated that land status affect the technical inefficiency with negative.

Conclusion

Level of SOP implementation of organic rice farming in Bantul Regency is high score at 71.26%. Fertilization activities, controlling plant disturbing organisms and sorting and packaging scores are still

below average. The union farmer group needs to assist its members to implement the standards (SOP) in order to increase the production of organic rice.

The average level of technical efficiency of organic rice farmers is 0.71 meaning that it has been categorized into efficient. The most efficient farmers are farmers owners, with land between 500-1000 m^2, with organic fertilizer of more than 200 kg and who apply the SOP of organic rice. The technical efficiency of organic rice farming in Bantul can be improved if farmers use more organic fertilizer. Organic fertilizers can improve soil structure, nutrient support and can increase water storage.

Factors that significantly affect the technical inefficiency is farmers' education level. While age, experience and land status do not give any affect. In organic rice farming, increasing knowledge and skill through non-formal education is more needed than that of through formal education. The government through the Ministry of Agricultural should provide more courses or training for organic rice farmers, for example, the training of organic fertilizer production to be used by farmers to improve the level of productivity.

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