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Factors that Influence Rice Production and Technical Efficiency in the Context of an Integrated Crop Management Field School Program

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Abstract: This research estimates the effect of production input on rice production and the effect of socio-economic factors on the technical efficiency of rice farms in the program of the Integrated Crop Management Field School (ICMFS). Data were collected from 78 rice farmer household heads from two randomly chosen villages in Indonesia. The results show that seed, fertilizer, pesticide and labor significantly positively affect rice production. Socio-economic factors such as farmer age, education and experience, the number of household members and the frequency of visiting the ICMFS field laboratory had significant positive effects on the level of technical efficiency. Thus, the ICMFS, by continuing to increase ICMFS program to the people of rural areas and by taking into account socio-economic status of farmers, can improve rice farming production and efficiency.

Keywords: Field School, Socio-Economic Status, Technical Efficiency, Rice Production

Introduction

Rice is a basic need for the people of Indonesia and the main product produced by most farmers; thus, increasing rice production to achieve food self-sufficiency is an important goal for the country. Within the next decade, Indonesia should be able to independently meet the needs of the community. Achieving this increase might best be done through an increase in productivity potential and the potential availability of new land that could be used as irrigated land for rice.

The policy of the central government in the development of rice farms, including efforts to increase rice production, is focused on the application of the Integrated Crop Management Field School (ICMFS). Parigi Moutong organized ICMFS, but the resulting productivity remains below the expected productivity. Productivity of rice in Parigi Moutong Regency is 5.24 tons/ha, below the potential of >7 tons/ha for rice. Therefore, the income of rice farms has not yet significantly increased (DGFC, 2012). One of the problems identified as limiting production is an inefficient use of production inputs. Increasing productivity could thus be done by increasing the efficiency of production input usage. Production inputs of seeds, fertilizer, pesticide and labor may affect agricultural production in Indonesia (Effendy, 2010; 2015).

Directly and indirectly increase productivity and income of participating communities and indirectly increase income of communities in the surrounding area. Based on the results noted above, it appears that the ICMFS program could best improve rice production through a focus on production inputs. The objective of this research is to estimate the potential effect of production inputs on rice production and also to estimate the socio-economic factors that can affect the technical efficiency of rice farms in the ICMFS program.

Research Methods

Research was conducted in Parigi Moutong Regency. Two villages, Dolago Village and Tolai Village, were randomly selected for use in the study. For both villages, sample units consisted of Household Heads (HH) that lived in the villages and farmed rice. A total of 385 HH entered the ICMFS group: 187 in Dolago Village and 198 in Tolai Village.

The appropriate sample size for each village was calculated using the formula from Parel *et al*. (1973):

$$n = \frac{NZ^2\sigma^2}{Nd^2 + Z^2\sigma^2} \tag{1}$$

Where:

n = Number of samples for each village
N = population size of each village
Z = Standard normal deviate at the desired confidence level (90%) = 1.645
σ^2 = Population variance
d^2 = Standard error (0.1)

Based on this, the number of samples used in Dolago Village was 36 HH and in Tolai Village was 42 HH (Table 1).

The frontier production function was used to address the research objective. The approach of the frontier production function is based on a model developed by Coelli *et al*. (2005), which follows the form of the Cobb-Douglas model:

$$\ln Y_i = \lambda_0 + \sum_{j=1}^{k} \lambda_j \ln X_{ji} + (V_i - U_i) \quad (2)$$

The specific equation considered in this study was:

$$\ln(PROD) = b_0 + b_1 \ln(SEED) + b_2 \ln(PU) + b_3 \ln(PEST) + b_4 \ln(L) + (V_i - U_i) \quad (3)$$

Where:

$PROD$ = Rice production (kg)
$SEED$ = Rice seed (kg)
PU` = Fertilizer (kg)
$PEST$ = Pesticide (liter)
L = Labor (days x people working per day = DPW)
V_i = Random error term
U_i = Random variable that represents technical inefficiency of sample i

Technical efficiency of farmer i's farm production is estimated as (Coelli *et al*., 2005):

$$TE_i = \frac{y_i}{y_i^*} = \frac{\exp(x_i\beta + v_i - u_i)}{\exp(x_i\beta + v_i)} = \exp(-u_i) \quad (4)$$

where, y_i is the observed production and y_i* is the expected frontier production based on the stochastic frontier production function.

A multiple linear regression model was then used to estimate socio-economic effects on technical efficiency:

$$TE = \delta_0 + \delta_1\ UP + \delta_2\ PDK + \delta_3\ PENGA + \delta_4\ JARTP + \delta_5\ PDP + \delta_6\ KICMFS + \varepsilon_i \quad (5)$$

Where:

TE = The estimated technical efficiency level
UP = Age of farmer (years)
PDK = Education (elementary Vs. beyond elementary)
$PENGA$ = Experience of farms (years)
$JARTP$ = Number of productive household members
PDP = Income (IDR)
$KICMFS$ = Participation in ICMFS field laboratory visits (frequency)

Results and Discussion

Factors Affecting Rice Production

The analysis results of stochastic frontier production function of Cobb-Douglas model on rice farms are shown in Table 2.

Seed quality and quantity had significant effects on rice production. Increasing seed numbers increased the population number of rice crops and thus increased rice production. This research is relevant to the research of Effendy (2010).

Fertilizer had a significant effect on rice production. Additional fertilizer on agricultural land increased the nutrients nitrogen, sulfur and potassium in the soil that were needed by rice. This result agrees with the research of Li *et al*. (2008; Effendy, 2015).

Pesticides significantly affected rice production, reducing damage to rice panicles by pests and disease, to maintain production. Pesticide use to control pests and diseases of rice crops is necessary to prevent crop failure. Our results support the research of Dewi and Idris (2005), but are contrary to the research of Khazanani and Nugroho (2011).

Labor affects rice production (Li *et al*., 2008; Khazanani and Nugroho, 2011; Effendy, 2010; 2015). Additional labor allows rice farm activities, for example, soil tillage, weeding, fertilization, pest and disease control, to be implemented in a timely manner that in turn will increase rice production. Additional labor increases rice production, which has implications for increasing a farmer's income.

Factors Affecting Technical Efficiency

The level of technical efficiency of rice farms was analyzed in conjunction with factors affecting production using the stochastic frontier production function of the Cobb-Douglas model. Data were analyzed using multiple regression analysis in SPSS software, version 18.00 and are shown in Table 3.

The age of farmers had a positive effect on the level of technical efficiency of rice farms in the ICMFS program. Age of farmers was positively correlated with rice farm experience and increased experience and knowledge led to increased technical efficiency. This indicates that if a farmer consistently grows rice, they will increase technical efficiency over time.

Table 1. Number of samples

Village	N	Z	Z2	d	d2	var	n
Dolago	187	1.645	2.71	0.10	0.01	0.161	36
Tolai	198	1.645	2.71	0.10	0.01	0.196	42
Total	385						78

Table 2. Parameter estimates based on the stochastic frontier production function of the Cobb-Douglas model on rice farms

Variable	Coefficient	Standard-error	T-ratio	T-table (5%)
Intercept	8.681			
Seed	0.465	0.031	14.883*	1.993
Fertilizer	0.359	0.023	15.348*	1.993
Pesticide	0.628	0.034	18.299*	1.993
Labor	0.251	0.026	9.702*	1.993
Sigma-squared	0.160	0.033	4.883*	1.993
Gamma	0.976	0.025	38.284*	1.993
Log likelihood function	5.998			
LR	12.420	$x^2 = 9.49$		

* = Significant at α 5% two-tail test

Table 3. Parameter estimation for technical efficiency level of rice farmers in ICMFS program

Variable	Coefficient	Standard Error	t- count	p
Intercept	0.747			
Age	0.073	0.017	4.280*	0.000
Education	0.081	0.015	5.422*	0.000
Experience	0.039	0.013	3.044*	0.003
Number of Family Members	0.056	0.014	3.911*	0.000
Income	0.012	0.012	1.017^{ns}	0.313
Visits to the Laboratory ICMFS	0.031	0.011	2.916*	0.005
F_{count}= 24.674* p = 0.000				
Adjusted Determinant coefficient (R2) 0.648				

* Significant at α 1%

Farmer education level was also positively related to the level of technical efficiency of rice farms in the ICMFS program. Farmers that were educated beyond the level of elementary school had, on average, farms with levels of technical efficiency 0.081% higher than the farms of farmers who were not educated beyond elementary school. This is likely because a higher education level of farmers provides them with higher technical and management capabilities to absorb information technology. The higher the education level of farmers, the better their ability to apply technology and allocate available resources efficiently. This result agrees with that of Mohapatra (2011; Krasachat, 2012), who concluded that education significantly contributed to increasing the efficiency of agriculture.

Experience working on rice farms had a positive effect on the level of technical efficiency of rice farms in the ICMFS program. This research supports research of Wollni and Brümmer (2012), who concluded that the most important factor affecting the level of technical efficiency of coffee farms in Costa Rica was farmer experience in the cultivation of coffee.

The number of family members also positively affected the level of technical efficiency of rice farms in ICMFS program. Research of Bello *et al*. (2012), which identified factors affecting the use of rice farming technology in Nasarawa, Central Nigeria. Characteristics of farmers such as age, size of household, social participation, agricultural experience, land area, income of farms and extension contacts, explained 67.0% of variation in the application of rice technology by farmers.

The income of farms was not related to the level of technical efficiency for rice farms in the ICMFS program, likely because there was little variation in income among rice farms in this study. Higher frequency of ICMFS field laboratory visits led to increased levels of technical efficiency for rice farms in the ICMFS program. Rahman and Hasan (2008) similarly concluded that providing an agricultural information source could increase the technical efficiency of farmers in Bangladesh. Furthermore, Jahan and Pemsl (2011) found that training had significant positive effects on the technical efficiency of farmers, total farmer productivity and the net income of small-scale farmers in Bangladesh. Rahman and Rahman (2008) suggest that increasing of extension services and the application of technology could increase the technical efficiency of farmers and thus increase rice production in Bangladesh.

The ICMFS field laboratory provided a non-formal education. Non-formal education can improve the ability of rice farmer to make decisions and their ability to apply the technology on their farms and thus increase the technical efficiency of farms.

Conclusion

Seeds, fertilizer, pesticide and labor all had significant positive effects on rice production. Socio-economic factors, such as the age of farmers, their education level and experience level, number of family members and frequency of ICMFS field laboratory visits had significant positive impacts on the level of technical efficiency of rice farms. Based on these results, the ICMFS is expected to continue increasing ICMFS programs to rural communities, paying attention to the socioeconomic status of farmers.

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Author's Contributions

Moh. Nur Rasyid: Contributions to conception, design, and acquisition of data and Analysis and interpretation of data.

Budi Setiawan Hanani, Moch. Muslich Mustadjab and Nuhfil Hanani: Contribute in drafting the article or reviewing it critically for significant intellectual content.

Ethics

This paper is original and authors confirm that all of other authors have read and approved the paper.

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