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ESTIMATION OF RICE SEED PRODUCTION EFFICIENCY USING THE STOCHASTIC FRONTIER PRODUCTION FUNCTION

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Abstract :
Production efficiency is a crucial factor in producing seeds. This paper aims to estimate the level of efficiency of rice seed production and determine the factors that influence it using a frontier stochastic production function approach. The rice varieties developed are Inpara3, Inpari Nutri Zink and Baroma. The research was conducted in Rawa Medang Village, Batang Asam District, West Tanjung Jabung Regency, Jambi Province, in December 2021. Data collection was carried out through observation and in-depth interviews with seed breeders. By using the frontier production function, the conclusion is obtained: The efficiency level of rice farming for superior varieties is relatively good, with the efficiency level at level 6. All rice seed breeders show effective performance. To increase the efficiency of rice farming in the future, it is necessary to sharpen the use of production input inputs. The consideration is that the breeder's orientation is to produce quality seed for use by the farming community. Therefore, more intensive technological assistance is needed.

Keywords: Baroma, Efficiency, Frontier Stochastic, Inpari 3, Inpari Nutri Zinc

INTRODUCTION

Seeds are a very crucial production input in production increase activities. Rice seeds are grains produced specifically to sow or sow into crops. The seeds developed are certified seeds whose production goes through a certification system. In the production system, seeds that receive field inspection and laboratory testing by authorized agencies meet the specified standard requirements.

According to BB Padi (2020), seeds are produced and maintained so that the variety's identity and level of purity can be maintained, meet the established seed quality standards, and go through a certification process as quality seeds by the Seed Supervision and Certification Center. The need for seeds is not only in quantity, which must be adequate per unit area but also in quality. In terms of rice production, new superior varieties (VUB) are required to achieve optimal rice productivity and even reach frontier production.

To support increased rice production in Jambi Province, in 2020, three new types of superior rice varieties were introduced: Inpara 3, Inpari Nutri Zinc, and Baroma. The introduction of VUB rice seeds is targeted to meet the need for rice seeds in Jambi Province, which has around 118 thousand rice fields in Hectare. With the assumption that 25 kg of rice seeds are used for each hectare, then to meet the rice seed needs of the entire Jambi province, around 2,950 tons of rice seed support is needed per planting season. If the planting index is 2.5, around 7,375 tons will be needed.

Seed development is carried out by breeders spread across the Jambi Province to meet the need for rice seeds whose quality is guaranteed. The class of seeds developed by breeders is the basic seed class known as FS (foundation seed) - white label, which is a descendant of Type Seeds (label). Yellow).

Basic Seeds (BD) are the first offspring of Type Seeds. Basic Seeds are produced under intensive guidance and strict supervision to maintain varietal purity. Basic seeds are produced by agencies/agencies appointed by the Directorate General of Food Crops, and their production is certified by the Seed Supervision and Certification Center (BB Padi, 2016). Regarding breeding rice varieties Inpara 3, Inpari Nutri Zinc, and Baroma, the question is: what is the frontier production efficiency of VUB rice seeds, and what factors influence the level of efficiency of seed production?

According to Makarim, et.al., (2000), the achievement of rice farming efficiency, both consumption-oriented and seed-oriented, is influenced by cultivation management which includes the effectiveness of fertilization, the intensity of pest control, the quality of the seeds used, land conditions that are deficient in K nutrients and other elements. Micro, soil physical properties and weed control.

The frontier production function describes the maximum production that can be produced for a number of sacrificed production inputs (Mahmudach, 2007). The frontier production function was first developed by Aigner, Lovell, and Schmidt (1977). Empirically, the Stochastic Frontier production function is an extension of the original model deterministic method for measuring unexpected effects developed by Aigner and Chu (1968) in Coelliet et al., (1998). The characteristic of the frontier production function is that there is a separation of the impact of shocks to exogenous variables on output through the contribution of variance, which describes technical efficiency (www.atatmat.net, 2020).

In Indonesia, research on rice farming efficiency analysis using a frontier production function approach has been carried out by many researchers, including Sumaryanto (2001), Ulpahet.al., (2018), and Hidayah, et.al., (2013). The output of these researchers is grain for consumption, not oriented towards producing seeds. This paper aims to estimate the efficiency of rice seed production and determine the factors that influence it using a stochastic frontier production function approach.

RESEARCH METHOD

The research was conducted in Jambi Province, focusing on breeding rice seeds of the Inpara 3, Inpari Nutri Zinc, and Baromadi varieties, Rawa Medang Village, Batang Asam District, West Tanjung Jabung Regency, Jambi Province, December 2021. This location is the study location for the Source Seed Management Unit (UPBS) whose governance applies the Integrated Plant Management (PTT) philosophy.

The data used includes primary data and secondary data. Primary data was collected through field observations and in-depth interviews with seed breeders in the village of Rawa Medang Village, Batang Asam District, West Tanjung Jabung Regency, Jambi Province. The data collected includes breeder characteristics, plant vegetative growth performance, financing structure, and rice farming income in one planting season, as well as factors predicted to influence rice farming efficiency. Secondary data collected includes the environmental conditions of the land at the study location, seed production data, and other relevant secondary data.

The data collected was analyzed qualitatively and quantitatively. Qualitative analysis using tabulation and quantitative analysis includes analysis of frontier production functions, levels of technical efficiency, and factors that determine the level of technical efficiency. The analysis model uses a stochastic production frontier approach, following Sumaryanto (2001), Hidayah et al., (2013), and Aigner et al., (1977). The general form of the stochastic production frontier, as presented by Aigner et al., (1977), is:

$$\ln y_i = \propto_0 + \sum_{i}^{n} \beta_k \; lnx_{ki} + \varphi \, D_i + \epsilon_i$$

The measurement of technical efficiency of rice farming production for the third farmer is interpreted from the equation, following the method of Coelli et al., (2005), namely:

$$TE_i = \frac{y_i}{y_i^*} = \frac{\exp(X_i\,\beta + v_i - \mu_i)}{\exp(X_i\,\beta + v_i)} = \exp(-\mu_i)$$

In this case the TE_i value is between 0 and 1 or 0<TE_i<1.

The empirical model used is the stochastic frontier production function model, with the following formula:

$$\ln Y_i = \beta_0 + \beta_1\, lnX_{1i} + \beta_2\, lnX_{2i} + \ldots + \beta_6\, lnX_{6i} + \epsilon_i$$

In this case:
Y = rice production (seed + consumption) (in kg/ha)
X1 = land area (hectares)
X2 = seeds (kg/ha)
X3 = Urea fertilizer (kg/ha)
X4 = NPK fertilizer (SP-36) (kg/ha)
X5 = KCl fertilizer (kg/ha)
X6 = pesticide (liter/ha)
X7 = labor(HOK)
D = season dummy variable, where: 0 = rainy season, 1 = dry season
ϵ_i = vi–ui=error term component where vi is a random variable caused by external factors such as climate, the distribution is symmetrical and normally distributed. Meanwhile, ui is a non-negative random variable reflecting the error component which is internal (can be controlled by the farmer) and seems to be related to the farmer's managerial capability in managing his farming business. This component has an asymmetric distribution (one sided), namely ui>0. If the production process is efficient (perfect), then the output produced coincides with the maximum potential, meaning u = 0. On the other hand, if u > 0 means it is below the maximum potential.
β_0,…,β_6 = estimated parameters

Parameter estimation using the OLS method using SPSS version 32 tools.

RESULTS AND DISCUSSION

Land Environmental Conditions

Land conditions at the research location were identified from soil acidity, organic C content, N elements, and available P, and K elements. Based on the analysis results of Mahbub et al., (2018), it was obtained that the location of Rawa Medang Village, Batang Asam District, West Tanjung Jabung Regency, is classified as predominantly sour and slightly sour with a pH between 4.8 – 5.7. The total C-organic and N values are relatively low, with values < 2 percent, due to the behavior of farmers who usually burn rice straw waste, or if it is not burned, the rice straw is taken out and not returned to the land.

Available P-content at the research location is classified as low to very high, while total P-- is classified as very low to medium. Likewise, the dominant K-total content is very low. However, because the paddy soil is flooded, there will be a change in the redox potential (Eh), which causes the availability of P and K in the solution to increase. Potassium (K) is a mobile nutrient, absorbed by plants in the form of K+ from the soil solution. In soil, the K contained in the soil solution is in equilibrium with the K adsorbed by ciliates. A decrease in Eh due to flooding will produce Fe2+ and Mn2+, which in large quantities can replace K adsorbed by clay so that K is released into solution and made available to plants. Apart from that, the need for K can be met by irrigation water and decomposition of organic materials. Aluminum saturation is relatively low, so it does not hinder cultivating rice in paddy fields. With the existence of land like that, it shows a picture that is conducive to rice development.

Breeder Characteristics

10 breeders are developing superior rice varieties in Rawa Medang Village, Batang Asam District, West Tanjung Jabung Regency, Jambi Province. In terms of age, the breeders are still relatively productive, as shown by their age range of 35 – 55 years. Most (70%) are between 35 – 45 years old, and only 10% are over 50. In this way, breeders who develop this rice variety are quite conducive.

The breeder's age is related to farming experience. Assuming that the breeders begin to be active in farming at the age of 20, the breeders have at least 15 years of experience and a maximum of 35 years. The experience factor in rice farming can be a determining factor for success. Apart from the age factor, the dynamics of breeder activities are also determined by their formal education base. 60% of breeders have a formal education base of completing Junior High School (SLTP), and the rest have completed elementary school.

This rice seed breeding activity is generally carried out on one's rice fields. The land area varies from as narrow as 0.5 hectares to as wide as 2 hectares. In farming, this land area factor is a reference in calculating financing. This means that the larger the area of cultivation land, the more costs are required, and vice versa. The costs required are not limited to providing production facilities, but also to paying work wages. The distribution of land ownership cultivated by breeders at the study location is shown in Table 1 in detail.

Table 1. Distribution of Ownership of Land Owned by Farmers

Land area (ha)	Total	
	(People)	(%)
0.5	2	20
1.0	4	40
1.5	2	20
2.0	2	20
Total	10	100

Performance of Rice Varieties

The superior rice varieties developed by breeders consist of Inpara 3, Inpari Nutri Zinc and Baroma. All of these rice varieties are products of the Center for Rice Research (BB Padi) which were released between 2008 and 2019. In detail, the performance of the three rice varieties is presented in Table 2.

Table 2. Description of rice varieties Inpara 3, Inpari Nuti Zinc and Baroma

Parameter	Inpara 3	Inpari Nutri Zinc	Baroma
Year of release	2008	2019	2019
Rice status	Swamp	Irrigation Rice Fields	Irrigation Rice Fields
Plant Age (hr)	127	115	113
Plant height (cm)	108	95	112
Plant condition	Stand	Stand	Stand
Potential yield (tons/ha)	5.6	9.98	9.18
Average yield (tons/ha)	4.6	6.21	6.01
Rice texture	Pera	Pulen	Pera
Amylose content (%)	28.6	16.60	22.55
Glycemic Index	59.2	-	-
Zinc content (ppm)	-	34.51	-
Average Zinc Content (ppm)	-	29.54	-

Besides varying performance, each variety has unique advantages. The Inpara 3 variety has a glycemic index (IG) in the medium category. GI is a number (scale of 1-100) that shows how quickly carbohydrate-rich foods are processed into glucose in the body. The standard GI is low < 55, medium 55-69, and high > 70. GI is often used as a reference in diet to control high blood sugar (glucose) levels. Rice with a low glycemic index can be recommended for consumption by type 2 diabetes sufferers on a diet (Indrasari et al., 2008).

Meanwhile, the Nutri Zink rice variety, as the name suggests, contains zinc or zinc, which is an essential nutrient that helps maintain the body's immune system. This nutrient is important to support the body's metabolic functions. Zinc helps stimulate the performance of at least 100 types of enzymes (Afifah, 2020).

Technological Intervention

Technological intervention is carried out according to recommended standards to produce superior rice seeds. The seeds breeders use are foundation seed (FS) class or white label. According to BB Padi (2016), what is meant by Basic Seeds (BD) are the first offspring of Type seeds produced under intensive guidance and strict supervision so that the purity of the variety can be achieved. Maintained. Basic seeds are produced by agencies/agencies appointed by the Directorate General of Food Crops, and their production is certified by the Seed Supervision and Certification Center (BPSB).

Plant cultivation uses Integrated Crop Management (PTT), starting with perfect soil cultivation using irrigation water management. The planting method uses the Jajar Legowo 4:1 system, a planting pattern that only adds additional plant inserts to the two rows of edge plants. The basic consideration for using jajar legowo4: 1 is that, according to recommendations, it is suitable for application in locations with high soil fertility levels. The planting distance is 25 x 20 cm. Plant seeds are young, less than 21 days after sowing. Planting per hole 1 – 3 stems.

Plant maintenance, which includes fertilization, is carried out with balanced and efficient principles using PUTS. The fertilizer doses used are NPK Phonska 300 kg/ha and Urea 100 kg/ha. Meanwhile, insecticides/pesticides are used to control pests and diseases. The results are immediately threshed when harvesting and post-harvest are done on time. The results of observations of plant vegetative growth are mainly plant height, and it seems that all varieties are still relatively low compared to the description.

The results of measuring the height of Inpara 3, Inpari Nutri Zink, and Baroma rice plants were around 71.3 cm, 53.7 cm, and 82.5 cm, respectively. Meanwhile, according to the description, the respective heights of Inpara 3, Inpari Nutri Zink, and Baroma plants are 108 cm, 95 cm, and 112 cm, respectively. There are allegations that this is influenced by land conditions that differ from the BB Padi environment.

Regarding the number of tillers per hill, it is not recorded in the plant description issued by BB Padi, therefore there is no evaluation. When compared between varieties, we can see the Baroma varieties (24.5 stems/clump), Inpara 3 (20.5 stems/clump), and Inpari Nutri Zink (17.7 stems/clump).

Cost and Revenue Structure

Rice farming to produce seeds is relatively the same as farming, whose products are for consumption. Financing is used to purchase production inputs, sacks, and labels, as well as financing for payment of work wages. Apart from seeds, the inputs used are organic fertilizer in the form of compost from cow dung, inorganic fertilizer in the form of Urea, Ponska, KCl, and Kiesrit, as well as PPC biofertilizer and pesticides. Additional costs, apart from those used for input, are the costs of purchasing sacks and labels for seed packaging.

Payment of work wages, used for land processing labor or renting tractors, repairing rice fields, making seedbeds, removing seedlings and planting costs, fertilizing costs, spraying pests and diseases, harvest wages or combining harvester rentals, transportation costs from the farming land to the house, costs drying, sorting and packaging. Expenditures for labor wages between rice varieties are relatively the same. Even if there is a difference, the difference is not significant. The total expenditure for payment of wages for rice farming in Inpara 3, Inpari Nutri Zink, and Baroma is around IDR 7.2 million, 7.3 million, and 7.4 million, respectively. Thus, the total costs for 1 hectare of Inpara 3, Inpari Nutri Zink, and Baroma rice are IDR 11.7 million each, IDR 11.8 million, and IDR 11.9 million, respectively.

Farming production in grain, for Inpara 3, Inpari Nutri Zink, and Baroma rice, is 3.9 tons each, 3.95 tons, and 4.2 tons. Of the total grain production, the quality of the seeds from each rice variety is around 3 tons, 3.18 tons, and 3.3 tons. Meanwhile, there is no difference in the selling price of seed-quality and consumption-grade grain for the three rice varieties. The selling price for consumption of seeds and grain is IDR 9,000/kg and IDR 4,500/kg.

Financially, seed breeding farming for the three superior rice varieties in Rawa Medang Village, Batang Asam District, West Tanjung Jabung Regency, and Jambi Province is quite profitable, as shown by the BC ratio values above 1. The cost structure of farming for rice seed breeding is presented in Table 3 in detail.

Table 3. Cost structure of rice seed farming (per ha) in MH

Description	Inpara		Inpari Nutri Zinc		Baroma	
	Cost (Rp)	Reception stage proportion (%)	Cost (Rp)	Reception stage proportion (%)	Cost (Rp)	Reception stage proportion (%)
Financing						
• Production input costs	4.545.000	14.64	4.545.000	14.17	4.545.000	13.47
• Cost Wages	7.225.000	23.27	7.333.000	22.85	7.355.000	21.79
Total	11.770.000	37.91	11.878.000	37.02	11.900.000	35.26
Results						
• Seed (kg)	27.000.000	86.96	28.620.000	89.20	29.700.000	88.00
• Harvested Dry Grain (kg)	4.050.000	13.04	3.465.000	10.80	4.050.000	12.00
Reception	31.050.000	100	32.085.000	100	33.750.000	100
Income	19.280.000		20.207.000		21.850.000	
R/C	2.64		2.70		2.84	
B/C	1.64		1.70		1.84	

Production Efficiency

Generally, the production process is inefficient for the following two reasons. First, because it is technically inefficient, this occurs because of the failure to achieve maximum productivity, meaning that maximum production cannot be produced per unit of input package (input bundle). Second, it is allocatively inefficient. This happens because, at a certain level of input and output prices, the proportion of input use is not optimal. After all, the marginal revenue product is not the same as the marginal cost of the input used. Economic efficiency includes technical efficiency and allocative efficiency (Sumaryanto, 2001).

From the financing structure and farming income, it is known that the productivity of rice varieties Inpara 3, Inpari Nutri Zink, and Baroma in MH 2021 is 3.9 tons each, 3.95 tons, and 4.2 tons, respectively. Compared with the description, the rice productivity achievements are still relatively low. It is suspected that the relatively low productivity of rice is caused by environmental factors that are different from the environmental conditions at BB Padi.

Concerning the estimation of the stochastic frontier production function, the analysis was not carried out per variety. Still, it was carried out based on the average value of the three varieties planted. This was done because there was no real difference in input behavior. In this way, the estimation results of the stochastic frontier production function are obtained, as presented in Table 4.

Table 4. Results of estimation of stochastic frontair production function parameters

Parameter	Coefficient Value	Standard error
Intercept (β_0)	2.7365	0.5224
Land(β_1)	0.6841	0.2797
Seed(β_2)	-0.0907**	0.0525
Urea Fertilizer(β_3)	0.1319	0.0427
NPK Fertilizer(β_4)	-0.0739***	0.0337
FertilizerKCl(β_5)	0.1202***	0.0472
Other Input(β_6)	0.0409	0.0171
Labor(β_7)	-0.0928**	0.0498
Planting Season Dummy (φ)	-0.0525**	0.0311
σ^2	0.3774	0.0073
γ	0.9998	0.9999
Log likehood function	40.7007	
LR test of the one-sided error	22.9783	

Table 4 shows that the seed use factor has a negative and statistically significant effect. This means that the amount of seed used at the study location, 25 kg per hectare, is considered adequate. If the use of seeds is increased per hectare, what will be obtained is not an increase in yield but a decrease in efficiency.

The recommendation to use 25 kg of seed per hectare has proven to be effective, and it is thought to be related to the planting method, which uses the Jajarlegowo 4:1 principle. This analysis also ensures that the seeds used are of superior quality, as proven by their growth capacity of close to 100 percent. Theoretically, if seed viability is high (above 95%) and the seeding, seed transfer, and planting methods are carried out well, then the need for seeds for rice farming is only around 25 - 30 kg per hectare.

Another interesting phenomenon is the estimated parameter results for fertilizer. The production response to N fertilizer (Urea) is positive, while to P fertilizer, it is negative. This implies that with the actual application of fertilizer, production can be increased if urea fertilizer is used; on the other hand, Phosphorus fertilizer can be reduced.

For K fertilizer (KCI), the production response is positive and real. The implication is that the dose of K fertilizer needs to be increased. From an agronomic theory point of view, the optimal location of macro fertilizers (N, P, K) is influenced by many factors such as soil pH, the content of other elements that influence the availability of macro fertilizers, the cation exchange capacity (CEC) of the soil, the method of fertilization and the characteristics of the fertilizer applied. (content, physical structure).

In such a context, it is also necessary to consider the influence of irrigation water quality and its management because various chemical elements are also dissolved in the irrigation water, either increasing the availability of nutrients for plants or indirectly having a negative impact on the plant's absorption capacity for nutrients, due to changes in soil pH.

The estimation results also show a tendency for excessive use of labor. It seems that this is also related to the cultivation area and labor availability at the study location. In line with the phenomenon of inter-seasonal productivity at the study location, the estimation results also show that the influence of the seasonal "dummy" variable is harmful and real.

Level of Technical Efficiency and Factors That Influence It

The level of technical efficiency (TE) at the study location is at level 6. On a scale 10, the efficiency level is considered moderate, not too good, but not bad either. This detects productivity levels that are still far from the production limits specified in the description. Achieving this level of technical efficiency has implications for technological assistance that needs to be improved so that the efficiency gains achieved can be higher.

The opportunity to increase productivity is still wide open so that not only can the impact be felt by farmers, but it also has a positive effect on farmers' interest in planting Inpara 3, Inpari Nutri Zink, and Baroma rice varieties. Based on this argument, further identification of TE distribution is essential. From the results of the correlation analysis of efficiency levels with several variables that are strongly suspected to be related to farming efficiency, which include the area of cultivated land, use of labor, age, experience, and formal education base of breeders, the results are as shown in Table 5.

Table 5. Correlation of TE with variables that are thought to influence the level of efficiency

Variable	Correlation Coefficient	Standard Error
Arable land area	0.1423	0.1227
Labor	0.0479	-0.0479
Age	-0.3544***	0.0001
Experience	0.1002	0.2784
Formal education	0.0059	0.9495

The factor that is significantly correlated and has a negative sign is the breeder's age variable. The results of this analysis confirm that breeders who are relatively young are better able to accumulate, sort, and process information and more productive rice cultivation techniques.

The level of efficiency of farmer farming apparently does not have a strong relationship with the variables of cultivated land area, use of labor, experience, and formal education base. However, this does not mean that you can ignore these variables when it comes to increasing farming efficiency. Mentoring activities have a strategic role in supporting the achievement of rice farming efficiency levels carried out by breeders in an effort to produce quality rice seeds.

CONCLUSION

The efficiency level of rice farming for superior varieties consisting of Inpara3, Inpari Nutri Zink, and Baroma is relatively good, with the efficiency level at level 6. This means that all rice seed breeders in Rawa Medang Village, Batang Asam District, West Tanjung Jabung Regency, Jambi Province show effective performance. The findings that can be used as a basic basis for developing strategies to increase the efficiency of rice farming by breeders in the future are related to sharpening the use of production input inputs. The basic consideration is that the orientation of seed breeders is to produce quality distributed seeds for use by the farming community. Therefore, it is recommended that technological assistance be carried out more intensively.

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