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Analysis of Production Efficiency of Rice Seed Producers in Serdang Bedagai Regency, North Sumatera, Indonesia

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ABSTRACT

Rice holds strategic importance in the agricultural sector of North Sumatera Province. The production of rice in the region has shown fluctuations over the period of 2016 to 2021, mainly due to variations in the harvested area. To enhance rice production, it becomes imperative to focus on increasing both the extent of land under cultivation and the productivity of rice plants. The use of high-quality seeds plays a vital role in achieving agricultural success, as they contribute to improved productivity. The availability of superior seeds is closely associated with the efforts of seed production institutions, among which seed breeding centers are particularly significant. Serdang Bedagai Regency, being a major rice production center in North Sumatera, also serves as a hub for rice seed breeding activities. However, recent years have witnessed a decline in the number of rice seed breeders and the production of labeled rice seeds in this region. This decline can be attributed to inefficient utilization of production factors. Consequently, there is a pressing need to address this issue and improve production efficiency through a comprehensive analysis of rice seed breeders' performance in Serdang Bedagai Regency, North Sumatera Province. The primary objectives of this study are to examine the influence of various production factors, including land area, seeds, labor, fertilizer, and pesticides, on the production of rice seed breeders and to assess the levels of technical, allocative, and economic efficiency achieved by these breeders in Serdang Bedagai Regency. The research employs cross-sectional data from a sample of 50 farmers and applies the stochastic frontier production function as well as efficiency analysis techniques, including technical efficiency, allocative efficiency, and economic efficiency. The findings of this study reveal that both land area and seed usage significantly and positively impact the production of rice seed breeders. Conversely, the factors of labor, fertilizer, and pesticides demonstrate a non-significant negative influence on rice seed production in Serdang Bedagai Regency, North Sumatera Province. Moreover, the efficiency levels of rice seed breeding in this region have not reached their highest potential and require further improvement.

Keywords: Technical Efficiency, Allocative Efficiency, Economic Efficiency, Rice Seed Breeders, Stochastic Frontier

1. INTRODUCTION

Rice is a crucial agricultural commodity that plays a significant role in meeting the food demands of the growing population. In North Sumatera Province, the agricultural sector is of great importance, benefitting from the region's abundant natural resources. This province is known for its diverse superior agricultural commodities, including rice, which holds a central position in the agricultural sector. However, rice production in North Sumatera has experienced fluctuations during the 2016-2021 period, primarily influenced by changes in harvested areas. The highest recorded rice production was in 2018, reaching 5,340,200 tons, but it declined to 3,926,768 tons in 2021.

Serdang Bedagai Regency, located in North Sumatera Province, is recognized as one of the major rice production centers. With a paddy field area of 28,106 hectares and a total rice cultivation area of 61,002 hectares, the regency contributed 351,706 tons of milled rice in 2021, accounting for 8.96 percent of the total rice production in North Sumatera. Similarly, rice production in Serdang Bedagai Regency experienced fluctuations during the 2016-2021 period. The highest production was recorded in 2018 at 494,730 tons, but it decreased to 351,706 tons in 2021.

In the context of agricultural production, seeds play a crucial role in enhancing productivity and quality. The utilization of quality seeds, coupled with appropriate technology, is known to increase crop productivity and improve the overall quality of food crops. Therefore, ensuring the availability of quality seeds is essential to meet farmers' needs and facilitate accessibility. In rice cultivation, the use of quality seeds has a direct impact on rice plant productivity. The presence of seed breeding institutions, including rice seed breeders, is pivotal in meeting the seed requirements in North Sumatera, which are currently lower than the crop demand. North Sumatera houses various rice seed breeding businesses, ranging from farmer groups to private companies and state-owned enterprises. In 2021, there were 46 certified rice seed breeding units involved in the production and distribution of rice seeds in North Sumatera. In addition, Serdang Bedagai Regency, being a prominent rice production center, also serves as a hub for rice seed breeding in the province. In the same year, the regency housed seven rice seed breeding units. However, the production of labeled seeds from rice seed breeding in the regency has experienced a decline in the past three years (2019-2021), with labeled seed production decreasing from 2,685 tons in 2019 to 1,155 tons in 2021.

Increasing the production and productivity of rice seeds can contribute to the income of rice seed breeders. This income is highly influenced by the prices of output and input, as well as the production factors used. To achieve this increase, efforts are needed to improve the efficiency of using production factors in the production process. The success in increasing the productivity of rice seeds is closely related to the production land area, fertilizer use, selection of superior seeds, labor skills, technology application, and development strategies (Kusnadi et al., 2011). Inappropriate combinations of production factors can affect the resulting production and incurred costs. Additionally, research by Suprapti et al. (2014) shows that farmers' inability to reach maximum output with certain input usage can lead to production inefficiencies.

The decline in labeled rice seed production in Serdang Bedagai Regency can have a negative impact on the income of rice seed breeders and may be caused by inefficient use of production factors. The utilization of production factors by rice seed breeders in Serdang Bedagai Regency is still not optimal because their experience in seed breeding is generally acquired through personal experience or shared knowledge within farmer groups. Hence, the research objectives are as follows:

- To examine and analyze the influence of various production factors on the production of rice seed breeders in Serdang Bedagai Regency, North Sumatera Province.
- To assess and analyze the levels of technical, economic, and allocative efficiency exhibited by rice seed breeders in Serdang Bedagai Regency, North Sumatera Province.

2. LITERATURE REVIEW

2.1 Certified seeds and seed categories based on their grades.

Seeds play a crucial role in crop cultivation as they enable plant propagation and reproduction. The quality of seeds significantly impacts production outcomes. However, the availability of high-quality or certified seeds is limited due to farmers' lack of awareness regarding their utilization (Wirawan et al., 2002). Typically, farmers rely on a portion of their harvested seeds for subsequent planting seasons without ensuring their quality.

Utilizing high-quality or certified rice seeds in crop cultivation offers several advantages, including increased production per unit area and time, improved yield quality, and enhanced income for farmers. This necessitates implementing specific practices such as proper land preparation, utilizing superior seeds, maintaining crops under controlled conditions, timely harvesting, standardized packaging, and employing suitable storage and distribution methods. These practices ensure rice seeds with a germination rate above 80%, uniform varieties, synchronized plant growth, and freedom from pest and disease infestations (Hadi, 2009).

The seed industry has witnessed rapid technological advancements and has become a profitable sector, generating job opportunities. The growing awareness of the significance of using high-quality or certified seeds has propelled the growth of the seed industry at both large and small scales. This involvement extends to the farming community engaged in seed production, either through partnerships with large companies or independent seed production management (Hadi, 2009).

2.2 Definition of seed breeding farming business

Agronomy focuses on efficient resource allocation for maximizing profits (Soekartawi, 1995). It studies how farmers allocate land, labor, capital, and management to achieve profitability (Saeri, 2017).

Seed breeding aims to produce superior seeds for sourcing and disseminating improved varieties. The breeding process involves using higher-class source seeds, such as BD-class from BS-class and BP-class from foundation or breeder seeds. In rice seed breeding, roguing is conducted to eliminate plants with inconsistent morphological characteristics from the desired variety (Akbar, 2011).

Certified rice seed breeding is carried out by State-Owned Enterprises, private companies, and groups of seed breeding farmers. It increases farmers' income and promotes the use of certified superior rice seeds. Seed breeding farmers across Indonesia conduct breeding activities on their own land, meeting the requirements for certified seed breeding (Yustiarni, 2011).

The seed breeding process includes varietal purification, roguing, and aspects such as maintenance, packaging, and storage. These factors affect production costs, seed quality, and the income of seed breeding farmers (Kusnadi et al., 2015).

2.3 Understanding Production: Theory and Function

Production involves transforming inputs into outputs. It utilizes a production function that represents the maximum achievable output given a specific technology. Economists employ the production function to study various aspects of production, such as the contribution of production factors, economic growth, and technological changes (Sukirno in Himawan, 2015). The function describes the relationship between production factors (inputs) and the level of generated production. Efficiency and the specific combination of inputs used influence the output (Soejarwo, 2019).

The production function reflects the limits of output based on input utilization. It represents the points of maximum output at different input levels, with zero production inefficiency along the function line, also known as the "frontier production function" (Soekartawi, 2003).

The Cobb Douglas production function is a common form used in empirical research. It involves an equation with multiple variables, where one variable is the dependent variable (output, denoted as Y) and others are independent variables (inputs, denoted as X) (Soekartawi, 2003).

2.4 Efficiency

Efficiency is a crucial factor in evaluating different production choices as it measures the effectiveness of resource utilization. It determines the ability of a method to generate higher output using the same resources or achieve the same output with fewer resources. Soekartawi (2003) classifies efficiency into three types: technical efficiency, allocative efficiency, and economic efficiency.

Technical efficiency measures the maximum production level attained with a given level of input usage. A farmer is considered technically more efficient if they can achieve higher output while utilizing the same production technology. This can be observed by examining the impact of increasing inputs on production outcomes.

Allocative efficiency, also known as price efficiency, assesses the ability of farming practices to maximize profits. It occurs when the value of each input's product equals its marginal cost. Achieving allocative efficiency involves optimizing production factors to maximize profits by equating the value of the marginal product (NPM) with the input price.

Economic efficiency encompasses both technical efficiency and allocative efficiency. Farmers demonstrate economic efficiency when they achieve high production levels, sell products at favorable prices, and effectively manage input costs (Shinta, 2011). Kartasapoetra, as cited in Shinta (2011), emphasizes the consideration of various production factors and understanding the relationship between these factors and resulting products. Comparing factor prices with available capital is also crucial to ensure optimal production levels.

2.5 Stochastic frontier production function

The production process aims to efficiently convert inputs into outputs, measured through concepts such as the production frontier function and average production function (Adhiana and Riani, 2017). Coelli et al. (2005) discuss the general approach to studying production functions, which involves establishing a relationship between inputs and outputs using ordinary least squares. However, the average production function may not capture the maximum achievable production. To address this, the frontier function is introduced as a preferred method for measuring efficiency, as it avoids issues like simultaneous equation bias and multicollinearity (Farrell, 1957, as cited in Coelli et al., 2005).

In this research, the level of technical efficiency is measured using the stochastic frontier production function. This model, initially introduced by Aigner et al. (1977) and further developed by Aigner (1977) and Meese and Van den Broeck (1977) in Coelli (2005), extends the original deterministic model. It incorporates the effects of unforeseen factors, known as the stochastic frontier, within the production boundaries. The stochastic frontier production function employs a composed error structure with one-sided and two-sided symmetric components, where the one-sided component represents inefficiency effects.

2.6 Production Inputs.

Technical efficiency demonstrates the relative ability of a farming operation to achieve a certain output level using a specific amount of inputs at a given technological level. The inputs used in the paddy seed production farming in Serdang Bedagai Regency, North Sumatera Province, are land, seeds, labor, fertilizer, and pesticides.

Land

Land is essential for agricultural activities as it provides the basis for crop growth. The size of cultivated land directly affects production outcomes, with larger areas generally resulting in higher yields, as stated by Andriyani (2014). However, Soekartawi (2003) argues that land productivity is not solely determined by its size. Factors like limited capital and insufficient resource management can also influence productivity.

Seeds

Seeds are an important input in agriculture that facilitate the adoption of new technologies. By utilizing improved varieties with characteristics like pest and disease resistance and faster growth, seeds can enhance agricultural productivity. Kurniasih and Lubis (2022) found that seeds have a production elasticity of 0.134 in their study on the efficiency of paddy seedling farms. This implies that increasing seed quantity can still be done to optimize the production output of such farms.

Labor

Labor is a crucial production factor that requires careful consideration in the production process, encompassing not only the availability of labor but also its quality and type. The quantity of labor is influenced by factors such as labor quality, gender, seasonality, and wages. Neglecting the quality of labor can lead to inefficiencies in the overall production process. In the agricultural sector, labor is commonly measured using the unit of person-days of work (PDW).

Fertilizer

Fertilizer is an essential substance used to supply nutrients to plants and promote their growth. It plays a crucial role in increasing crop yields. Using recommended fertilizers can yield economic benefits. By applying the appropriate dosage of fertilizers, plant growth is enhanced, facilitating optimal metabolism and the synthesis of proteins, starch, and carbohydrates. This, in turn, contributes to improved plant growth and production (Maharaja, 2015).

Pesticides

Pesticides are chemical compounds used to control and eliminate plant pests. They encompass a wide range of substances with toxic properties that hinder the growth, development, behavior, reproduction, and other activities of pests. According to the United States Federal Environmental Pesticide Control Act, pesticides are specifically designed to eradicate or prevent infestations of various pests, excluding those affecting humans and animals. This definition also includes substances used as plant growth regulators or desiccants (Yuantari, 2011).

2.7 Research Hypothesis

Drawing upon the conceptual framework and research objectives, the hypothesis formulated for this study is as follows.

It is hypothesized that land, seeds, labor, fertilizers, and pesticides have an influence on the production of rice seedling breeding in Serdang Bedagai Regency, North Sumatera Province

It is hypothesized that rice seedling breeding in Serdang Bedagai Regency, North Sumatera Province has not reached the highest level of efficiency.

3. RESEARCH METHODS

The study was conducted in Serdang Bedagai Regency, North Sumatera Province, which was selected purposively due to its significance as a prominent rice production and rice seedling center in the region. The sample for this study was determined using simple random sampling, wherein individuals were randomly selected from the population. The researcher employed the Slovin formula to calculate the appropriate sample size, resulting in a sample size of 36 individuals (Sugiyono, 2013). However, considering the total number of active members in the rice seed grower groups, a sample of 50 rice seed growers will be selected to ensure proportional representation among the respondents.

The data collection process will involve both primary and secondary data sources. Primary data will include information on the utilization of production factors in paddy seedling farming and the quantity of production during a single planting season. Secondary data will be gathered from reputable sources such as the Department of Food Crops and Horticulture of North Sumatera Province, previous research studies, relevant literature, and other credible sources related to the specific topic of investigation.

Data Analysis Methods

The data obtained will be processed and analyzed qualitatively and quantitatively. Qualitative analysis will describe the characteristics and performance of rice seedling producers in Serdang Bedagai Regency. Quantitative analysis will utilize stochastic frontier production function analysis and dual function analysis. The efficiency of rice seedling producers will be measured using factors such as land, seeds, fertilizers, pesticides, and labor. Frontier 4.1 software will be used for data processing. Efficiency measurement can be performed through Data Envelopment Analysis (DEA) or Stochastic Frontier Analysis (SFA). The Stochastic Production Frontier (SPF) model is commonly used in farm efficiency analysis, considering the stochastic nature of the industry and incorporating elements of risk and sustainability.

Stochastic Frontier Production Analysis.

The study employs the Cobb-Douglas production function in the stochastic frontier analysis. It uses variables such as land area, rice seed quantity, labor, fertilizer amount, and pesticide amount to estimate rice seed production. The analysis is performed using the Frontier 4.1 software and Maximum Likelihood Estimation (MLE) method. The significance of coefficients is determined by comparing the t-value to the critical t-value.

Efficiency Analysis

Technical efficiency (TE) analysis compares actual and potential production, with TE values closer to 1 indicating higher efficiency. Allocative efficiency (AE) examines the relationship between cost and output, aiming to equalize marginal production value with input prices. Economic efficiency (EE) is achieved when both technical and allocative efficiencies are attained, with an EE value of 1 indicating efficiency.

Operational Definition

The term "production" in this study ensures the yield obtained from the breeding of paddy seeds within a single growing season. The quantity of production is measured in kilograms (kg). The land area discussed in this research represents the total area of land utilized by rice seed farmers for the purpose of production, and it is measured in hectares.

In the context of this study, "Seed" refers to the quantity of certified superior seeds employed during the cultivation process of paddy seeds. The quantity of seeds is measured in kilograms (Kg).

"Labor/Workforce" encompasses all individuals involved in the process of cultivating paddy seeds. It is quantified in terms of person-days of work, representing the number of individuals involved in one day's worth of work.

The term "Fertilizer" in this study denotes the collective use of fertilizers in paddy seed cultivation, aimed at fostering plant growth and maximizing production. The measurement for fertilizers is in kilograms (Kg).

"Pesticide" refers to liquids or substances employed to control pests and diseases in paddy plants within the scope of this research. The quantity of pesticides is measured in milliliters (ml).

4. RESULTS & DISCUSSION

Research Area

Serdang Bedagai Regency, located in North Sumatera, Indonesia, is a significant agricultural center covering an area of 1,900.22 square kilometers. It consists of 17 sub-districts, including Kotarih, Silinda, Bintang Bayu, Dolok Masihul, Serbajadi, Sipispis, Dolok Merawan, Tebing Tinggi, Tebing Syahbandar, Bandar Khalipah, Tanjung Beringin, Sei Rampah, Sei Bamban, Teluk Mengkudu, Perbaungan, Pegajahan, and Pantai Cermin. The regency's population in 2022 was approximately 667,998 individuals, residing in 162,534 households. The economy of Serdang Bedagai Regency is diversified, with the agricultural sector employing 36.42% of the working-age population, followed by the manufacturing industry (16.33%) and the service sector (47.25%). The regency boasts extensive paddy fields covering 29,142 hectares, including irrigated, rainfed, and tidal fields. Additionally, it has non-paddy agricultural land dedicated to gardens, orchards, fallow/cultivated land, plantations, and temporarily unused land, contributing to its prominence in the agricultural sector.

Characteristics of Sample Farmers.

This study involves 50 rice seed breeders who are members of 7 rice seed breeder groups in Serdang Bedagai Regency. The participants were selected based on various characteristics, including age, education level, land ownership status, family size, and the varieties they cultivate.

Table 1. Characteristics of rice seed breeders in Serdang Bedagai Regency.

Characteristics	**Number of Farmers**	**%**
Age group		
<15 Years	0	0.00
15-24 Years	1	2.00
25-34 Years	4	8.00
35-44 Years	10	20.00
45-54 Years	20	40.00
55-64 Years	7	14.00
65+ Years	8	16.00
Total	50	100.00
Education Level		
No school	1	2.00
Elementary school unfinished	3	6.00
Elementary school finished	10	20.00
Junior High School	7	14.00
Senior High School	26	52.00
Diploma/Higher Education	3	6.00
Total	50	100.00
Land Ownership Status		
One's own	42	84.00
Leased Land	4	8.00
Owned and Leased Land	4	8.00
Total	50	100.00
Number of Family Members		
0	2	4.00
1 – 2	28	56.00
3 – 4	14	28.00
5 – 6	6	12.00
≥7	0	
Total	50	100.00
Variety		
Cibogo	2	3,13
Ciherang	13	20,31
Mekongga	12	8.75
Inpari 32	34	53,13
Inpari 42	2	3,13
Inpari 48	1	1.56
Total	64	100.00

The age of rice seed breeders in Serdang Bedagai Regency is closely related to their management practices and productivity in rice seed cultivation. Productivity tends to be higher among breeders within the working-age range, particularly in the 45 to 54-year-old category. The majority of surveyed breeders, about 84.00 percent, fall within the productive age bracket of 15 to 64 years.

In terms of educational attainment, most rice seed breeders in Serdang Bedagai Regency have completed senior high school, indicating a satisfactory level of formal education. However, higher educational achievements such as diplomas or university degrees are relatively low, suggesting room for further professionalization in the agricultural sector.

The ownership status of agricultural land significantly affects the activities of rice seed breeders. Self-owned land is the prevailing ownership status, influencing cultivation expenses. In contrast, leased land introduces additional costs that may impact profits and the allocation of funds for agricultural inputs.

The number of family members living with rice seed breeders can have an impact on their income. On average, breeders in Serdang Bedagai Regency have 1 to 2 family members, which can result in increased expenses and potentially lower overall income.

The cultivation of superior rice varieties, particularly Inpari 32, plays a crucial role in rice production. In Serdang Bedagai Regency, breeders cultivate a variety of superior rice varieties, with Inpari 32 being the most prevalent. Its resistance to leaf blight contributes to its popularity among breeders.

Utilization of production inputs

The utilization of production inputs by the farmers surveyed is depicted in the table below, illustrating the distribution across various categories.

Table 2: Distribution of utilization of production inputs by rice seed farmers in Serdang Bedagai Regency

Production inputs	Number of Farmers	%
Land Area Class (M2)		
< 1,000	0	0.00
1,000 - 1,999	0	0.00
2,000 - 4,999	7	14.00
5,000 - 9,999	12	24.00
10,000 - 19,999	20	40.00
20,000 - 29,999	9	18.00
≥30,000	2	4.00
Total	50	100.00
Land Average - M2 - Acre	 13032 1,3	
Number of Seeds(chain/kg)		
0.8	7	14.00
1	13	26.00
1,2	3	6.00
1,3	4	8.00
1,4	4	8.00
1.5	4	8.00
1,6	5	10.00
2	10	20.00
Total	50	100.00
Number of Seeds(chain/kg)		
0.8	7	14.00
1	13	26.00
1,2	3	6.00
1,3	4	8.00
1,4	4	8.00
1.5	4	8.00
1,6	5	10.00
2	10	20.00
Total	50	100.00

The ownership of paddy fields is a significant factor in rice seed cultivation, impacting seed production efficiency among breeders. In this study, breeders solely rely on their owned paddy fields for rice seed cultivation. The surveyed breeders owned a total area of 65.16 hectares of paddy fields, with the majority cultivating fields ranging from 1 to 2 hectares. On average, the size of paddy fields owned by the surveyed breeders in Serdang Bedagai Regency was 1.28 hectares or 12,823 square meters.

The dominant seed varieties used by rice seed breeders include Inpari 32, Ciherang, and Mekongga. The quantity of seeds used per unit of paddy field area varies among individual farmers and farmer groups. The recommended seed requirement is 25 kilograms per hectare according to government guidelines. However, the surveyed breeders reported using seed quantities ranging from 20 to 50 kilograms per hectare. The variation in seed usage is influenced by factors such as breeders' experience, advice from agricultural extension workers, and information from rice breeding groups.

In terms of adhering to recommended guidelines, only 26.00 percent of the surveyed rice seed breeders in Serdang Bedagai Regency use the recommended 25 kilograms per hectare. 14.00 percent use seeds below the recommendation, while 60.00 percent exceed the recommendation.

Labor

Labor utilized in this study is divided into two groups: family labor and hired labor. Quantifying family labor accurately is challenging due to the efficient allocation of time by farmer families across various farming activities. Hired labor is engaged based on demand and agreed-upon wages.

Rice seed breeding in Serdang Bedagai Regency involves labor-intensive activities such as seedling production, land preparation, planting, and weeding. Human labor usage is measured in person-days of work (PDW), with 1 PDW equivalent to 7 hours. The amount of family labor employed varies based on the number of dependents in each breeder's household.

Hired labor is primarily utilized for tasks such as land preparation, planting, and harvesting, while a smaller number of farmers hire labor for activities like seedling production, fertilization, spraying, and roguing. On average, labor usage in rice seed breeding in Serdang Bedagai Regency is 33.37 PDW per hectare. Family labor accounts for an average of 12.19 PDW per hectare, while hired labor comprises 21.18 PDW per hectare. This indicates that most surveyed rice seed breeders employ labor for assistance in land preparation, planting, and harvesting.

Table 3: Utilization of labor input by rice seed farmers in Serdang Bedagai Regency.

Utilization of Labor	Labor (PDW)
1. Nurseries/Seedling	96
2. Soil Processing	220
3. Planting	894
4. Weeding and fertilizing	414
5. Eradication of pests and diseases	386
6. Rogue	96
7. Harvest	64
Amount	2,171

Utilization of Fertilizer

The economic efficiency of production factors in rice seedling production in Serdang Bedagai Regency is determined by multiplying the values of technical efficiency and allocative efficiency. The table shows that the economic efficiency values for all production factors deviate from unity. Specifically, the land area, seed, and pesticide factors have values greater than one, indicating a lack of economic efficiency. On the other hand, the labor and fertilizer factors have values less than one, indicating inefficiency in their allocation.

Table 4. Recommended doses of fertilizer for paddy rice (kg/ha) in Serdang Bedagai Regency.

Subdistrict	Urea	SP-36	KCl	NPK	ZA
Tebing Tinggi	300	50	50	250	100
Perbaungan	350	75	50	300	100
Pantai Cermin	350	75	50	300	100
Teluk Mengkudu	300	75	50	300	100
Serbajadi	350	75	50	300	100
Sei Rampah	300	50	50	250	100
Recommendation	300-350	50-75	50	250-300	100

Source: Agricultural Research and Development Agency, Ministry of Agriculture, 2021 and Food Crops and Horticulture Office of North Sumatera Province

In rice seed breeding practices in Serdang Bedagai Regency, the utilization of fertilizers often deviates from government-recommended dosages. Among the surveyed rice seed breeders, who collectively possess a land area of 67.96 hectares, the average quantities of fertilizers used are as follows: 17 kg/ha of Urea, 109 kg/ha of SP-36, 105 kg/ha of KCl, 191 kg/ha of NPK, and 125 kg/ha of ZA. The dosages of fertilizers implemented by breeders are influenced by factors such as farming experience, available capital, fertilizer availability in the local market, and prevailing fertilizer prices.

Pesticide

In rice seed breeding activities in Serdang Bedagai Regency, pest and disease management primarily involves weeding and the use of pesticides through spraying. Liquid pesticides are commonly used by most rice seed breeders, with spraying occurring approximately four times during a planting season, depending on the severity of pest and disease attacks. However, the excessive usage of pesticides can be attributed to established habits, farmer experiences, and a lack of comprehensive knowledge, leading to inefficient pesticide application. Additionally, the wide availability of pesticide options in the market without proper guidance poses challenges for farmers in selecting the most appropriate ones. To address these issues, the involvement of field extension workers or pest observation officers is crucial as they provide recommendations and guidance on proper spraying practices, enhancing the effectiveness of pest and disease control measures.

The analysis of the stochastic frontier production function in rice seed breeding farming

OLS (Ordinary Least Squares) and MLE (Maximum Likelihood Estimation) are estimation techniques used to estimate the parameters of the production function. OLS provides average performance estimates, while MLE provides estimates of maximum performance, considering the current level of technology. These techniques are crucial for obtaining consistent parameter estimates of the independent variables in the production function, excluding the intercept. They also establish the structure of the stochastic frontier production function in the model.

Estimating Parameters of the Cobb-Douglas Production Function using the Ordinary Least Squares (OLS) Method

The analysis of the stochastic frontier production function in rice seed breeding in Serdang Bedagai Regency involved a two-stage process. In the first stage, the OLS (Ordinary Least Squares) method was used to estimate the technological parameters and production inputs. This method provides an estimate of the average performance of the rice seed breeding production process given the current level of technology.

Before estimating the production input parameters using the OLS method, several classical assumption tests were conducted to evaluate the model's adequacy. These tests examined potential violations of classical assumptions regarding errors. The tests assessed multicollinearity, heteroscedasticity, normality, and autocorrelation.

Multicollinearity Test

The multicollinearity test is conducted to identify potential violations of the classical assumption of multicollinearity, which occurs when there is a linear relationship among the independent variables in a regression model (Firdaus, 2019). One way to assess multicollinearity is by examining the Variance Inflation Factor (VIF) and tolerance values within the regression model. If the VIF value exceeds 10 or the tolerance value is higher than 0.01, it indicates the presence of multicollinearity. Conversely, if the VIF value is below 10 and the tolerance value is less than 0.01, multicollinearity is considered absent, indicating that the VIF and tolerance values fall within an acceptable range.

Table 5: Multicollinearity test results

Model	Collinearity Tolerance	VIF Statistics
(Constant)		
Ln_Land	,102	9,770
Ln_Seed	, 181	5,515
Ln_Labor	,287	3,484
Ln_Fertilizer	,220	4,536
Ln_Pesticide	,397	2,519

The multicollinearity test results indicate that the independent variables (land area, seeds, labor, fertilizer, and pesticides) used in the regression model do not violate the assumption of multicollinearity. This is evident from the VIF values, which are all less than 10, and the tolerance values, which are below 0.01. Therefore, there is no evidence of significant linear relationships among the independent variables, confirming the absence of multicollinearity in the model.

Heteroscedasticity Test

The Glejser test is used to detect heteroscedasticity, which refers to the unequal variance of residuals in a regression model. It examines the significance level to determine if there is evidence of heteroscedasticity. By evaluating the significance level, we can assess whether there is a violation of the assumption of equal variance of residuals.

Table 6: Heteroscedasticity Test Results

Model	t	Sig.
(Constant)	0.890	0.378
Ln_Land	0.251	0.803
Ln_Seed	0.514	0.610
Ln_Labor	-0.106	0.916
Ln_Fertilizer	-1,757	0.086
Ln_Pesticide	1.516	0.137

The significance values of the variables in the regression model, based on the heteroscedasticity test results, are greater than 0.05. This suggests that the independent variables (land area, seeds, labor, fertilizer, and pesticides) do not violate the assumption of heteroscedasticity in the model.

Normality Test

The normality test serves the purpose of evaluating the normality of the collected data. Its primary objective is to determine whether the data adheres to a normal distribution or originates from a population that follows a normal distribution (Firdaus, 2019). The One Sample Kolmogorov-Smirnov test is commonly employed as the method for conducting the normality test. By examining the significance level, it is possible to ascertain whether the data exhibits a normal distribution.

Table 7. Kolmogorov Smirnov one sample normality test results

		Unstandardized Residuals
N		50
Normal Parameters, b	Means	,0000000
	std. Deviation	,13536822
Most Extreme Differences	absolute	,120
	Positive	,093
	Negative	-,120
Test Statistics		,120
Asymp. Sig. (2-tailed)		,069c

The significance value (asymptotic significance, 2-tailed) from the SPSS data output test results for the One Sample Kolmogorov-Smirnov test is 0.069. Since the significance value is greater than 0.05, it indicates that the data follows a normal distribution. Once it is confirmed that the model does not violate any classical assumptions, the next step involves estimating the production input parameters using the Ordinary Least Square (OLS) method. The estimation results obtained through the OLS method are presented below.

Table 8: Estimation of the Cobb-Douglas Production Function Using the OLS Method.

Input Variables	Estimated Parameters	Std. Dev	(t-value)
(Constant)	9,834	,490	20,082
Ln_Land	1.112	,108	10.416
Ln_Seed	, 116	,078	1,479
Ln_Labor	-,127	.081	-1,566
Ln_Fertilizer	-,212	.059	-3,603
Ln_Pesticide	,009	,016	,543
F-Count	160,673	,000	
R Square	,945		

The estimation results indicate that the average production function used in the study effectively captures the behavior of rice seed breeders in the production process. The high coefficient of determination (R-squared) of 0.945 suggests that the included production factors (land, seed, labor, fertilizer, and pesticide) can explain 94.5% of the variation in rice seed breeding production. The remaining 5.5% of the variation may be attributed to other factors not considered in this study. The calculated F-value of 160.673 is statistically significant at a 5% level of significance, indicating that the input variables collectively have a significant impact on the production process.

The simultaneous elasticity of production ($\sum\beta$) is estimated to be 0.898. This value indicates that rice seed breeding production exhibits decreasing returns to scale. It suggests that as more inputs are added, the incremental output increases at a diminishing rate, reaching a point of saturation. This finding aligns with the assumptions of the Cobb-Douglas production function, where additional inputs lead to diminishing marginal returns, indicating that the incremental output decreases as more inputs are added.

Estimated Parameters of Cobb-Douglas Production Function using Maximum Likelihood Estimation (MLE).

The second stage involves estimating all the parameters of the production factors using the Maximum Likelihood Estimation (MLE) method.

Table 9: Estimation of the Cobb-Douglas Production Function Using the MLE Method

Input Variables	Coefficient	(t-ratio)
(Constant)	9,806	21,473
Ln_Land	1,099	11,476
Ln_Seed	0.116	1,860
Ln_Labor	- 0.104	- 1.392
Ln_Fertilizer	- 0.181	- 3,162
Ln_Pesticide	- 0.498	- 0.504
Sigma-square		0.382
Gamma		0.966
OLS log-likehoods		29,546
MLE log-likehoods		29,804
LR testone-side error		0.517

The estimated value of gamma (γ) using the Maximum Likelihood Estimation (MLE) method is 0.966. This indicates that 96.60% of the error term in the production function is attributed to inefficiency effects of the surveyed farmers, while the remaining 3.40% is associated with noise effects such as climate, weather, pests, and other factors. A value close to 1 suggests that inefficiency effects have a significant influence on the error term.

The generalized likelihood ratio (LR) test value for the model is 0.517, which is smaller than the critical value obtained from the Kodde and Palm table at a significance level of α = 5% (5.138). This suggests that the production of rice seedlings does not exhibit significant technical inefficiency effects.

The estimated value of sigma-square (Σ2) in the MLE method is 0.382, indicating that the error term of technical inefficiency (ui) follows a normal distribution.

The log-likelihood value obtained from the MLE method is 29.80, which is greater than the log-likelihood value obtained from the Ordinary Least Squares (OLS) method (29.54). This suggests that the production function estimated using the MLE method is appropriate and effectively represents the conditions of the research location.

The t-test is employed to assess the significance of the independent variables on the dependent variable. The tabulated t-value with α = 5% and df = 45 is 1.679. In this study, the variables "land" and "seeds" exhibit a significant positive effect on rice seedling production at a significance level of α = 5%. However, the variables "labor," "fertilizer," and "pesticide" do not have a significant positive effect on rice seedling production in the research location.

1. Land

The variable "land area" demonstrates a significant positive effect on rice seedling production, as indicated by a calculated t-value of 11,476, exceeding the tabulated t-value (1,677) at a significance level of α = 5%. The coefficient value for land area is 1.099, implying that a 1% increase in land area, with other inputs held constant, leads to a 1.09% increase in production. This finding aligns with previous studies conducted on rice seedling production and organic rice farming, which also highlight the positive impact of land area on production.

On average, rice seedling farmers in Serdang Bedagai Regency possess a land area of 12,823 m² or approximately 1.28 hectares. This suggests that they have larger land areas compared to small-scale farmers in North Sumatera and have the potential for further improvement. However, it is essential to ensure the proper utilization of inputs and implement sound management practices to maximize production gains when expanding land area.

2. Seeds

The variable "seed quantity" demonstrates a significant positive effect on rice seedling production, as evidenced by a calculated t-value of 1.860, exceeding the tabulated t-value (1.677) at a significance level of α = 5%. The coefficient value for seed quantity is 0.116, indicating that a 1% increase in seed quantity, with other inputs held constant, leads to a 0.12% increase in production. This finding is consistent with previous studies conducted on rice seedling production and organic rice farming, which also highlight the positive impact of seed quantity on production.

It is important for rice seedling farmers to ensure the use of an adequate quantity of seeds to maximize production. Proper seed selection, quality control, and appropriate seed-to-land ratio are essential factors to consider in order to achieve optimal results. By paying attention to seed quantity as an input, farmers can enhance their rice seedling production and overall productivity.

3. Labor

The variable "labor" exhibits a calculated t-value of -1.392, which falls below the tabulated t-value (1.677) at a significant level of α = 5%. This suggests that the number of labor days does not have a significant effect on rice seedling production in Serdang Bedagai Regency. The coefficient value for labor is -0.104, indicating that a 1% increase in the number of labor days, assuming other inputs remain constant, results in a 0.10% decrease in production. Labor has a negative impact on production. This finding aligns with the research conducted by Zulkarnain et al. (2022) on Technical, Allocative, and Economic Efficiency in Rice Farming, where the coefficient value for labor is -0.024 and negative.

4. Fertilizer

The variable "fertilizer" demonstrates a calculated t-value of -3.162, which is below the tabulated t-value (1.677) at a significant level of α = 5%. This suggests that the quantity of fertilizer does not have a significant effect on rice seedling production. The coefficient value for fertilizer is -0.181, indicating that a 1% increase in the amount of fertilizer, assuming other inputs remain constant, leads to a 0.18% decrease in production. Fertilizer negatively impacts production.

5. Pesticides

The variable "pesticide" exhibits a calculated t-value of -0.504, which is below the tabulated t-value (1.677) at a significant level of $\alpha = 5\%$. This suggests that the quantity of pesticide does not have a significant effect on rice seedling production. The coefficient value for pesticide is -0.498, indicating that a 1% increase in the amount of pesticide, assuming other inputs remain constant, results in a 0.49% decrease in production. Pesticide negatively influences production.

Distribution of Technical Efficiency.

Efficiency serves as a metric to evaluate the effectiveness of agricultural practices, including rice seedling production. Technically efficient rice seedling production refers to the ability to achieve a desired level of output using minimal inputs or maximizing output with a specific input combination. In this study, the classification of farmers as technically efficient aligns with Coelli's (2005) framework. According to this framework, if the efficiency index value equals or exceeds 0.7, it signifies technically efficient rice seedling production. Conversely, if the efficiency index value is below 0.7, it indicates that rice seedling production has not yet achieved technical efficiency.

Table 10. Distribution of technical efficiency values in rice seedling production in Serdang Bedagai Regency

Index	Number of Respondent Farmers	Percentage
0.00 - 0.10	0	0.00
0.11 - 0.20	0	0.00
0.21 - 0.30	0	0.00
0.31 - 0.40	0	0.00
0.41 - 0.50	0	0.00
0.51 - 0.60	0	0.00
0.61 - 0.70	0	0.00
0.71 - 0.80	1	2.00
0.81 - 0.90	4	8.00
0.91 - 1.00	45	90.00
Total	50	100.00
Average efficiency		0.9329
Minimum efficiency		0.7735
Maximum efficiency		0.9790

According to the table, all the farmers surveyed in the study demonstrate technical efficiency, as their efficiency index values exceed 0.7. The lowest technical efficiency value among the farmers is 0.77, while the highest value is 0.97. On average, the respondent farmers achieve a technical efficiency level of 0.93, which corresponds to 93.29% efficiency in rice seedling production. This indicates that, on average, there is still a 6.71% opportunity for further improvement in achieving maximum efficiency in rice seedling production in Serdang Bedagai Regency. This can be accomplished by enhancing skills and knowledge in adopting efficient cultivation technologies and implementing effective farm management practices. Additionally, incorporating production inputs that have a significant impact on rice seedling production can contribute to optimizing efficiency.

Efficiency allocative

Allocative efficiency in rice seedling production is achieved when the allocation of resources, specifically land area and seeds, is optimized to minimize costs while maximizing output. The analysis conducted in this study reveals that land area and seeds are the two variables that have a significant influence on seedling production. Therefore, it is crucial to carefully manage and optimize the utilization of these variables, as increasing their input levels can have a significant impact on overall farm production.

To assess allocative efficiency, a comparison is made between the marginal value of rice seedling production and the prices associated with the variables that have a significant influence, namely land area and seeds. This comparison allows for the evaluation of resource allocation decisions.

Table 11. Allocative efficiency of production factors in captive rice farming in Serdang Bedagai Regency

Variable	X	px	B	Y	Py	X.Px	byYPY	byYPY / X.Px
Land (X1)	65	7,488,490	1,099	331,001	11,982	487,950,000	4,358,640,594	8.93
Seed (X2)	2098	12210	0.116	331,001	11,982	25,610,000	460,056,696	17.96
Labor (X3)	2.172	200,012	-0.104	331,001	11,982	434,495,000	- 412,464,624	-0.95
Fertilizer (X4)	35,766	4,404	-0.181	331,001	11,982	157,519,150	- 717,847,086	-4.56
Pesticides (X5)	394,625	123	-0.498	331,001	11,982	48,630,000	-1,975,070,988	-40.61

The analysis of production factor allocation efficiency in rice seedling production reveals inefficiencies in the utilization of land area and seeds, indicated by efficiency values greater than 1. This suggests a need to increase the allocation of these variables for improved efficiency. On the other hand, labor, fertilizer, and pesticide inputs are inefficiently allocated, with efficiency values less than 1. Hence, it is necessary to reduce the allocation of labor, fertilizer, and pesticide inputs to enhance efficiency.

The inefficiency in labor utilization can be attributed to the contractual system utilized by rice seedling farmers. As for fertilizer and pesticide usage, inefficiencies arise from relying on personal farming experiences and the experiences of fellow farmers within the same group.

EfficiencyEconomy

The economic efficiency of rice seedling production can be achieved by considering both technical efficiency and allocative efficiency. Economic efficiency is determined by multiplying the technical efficiency and price efficiency of production factors.

Table 12. Economic efficiency of production factors in rice seed farming in Serdang Bedagai Regency

Variable	ET	EA	EE = ET x EA
Land Area (X1)	1.10	8.93	9,82
Seed (X2)	0.12	17.96	2.08
Labor (X3)	-0.10	-0.95	0.10
Fertilizer (X4)	-0.18	-4.56	0.82
Pesticides (X5)	-0.50	-40.61	20,23

The economic efficiency of production factors in rice seedling production in Serdang Bedagai Regency is derived from the multiplication of the technical efficiency and allocative efficiency values. As depicted in the table provided, the economic efficiency values for all production factors are not uniform and deviate from unity. Specifically, the factors of land area, seed, and pesticide exhibit values greater than one, indicating their failure to attain the level of economic efficiency. Conversely, the factors of labor and fertilizer display values less than one, signifying inefficiencies in their allocation.

CONCLUSION AND SUGGESTIONS

The analysis of production efficiency among rice seed breeders in Serdang Bedagai Regency reveals several key findings. Land area and seed quantity significantly influence production, while labor, fertilizer, and pesticide inputs have minimal impact. The average technical efficiency is 0.93, indicating room for improvement. Allocative efficiency values for land area and seeds are greater than 1, suggesting a need for increased allocation, while labor, fertilizer, and pesticide inputs have values less than 1, indicating excessive allocation. Economic efficiency values for all factors deviate from unity, with land area, seeds, and pesticides exceeding 1, and labor and fertilizer below 1. To enhance productivity, increasing land area and seed utilization is crucial. Providing extension activities, optimizing agricultural machinery, and improving resource allocation will further improve efficiency in rice seed breeding.

Declaration by Authors

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