Technical Efficiency Analysis of Environmentally Friendly Shallot Farming Based on the Planting Season in Bantul District

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Abstract. The center of shallot production in DIY is Bantul Regency, which has recently implemented an environmentally friendly system. The objectives of this study are 1) Analyzing the factors affecting production. 2) Analyze the level of technical efficiency. 3) Analyze the factors affecting the inefficiency. Respondents used amounted to 66 people. Samples were taken in two hamlets of Nawungan I and Nawungan II in Bantul Regency. The data analysis method used is the multiple regression of frontier stochastic production functions. The results showed that land area, seeds, manure, liquid organic fertilizer (POC), SP 36 fertilizer affects the production of environmentally friendly shallots in both growing seasons, while other production factors that affect the growing season of one synthetic pesticide and in the growing season two NPK fertilizers, ZA fertilizer and KCL fertilizer. The average technical efficiency value in growing season one is 0.692 and growing season two is 0.657 so that environmentally friendly shallot farming is suspected to be not technically indicine. Age and farming experience in both growing seasons affect the inefficiency of environmentally friendly shallot farming, while other factors that influence in both growing seasons are the number of family members and education level. **Keywords:** shallots, technical efficiency, inefficiency, environmentally friendly.

1 Introduction

Indonesia is renowned as an agrarian country that consistently contributes to national income each year, particularly in the agricultural sector, which includes several key commodities such as plantation, food crops, and horticulture [1],[2],[3]. In daily life, the public is more closely connected to horticultural commodities than to other agricultural products, as horticulture is highly promising and has substantial economic value, making it ideal for continuous development [4],[5]. Shallots are among the high-value horticultural commodities that warrant further development and are consistently cultivated by farmers [6],[7]. As a staple ingredient, shallots are widely used in both household and food industry processing. Therefore, it is not surprising that demand for shallots is expected to grow in tandem with

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Indonesia’s population growth [8]. Globally and nationally, there is a growing trend toward environmentally friendly agriculture, focusing on sustainability, food security, and consumer health. In Indonesia, this trend is gaining traction as the market demands agricultural products free from chemical residues and of high quality. Environmentally friendly practices in shallot farming are particularly relevant as they contribute to environmental conservation and improve product safety, adding value to agricultural products in both domestic and international markets.

Indonesia’s shallot production hub is in Central Java Province, with a production output of 6,111,651 quintals [1]. Among these, the highest shallot production is in Brebes Regency, amounting to 4,016,155 quintals [2]. Although the Special Region of Yogyakarta also cultivates shallots, its production volume is significantly lower than that of Central Java. However, Yogyakarta has undertaken initiatives to increase shallot production to meet local demand and reduce reliance on external supply [4]. According to data from the BPS, shallot production in Yogyakarta has shown an average annual increase of 0.36% over the past five years (2016–2020) [5]. It is crucial to sustain and even further increase this production in Bantul Regency to consistently meet consumer demand in Yogyakarta and other regions. Bantul Regency, as one of Indonesia's main shallot production centers, holds strategic potential for environmentally friendly farming. However, its geographic and climatic conditions present unique challenges. Production decreases can, however, occur due to declining soil fertility caused by prolonged use of synthetic substances without incorporating organic matter into the shallot farmland, as is common in conventional farming. Efficient input allocation and appropriate technology applications are essential to successfully implement eco-friendly farming in this area. The success of these initiatives could serve as a model for other regions facing similar agricultural challenges.

Why does shallot production decline frequently? To prevent further production declines in the future, farmers must undertake essential initiatives, such as substituting synthetic fertilizers with organic fertilizers [7]. Recently, environmentally friendly farming practices have become more prevalent, characterized by reducing synthetic fertilizer use and substituting it with organic fertilizers; in some cases, synthetic pesticides are also avoided [8]. Predominantly, this involves the application of compost, manure, and plant-based pesticides, such as neem leaves and rice-washing water [9]. Support from the Indonesian government and local institutions is essential for developing environmentally friendly shallot farming. Through various programs initiated by the Ministry of Agriculture, policies promoting sustainable agricultural practices are in place, including technical training in soil management and the use of organic fertilizers. These programs aim to improve yield without compromising the environment, aligning with national goals for sustainable agriculture.

Increasing awareness among farmers of environmentally friendly, chemical-residue-free products has driven a shift from conventional systems to eco-friendly agriculture, as seen in two hamlets in Selopamioro Village, Imogiri District [10]. Environmentally friendly farming is a shallot cultivation system currently practiced in Bantul Regency by the Lestari Mulyo farmer group in Nawungan I Hamlet and the Sido Rukun farmer group in Nawungan II Hamlet, Selopamioro Village, Imogiri District [11]. The potential of shallot production using eco-friendly methods in Imogiri District should be preserved and further enhanced, including through the efficient use of available resources to maximize output.

To achieve optimal and environmentally friendly shallot production, further research is crucial. By understanding the technical efficiency factors affecting shallot production, policymakers and farmers can develop strategies for sustainable shallot farming. This research is expected to contribute to effective policy planning and provide actionable recommendations to help farmers meet production challenges sustainably. This eco-friendly shallot farming involves both internal and external factors influencing production success [12], [13]. Internal factors focus on farmers’ technical and managerial capabilities in farming, including land area and ownership, education, age, income, experience, technological expertise, and farmers' ability to process agricultural information to boost production [8]. External factors, on the other hand, include elements beyond the farmers' control, such as climate, input prices, and plant pests and diseases. Based on these factors, eco-friendly shallot farmers must allocate their production inputs efficiently to achieve optimal yields each planting season. Therefore, analyzing the factors influencing technical efficiency and inefficiency in environmentally friendly shallot farming by planting season in Bantul Regency is essential.

2 Methods

This study employs a descriptive analysis method, which serves as a fundamental approach for analyzing available data, providing a clear picture of the facts and relationships of the studied phenomena [14]. The sampling in Selopamioro Village was based on two farmer groups implementing eco-friendly cultivation systems with the longest farming experience.

Table 1. Distribution of Farmer Groups in Selopamioro Village

Farmer Group Name	Location	Land Area (ha)
Sapu Angin	Lanteng I	10,76
Ngudi Lestari	Siluk II	15
Tani Maju	Jetis	13
Lestari Mulyo	Nawungan I	85
Ngudi Rahayu	Lemah Rubuh	7
Sumber Baru	Kajor Wetan	17,8
Sedoyo Makmur	Kajor Kulon	16,5
Ngudi Hasil	Siluk I	15
Ngudi Lestari	Lanteng II	25
Ngudi Rahayu	Pelematung	10
Ngudi Mulyo	Putat	8,15
Sari Mulyo	Kalidadap II	66,16
Ngudi Makmur	Nogosari	34,37
Wonorejo	Srunggo I	49
Tri Martani	Kalidadap I	26
Bumi Mukti	Srunggo II	49,08
Sido Rukun	Nawungan II	80
Amrih Makmur	Kedung Jati	0

Source: Imogiri Agricultural Extension Service (2021)

The data indicates that Lestari Mulyo and Sido Rukun have the largest land areas compared to other farmer groups. Sampling from two hamlets—Nawungan I and Nawungan II—was selected through a random draw from half of the environmentally friendly shallot farmer population in Selopamioro Village. The total population of environmentally friendly shallot farmers is listed in Table 2.

Table 2. Population and Sample of Eco-Friendly Farmers

Farmer Group	Respondent	
	Total Population	Number of amples
Lestari Mulyo	60	30
Sido Rukun	72	36
Amount	132	66

Source: Farmer Group (2021)

Formula:

$$\frac{Number\ of\ Respondents}{Total\ Population} \times Farmer\ Group\ Population$$

N1: $\frac{66}{132} \times 60 = 30$

N2: $\frac{66}{132} \times 72 = 36$

In this study, 66 farmer respondents were selected from the total population, including 30 farmers in the Lestari Mulyo group (Nawungan I) and 36 farmers in the Sido Rukun group (Nawungan II). Data collected through farmer interviews will be analyzed using the following method:

2.1 Production Function

The Cobb-Douglas stochastic frontier production function multiple regression analysis is used to estimate production factors affecting the environmentally friendly shallot farming system for the first and second planting seasons. Production function analysis is necessary to evaluate production based on inputs, including land area (X_1), seeds (X_2), manure (X_3), liquid organic fertilizer (X_4), SP-36 fertilizer (X_5), NPK fertilizer (X_6), ZA fertilizer (X_7), KCL pesticide (X_8), synthetic pesticides (X_9), plant-based pesticides (X_{10}), and Workforce (X_{11}) as follows:

$$ln\ ln\ Y = ln\ ln\ b_0 + b_1\ ln\ X_1 + b_2\ ln\ X_2 + b_3\ ln\ X_3 + b_4\ ln\ X_4 + b_5\ ln\ X_5 + b_6\ ln\ X_6 + b_7\ ln\ X_7 + b_8\ ln\ X_8 + b_9\ ln\ X_9 + b_{10}\ ln\ X_{10} + b_{11}\ ln\ X_{11} + (v_i - in_i)$$

Description:

AND = Red onion production in one planting season (kg)
b_0 = Constant
b_{1-11} = Regression coefficient
X_1 = Land Area (m^2)
X_2 = Seedlings (kg)
X_3 = Manure (kg)
X_4 = Liquid Organic Fertilizer (l)
X_5 = Pupuk SP 36 (kg)
X_6 = Pupuk NPK (kg)
X_7 = Pupuk ZA (kg)
X_8 = Pupuk KCL (kg)
X_9 = Synthetic pesticides (l)
X_{10} = Vegetable Pesticides (l)
X_{11} = Workforce (HKO)
v_i = Random error (disturbance term)
in_i = Inefficiency effects that appear

2.2 Technical Efficiency Analysis

Technical efficiency measures the relationship between actual production and potential production (frontier production). Actual production in farming often faces external factors that lead to inefficiency. In this study, technical efficiency will be analyzed using Frontier 4.1 software. The software provides parameter estimation using the MLE approach, resulting in the efficiency level of environmentally friendly shallot farming as follows:

$$\mathrm{TEi} = \frac{\mathrm{Y}}{\mathrm{Y}^{*}} - \frac{\mathrm{E}\left(\mathrm{Yi}\ \middle|\mathrm{Ui,Xi}\right)}{\mathrm{E}\left(\mathrm{Yi}\ \middle|\mathrm{Ui} = 0\mathrm{iXi}\right)}$$

. Description:
Tei = Technical efficiency of the i-th producer (ranges from 0 to 1)
YY = Actual Output
Y∗ = Potential Output (derived from the stochastic frontier production function)

The level of technical efficiency lies between $0 \leq TE_i \geq 1$

The technical efficiency level of environmentally friendly shallot farming in the first and second planting seasons is considered efficient if the farming analysis result approaches 1 and technically inefficient if it approaches 0.

Inefficiency Factors, the stochastic frontier approach in the production function identifies inefficiency using the delta value in Maximum Likelihood Estimation (MLE). To determine the inefficiency of environmentally friendly shallot farmers in the first and second planting seasons, certain farmer characteristics are used as factors, including age (Z_1), education level (Z_2), environmentally friendly farming experience (Z_3), and family size (Z_4). The equation used to measure inefficiency among environmentally friendly shallot farmers in the first and second planting seasons is as follows:

$$U_i = \delta_0 + \delta_1 Z_1 + \delta_2 Z_2 + \delta_3 Z_3 + \delta_4 Z_4$$

Where:
Ui = Inefficiency
δ_0 = Constant
δ_{1-4} = Regression coefficients
Z_1 = Farmer's age
Z_2 = Farmer's education level
Z_3 = Farmer's experience in environmentally friendly farming
Z_4 = Farmer's family size

3 Results and Discussion

3.1 Production Function

The multiple regression analysis of the production function in this study was conducted using Maximum Likelihood Estimation (MLE) via Frontier 4.1 software. The analysis focused on independent variables (factors affecting production) and dependent variables (production outcomes). The results for the environmentally friendly red onion farming production function, based on a stochastic frontier approach across two planting seasons, are presented in Table 3 below:

Table 3. Results of Cobb-Douglas Production Function Regression Analysis

No	Variable	Planting Season I	Planting Season II
		Coefficient	T-value
1	Constant	1.316654	1.5293
2	Land Area (X1)	-0.000065***	-3.0804
3	Seeds (X2)	0.274887***	5.4799
4	Manure (X3)	0.000043***	2.5183
5	Liquid Organic Fertilizer (X4)	0.711441***	8.2990
6	SP 36 Fertilizer (X5)	0.000075***	3.4642
7	NPK Fertilizer (X6)	0.005892	0.3079
8	ZA Fertilizer (X7)	0.000006	0.5731
9	KCL Fertilizer (X8)	-0.022998	-1.1123
10	Synthetic Pesticide (X9)	0.000085*	1.4276
11	Botanical Pesticide (X10)	-0.007061	-0.7497
12	Labor (X11)	-0.000002	-0.1427
Sigma-squared		0.484886	
Gamma		0.999999	

Notes:

- *** : Significant at T-table = 2.2960, α = 1%
- ** : Significant at T-table = 1.6730, α = 5%
- * : Significant at T-table = 1.2971, α = 10%

Table 3 shows that the variance/sigma square and γ (gamma) values indicate inefficiencies in the stochastic frontier production function during both planting seasons. The variance (sigma square) value for the environmentally friendly red onion farming during the first planting season was 0.484886, with a gamma value of 0.99, indicating that 99% of the error term stems from inefficiencies on the farmers' part, while the remaining 1% is due to external factors (noise). The second planting season exhibits similar results, with a variance of 0.859388 and gamma also at 0.99, suggesting a 99% inefficiency rate due to farmer practices and only 1% due to external factors.

The estimated coefficients for the variables are both positive and negative, where negative and significant coefficients indicate that increasing the input will reduce environmentally friendly red onion production. Conversely, a positive and significant coefficient suggests that increasing input will boost production. Based on the T-values, the constant is significant and positively impacts environmentally friendly red onion production during the first planting season, indicating that without any production factors, red onion production in the first season would be 1.316654 kg. Similarly, in the second season, production without production factors would amount to 2.118558 kg.

According to the estimates in Table 3, six input variables significantly impact environmentally friendly red onion production during the first planting season, while eight variables are significant in the second season. Significance is determined by the T-values exceeding the T-table values. In the first planting season, the significant variables, ordered from the highest coefficient, include liquid organic fertilizer (POC), seeds, synthetic pesticides, SP 36 fertilizer, manure, and land area. In the second planting season, they include seeds, liquid organic fertilizer (POC), NPK fertilizer, SP 36 fertilizer, manure, ZA fertilizer, land area, and KCL fertilizer. These variables are explained as follows:

3.1.1 Land Area

Land area (X_1) in both planting seasons had a negative and significant effect at the ten percent level on the environmentally friendly shallot production in Bantul Regency. The coefficient value of the land area variable (X_1) in the first planting season was -0.000065, while in the second planting season, it was -0.000077. It is estimated that a 1% increase in land area in both planting seasons statistically reduces environmentally friendly shallot production by 0.000065 percent in the first planting season and 0.000077 percent in the second. This negative effect is thought to stem from suboptimal land cultivation techniques, and farmers assume that the larger the cultivated area, the higher the production. This research is consistent with findings showing that land area negatively impacts shallot production [15] but differs from research by Maryanto et al. [16], which found that land area positively affects potato production in South Sulawesi.

3.1.2 Seeds

The seed variable (X_2) in both planting seasons had a positive and significant effect on the environmentally friendly shallot production in Bantul Regency. As shown in Table 3, in the first planting season, the T-count was greater than the T-table at the one percent level, like the second season. This result aligns with findings from Nursan and Wathoni [17] and Mutiarasari *et al.* [18] regarding the influence of seeds on shallot production. Seeds planted in environmentally friendly shallot farming in Bantul Regency positively influenced production, with a coefficient of 0.27488 in the first season and 0.534547 in the second. This means that a 1% increase in seed use during both seasons will increase shallot production by 0.27488% in the first season and 0.534547% in the second. The positive impact likely stems from the belief that more seeds lead to higher yields. In practice, farmers often plant one large seed or 2-3 smaller seeds per spot, depending on soil and water conditions.

3.1.3 Manure

Manure (X_3) significantly impacted shallot production at a one percent significance level in the first planting season and a five percent level in the second season. This aligns with Gultom et al. [19], who found that compost fertilizer positively affects semi-organic rice production in Cigombong, West Bogor. Manure used in environmentally friendly shallot farming in Bantul Regency had a positive coefficient of 0.000043 in the first season and 0.000035 in the second. This suggests that a 1% increase in manure use in both seasons increases environmentally friendly shallot production by 0.000043% in the first season and 0.000035% in the second. This positive effect is attributed to the belief that more manure leads to higher yields. Farmers use manure to enrich the soil in the first season and reapply it in the second season to replenish soil nutrients.

3.1.4 Liquid Organic Fertilizer (POC)

Liquid organic fertilizer (X_4) significantly influenced environmentally friendly shallot production in Bantul Regency at a one percent level, as shown in Table 3. In both seasons, T-counts were higher than T-tables at the one percent level, indicating that POC has a significant positive effect on shallot production. POC is one of the variables that positively impacted environmentally friendly shallot production in Bantul Regency. The coefficient in the first planting season was 0.7114, while in the second season, it was lower at 0.2768. This means that a 1% increase in POC use during both seasons will increase production by 0.7114% in the first season and 0.2768% in the second. The difference in POC use between the two seasons may be due to varying land areas; a single bottle of POC (12 ml per hectare) is recommended for one hectare.

3.1.5 SP 36 Fertilizer

SP 36 fertilizer (X_5) had a significant positive effect on environmentally friendly shallot production in Bantul Regency. As shown in Table 3, T-counts were higher than T-tables in both seasons at a one percent level. SP 36 fertilizer used in environmentally friendly shallot farming in Bantul Regency positively impacted production, with a coefficient of 0.0000755 in the first season and 0.0000424 in the second. This suggests that a 1% increase in SP 36 use will increase shallot production by 0.0075% in the first season and 0.0042% in the second. This positive effect is attributed to the belief that more SP 36 fertilizer increases yield, although excessive use can cause premature yellowing of shallot leaves.

3.1.6 NPK Fertilizer

NPK fertilizer (X_8) was not significant in the first season but had a positive value toward shallot production at a ten percent significance level. In the second season, NPK fertilizer was significant and positively influenced shallot production at a ten percent level, consistent with Sidharta et al. [20], who analyzed the technical efficiency of fertilizer and pesticide use in asparagus cultivation in Bandung. NPK fertilizer in environmentally friendly shallot farming in Bantul Regency positively impacted production, with a coefficient of 0.0058 in the first season and 0.019 in the second. This suggests that a 1% increase in NPK use will statistically increase shallot production by 0.0058% in the first season and 0.019% in the second. Farmers believe that more NPK fertilizer leads to higher yields.

3.1.7 ZA Fertilizer

ZA fertilizer (X_7) in the first planting season is not significant to the amount of environmentally friendly shallots produced in Bantul Regency. However, it has a positive coefficient value of 0.0000065, meaning that every 1% increase in ZA fertilizer (X_7) in shallot farming will statistically affect the increase in environmentally friendly shallot production. This is in line with Tinaprilla et al. [21], who stated that ZA fertilizer (X_7) does not have a significant effect in their study on the technical efficiency of rice farming in West Java.

In contrast, during the second planting season, the T-value is greater than the T-table at the 1% level. This indicates that the ZA fertilizer (X_7) variable in the second planting season is significant but has a negative effect. The coefficient value in the second planting season is -0.000019, meaning that every 1% increase in ZA fertilizer (X_7) will decrease the shallot production by 0.000019%.

3.1.8 KCL Fertilizer

KCL fertilizer (X_8) in the first planting season has a negative and insignificant effect on the environmentally friendly shallot production in Bantul Regency, with a coefficient value of -0.023. This means that every 1% increase in KCL fertilizer (X_8) in environmentally friendly shallot farming will statistically reduce production by 0.023. The lack of a significant effect of KCL fertilizer (X_8) in both planting seasons is in accordance with the research by Tristya et al. [22] on the technical efficiency of shallots in South Lampung.

In contrast, during the second planting season, the T-value is greater than the T-table at the 10% level. In this second season, the KCL fertilizer (X_8) variable has a negative effect but is significant. The coefficient value in the second planting season is -0.0279. The negative effect means that every 1% increase in KCL fertilizer (X_8) will result in a decrease in shallot production by 0.0279%.

3.1.9 Synthetic Pesticides

Synthetic pesticides (X_9) have a positive and significant effect on shallot production at the 10% level in the first planting season. The coefficient value is 0.000085, indicating a positive relationship between synthetic pesticides (X_9) and the amount of shallot production. This means that every 1% increase in synthetic pesticides will increase the shallot yield by 0.000085% during the first planting season, consistent with the research by Nursan & Wathoni [17] on shallots in Bima, West Nusa Tenggara. In contrast, during the second planting season, the synthetic pesticide (X_9) variable does not have a positive effect but is not significant in relation to the amount of shallot production at the 10% level. The coefficient value in the second planting season can be interpreted as every 1% increase in chemical pesticides will increase the shallot production by 0.0000226%. However, the absence of an effect of synthetic pesticides on production is consistent with the research on shallots in East Lombok [23].

3.1.10 Botanical Pesticides

Botanical pesticides (X_{10}) in the first planting season have a negative and insignificant effect on shallot production at the 10% level. The negative coefficient value of -0.007 indicates a negative relationship between botanical pesticides (X_{10}) and shallot production. This means that every 1% reduction in botanical pesticides (X_{10}) will statistically reduce production by 0.007%.

In contrast, during the second planting season, based on the T-value, the botanical pesticide (X_{10}) variable is not significant to the amount of shallot production at the 10% level. The coefficient value is 0.022, which is positive, meaning that every 1% increase in botanical pesticides (X_{10}) in the second planting season will statistically increase the shallot production by 0.022%.

3.1.11 Labor

Labor (X_{11}) in both planting seasons has a negative and insignificant effect on shallot production in the first planting season at the 10% level. The negative coefficient value is -0.0000026 in the first planting season, and similarly, in the second planting season, it is -0.113. This means that every 1% increase in labor will statistically lead to a decrease in shallot production of 0.0000026% in the first planting season and 0.113% in the second planting season. This finding is in line with Mutiarasari et al. [18], who state that labor does not affect shallot production in Majalengka, West Java.

3.2 Technical Efficiency

The results of the technical efficiency analysis are used to measure the farmers' ability to manage environmentally friendly shallot farming in the first and second planting seasons in Bantul Regency to see if it is already efficient or not. The distribution of the technical efficiency level is shown below:

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Table 4. Distribution of Technical Efficiency of Environmentally Friendly Shallot Farmers

Technical Efficiency	Planting Season I		Planting Season II	
	Number of people)	Percentage (%)	Number of people)	Percentage (%)
0,11-0,20	3	5	1	2
0,21-0,30	0	0	1	2
0,31-0,40	7	11	7	11
0,41-0,50	6	9	14	21
0,51-0,60	5	8	6	9
0,61-0,70	8	12	10	15
0,71-0,80	9	14	8	12
0,81-0,90	13	20	9	14
0,91-1,00	15	23	10	15
Amount	66	100	66	100
Minimal	0,156			0,137
Maximum	0,999			0,999
Mean efficiency	0,692			0,654

The technical efficiency level of farmers is categorized as efficient if it has a value ≥ 0.700 [19]. Based on Table 4, the average distribution of the first planting season is 0.692 and the second planting season is 0.654, indicating that neither planting season is technically efficient. From the average efficiency index value in the first planting season, farmers have reached 69.2% of the potential production obtained with the combination of production inputs. If farmers want to achieve maximum efficiency in the first planting season, there is still an opportunity to increase their production by 30.8% from the average farmer. The same goes for the second planting season, where the technical efficiency index is 65.4%, indicating that farmers have reached 65.4% of the potential production obtained with the combination of production inputs. If farmers wish to achieve maximum efficiency in the second planting season, they still could increase their production by 34.6% from the average farmer. It is noted that the distribution of farmers with below-average technical efficiency is 28 individuals in the first planting season and 29 individuals in the second planting season for environmentally friendly shallot production in the region. The farmer with the lowest technical efficiency level in the first planting season has a score of 0.156. Meanwhile, the highest score for both seasons is the same at 0.99, with the percentage for the first planting season being higher than the second at 23%.

Farmers engaged in environmentally friendly shallot farming in the first planting season, and those who experienced an increase in technical efficiency totaled 29 farmers. The increase in production by environmentally friendly shallot farmers from both planting seasons is presumed to be influenced by internal farmer factors such as age, education level, farming experience, and family size. Farmers who experience improvements tend to be between the ages of 40-60, with an average education level of elementary school and family dependents not exceeding 5.

The analysis of the technical efficiency of farmers in Table 4 indicates that the model used still has inefficiency problems, which are suspected to be caused by internal farmer factors. Thus, the factors influencing inefficiency need to be analyzed. Age, farming experience, education level, and family size will be jointly analyzed for their effects through the frontier program 4.1, which will be obtained from the MLE method. The results of estimating the inefficiency effects of environmentally friendly shallot farmers in the first and second planting seasons will be discussed in the following section.

3.3 Inefficiency

The following presents the results of the analysis estimating the level of inefficiency in environmentally friendly shallots in Bantul Regency during the first and second planting seasons in Table 5:

Table 5. Analysis Results of Inefficiency in Environmentally Friendly Shallot Farmers

Variable	Planting Season I		Planting Season II	
	Coefficient	T-count	Coefficient	T-count
Age	-0,07069*	-1,3267	-0,04247*	-1,1327
Level of education	-0,00007ns	-0,9364	-0,00020***	-2,4519
Farming Experience	0,11153***	2,8902	0,06606*	1,6036
Number of Family Members	-0,0001***	-2,4856	-0,00005ns	-0,6244

Notes:
***: significant at T-table = 2.2960, α 1%
**: significant at T-table = 1.6730, α 5%
*: significant at T-table = 1.2971, α 10%
ns: not significant

3.3.1 Age

The age of farmers is significant to inefficiency at the ten percent level during both planting seasons. However, the coefficient values in both planting seasons are negative, with -0.0706 in the first season and -0.0424 in the second season. This suggests that every 1% increase in the age of farmers leads to a decrease in inefficiency, meaning the environmentally friendly shallot farming they manage becomes more technically efficient in both planting seasons. In other words, older farmers are technically more efficient in their environmentally friendly shallot farming during both planting seasons. Conversely, younger farmers tend to be less efficient in managing their farming. This is closely related to farming experience; the longer farmers manage their shallot farms, the more technically efficient they become. This statement is consistent with research on shallots in Demak [24].

3.3.2 Education Level

The education level is not significant to inefficiency at the ten percent level. In the first planting season, education level is not significant and has a negative coefficient value of -0.0000746. This means that a 1% increase in education statistically can reduce the level of inefficiency, indicating that higher education levels among farmers correspond to less efficient environmentally friendly shallot farming. This aligns with research [17], which states that education level does not have a significant impact on shallot farming in Bima.

In contrast, in the second planting season, the education level is significant to inefficiency at the one percent level, but it has a negative value like the first season, with a coefficient of -0.000202. This means that a 1% increase in education will further reduce the level of inefficiency in the second planting season. If the level of inefficiency decreases, then environmentally friendly shallot farming becomes more technically efficient. This is consistent with research on shallots in Demak [24].

3.3.3 Farming Experience

Farming experience has a positive and significant impact on the level of inefficiency at the one percent significance level with a coefficient of 0.1115. Similarly, in the second planting season, it also has a positive and significant effect at the ten percent level with a coefficient of 0.0660. This indicates that the longer the farming experience in shallot farming, the lower the level of inefficiency, making the shallot farming managed by farmers more efficient [22]. which states that farming experience affects the level of inefficiency in research on shallot farming in South Lampung.

3.3.4 Number of Family Members

Logically, the more family members involved in managing environmentally friendly shallot farming, the more efficient the farming operation, as there are more dependents that need to be fulfilled. However, based on the analysis results shown in the T-count values in Table 5, the number of family members in environmentally friendly shallot farming has a negative and significant impact on the level of inefficiency at the one percent significance level with a coefficient of -0.000164. Every 1% increase in the number of family members reduces the level of inefficiency in the production of environmentally friendly shallots. This means that the involvement of family members in managing environmentally friendly shallot farming during the first planting season raises the technical efficiency level. This is in line with research on technical efficiency and sources of technical inefficiency in organic rice farming in Tasikmalaya Regency [25]. However, in the second planting season, the number of family members is not significant at the ten percent level, with a negative coefficient of -0.0000529. Every 1% increase in the number of family members statistically lowers the level of inefficiency in the production of environmentally friendly shallots.

4 Conclusion and Recommendation

4.1 Conclusion

Based on the objectives studied, the factors of land area, seeds, manure, liquid organic fertilizer (POC), and SP 36 fertilizer influence the production of environmentally friendly shallots in both planting seasons, while other production factors influencing the first planting season include synthetic pesticides, and for the second planting season, NPK fertilizer, ZA fertilizer, and KCL fertilizer.

The average technical efficiency level in the first planting season is 0.692, and in the second planting season is 0.657, indicating that environmentally friendly shallot farming in Bantul Regency in both planting seasons is not yet technically efficient.

The factors of age and farming experience influence the inefficiency of environmentally friendly shallot farming in both planting seasons, while other factors that influence the first planting season include the number of family members, and for the second planting season, the education level.

4.2 Recommendations

The level of technical efficiency in environmentally friendly shallot farming in Bantul Regency can be improved by enhancing farm management. Experienced farmer group members can guide younger group members on effective cultivation practices to maximize production results.

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