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RESEARCH ARTICLE

The Impact of Production Factor Utilization on Shallot Farming with Surjan Technology System on Sub–Optimal Land to Enhance Production Efficiency

ALIUDIN [1*] , ***Setiawan Sariyoga*** [2] , ***Aris Supriyo Wibowo*** [2]

[1] *Department of Agricultural Sciences, University of Sultan Ageng Tirtayasa, Serang 42124, Indonesia*

[2] *Department of Agribusiness, Sultan Ageng Tirtayasa University, Serang 42118, Indonesia*

ABSTRACT

This study aimed to determine the effect of production factor utilization on shallot production. Three production factors were investigated, including seeds, land area, and NPK fertilizer. The application of these production factors was implemented among farmers who used the Surjan cultivation technology system. This study employed a quantitative method with a descriptive approach. The sampling technique used was proportional stratified random sampling, with a total sample of 44 shallot farmers. The analysis used included multiple linear regression and the Cobb–Douglas production function. The results showed that the elasticity values of seed, land, and NPK fertilizer production factors were 0.223, 0.471, and 0.236, respectively. The analysis results indicated that the production elasticity values of each production factor, namely seeds, land, and NPK fertilizer, were positive but less than 1. This means that the addition of these three production factors still had a positive impact on increasing shallot production. Therefore, farmers could increase the use of seeds, expand land area, and add NPK fertilizer up to a certain limit. The overall elasticity value was 0.93, indicating that the three inputs could still be increased in use. In this condition, farmers could combine the use of these inputs to achieve optimal production. Additionally, the use of high–quality seeds and increasing the quantity per hectare was recommended. Land expansion could be achieved through extensification or by increasing the cropping index.

*CORRESPONDING AUTHOR:
ALIUDIN, Department of Agricultural Sciences, University of Sultan Ageng Tirtayasa, Serang 42124, Indonesia; Email: aliudin@untirta.ac.id

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1. Introduction

Shallots were a significant horticultural crop in Indonesia, widely cultivated in various regions as a commercial crop due to increasing demand. However, the supply of this commodity often failed to meet market demand. Shallot production was characterized by high production risks, resulting in substantial impacts on production levels when failures occurred during the biological production process. This discrepancy between expected and actual production levels had significant consequences. According to data from Indonesia's research in 2020, Indonesia imported 8.17 thousand tons of shallots from Vietnam, Malaysia, and Thailand, while domestic production was 1.82 tons [1]. This indicated that shallot production in Indonesia remained limited, contributing to the high price of shallots. Furthermore, from a macroeconomic perspective, shallots were an agricultural commodity that contributed to inflation, alongside soybeans and chilies.

The high price of shallots at the farm level led to changes in behavior in the use and combination of various inputs required. There was a tendency for farmers to use inputs beyond optimal limits, which resulted in increased production costs and caused farmers to produce beyond the break–even point.

This research was important for controlling the use of production factors, which was crucial for achieving production efficiency. The study provided valuable insights for farmers to control the use of production factors, thereby reducing production costs and mitigating production risks. Through the control of production factors, farmers were able to indirectly optimize their.

The management technology for managing shallot plants to reduce production costs involved controlling production inputs. This technology was based on the behavior of farmers who lacked control over the use of production inputs. The control over the use of production inputs was necessitated by the characteristics of the farmers, specifically their small–scale farming operations with limited land ownership and small–scale business management.

The farming land used for shallot production was not very large and tended not to guarantee efficiency, meaning that a small additional input had a very low response to output. As a result, the production cost per kilogram of shallots was very high. This high production cost caused the selling price per unit of shallots to be uncompetitive in the market. The high selling price at the farmer level resulted in low product competitiveness in the market, indicating a low comparative advantage of shallots.

The efficient use of inputs was a suitable business strategy to enhance the competitiveness of shallot products in the market. Efficient use of inputs had two benefits, namely, reducing production costs and protecting producers from rising production costs, as well as shielding consumers from price pressures due to increased production costs [2].

Shallot farmers in Tonjong village faced constraints related to high production costs and challenges in competing in the market. These obstacles were detrimental to shallot farmers, and this research aimed to provide solutions to help farmers understand the response to the use of production inputs during the shallot production process. The analytical tool employed was a modified Cobb–Douglas production function [3]. The benefits of using the modified Cobb–Douglas production function included identifying production inputs that had reached optimal levels, those that were not yet efficient, and those that had achieved efficiency [4].

Three important production factors in shallot cultivation were focused on in this research, namely land, seeds, and NPK fertilizer. Land was the most critical medium in the shallot cultivation system. The characteristics of land in the Surjan system technology determined the level of production efficiency. In addition to land, seeds and NPK fertilizer were also crucial production factors in the shallot production system. High–quality shallot seeds that were resistant to pests and diseases, and NPK fertilizer, which provided essential nutrients for shallot growth, were necessary for producing high–quality shallots. The application of NPK fertilizer not only involved the dosage but also the technique of fertilization. Previous research had shown that the technique of NPK fertilization could increase shallot production [5]. Furthermore, other research had found that land area, seeds, NPK fertilizer, and labor had a positive and significant effect on shallot production [6]. Another study had also demonstrated that improving the technology of shallot seed production could enhance the quality and quantity of production [7]. This research aimed to investigate how these three production factors – seeds, land, and NPK fertilizer – were applied by farmers in the Surjan system technology.

To answer the research question about the influence of production factors on shallot production, the appropriate analyses used were multiple linear regression analysis and Cobb–Douglas production function analysis. These two analyses supported each other in answering the research question [8]. Multiple linear regression analysis was used to determine the effect of land, seeds, and NPK fertilizer on shallot production, based on regression coefficients, t–test results, and F–test results that were obtained [9]. Thus, this analysis helped researchers understand how these production factors had affected shallot production. Meanwhile, Cobb–Douglas production function analysis was used to determine the elasticity of production of the three production factors, namely land, seeds, and labor [10]. This production elasticity was important for understanding the response of these production factors to shallot production.

2. Materials and Methods

2.1. Research Methods

The materials and methods used in this study were described in sufficient detail to allow others to replicate and build on the published results. The research employed a descriptive analysis method. The sampling technique used was proportional stratified random sampling, with the basis for grouping samples (stratification) being the area of land used for shallot farming.

The total sample was divided into two groups: the first group consisted of farmers with a land area of less than 0.25 ha, and the second group consisted of farmers with a land area of more than 0.25 ha. The sample size was determined using the method described in Cochran [11]. The sample consisted of 44 members of the population in Tonjong village, Kramatwatu District, comprising 30 farmers with a shallot planting area of less than 0.25 ha and 14 farmers with a shallot planting area of more than 0.25 ha.

$$n = \frac{\mathrm{N}}{\mathrm{N}d^2 + 1} \tag{1}$$

$$n = \frac{44}{44\ (0.1)^2 + 1} \tag{2}$$

$$\mathrm{n} = 30 \tag{3}$$

Based on this formula, the sample size for shallot farmers was determined to be representative of 30 farmers. The sample was then allocated based on the planting area using the following formula:

$$n_i = \frac{\mathrm{Ni}}{\mathrm{N}} \times \mathrm{n} \tag{4}$$

Notation:

n_i = number of samples with the i–th planting area,
Ni = number of populations with the i–th planting area,
N = total population, and
n = sample size.

Based on the above formulation, the sample size of farmers with a planting area of less than 0.25 ha was calculated as follows:

$$n_1 = \frac{14}{44} \times 30 \tag{5}$$

$$n_1 = 10 \tag{6}$$

Therefore, the sample size of farmers with a planting area of less than 0.25 ha was determined to be 10 productive farmers. Using the same formulation, the sample size of farmers with a planting area of more than 0.25 ha was calculated to be:

$$n_1 = \frac{30}{44} \times 30 \tag{7}$$

$$n_1 = 20 \tag{8}$$

Therefore, the sample size of farmers with a planting area of more than 0.25 ha was determined to be 20 productive farmers.

A Sample of 30 shallot farmers was observed, which was considered sufficient because the characteristics of the sample farmers in cultivating shallots using the Surjan technology were relatively homogeneous. The sample was selected from a population of 44 shallot farmers. The sample size was deemed representative for this study, in line with the opinion that a smaller sample size can still be sufficient for statistical analysis if the sample represents the population well and has homogeneous characteristics [12].

A survey was conducted among shallot farmers who applied the Surjan technology on sub–optimal land. The farmers had experience in farming shallots for more than 10 seasons using the Surjan technology. They used the same technology in land preparation and in the application of production factors. The cultivation system was carried out in the same ecosystem. Based on the survey results, the characteristics of the sample based on the amount of seeds applied, land area, and NPK fertilizer can be seen in **Figure 1**. Factors of production were considered to be any resources utilized in the production of goods or services. These factors were broadly classified into three main categories: seeds applied, land area, and NPK fertilizer [13].

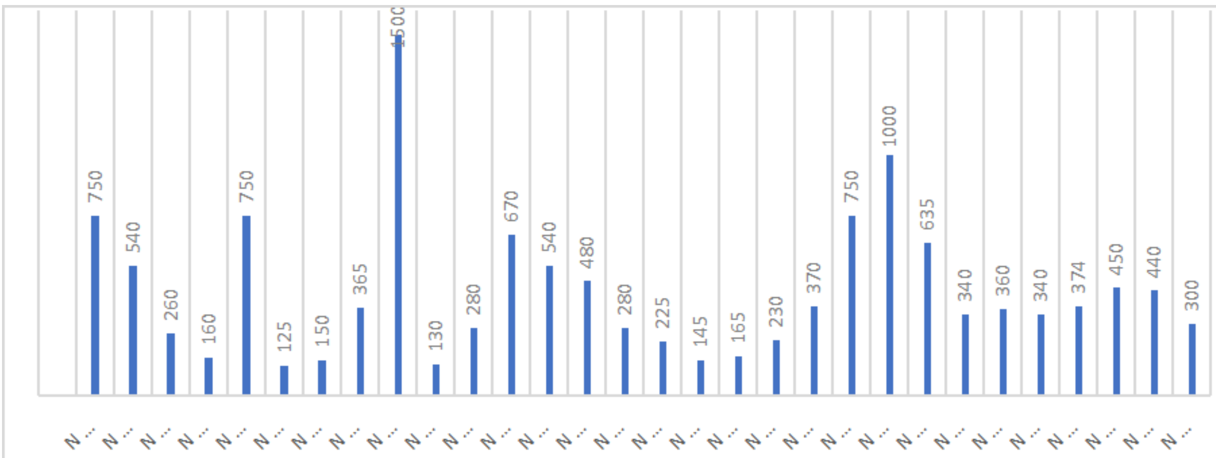

Figure 1. Distribution of sample variation based on the quantity of seeds applied, measured in kilograms.

The amount of shallot seeds used by the farmer respondents in this study varied greatly, ranging from 125 kg to 1500 kg. The variation in seed quantity was directly related to the land area used for shallot cultivation. The larger the land area used, the more seeds were needed to achieve optimal production. According to previous research, the amount of seeds used was found to have a significant impact on shallot production [14, 15]. The right amount of seeds could increase production and quality of shallots, while too much or too little seed could reduce production and quality. In this study, the variation in seed quantity used by farmer respondents could be attributed to several factors, such as differences in land area, soil type, and cultivation techniques used. Therefore, it was important to understand the characteristics of the sample based on seed quantity to comprehend the factors that affected shallot production.

The land area for shallot cultivation at the research location varied greatly, with the smallest land area being 0.1 hectares and the largest being 1.5 hectares (**Figure 2**). The land area used by farmers was directly related to the amount of seeds and the availability of farming capital. According to previous research, land area was found to have a significant impact on shallot production [16]. A larger land area enabled farmers to increase production and improve efficiency.

The use of NPK fertilizer in shallot cultivation varied greatly, with the lowest amount being 20 kg and the highest being 120 kg (**Figure 3**). Based on the **Figure 3** it was evident that the application of NPK fertilizer varied significantly. According to previous research, the use of NPK fertilizer was found to have a significant impact on the yield and quality of shallots [17, 18]. Based on the characteristics of the three indicators, namely land area, seeds, and NPK fertilizer, there was a tendency for a strong relationship, where higher land area, seeds, and NPK fertilizer were associated with higher requirements for these inputs. However, the level of response to these inputs was not yet known. Therefore, the research question designed for this study was how the use of land, seeds, and NPK fertilizer, both partially and simultaneously, affected shallot production. To support this research design, a hypothesis was constructed that the use of land, seeds, and NPK fertilizer, both partially and simultaneously, had an impact on shallot production.

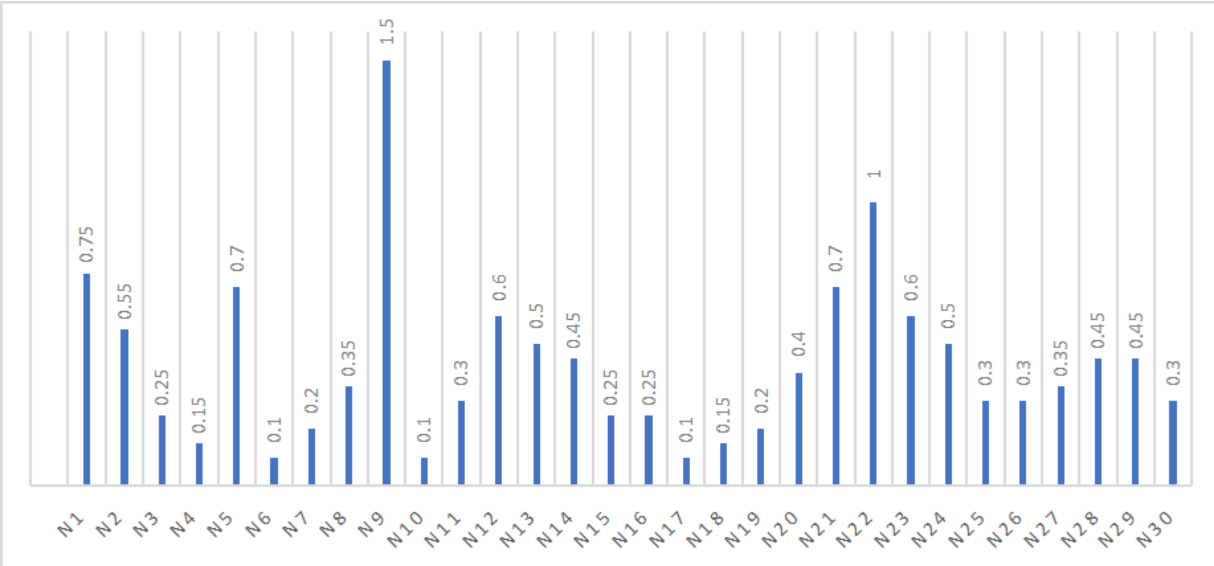

Figure 2. Distribution of sample variation based on land area used for shallot cultivation, measured in hectares.

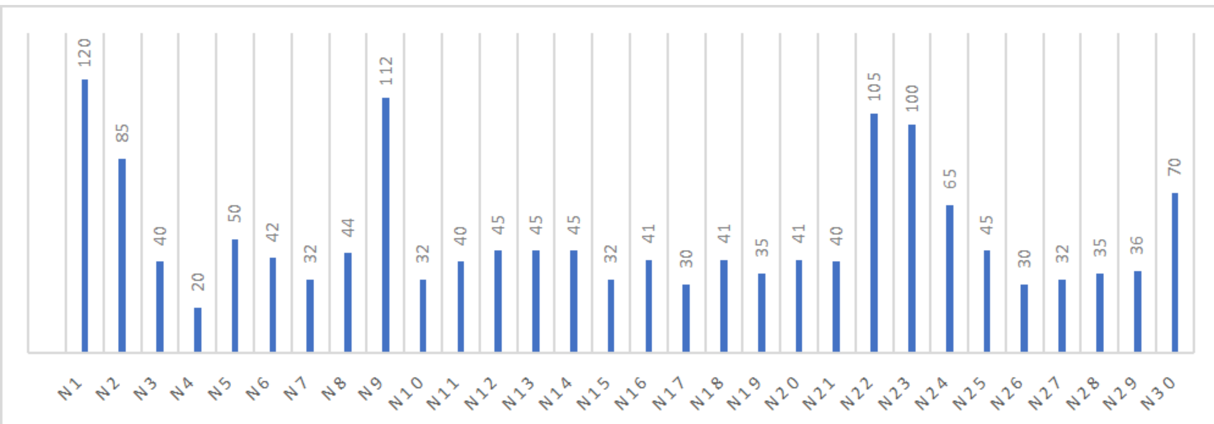

Figure 3. Distribution of sample variations based on NPK fertilizer used for shallot cultivation, measured in kilograms.

2.2. Data Analysis Techniques

To examine the response to the use of production factors, a modified Cobb–Douglas production model was employed. The modified Cobb–Douglas production function model was a widely used tool in agricultural economics research due to its practicality and ease of transformation into a linear form. The regression coefficients yielded by the Cobb–Douglas production function represented the elasticity of production factors and provided insights into the impact of scale on returns (return to scale) [19]. The modified Cobb–Douglas production function was determined to be highly appropriate for analyzing the impact of production factors on horticultural crops, specifically those with short growth cycles. This function was not only easy to apply but also well–suited for samples of smallholder farmers. Its applicability was particularly relevant for countries like Indonesia, the Philippines, Vietnam, and others with similar agricultural contexts.

The form of modification of the Cobb–Douglas production function used in this study was as follows:

$$Y = b_0 \, X_1^{b_1} \, b_2^{b_2} \, b_3^{b_3} \, \mu \tag{9}$$

Where Y represented shallot production, X_1, X_2, and X_3 denoted seed, land, and NPK fertilizer, respectively, b_0 was the intercept, b_1, b_2, and b_3 were the regression coefficients, and μ represented the error term. The Cobb–Douglas production function was employed to examine the relationships between the independent variables and shallot production, as well as to estimate the production elasticities of each input. The analysis revealed that seed, land, and NPK fertilizer all had positive effects on shallot production.

When the model was transformed into a linear form, the mathematical formulation took the form of ln :

$$\ln Y = lnb_0 + b_1 lnX_1 + b_2 lnX_2 + b_3 lnX_3 + u \tag{10}$$

This model was a log–linear form of the Cobb–Douglas production function, which was transformed into a linear form using the natural logarithm (ln) transformation. The model was used to estimate the relationships between the independent variables (seed, land, and NPK fertilizer) and shallot production. The regression coefficients (b_1, b_2, and b_3) represented the production elasticities, which measured the percentage change in shallot production resulting from a percentage change in the independent variables. The model was estimated using the ordinary least squares (OLS) method.

3. Results

3.1. Regression Coefficients and Production Elasticity

The results of the regression model analysis in this study were useful for determining elasticity. Through the regression coefficient values, each variable from the multiple regression equation could be transformed into elasticity after being converted into the Cobb–Douglas production function equation (**Table 1**).

Table 1. Estimated Coefficient Regression Values of Shallot Production in Tonjong Village.

Number	Production Factors	Regression Coefficient	Standard Error
1	Seed	0.223	0,491
2	Land	0.471	0,471
3	NPK fertilizer	0.236	0,236

Based on the results presented in **Table 1**, a multiple linear regression model was developed as follows:

$$\ln Y = -1.03 + 0.223 \, lnX_1 + 0.471 \, lnX_2 + 0.236 \, lnX_3 + e \tag{11}$$

Equation (11) represents a multiple regression analysis model that shows the effect of using land, seeds, and NPK fertilizer as production factors. This model can be used to analyze the relationship between shallot production variables and land, seeds, and NPK fertilizer production factor variables, as well as to predict changes in shallot production variables in response to changes in land area, shallot seeds, and NPK fertilizer variables.

This model was a multiple linear regression model in natural logarithm (ln) form, which was commonly used to analyze the relationship between the dependent variable (Y) and independent variables (X_1, X_2, and X_3). Here is an explanation of the model: ln Y was the dependent variable that was transformed into natural logarithm form. This meant that the model analyzed the relationship between the independent variables and the proportional change in the dependent variable. X_1, X_2, and X_3 were the independent variables that were also transformed into natural logarithm form. The regression coefficients (β) for each independent variable were estimated as follows:

β_1 = 0.223 for ln X_1
β_2 = 0.471 for ln X_2
β_3 = 0.236 for ln X_3

These regression coefficients represented the production elasticity, which was the proportional change in the dependent variable (Y) in response to a proportional change in the independent variables (X_1, X_2, and X_3). e was the error term that represented the error or disturbance that could not be explained by the model. The interpretation of the regression coefficients was as follows:

A 1% increase in Land (X_1) was associated with a 0.223% increase in Shallot Production (Y), ceteris paribus.
A 1% increase in Seeds (X_2) was associated with a 0.471% increase in Shallot Production (Y), ceteris paribus.
A 1% increase in NPK Fertilizer (X_3) was associated with a 0.236% increase in Shallot Production (Y), ceteris paribus.

Subsequently, equation (11) was transformed into the Cobb–Douglas production function equation, which took the following form:

$$Y = 0.031\, X_1^{0.223}\, X_2^{0.471}\, X_3^{0.236}\, e \quad (12)$$

The coefficients in the multiple linear regression equation (equation 12) represented the influence of each shallot production factor on shallot production outcomes. The results from equation (12) indicated that the regression coefficients for seed (X_1), area of shallot farming land (X_2), and NPK fertilizer used in shallot farming (X_3) were 0.223, 0.471, and 0.236, respectively. After transformation into a Cobb–Douglas production function, these coefficients showed the elasticity of each production factor on shallot production outcomes. Specifically, the elasticity of seed production (X_1) was 0.223, land area elasticity (X_2) was 0.471, and NPK fertilizer elasticity (X_3) was 0.236. The total production elasticity from the use of seed, land, and NPK fertilizer production factors was 0.930, which was less than 1, indicating decreasing returns to scale.

3.2. The Results of the Partial t–Test Analysis Examining the Effect of Production Factors on Production Output

The variables tested were seed, land, and NPK fertilizer (**Table 2**). The regression coefficient indicates the magnitude of the variable's influence on shallot production. The larger the coefficient value, the greater the variable's influence. The t–statistic was used to test the significance of the variables. The larger the t–statistic value, the more significant the variable. The t–table value is a critical value used to determine the significance of the variables. The significance value indicates the acceptable level of error. If the significance value is less than 0.05, the variable is significant.

Table 2. The t–test results revealed the significant partial effects of production factors, such as seed, land, and NPK fertilizer, on shallot production.

Variable	Regression Coefficient	t–Statistic	Significance
Seed	0,223	0,454	0,654
Land	0,471	1,061	0,298
NPK	0,236	1,491	0,148

The results of the t–test analysis showed that all variables (seed, land, and NPK fertilizer) had no significant effect on shallot production, as the significance values (p–values) were all greater than 0.05. This finding is consistent with the positive coefficients of the regression analysis for seed, land, and NPK fertilizer. The positive coefficients indicate that there is an opportunity for farmers to increase the use of seed, land area, and NPK fertilizer, as additional inputs are likely to enhance shallot production. Consequently, with increased usage, a significant relationship between input usage (seed, land area, and NPK fertilizer) and shallot production may emerge.

3.3. Results of the F–Test Analysis on the Simultaneous Effect of Production Factor Utilization on Production Yield

The results of the F–test in **Table 2** indicated that the regression model used could explain the variation in shallot production well, and the variables land, shallot seeds, and NPK fertilizer collectively had a significant effect on shallot production. The F–test results showed that the regression model used to analyze the effect of land (X_1), shallot seeds (X_2), and NPK fertilizer (X_3) on shallot production was significant. Here is an explanation of the F–test results: The degree of freedom (df) for regression was 3, which meant that the regression model had 3 independent variables (X_1, X_2, and X_3); The calculated F–value (F hitung) was 44.78, which was the F–value generated from statistical calculations; The critical F–value (F_tabel) was 2.74, which was the critical F–value from the F–distribution table (**Table 3**). The significance level (p–value) was 0.000, which meant that the probability of Type I error (α) was very small, less than 0.001.

Since the calculated F–value (44.78) was greater than the critical F–value (2.74) and the significance level (0.000) was less than α (typically 0.05), it was concluded that the regression model as a whole was significant. This meant that the independent variables (X_1, X_2, and X_3) collectively had a significant effect on the dependent variable (shallot production).

Table 3. F–test Results.

Model	Df	Calculated F–Value	Critical F–Value	Significance
Regression	3	44.78	2,74	$0,000^b$
Residual	26			
Total	29			

4. Discussion

Equation (2) indicated that the response to the use of seed production factors in shallot farming was positive but less than 1, suggesting that the elasticity of seed production was inelastic. Under these conditions, additional seed production factors elicited a relatively modest response in production outcomes. The elasticity of seed production was estimated to be 0.223, meaning that every 1 percent increase in shallot seeds would result in a 0.223 percent increase in shallot production. At this stage, shallot farmers could add inputs to a certain extent because increasing shallot seeds would lead to an increase in shallot production. In addition to increasing input, shallot farmers could also consider treating shallot seeds to enhance production. The use of suitable concentrations of sulfate, potassium, and calcium nitrate was found to increase the germination percentage, seed length, and number of seeds [20]. However, in the study location, fertilizer application was limited to NPK, which contains nitrogen, phosphorus, and potassium. There was a tendency that NPK fertilizer could be substituted with fertilizers containing sulfate, potassium, and calcium. In the Surjan system technology, fertilizer application not only considers the nutrient requirements of shallot plants but also takes into account the nutrient needs of other crops planted concurrently with shallots as diversification crops.

The elasticity of land area production was estimated to be 0.41, indicating that the expansion of shallot farming land still responded rapidly to shallot production outcomes. Farmers could increase land area inputs. The pattern of the shallot cultivation system using the Surjan system technology at the research location could be achieved not only through agricultural expansion but also by increasing the cropping index. During the research year, the cropping index was only once per year and could be increased to 2 or 3 times per year. This increase in cropping index had to be supported by cultivation technology, particularly pest control technology, fertilization technology, and water resource management technology. Furthermore, to expand the land area, reducing the types of crops planted could also be an option. Crops that were less supportive of shallot cultivation, such as chili and tomato plants, which competed for nutrients, could be eliminated, allowing farmers to focus on one crop. This approach would not only reduce production risks but also optimize production costs. Additionally, adding sulfur was found to be beneficial for increasing shallot production, and sulfur had a positive influence on shallot production [21].

The elasticity of NPK fertilizer production in shallot farming was estimated to be 0.236. This indicated that the use of NPK fertilizer in shallot farming was still at an increasing stage, meaning that increasing NPK fertilizer use in shallot farming could still be performed. Every one percent increase in the NPK fertilizer production factor resulted in a 0.236 percent increase in production. The NPK fertilizer elasticity value suggested that shallot farming at the research location was not yet intensive, particularly in terms of NPK fertilizer allocation for watering plants. Based on observations, the watering technology used at the research location was still conventional, involving lifting water from the valley to the top of the land, which was both ineffective and inefficient. Watering was done twice a day, in the morning and evening. Delays in watering could hinder the vegetative growth of shallot plants. To improve soil fertility, manure could be added. Previous research showed that adding 20 tons of poultry manure per hectare during the rainy season resulted in the best growth and yield of shallots compared to the dry season. However, the behavior of shallot farmers during the rainy season, who continued to water their crops, reduced the production efficiency of shallots [22].

If vegetative growth was disrupted, shallot production would be suboptimal, resulting in small and unevenly sized bulbs, pale outer skin, and a reduced number of bulbs. This would ultimately lead to decreased shallot production. Good shallot seeds were typically harvested between 45 and 50 days [23]

Based on the total elasticity with an index of 0.93, the elasticity value was less than 1, indicating that the farming conditions at the research location were characterized by increasing returns to scale. When faced with these conditions, farming businesses required efforts to increase inputs to optimal levels. In relation to this research, farmers at the research location needed to improve, manage, and combine the use of these three inputs to achieve maximum production results. In addition to improving farm management, another crucial aspect for increasing production was the principle of input maximization or cost minimization. These two principles were essential because farmers at the research location had two distinct characteristics based on production costs: those with limited budgets and those with sufficient funds. For shallot farmers with limited budgets, the production principle employed was cost minimization. This principle could be achieved by optimizing the combination of production factors and allocating them appropriately to attain optimal production. A strategic step would be to reduce production factors that had a minimal impact on production increases. The principle of profit maximization could be achieved by combining production factors in a way that corresponded to planned profits. Strategic steps that could be taken by shallot farmers include expanding land area, increasing NPK fertilizer, improving cultivation technology, adding seeds, and enhancing risk management systems.

Evidence that these three variables had a positive influence was observed from the results of the t–test conducted in this study. The t–test was used to examine the partial effect of the three production factors, namely land, seeds, and NPK fertilizer, on production outcomes, with a significance level of 95% and a t–table value of 2.024. The results of the t–test showed that the seed production factor had a t–calculated value of 0.65, which was smaller than the t–table value of 2.024, indicating that the effect of the seed production factor was not significant. Similarly, the results of the t–test on the use of land production factors had a t–calculated value of 1.06, and the NPK fertilizer t–test result was 1.49, both of which were smaller than the t–table value of 2.024, indicating that the effects of land and NPK fertilizer production factors were also not significant. Based on the t–test results, it was found that the use of land, seed, and NPK fertilizer production factors was still not optimal, and farmers could still increase land area, add the amount of seeds, and increase NPK fertilizer to optimize production.

Other variables that were not included in the model, such as fertilizer use, climate, and cultivation technology and management, need to be considered by farmers. Climate and weather variables were related to planting schedules. Shallot plants require full sunlight with sufficient water availability. Therefore, it was optimal if planting was performed in early October, and harvesting occurred in November, as this allowed for the expansion of land production factors without disrupting the garden system in the Surjan pattern at the research location. During this season, shallot farming could be carried out in monocultures. The rainfall in this month was low, and water availability was limited, so water was focused solely on watering shallot plants and not shared with other plants. Variables that had optimal effects that needed to be considered were the use of fungicides and pesticides; although these variables did not have a direct effect on shallot production, they were important for maintaining shallot production. The use of fungicides and pesticides had a significant effect on shallot production [24].

Although agricultural management production factors were not included in this study, management was difficult to measure through the Cobb–Douglas production function because management variables were qualitative in nature, making it challenging to quantify their parameters. Technically, to successfully prove this model, management variables needed to be considered, such as how to manage NPK fertilizer use, arrange planting schedules, regulate land use, and manage fertilization. The model resulting from the Cobb–Douglas production function analysis was very good because it produced positive elasticity values for the three production factors. This was a valuable finding, indicating that the model could be directly applied to agricultural land at the research location. However, this finding also showed that the production factors of land, seeds, and NPK fertilizer in the Cobb–Douglas production function modeling did not stand alone. This was a limitation of the Cobb–Douglas production function, which could not explain technical variables such as climate or management. Nevertheless, in actual conditions, shallot production was influenced by these variables, namely climate and management. Although these two variables were not included in the model, their indirect effects could be observed through the F–test.

The positive elasticity value from this model was a new finding in this research. Typically, these three variables in seasonal crop farming in Asian countries, especially in Indonesia, showed negative elasticity. In European countries, where farmers had large areas of land with adequate technological support, the relationship between input and output for each variable, namely seeds, NPK fertilizer, and land, moved linearly (tending to follow a constant return–to–scale pattern), and was not a new discovery. This research was conducted in locations with a tendency for overuse of inputs, which often occurred in small farming businesses in Asian countries. Consequently, many studies on annual crops with the same function have found variables with negative elasticity among these three variables. Negative elasticity indicated that the performance of using these production factors had reached a saturation point in the annual crop production system. However, the results of the analysis in this research showed that the position was in the rational region of production stage 1. At this stage, farmers could freely add these three production factors to the shallot farming system because the addition of the three inputs, namely seeds, land, and NPK fertilizer, still provided positive additions to shallot production. Another finding was that the NPK fertilizer variable in the elasticity model was positive, which could be interpreted to mean that shallot cultivation using the Surjan system technology was very intensive but still required additional NPK fertilizer.

The results of this research can be utilized by small farmers in Indonesia and other countries worldwide that have similar agronomic, climate, and land characteristics to the research location. If the results of this research are applied to different conditions, there is a tendency for the response of the three production factors, namely land, seeds, and NPK fertilizer, to differ in terms of their impact on production outcomes. These differences can be observed in the size of the shallot bulbs, the number of shallot tillers, and the color of the shallot skin.

The use of the Cobb–Douglas production function in this research still required further review because the Cobb–Douglas production function had several weaknesses: the elasticity of output to input had to be treated with caution in applied research. In addition to its advantages, the Cobb–Douglas production function model had the property of being easy to use, namely, that the input exponent could easily represent the input–output elasticity, so that the sum of these exponents showed whether there were increasing, constant, or decreasing returns to scale [25]. However, this function also had limitations, namely, that the measurement of NPK fertilizer in the Cobb–Douglas production function applied in this research was contrary to the law of diminishing marginal returns. The resulting model showed that when the NPK fertilizer input variable with a certain level of technical productivity was followed by an increase in the amount of physical capital input, NPK fertilizer became more productive as the use of NPK fertilizer increased.

5. Conclusions

Based on the discussion, it was concluded that the three production factors, namely seeds, land, and NPK fertilizer, had positive production elasticity values below one. This indicates that shallot production was not yet efficient. The findings suggest that the use of these three production factors can still be increased in shallot farming. The Cobb–Douglas production function modeling for shallots in this study was limited to only three research variables, namely seeds, land, and NPK fertilizer. To determine how other variables outside the model affected the results, further research could be conducted by incorporating other variables into the model. Technically, other variables had a direct impact on shallot production outcomes. Other production factor variables that could be included in the model were fertilizers other than NPK, such as urea, N fertilizer, and sulfur fertilizer, which were applied at the research location. In other regions in Indonesia and Asia, fertilizer variables could be adjusted according to local agronomic conditions and ecosystems. The results of this study are crucial for applications in agricultural production economics. Specifically, the theory of the relationship between input and output variables needs to be considered. This study can also be utilized by shallot farmers in Indonesia, Asia, and globally, provided that climate conditions, farmer characteristics, and soil conditions, as well as the types of seeds used, are similar to those in the research location. The results of this study differ from laboratory–scale research on NPK fertilizer. The advantage of this study is that it used data from farmers without intervention, reflecting actual farmer behavior in the use of seeds, land, and NPK fertilizer.

6. Patents

The results of this study are not yet patented, but we plan to file a patent application next year for a Cobb–Douglas production function model that can be used in shallot farming.

Author Contributions

This research is the result of collaboration between all authors, with equal contributions to the research.

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Institutional Review Board Statement

Not applicable.

Informed Consent Statement

Not applicable.

Data Availability Statement

The research data were obtained from the Agribusiness Laboratory, Faculty of Agriculture, Sultan Ageng Tirtayasa University. The complete research report was documented in the archives of the Research and Community Service Institution of Sultan Ageng Tirtayasa University (To ensure data confidentiality, it was not publicly disclosed).

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Conflicts of Interest

The authors declare no conflict of interest.

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