The efficiency of shallot farming in the highlands and lowlands in Magetan Regency, East Java Province

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Abstract. Shallots are suitable for farming in the lowlands, however farmers in Magetan Regency mostly plant shallots in the highlands. Shallots farming in the highlands to require special treatment in the production process to affect the use of production factors. This study aims to analyze the factors influencing the production and efficiency of using production factors in shallot farming. Determination of the research location purposively considered Magetan Regency as a shallot farming area in both the highlands and lowlands. Twenty-five farmers in the highlands and 25 in the lowlands were selected using a simple random sampling method. The analysis technique employed the Cobb-Douglass production function. The efficiency of production factors was measured based on the comparison between the marginal value product and the input price. The results revealed that the production factors of liquid pesticides, labor, and adhesives significantly influenced the production of shallots in both the lowlands and highlands. The use of liquid pesticides was inefficient, and the workforce has not been efficient. Therefore, farmers should reduce liquid pesticides and increase the workforce to maximize profits from shallot farming.

1 Introduction

Shallots are vegetable commodities included in the non-substituted spice group and are widely used as food seasonings and traditional medicines. Shallots are also a source of income and employment opportunities with a high enough contribution to the economic development of a region [1]. Shallots in Indonesia are cultivated in all provinces, with production centers in Central Java, East Java, West Nusa Tenggara (NTB), West Java and West Sumatra and shallot production in Indonesia in 2020 reached 1,815,445 tons [2].

Horticultural crops, including shallots generally an annual plant that is relatively sensitive to stress (excess and lack of) water. Technically, the vulnerability of horticultural crops is related to land use systems, soil properties, cropping patterns, technology for managing soil, water, and plants, as well as varieties. The vulnerability of horticultural crops to rainfall patterns will have an impact on the planted area, productivity and yield quality [3].

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Shallots grow well in the lowlands with an altitude of 0-450 m above sea level with an air temperature of 25-32°C and a dry climate. Shallots grown in the lowlands with hot temperatures produce large tubers. However, shallot plants still grow and have bulbs in the highlands, but the planting age is 0.5-1 month long, and the tuber yield is lower [1]. This situation is in line with the production of shallots in the lowlands of Bantul Regency of 12,243 kg/ha [4]. On the other hand, the production of shallots in the highlands of Majalengka Regency at an altitude of 1,300 m above sea level reached 5,024 kg/ha, and an altitude of 850 m asl obtained a yield of 7,544 kg/ha [5].

Shallot farming can achieve maximum productivity if the farming system is carried out intensively. Farming productivity is closely related to efficiency because it compares output and input used in production [6]. The managerial capabilities of farmers greatly influence the level of efficiency in applying farming and postharvest technology, as well as their ability to process information relevant to their farming business; thus, decisions can be made appropriately [7].

Magetan is a regency in East Java Province, located at the foot of Mount Lawu and the air temperature ranges 16-20ºC in the highlands and 22-26ºC in the lowlands. Rainfall in the period 2009 – 2018 is very volatile with an average of 8.1 wet months and 3.9 dry months [8]. Magetan is highly suitable for the farming of horticultural crops. One of the farmed horticultural crops is shallots. Farmers grow shallots in both the lowlands and highlands. Besides being influenced by altitude, temperature and rainfall, the amount of shallot production is also greatly influenced by production factors. There is a tendency for farmers to use production factors based on habit or availability. Low-priced production factors are applied in large quantities, while relatively expensive ones are employed in small quantities.

Research on the efficiency of existing shallot farming generally does not pay attention to altitude, such as those conducted by [9] in Madiun Regency, by [10] in Brebes Regency, and by [11] in Sigi Distrct. Therefore, it is necessary to conduct studies on the efficiency of shallot farming in the lowlands and highlands which are useful for developing shallots, especially in the highlands. The research aims to analyze the factors affecting production and to analyze the efficiency of the use of production factors in shallot farming in the lowlands and highlands.

2 Research method

2.1 Method

This research was conducted in Magetan Regency, East Java Province, using descriptive analysis under the survey method. Magetan Regency was selected purposively with the consideration that it develops shallot farming in the highlands and lowlands. A total of 25 farmers in Plaosan District representing the lowlands and 25 farmers in Panekan District representing the highlands were selected using the simple random sampling method. This study employed primary data from interviews based on questionnaires and secondary data obtained by the documentation method.

2.2 Technical analysis

Data analysis employed the Cobb-Douglass production function, which can be mathematically written as follows [12].

$$Y = aX1^{b1}\, X2^{b2}\, X3^{b3}\, X4^{b4}\, X5^{b5}\, X6^{b6}\, X7^{b7}\, X8^{b8}\, X9^{b9}\, X10^{b10}\, D^{d}\, e^{u} \quad (1)$$

Y is production (kg), a is constant, b1,… b10, d are the regression coefficient, X1 is land area (m^2), X2 is seed (kg), X3 is manure (kg), X4 refers to Urea & ZA fertilizer (kg), X5 is Phonska fertilizer (kg), X6 refers to TSP & SP36 fertilizer (kg), X7 is liquid pesticide (liter), X8 is pesticide (grams), X9 is adhesive (liter), X10 is labor (work day), D is dummy location if D = 0 is highland and if D = 1 is lowland, e is natural logarithm, and u = error (disturbance term).

Based on the production function mentioned above, the effect of production factors on the production of shallots was simultaneously tested using the analysis of variance (ANOVA) [13], and the preparation of hypotheses can be written :

Ho: bi = 0 means the independent variable of production factor (X) does not affect the dependent variable of shallots production

Ha: one of bi ≠ 0 means that the independent variable of production factor (X) affects the dependent variable of shallots production

Hypothesis test:
The following formula was applied to calculate the F-test:

$$Fcount = \frac{\sum(\grave{Y}i - \bar{Y})^2/(k-1)}{\sum(Yi - \bar{Y})^2/(n-k)} \quad (2)$$

F table = F (α%: k-1; n-k)
$\grave{Y}$ production is based on counting, $\bar{Y}$ is average production, Y is production based on the survey, k is the number of variables, n is the number of samples, and α is an error rate.

Formulation of the F-test hypothesis is as follows:

If F count > from F table, Ho is rejected and Ha is accepted, meaning that the production factors (X) simultaneously effect on shallots production

If F count < from F table, Ho is accepted and Ha is rejected, the meaning simultaneously the factor of production (X) has no effect on shallot production.

Partially the effect of production factors is tested using the t-test. The formulation of the hypothesis is written as follows:

Ho: bi = 0, it means that the production factor *i-th* does not significantly affect the production of shallots

Ha: bi ≠ 0, it means that the production factor *i-th* has a significant effect on the production of shallots

Hypothesis test:
The t-test was calculated by the following formula:

$$t\ count = bi/sbi \quad (3)$$

$$t\ table = t(\alpha\%\ ; n-k)$$

bi is the regression coefficient, sbi is the standard deviation bi, k is the number of variables, n is the number of samples, and α is an error rate.

The formulation of the t-test hypothesis is as follows:

If t count > from t table, Ho is rejected, , meaning that the i-th production factor has a significant effect on the production of shallots

If t count < from t table, Ho is accepted Ha is rejected, meaning that the i-th production factor has no significant effect on onion production

The efficiency of using production factors was analyzed based on the comparison between the marginal value product and the input price [14] by the following formula:

$$K = (MVP/Px) \quad (4)$$

K is the efficiency index, MVP is the Marginal Value Product, and Px is the price of production factor.
The criteria of efficiency:
If MVPx / Px > 1 means that the use of production factor x is inefficient. The use of the production factor x must be increased to achieve efficiency.
If MVPx/Px = 1 means that the use of production inputs is efficient
If MVPx / Px < 1 means that the use of production factor x is inefficient. The use of the production factor x must be reduced to achieve efficiency.

The efficiency level was calculated using the t-test variable using the K value, as follows:
Ho: K = 1 means that the input usage is efficient.
Ha: K ≠ 1 means that the use of input is inefficient or not yet efficient.

Hypothesis test:
The t-test was carried out with the following calculations:

$$t\ count = \frac{(1-K)}{\sqrt{var\ K}} \quad (5)$$

$$Var\ K = (K/bi)^2\ var\ (bi) \quad (6)$$

K is the efficiency index, and bi is the regression coefficient.

Conclusion:
If t count > from t table, Ho is rejected, meaning that the value of K is unequal to 1, then the input usage has not been efficient or inefficient.
If t count < from t table, Ho is accepted, meaning that the K value is equal to 1, then the use of input is efficient.

3 Results and discussion

3.1 Profile of shallot farmers

Shallot farmers who are used as respondents are members of farmer groups in the Plaosan District representing the lowlands and Panekan District representing the highlands. The average age of shallot farmers was 46.92 years in the lowlands and 53.32 years in the highlands. Their average age is included in the productive age category, a group with the potential to carry out an activity. In the productive age range, a person is in the excellent physical condition and is responsive to any changes or innovations [15]. The age of shallot farmers in Magetan Regency is similar to those in Central Java, with an average age of 51 years [16]

Regarding education, most shallot farmers in both the lowlands and highlands were elementary and junior high school graduates. However, the education level of shallot farmers in the lowlands was relatively higher than in the highlands. The education level of shallot farmers in Magetan is similar to those in Madiun; 78% were elementary and junior high school graduates. Low educational background is not a barrier for farmers to carry out their activities [15]. Farmers can increase their knowledge through informal education through courses, training and search for information in print and electronic media [17].

Table 1. Profile of shallot farmers on the lowlands and highlands in Magetan Regency

Description	Lowland		Highland	
	Total (person)	Percentage (%)	Total (person)	Percentage (%)
Age (years):				
32 - 47	5	20.00	8	32.00
48 - 55	13	52.00	6	24.00
56 - 64	7	28.00	11	44.00
Education:				
Elementary School	6	24.00	14	56.00
Junior High School	7	28.00	9	36.00
Senior High School	11	44.00	2	8.00
University	1	4.00	-	-
Experience (years)				
1-10	3	12.00	1	4.00
11-20	10	40.00	9	36.00
21-30	8	32.00	12	48.00
31-40	3	12.00	3	12.00
41-50	1	4.00	-	-
Land Area (m^2)				
100 – 967	17	68	9	36
968 – 1,835	6	24	9	36
1,836 – 2,703	1	4	2	8
2,704 – 3,570	1	4	5	20
Land Status				
Owner	15	60	17	68
Land rent	10	40	8	32

In terms of farming experience, shallot farmers in the lowlands have been working for an average 21.4 years with a maximum of 40 years of farming experience and a minimum of 5 years. Conversely, shallot farmers in the highlands had an average of 24.48 years of farming experience, with a maximum of 40 years and a minimum of 10 years. The level of experience of farmer in Magetan in farming shallots is similar to that in Majalengka; most had more than ten years of farming experience [5].

The land planted with shallots in Magetan Regency was relatively narrow, with an average area of 1,578 m^2 with the narrowest land area of 200 m^2 and the widest of 3,400 m^2. In contrast, for land in the highlands, the average was 1,684.55 m^2, with a minimum land-use area of 100 m^2 and a maximum of 3,570 m^2. The area of land affects the use of production factors. The wider the area, the more the use of production factors, also affecting production costs.

Based on the land status, it turns out that not all shallot farmers in Magetan Regency use their land for farming. As many as 40% of farmers in the lowlands and 32% of farmers in the highlands use other people's land by renting. Farmers who use leased land tend to be more intensive in caring for their plants than farmers who use their land [18].

3.2 Production and use of production factors

The shallot farmers in both the lowlands and highlands tended to use more production factors than the recommendations of the Agriculture Department of Magetan Regency. However, the resulting production was lower than the set standard. It implies that the technical cultivation carried out by farmers was inappropriate.

Table 2. The use of production factors on shallot farming in the lowlands and highlands in Magetan Regency (per hectare).

Description	Lowland	Highland	Recommendation
Production (kg)	6,439.52	5,829.45	10-15
Seeds(kg)	1,501.90	534.26	1,000-1,200
Manure (kg)	228.13	219.64	7,000 -10,000
Urea and Za (kg)	329.65	344.41	300
Phonska (kg)	352.34	243.38	200
TSP & Sp36 (kg)	220.72	255.26	300
Liquid Pesticide (ml)	2,116.60	2,505.12	-
Solid pesticide (grams)	849.17	1,887.74	
Adhesive (l)	2,636.43	1,780.89	-
Labor (workday)	283.77	184.02	

Shallot seedlings used by farmers in the lowlands averaged 1,501.90 kg per hectare, while in the highlands, it averaged 534.26 kg per hectare. The type of seed used in the lowlands was the Bauji variety, while in the highlands, they used the Thailand variety, which has good adaptability in the dry season and is resistant to the rainy season. The Bauji variety is cheaper than the Thailand variety, causing the use of seeds in the lowlands to be more than in the highlands. In addition, farmers in the lowlands in cultivating shallots use closer spacing.

Manure used by shallot farmers in Magetan Regency was still far from the recommendation of the Department of Agriculture, 7-10 tons/ha. They prioritized the use of chemical fertilizers rather than organic fertilizers. They used manure at the beginning of land farming as a basic fertilizer to improve the nutrient content of the soil. Chemical fertilizers were given as supplementary fertilizers to accelerate growth and provide nutrients for shallot plants. The use of organic fertilizers combined with non-organic can increase the yield of shallots 17.63 -79.49% [19].

One of the indirect impacts of climate change is the number of pests and diseases that attack plants [20]. Therefore, the use of pesticides in shallot cultivation is quite important. Shallot farmers in the lowlands and highlands used two types of pesticides: liquid and solid pesticides. The liquid pesticides used in the lowlands were remazol, zeram, plethora, mastofol, score, and demacide. Moreover, the liquid pesticides used on shallots in the highlands comprised agrimec, tenano, golma, folicur gold, spontaneity, and atonic. The solid pesticides used by farmers in the lowlands consisted of antracol, tiezene, gandasil B, masalgin, velimex, polycom, and cabrio top, while in the highlands, they used cabrio top, gandasil B, and antracol.

3.3 Production function

The research used the Cobb-Douglass production function, where the dependent variable was shallot production and the independent variable was production factors [12]. Based on the regression analysis results, the value of the Coefficient of Determination (R^2) was 0.553, meaning that 55.3% of the variation in shallot production variables could be explained by independent variables such as land area, seeds, manure, urea & ZA fertilizers, phonska fertilizers, TSP & SP36 fertilizers, liquid pesticides, solid pesticides, adhesives, and labor. The remaining 44.7% could be explained by variables excluded in the model, such as rainfall, climate, soil fertility and farming experience.

The results of the analysis of variance (F-test) show that the Fcount value of 4.278 was greater than the F table of 2.81, at an error rate of 1%. It indicates that the independent variables of land, seeds, manure, urea & ZA fertilizers, phonska fertilizers, TSP & SP36 fertilizers, liquid pesticides, solid pesticides, adhesives, and labor had a significant effect on shallot production in the lowlands and highlands. It is in line with the research of [21], stating

that the variables of capital, land area, fertilizer, seeds, and labor had a significant effect on increasing shallot production in Lam Manyang Village.

Table 3. Analysis results of Cobb-Douglass production function on shallot farming in the lowlands and highlands in Magetan Regency

Variable	Regression Coefficient	t count	Significant
Constant	16.817	2.490	0.017**
Land area	-0.048	-0.244	0.807
Seeds	0.453	1.596	0.118
Manure	-0.052	-0.159	0.874
Urea & ZA Fertilizer	0.005	0.060	0.952
Phonska Fertilizer	0.005	0.067	0.946
TSP & SP36 Fertilizer	0.061	1.365	0.180
Liquid Pesticide	0.107	2.415	0.020**
Solid Pesticide	-0.022	-0.637	0.527
Adhesive	-0.076	-1.910	0.063*
Labor	0.567	1.968	0.056*
Dummy (Location)	-0.036	-0.088	0.929
R Square	0.553		
Fcount	4.278		
Ftable : 1% ; 10 ; 39	2.810		
Ttable : 5% ; 11	2.009		
Ttable : 10% ; 11	1.675		

Note: ** : significant at level = 5%

* : significant at level = 10%

Table 3. displays that the factors with a significant positive effect encompassed liquid pesticides and labor, while adhesives have a negative effect. Seedling production factors, manure, urea & ZA fertilizers, phonska fertilizers, TSP & SP36 fertilizers, and solid pesticides did not significantly affect the production of shallots in the lowlands and highlands.

The production factor of liquid pesticide had a regression coefficient of 0.107 and was significant at an error rate of 5%, can be interpreted that liquid pesticides affect the production of shallots in the lowlands and highlands. It implies that if the use of liquid pesticide production factors increases by 1% and other factors constant the shallot production in the lowlands and highlands will increase by 0.107%. Liquid pesticide is a production factor playing a crucial role in shallot farming because shallots are prone to attack by pests and diseases [22]. Liquid pesticides are used to eradicate caterpillar pests and fungi frequently disturbing shallot plants.

The regression coefficient of the labor production factor was 0.567 and was significant at an error rate of 10%, meaning that if the use of labor is increased by 1% and other factor constant, the shallot production in the lowlands and highlands will increase by 0.567%. This is in accordance with research conducted by [7], which the labor production factor was significant effect on shallot production. The use of labor was highly influential in producing shallots in the lowlands and highlands, such as land management activities, planting, fertilizing, watering, weeding, pest control, and harvesting. Using labor outside the family and within the family with a proper number and good quality could increase the production of shallots.

The adhesive had a regression coefficient of -0.076 and was significant, meaning that if the use of the adhesive variable is increased by 1% and other factors constant, the shallot production in the lowlands and highlands will decrease by 0.076%. Shallot farmers in the lowlands and highlands used pesticide adhesives to help eradicate, paste, and level the pesticide solution applied to plants and improve the performance of foliar fertilizers and pesticides. Therefore, using adhesives, pesticides, and foliar fertilizers will quickly be

absorbed by the leaves. Hence, when exposed to rainwater, fertilizers and pesticides will not be carried away by rainwater.

The production factors of seed, urea and Za fertilizer, Phonska fertilizer, and SP36 fertilizer had no significant effect and had a positive value. If the production factors are increased, and other factors remain, there is a tendency for shallot production in the lowlands and highlands to increase. The production factors of land area, manure and solid pesticides had no significant effect and had a negative value, it means that if the use of these production factors is increased and other factors constant, there is a tendency for shallot production in the lowlands and highlands to decrease. This situation is different from shallot farming in Majalengka, where land area, number of seeds, and pesticides were input factors that significantly affected the production of shallots [18].

The regression coefficient for the location of the dummy variable was -0.036 and was insignificant, signifying no difference between shallot production in the lowlands and highlands. Differences in temperature and rainfall in the highlands and lowlands have no effect on shallot production. The highlands had the same production potential as the lowlands.

3.4 Efficiency of production factors

The efficiency analysis was carried out on production factors significantly affecting shallot production and the positive coefficient. The efficiency of production factors was analyzed by comparing the marginal value product and the input price (MVP/Px). Production factors are efficient if MVP/Px = 1 and inefficient if MVP/Px ≠ 1 [14]. If the use of factors of production is efficient then the profit is maximum.

Table 4. The efficiency of production factors on shallot farming in the lowlands and highlands in Magetan Regency.

Description	MVP	Px	K = MVP/Px	Efficiency Category
Liquid Pesticide	8,657.33	24,383	0.36*	Not efficient
Labor	1,206,769.39	62,500	19.31*	Not yet efficient

Note : * significant at 10% level

The value of MVP/Px in the production factor of liquid pesticides was 0.36, less than 1, and the t-test results revealed a significant difference, meaning that the use of liquid pesticide production factor was not efficient. To achieve the level of efficiency in shallots farming, the use of liquid pesticides must be reduced. Shallot farmers in Magetan use large amounts of liquid pesticides, namely 2.117 ml in the lowlands and 2.888 ml in the highlands. Factors that influence the behavior of farmers in the use of pesticides are education and knowledge of farmers about the agricultural system [23]. Excessive use of liquid pesticides and not in accordance with recommendations can result in residues on shallots that can harm consumers [24].

The MVP/Px for the labor production factor obtained a value of 19.31, greater than 1. In other words, the use of labor has not yet efficient. In order for onion farming to be efficient, the use of labor needs to be increased. The types of work in shallot farming requiring much labor are land processing and harvesting. This situation is in line with the research of [7] that labor production factors on shallots farming in Pati Regency are not yet efficient.

4 Conclusions

Simultaneously, the production factors of land area, seeds, organic fertilizers, Urea and Za fertilizers, Phonskha fertilizers, SP36 fertilizers, solid pesticides, liquid pesticides, adhesives,

labor and location affected shallot production in the lowlands and highlands. Partially, the production factors of liquid pesticides, labor, and adhesives significantly influenced the production of shallots in the lowlands and highlands in Magetan Regency. The use of labor has not been efficient. Thus, its number should be added. The production factor of liquid pesticides was inefficient. Hence, its use should be reduced to maximize the shallot profit.

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