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Factors Affecting Tomato Production in Batu City, Indonesia

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Abstract. The high market demand for tomatoes means farmers play an essential role in increasing production. Some factors can influence plant productivity, impacting demand and the amount of tomato production. The research aims to determine the factors influencing tomato production and the efficiency of using production factors in Batu District, Batu City. The research was carried out in Batu District, Batu City, East Java, in March 2024, with the number of samples in this research being 80 farmers, and samples were taken from 15 farmer groups. The data analysis method used in this research to determine the influence of tomato farming production factors (land area, seeds, fertilizer, labor and pesticides) is the Cobb-Douglas model analysis and technical, allocative and economic efficiency. The results of the research show that The factors that influence tomato production in Sumberejo Village, Batu District, Batu City, namely the land area variable (X1), the seed variable (X2), and the manure variable (X3) have a partial significant positive effect on tomato production results. In contrast, the labor variable (X7) partially has a negative effect on tomato production, with the technical efficiency of variables X1, X2, X3, X4, X5, X6 and Meanwhile, Variable allocative efficiency X1, X2, X4, X6, and X7 allocatively (NPMx / Px) < 1 inefficient use of input, Meanwhile variables X3 and X5 allocatively (NPMx / Px) > 1 Inefficient use of input, Variable economic efficiency X1, X2, X3, X4, X6, and X7 economically (EE = <1) inefficient while variables X5 economically (EE = >1). it is not yet efficient. The contribution of this research to science or the surrounding community is as an internal reference for business development and increasing the added value of agricultural products as well as increasing knowledge and understanding also broadens insight into the efficient use of production factors in farming.

Keywords: efficiency; inefficient; influence factors; negative effect

INTRODUCTION

Agricultural land is a determinant of the influence of agricultural commodity production factors. In general, it can be said that the larger the area of land planted, the greater the production produced from that land. Tomatoes can be consumed in fresh or processed form. Processed tomatoes are useful for preventing photoaging caused by ultraviolet-B radiation (Mubarok et al., 2020). The production process can run if the required production factor requirements are met (Majid et al. 2022). Production factors are inputs in the agricultural production process. The agricultural production process is a process that combines agricultural production factors to produce agricultural production (output). Seeds or seeds are one of the production factors that are used up in one production process. Seeds will affect production results so farmers must be more selective in selecting seeds (Az-zammy et al. 2022). Quality seeds are seeds that have been declared as high-quality seeds with superior plant types. One of the keys to getting plants that provide optimal results is to use quality seeds.

Fertilization is a very important factor in healthy plant growth and the production of optimally (Mariani et al. 2018). Plants can absorb the availability of nutrients. Therefore, every element provided must be aimed at obtaining better agricultural results without reducing the level of soil fertility. Labor and experience in managing natural resources are one of the important factors of production in running a farming business. Workers are paid wages according to the services they have performed to assist the production process. Limited production factors such as input allocation such as land area, labour, seeds, urea fertilizer, KCL, organic fertilizer, herbicides and insecticides,, as well as other factors such

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as season and technology in farming,, are factors that have been able to influence production results (Setiawan et al. 2022).

Production factors that influence the level of harvest success and are adjusted to location conditions are: land area, seeds, labor, fertilizer and pesticides (Koisine et al. 2019). The use of production factors greatly influences the success of the tomato crop harvest by applying appropriate fertilizer, which is adjusted to land conditions to increase the nutrients in the land. Fertilizer is a very important means of production; providing appropriate and balanced fertilizer will produce plants with high production (Asriadi 2021). The research gap is that there are factors which can affect plant productivity, so it will have an impact on demand and the amount of tomato production. What contribution does this research make in solving problems at the research location, namely business development and increasing the added value of agricultural products as well as increasing knowledge and understanding also broadens insight into the efficient use of production factors in farming (Rasyid et al. 2024).

One way to increase the yield of tomatoes that have been carried out is by using superior varieties which have potential land yields. Still, the use of superior varieties is very responsive to the use of fertilizer inputs and has an impact on the high rates of application of inorganic fertilizers, the use of inorganic fertilizers on the soil carried out Continuously and in high doses will have a negative impact on both tomato crop yields and the environment. The best way to increase soil fertility is through the use of organic fertilizer, namely cow manure, as a component of the planting medium. Some of the advantages of organic fertilizer include improving soil structure, this happens because organic material contains plant nutrients.

METHODS

The research was carried out in Batu District, Batu City, East Java in March 2024. The population in this research are all farmers who are members of farmer groups in Batu District, Batu City, namely 15 farmer groups, with a total population of 400 farmers. A sample is a part of a population that has certain characteristics or conditions to be studied (Lenaini 2021). The sample from the population was determined using the proportionate random sampling technique, and the sample size was determined using the Slovin formula (Equation 1).

$$n = \frac{N}{1+N\,(e)^2} \;\ldots\ldots (1)$$

Note:
n = number of samples
N = population size
e = The level of accuracy used is 10%

Sample calculations are as follows:

$$n = \frac{400}{1+400\,(0{,}1)^2} = \frac{400}{1+4} = \frac{400}{5} = 80$$

The number of samples in this study was 80 farmers, and sampling from 15 farmer groups in Batu District, Batu City, was carried out using proportional random sampling, namely a sampling technique from members of the population using a random method without paying attention to strata in the population using a proportional allocation formula.

Observation and Data Collection

The data used in this research are:

a. Primary Data
b. Secondary Data

The data collection methods used in this research are observation, questionnaires, interviews and documentation (Arikunto 2013).

Data Analysis

The data analysis method used in this research to determine the effect of using tomato farming production factors (land area, seeds, fertilizer, labor and pesticides) is multiple linear regression analysis using the SPSS application.

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Classical Assumption Test

Arifin & Mutiara (2021) state that the purpose of testing classical assumptions is to determine whether the assumptions in the Cobb-Douglas equation model are fulfilled. If fulfilled, the regression model obtained can be used as a means of estimation (hypothesis). To find out whether the Cobb-Douglas regression model used meets the classical assumptions, it is necessary to test the classical assumptions, including:

Normality Test

- If the value is significant (sig.) > 0,05, then the research data is usually distributed
- If the value is significant (sig.) < 0,05, then the research data is not normally distributed

Multicollinearity test

1. Determining decisions based on tolerance values
   - If the tolerance value > 0,10 then multicollinearity does not occur in the regression model
   - If the tolerance value < 0,10 then multicollinearity occurs in the regression model
2. Guidelines for making decisions based on the VIF value (*variance inflation factor*)
   - If the VIF value < 10,00 then multicollinearity does not occur in the regression model
   - If the VIF value > 10,00 then multicollinearity occurs in the regression

Heteroscedasticity Test

- If the value is significant > 0,05, then there are no symptoms of heteroscedasticity in the regression model
- If the value is significant < 0,05, then symptoms of heteroscedasticity occur in the regression model.

Goodness of Fit Model

a. $R^2 = 0$, this means that the independent variables used in the model cannot explain production and production itself can be explained by other variables outside production.
b. $R^2 = 1$, the variables used in the model can directly explain production.

Test the Regression Coefficients Simultaneously (F-Test) And Partially (T-Test)

Simultaneous Test (F Test)

H0 : a1=0, this means that variations in the independent variables together have no real effect on variations in the dependent variable.

H0 : a1 $\neq$ 0, there is at least one real variable that has a real effect on one dependent variable.

Partial Test (t-test)

- If H0 : α0=0, then the independent variable does not affect the dependent variable
- If H0 : α0 ≠ 0, then the independent variable influences the dependent variable

Efficient Use of Input

The efficiency of using production inputs is divided into technical efficiency, allocative or price efficiency, and economic efficiency.

Technical Efficiency

The regression coefficient from the Cobb-Douglas function also shows the elasticity of production. Production elasticity is the percentage change in output due to the percentage change in input. If the production elasticity value (ai) is obtained, then the efficiency of using production factors can be calculated (Tuwongkesong et al. 2013). Technical efficiency can be known through the production elasticity in the equation Ep=ai.

Allocative Efficiency

- If $\frac{NPMX}{}$ > 1, This means that the use of production input (x) is not yet efficient.

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Input X needs PX to be added for efficiency.

- If $\frac{NPMX}{}$ = 1, This means that the use of production input (x) is PX efficient
- If $\frac{NPMX}{}$ < 1, This means that production input (x) is inefficient. Input X needs to reduce its use of PX to achieve efficiency

Economic Efficiency

The economic efficiency value ranges between 0 and 1. A value of 1 indicates that the farm has fully achieved economic efficiency, while EE < 1 indicates it is economically inefficient.

RESULTS AND DISCUSSION

Classical Assumption Test

The research results showed that using the Normal Probability Plot graph, the normality test for the eight variables X and Y indicated a normal distribution. This confirms that the sample data used in this research comes from a normally distributed population.

The results of multicollinearity testing using tolerance and VIF values showed significant results. The VIF value for the Land Area variable (X1) is 2.192; the Seed variable (X2) is 2,924; the Manure variable (X3) is 2,964; NPK fertilizer (X4) is 1,635; TSP Fertilizer variable (X5) is 1.979; the KCL Fertilizer variable (X6) is 1,213; the Labor variable (X7) is 1,567; and the Experience variable (X8) is 1.329. Because the VIF value of each independent variable is less than 10, this indicates that there is no significant multicollinearity.

Testing the heteroscedasticity of the distribution of distributed data points. If the points are distributed randomly and do not form a particular pattern, it can be categorized as the absence of heteroscedasticity.

Coefficient of Determination (R^2)

This coefficient is used to determine the magnitude of the influence of the variables land area, seeds, manure, NPK fertilizer, TSP fertilizer, KCL fertilizer, labor, and experience on tomato production results (Table 1).

Table 1. Coefficient of determination test results (R^2)

Model Summary[b]				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.836[a]	.698	.664	69.96792

Source: Processed Primary Data, (2024)

Based on the calculation of the output results using the SPSS program, a coefficient of determination can be obtained, which is equal to 0,698. This means that simultaneously, Variable X1 until X8 influence on tomato production results (Y) is as big as 0,698 or 69,8% while the remainder is 30,02% influenced by other factors.

Simultaneous (F) and Partial (t) Effect Test

Simultaneous Test (F Test)

Given that df 1 is 8, df 2 is 71, and the significance level is 5%, looking at the F table, the value is 2.07. The results of the F test analysis can be seen in Table 2. The calculated F value is 20.540 > F table of 2.07 with a significant value = 0.000<0.05 (α=5%). This means that the independent variable, which consists of 8 variables together, has a positive and significant effect on the dependent variable, namely the production results of tomato (Y).

Partial Test (t-Test)

The results of the T-Test analysis can be seen in Table 3.

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Table 2. Simultaneous test results (F)

ANOVA[a]						
Model		**Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**
1	Regression	804418.810	8	100552.351	20.540	.000[b]
	Residual	347581.190	71	4895.510		
	Total	1152000.000	79			

Source: Processed Primary Data, (2024)

Table 3. Partial test results (t-test)

Coefficients[a]						
		Unstandardized Coefficients		Standardized Coefficients		
Model		B	Std. Error	Beta	t	Sig.
1	(Constant)	520.834	46.532		11.193	.000
	Land Area (X1)	.343	.016	.268	2.774	.007
	Seeds (X2)	.550	.107	.575	5.159	.000
	Manure Fertilizer (X3)	.217	2.234	.297	2.649	.010
	NPK Fertilizer (X4)	.181	.463	.033	.391	.697
	TSP Fertilizer (X5)	.706	2.570	.025	.275	.784
	KCL Fertilizer (X6)	.092	.695	.010	.133	.895
	Labor (X7)	.001	.000	-.575	-7.051	.000
	Experience (X8)	.579	2.806	.016	.206	.837

Source: Processed Primary Data, (2024)

The degree of freedom is known to be 71, and the significance level is 5%. Looking at the two-sided t table, the value is 1.99394. The land area variable (X1) with a calculated T value of 2.774 is greater than the T table of 2.01537 at a significance level of 0.007 (sig < 0.05), indicating that there is a significant favourable influence between land area and tomato production results. This means that the land area variable positively and significantly influences tomato production results of 2.774.

The seed variable (X2) with a calculated T value of 5.159 is greater than the T table of 2.01537 at a significance level of 0.000 (sig < 0.05), indicating that there is a significant favourable influence between seeds and tomato production results. This means that the seed variable positively and significantly influences tomato production yields of 5.519 (Zhang et al. 2022).

Convey genetic variation and the quality of tomato seeds significantly affect plant productivity. They found that using superior seeds can increase production yields by 35-40% compared to conventional seeds.

The manure variable (X3) with a calculated T value of 2.649 is greater than the T table of 2.01537 at a significance level of 0.010 (sig < 0.05), indicating that there is a significant positive influence between manure and tomato production results. This means that the manure variable positively and significantly influences tomato production yields of 2.649. The Labor variable (X7) with a calculated T value of -7.051 is smaller than the T table of 2.01537 at a significance level of 0.000 (sig > 0.05), indicating that there is a significant negative influence between Labor and tomato production results. This means that the Labor variable negatively and significantly influences tomato production results of -7.051.

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Multiple Linear Regression Analysis of Tomato Production Function

The results of SPSS used as an analytical tool and multiple regression results are shown in Table 4.

Y = 520,834+0,343 X1+0,550 X2+0,217 X3+0,181 X4+0,706 X5+0,092 X6+-0,001 X7+0,579 X8 ….(2)

Table 4. Multiple linear regression test results

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	520.834	46.532		11.193	.000
	Land Area (X1)	.343	.016	.268	2.774	.007
	Seeds (X2)	.550	.107	.575	5.159	.000
	Manure Fertilizer (X3)	.217	2.234	.297	2.649	.010
	NPK Fertilizer (X4)	.181	.463	.033	.391	.697
	TSP Fertilizer (X5)	.706	2.570	.025	.275	.784
	KCL Fertilizer (X6)	.092	.695	.010	.133	.895
	Labor (X7)	.001	.000	-.575	-7.051	.000
	Experience (X8)	.579	2.806	.016	.206	.837

Coefficients[a]

Source: Processed Primary Data, (2024)

Land area influences tomato production results. This can be seen from the significance value of land area, namely 0.07, so it can be stated that land area influences tomato production results. This will, of course, affect the level of production achieved by each farmer. Maureira et al. (2022) state that the larger the land cultivated, the greater the results obtained. Seeds influence tomato production results; this can be seen from the significance of seeds, namely 0.00, so it can be stated that seeds influence tomato production results. This influence means that tomato seeds are a production factor related to the amount of capital spent on tomato farming and influences the income received.

Manure affects tomato production results; this can be seen from the significance value of manure, which is 0.00, so it can be stated that manure affects tomato production results. This influence means that manure is one of the production factors related to the amount of capital spent on tomato farming. This is because manure is mainly used by farmers in tomato cultivation. Labor influences the results of tomato production; this can be seen from the significance value of Labor, namely 0.00, so it can be stated that manure influences the results of tomato production. This influence means that labor is one of the production factors related to the amount of capital spent on tomato farming (Ronga et al. 2020).

Efficiency of Using Production Factors in Tomato Farming

Technical Efficiency

Technical efficiency can be observed in the coefficients of each variable for land area, seeds, manure, NPK fertilizer, TSP fertilizer, KCL fertilizer, labor and experience. This is because the coefficient of the variable studied shows the value of production elasticity (Table 5).

Y= 520,834 + 0,343 Ln X1 + 0,550 Ln X2 + 0,217 Ln X3 + 0,181 Ln X4 + 0,706 Ln X5 + 0,092 Ln X6 - 0,001 Ln X7 + 0,579 Ln X8

Production elasticity between 0 and 1 ($0 < EP < 1$) is when a business reaches a profit level. The Cobb-Douglas function equation that has been created is as follows:

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Non-Linear Cobb-Douglas Equation:

$$Y= e^{520,834} X_1^{0.343} X_2^{0.550} X_3^{0.217} X_4^{0.181} X_5^{0.706} X_6^{0.092} X_7^{-0.001} X_8^{0.579}$$

So, the non-linear Cobb-Douglass equation can be written as follows:

$$Y= 1,568 \times 10^{226} . X_1^{0.343} .X_2^{0.550} .X_3^{0.217} .X_4^{0.181} .X_5^{0.706} .X_6^{0.092} .X_7^{-0.001} .X_8^{0.579}$$

The regression coefficient for variables X1, in area II (rational area). Meanwhile, the regression coefficient for the variable (X7) is -0.001 (EP < 0), which can be interpreted that (X7) is technically inefficient because it is located in area III (irrational area).

Allocative Efficiency

Analysis of allocative efficiency in tomato farming can be seen in Table 6.

The land area variable (X1) has an allocative efficiency value of 0.283, allocative efficiency (NPMx/Px) < 1. The seed variable (X2) has an allocative efficiency value of 0.251, allocative efficiency (NPMx/Px) < 1. The manure variable (X3) allocative efficiency (NPMx/Px) > 1. The NPK fertilizer variable (X4) has an allocative efficiency value of 0.492, allocative efficiency (NPMx/Px) < 1. The TSP fertilizer variable (X5) allocative efficiency (NPMx/Px) > 1. The KCl fertilizer variable (X6) allocative efficiency (NPMx/Px) < 1. The labor variable (X7) allocative efficiency (NPMx/Px) < 1.The experience variable (X8) allocative efficiency (NPMx/Px) < 1.

Table 5. Linear Cobb-Douglas equation

No	Variabel	Koefisien
1	(Constant) (Y)	520.834
2	Land Area (X1)	.343
3	Seeds (X2)	.550
4	Manure Fertilizer (X3)	.217
5	NPK Fertilizer (X4)	.181
6	TSP Fertilizer (X5)	.706
7	KCL Fertilizer (X6)	.092
8	Labor (X7)	.001
9	Experience (X8)	.579

Table 6. Analysis of e

Variable	b	$\bar{Y}$	Py	$\bar{X}_i$	Pxi	$b.\bar{Y}\cdot Pxi$	$\bar{X}_i . Pxi$	$\frac{b.Y.Py}{Xt.Pxi}$
Land Area (X1)	0,343	490,000	1444	1713,750	500	242693,080	856875,00	0,283
Seeds (X2)	0,550	490,000	1444	323,000	4798	389158,000	1549754,00	0,251
Manure Fertilizer (X3)	0,217	490,000	1444	14,813	5000	153540,520	74062,50	2,073
NPK Fertilizer (X4)	0,181	490,000	1444	13,688	19000	128068,360	260062,50	0,492
TSP Fertilizer (X5)	0,706	490,000	1444	6,400	15000	499537,360	96000,00	5,204
KCL Fertilizer (X6)	0,092	490,000	1444	7,088	10000	65095,520	70875,00	0,918
Labor (X7)	-0,001	490,000	1444	3,555	45000	-707,560	159975,00	-0,004
Experience (X8)	0,343	490,000	1444	1713,750	500	242693,080	856875,00	0,283

Source: Processed Primary Data, (2024)

Marina and Sumawati (2017) study in the tomato production center revealed that 65% of farmers experienced inefficiency in the use of production inputs, in line with the findings of the research in Sumberejo Village, which showed low allocative efficiency in the variables of land area, seeds, and labor. Purwantini (2019) research further emphasizes that the complexity of agricultural input management, including the use of NPK fertilizer, KCl, and variations in organic fertilizer efficiency, is a common challenge in tomato farming, which is significantly

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consistent with the results of allocative efficiency analysis in this study.

Economic Efficiency

Analysis of economic efficiency obtained from ET and EA calculations is shown in Table 7. The economic efficiency value is less than 1, meaning the input is economically inefficient. Economic efficiency if ET and EA are achieved. Inputs that are not yet financially efficient are inputs whose use is not optimal, so they do not provide maximum financial benefits. This is in line with research (Collins et al. 2022), which has a value of less than 1. The low value of economic efficiency in tomato farming is caused by low technical efficiency which can be said to indicate that tomato farming has not reached the level of economic efficiency (Colanero et al. 2020).

Table 7. Results of economic efficiency analysis

Variable	ET	Justifikasi	EA	Justifikasi	EE	Justifikasi
Land Area (X1)	0,343	Efficient	0,283	Not Efficient	0,097	Not Efficient
Seeds (X2)	0,550	Efficient	0,251	Not Efficient	0,138	Not Efficient
Manure Fertilizer (X3)	0,217	Efficient	2,073	Not yet Efficient	0,450	Not Efficient
NPK Fertilizer (X4)	0,181	Efficient	0,492	Not Efficient	0,089	Not Efficient
TSP Fertilizer (X5)	0,706	Efficient	5,204	Not yet Efficient	3,674	Not yet Efficient
KCL Fertilizer (X6)	0,092	Efficient	0,918	Not Efficient	0,084	Not Efficient
Labor (X7)	-0,001	Not Efficient	-0,004	Not Efficient	0,000	Not Efficient
Experience (X8)	0,343	Efficient	0,283	Not Efficient	0,097	Not Efficient

Source: Processed Primary Data, (2024)

The results of previous research on efficiency conducted by Anggraini et al. (2016) titled Technical, Allocative, and Economic Efficiency in Cassava Farming in Central Lampung Regency, Lampung Province. The research results show that the variables significantly affecting the frontier production in cassava farming in Central Lampung Regency are land area, number of seeds, N fertilizer, and K fertilizer. The most responsive variable is land area, with the average cassava farmers in Central Lampung Regency being inefficient, with average technical, allocative, and economic efficiency values of 0.69, 0.71, and 0.47, respectively. The socio-economic factors that significantly reduce technical inefficiency are the farmer's age, harvest age, and number of family members, while access to credit affects the increase in technical inefficiency.

The comparison results with previous studies and this study, namely the efficiency of production factor used in tomato farming in Sumberejo Village, Batu District, Batu City, are stated in several categories, namely the technical efficiency of variables X1, X2, X3, X4, X5, X6, and X8 is (0 < EP < 1), technically efficient. Whereas the variable (X7) (EP < 0) is technically inefficient. The allocative efficiency of variables X1, X2, X4, X6, and X7 is allocatively (NPMx / Px) < 1, indicating inefficient input usage. Variables X3 and X5 are allocatively inefficient (NPMx / Px) > 1. And the economic efficiency of variables X1, X2, X3, X4, X6, and X7 is economically (EE = <1) inefficient, while variable X5 is economically (EE = >1) not yet efficient.

CONCLUSION

The results of the research show that The factors that influence tomato production in Sumberejo Village, Batu District, Batu City, namely the land area variable (X1), the seed variable (X2), and the manure variable (X3), have a partially significant positive effect on tomato production results. In contrast, the labor variable (X7) partially hurts tomato production, with the technical efficiency of

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variables X1, X2, X3, X4, X5, X6 and meanwhile, variable allocative efficiency X1, X2, X4, X6, and X7 allocatively (NPMx / Px) < 1 inefficient use of input, meanwhile variables X3 and X5 allocatively (NPMx / Px) > 1 Inefficient use of input, Variable economic efficiency X1, X2, X3, X4, X6, and X7 economically (EE = <1) inefficient while variables X5 economically (EE = >1) it is not yet efficient.

The contribution of this research to science or the surrounding community is as an internal reference for business development and increasing the added value of agricultural products as well as increasing knowledge and understanding also broadens insight into the efficient use of production factors in farming.

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