ANALYSIS OF POTATO FARMING PRODUCTION FACTORS

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ABSTRACT: There have been many research results that show that production factors affect agricultural production. However, a thorough analysis of production factors has not been carried out much. In addition, there has been no comprehensive analysis of the efficiency of potato production factors in Indonesia. Therefore, this study was conducted to determine the production factors that significantly affect potato production and the efficiency of the use of production factors. A Cobb-Douglas production function analysis was carried out to determine the influence of production factors on potato production. Furthermore, an allocative efficiency analysis was carried out to determine the efficiency of using production factors. The study results showed that the production factors of land area, seed, urea fertilizer, NPK fertilizer, fungicide, land cultivation labor, and harvest labor positively and significantly affected potato production. This study also found that only the input factor of planting labor had a significant adverse effect on potato production. In the allocative efficiency analysis, it was found that the use of production factors of seed, urea fertilizer, NPK fertilizer, fungicide, land cultivation labor, and harvest labor is inefficient, so these production factors must be increased in their use. On the other hand, the production factor of the land area shows inefficient results, so the land area must be reduced to achieve optimal efficiency.

KEYWORDS: Production Factors; Potato Production; Production Efficiency

INTRODUCTION

Despite the increase in potato production in Indonesia, it has not yet met market demand. However, the potential for further growth is promising, supported by the availability of various resources for potato cultivation development. Potatoes, as a horticultural commodity, hold great promise for food diversification, and with the right strategies, potato production can be increased to meet the high demand (Salsabila *et al.*, 2022).

The use of production factors in potato farming management highly determines potato production. These production factors, or inputs, are resources used to produce something. They play a vital role because of their significant influence on crop size. Understanding and effectively managing these factors is crucial for increasing the production of potatoes (Kilo *et al.*, 2018). Agriculture's production factors generally used are land area, seed, fertilizer, pesticides, and labor. The optimal use of production factors is vital to get the desired amount of production.

Potato crop production tends to fluctuate due to various production factors. Each production factor plays a unique role and influences production results. Farmers can guarantee the desired production results by using effective and efficient production factors. On the other hand, inefficient use of production factors can cause production to be less than optimal (Adiyoga, 2016; Mardani & Salarpour, 2015; Van Evert *et al.*, 2017). This study shows the importance of analyzing the use of production factors in potato farming.

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The analysis of potato production factors is vital to find out the production factors that have a significant influence on potato production. Furthermore, an allocative efficiency analysis was carried out to determine the use of inefficient production factors. The analysis results can show the use of production factors that need to be added or subtracted. The potato production factors analyzed in this study are land area, number of seedlings, fertilizer use, pesticide use, fungicide and herbicide, and labor (**Fig. 1**).

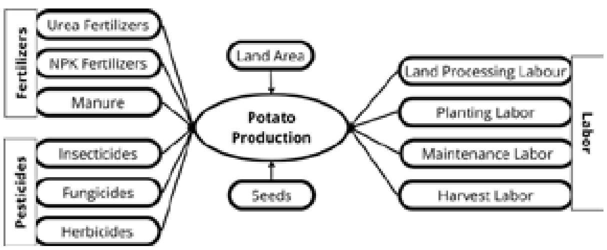

Fig.1. Conceptual Framework for the Influence of the Use of Production Factors

MATERIALS AND METHODS

Research Location, Data Collection, and Research Samples

Our research was conducted in Uluere District, Bantaeng Regency, South Sulawesi, a region known for its high potato production. This location was chosen purposively because the area has the highest potato production in Bantaeng Regency. The data collection technique used is a structured interview using a questionnaire that has been prepared. Respondents were sampled using a simple random sampling method from the farmer population. The *Cochran* formula is used to determine the minimum number of farmers to be sampled. The error tolerance limit has been set at 5%, so the number of samples selected for interview is 186 respondent farmers.

Data Analysis

The Cobb-Douglas function is a quantitative analysis tool used to determine the correlation between production and the production factors that affect it (Giang *et al.*, 2023; Zhang *et al.*, 2020). Therefore, this study's Cobb-Douglas Production Function Analysis determines the influence of production factors on potato farming. Cobb Douglas production function is a function or equation involving two or more variables, where the dependent variable is given the symbol Y and the independent variable is given the symbol X. The relationship between variables Y and X can be solved by regression, where the variation of Y will be affected by the variation of X (Nurprihatin & Tannady, 2017).

Specification of the Cobb-Douglas Equation Model

This study has an independent variable tested for its effect on the potato production as dependent variable. The independent variables including land area, seed, urea fertilizer, NPK fertilizer, manure, insecticide, fungicide, herbicide, land cultivation labor, planting labor, maintenance labor, and harvest labor. The specifications of the Cobb-Douglas Production Function Analysis model are presented in Equation 1.

$$\log Prod = \alpha + b1\log LL + b2\log B + b3\log Pa + b4\log Pb + b5\log Pc + b6\log Insek + b7\log Fungi + b8\log Herb + b9\log TKa + b10\log TKb + b11\log TKc + b12\log TKd + e \quad \text{......} \; 1)$$

where: Prod = Potato production (kg), LL = Land area (ha), B = Seed (kg), Pa = Urea fertilizer (kg), Pb = NPK fertilizer (kg), Pc = Manure fertilizer (kg), Insek = Insecticide (L), Fungi = Fungicide (L), Herb = Herbicide (L), TKa = Land Cultivation Labor (man-days), TKb = Planting labor (man-days), TKc = Maintenance labor (man-days), TKd = harvest labor (man-days), α = Regression Equation Intercept Coefficient, B1-B12 = Independent Variable Regression Coefficient, e = error terms

Allocative Efficiency Analysis

The allocative efficiency analysis was carried out by looking at the ratio between the Marginal Product Value (NPM) and its input price (P_x) (Cordanis *et al.*, 2020), where efficiency allocates if NPM/P_x is equal to one, as presented in Equations 2 and 3.

$$\frac{NPMXi}{Pxi} = 1 \quad (2)$$

or

$$\frac{Py.bi.Yi}{Xi.Pxi} = 1 \quad (3)$$

where: NPMxi = Marginal production value of the ith input, Pxi = Price per ith unit (Rp/unit), Py = Price per output unit (Rp/unit), Yi = Average production (kg), Xi = Average usage of the ith input (unit), Bi = Regression Coefficient,

To find out whether an input needs to be increased or decreased, its use can be done by comparing the marginal product value (NPMxi) with the marginal input price (Pxi), i.e. if:

NPMxi/Pxi > 1 means that the use of inputs is not yet efficient, so the use of inputs needs to be increased.

NPMxi/Pxi = 1, meaning that the use of inputs is already at an efficient level

NPMxi/Pxi < 1, meaning that the use of inputs is inefficient, so the use of inputs needs to be reduced

Model Testing

Model testing is used to determine the influence of significant variables jointly and partially. In this study, two tests were used, namely F-Test and t-Test, whose objectives and decision criteria were explained as follows:

The F-test is used to determine the significant influence between independent variables on dependent variables. If the value of F-count < F-table, then H0 is accepted, which means there is no significant influence between the independent and dependent variables. Then, if the value of F-count > F-table, H0 is rejected, which means that there is a significant influence between the independent variable and the dependent variable (Kadir, 2016).

The t-test determines how much influence each independent variable has on the dependent variable. If the t-calculated value > t-table, the individual independent variables significantly affect the dependent variables. Meanwhile, if the t-count is < t-table, then the independent variable partially does not significantly affect the dependent variable (Sarwono, 2018) .

RESULTS AND DISCUSSION

Research Results

The value of the determination coefficient (R2) is 0.750, so it can be concluded that 75% of the influencing factors of potato production are explained by the variables studied. This study obtained the F-table value of 1.808 from the 5% alpha table. The significance level obtained was <0.001, and the F-count value was 47.284, then a significant value of <0.001 <0.05 (alpha: 5%) and an F-count value (47.284) > F-table (1.808) was obtained, so it can be concluded that the independent variable has a simultaneous influence on the dependent variable. The t-test results showed independent variables that partially affected the dependent variables: land area, seed, urea fertilizer, NPK fertilizer, fungicide, land cultivation labor, and harvest labor. Meanwhile, other variables, namely manure fertilizer, insecticide, herbicide, planting labor, and maintenance labor have no partial effect on production. *Results of Cobb-Douglas Production Function Analysis*

Cobb-Douglas production function analysis was used to analyze the influence of production factors on potato production. The results of the study of the Cobb-Douglas production function can be seen in **Table 1**.

In **Table 1**, it can be seen that there are two types of regression coefficients, namely Unstandardized Coefficients and Standardized Coefficients. To make it easier to prepare the interpretation, the regression coefficients used are Standardized

Table 1. The results of the Cobb-Douglas function analysis of the influence of input use on potato production.

Coefficients[a]						
Type		Unstandardized Coefficient		Standardized Coefficient	t-value	Sig.
		B	Std. Error	Beta		
1	(Constant)	3.627	.942		3.852	.000
	ln LL (Land Area)	.419	.172	.223	2.430	.016*
	ln B (Seed)	.409	.066	.328	6.225	.000**
	ln Pa (Urea fertilizer)	.310	.075	.209	4.135	.000**
	ln Pb (NPK fertilizer)	.259	.093	.165	2.777	.006**
	ln Pc (Manure fertilizer)	-.058	.120	-.022	-.483	.629
	ln Insek (Insecticide)	.025	.071	.019	.352	.725
	ln Fungi (Fungicide)	.137	.068	.099	2.011	.046*
	ln Herb (Herbicide)	-.092	.064	-.060	-1.421	.157
	ln TKa (Land Cultivation Labor)	.237	.036	.457	6.562	.000**
	ln TKb (Planting Labor)	-.429	.110	-.367	-3.888	.000**
	ln TKc (Maintenance labor)	-.176	.120	-.136	-1.466	.145
	ln TKd (Harvest Labor)	.237	.097	.168	2.434	.016*
Dependent Variable: ln Prod						

Information: *Significant at a 95% confidence level, and **Significant at a 99% confidence level.

Coefficients, which are presented in the following equation:

$$\ln Prod = \alpha + 0.223\ \ln LL + 0.328\ \ln B + 0.209\ \ln Pa + 0.165\ \ln Pb - 0.022\ \ln Pc + 0.019\ \ln Insek + 0.099\ \ln Fungi - 0.60\ \ln Herb + 0.457\ \ln TKa - 0.367\ \ln TKb - 0.136\ \ln TKc + 0.168\ \ln TKd + e$$

Results of Allocative Efficiency Analysis

Farming can be considered efficient if a production factor's marginal product value (NPM) is equal to its price. (Kune *et al.*, 2016). If the marginal product value of an input is equal to one (NPMx/Px=1), then it can be interpreted that the use of the input is efficient. Meanwhile, if the marginal product value of an input is more than one (NPMx/Px>1), it means that the input is not efficient and needs to be added to achieve the level of efficiency. The use of inputs is said to be inefficient if (NPMx/Px<1), so to achieve a level of efficiency in the use of inputs needs to be reduced (Puryantoro & Wardiyanto, 2022). The results of the allocative efficiency analysis can be seen in **Table 2**.

The independent variables of seed, urea fertilizer, NPK fertilizer, fungiside, land cultivation labor, and harvest labor are not yet efficient, so it is necessary to add inputs to achieve an efficient level (**Table 2**). On the other hand, using inputs for land area and planting labor is inefficient, so it is necessary to reduce inputs.

Discussion

1. Land Area

The land area variable positively and significantly affected potato production, with a regression coefficient value of 0.223 and a significance level of 0.016. In addition, the t-test results showed a t-count value of 2.43 > t-table 2.00. Every 1% increase in land area will increase potato production by 0.223% if other variables are constant. The ratio between NPM from the input of land area to the land rental price per season per hectare is less than one (0.20), so it can be interpreted

Table 2. Results of allocative efficiency analysis of input use on potato production.

Variable	Bi	Average Y	PY	Xi	Pxi	PMxi	NPMxi	NPMxi/Pxi	Optimum[a]
Land Area*	0.223	3,370.86	12,316.67	0.46	100,000,000	1624.45	20,007,827.56	0.20[te]	2.31
Seed*	0.328	3,370.86	12,316.67	373.71	18,050	2.96	36,439.59	2.02[be]	754.45
Urea fertilizer*	0.209	3,370.86	12,316.67	130.85	2,400	5.38	66,311.74	27.63[be]	3,615.51
NPK fertilizer*	0.165	3,370.86	12,316.67	117.60	2,900	4.73	58,253.26	20.09[be]	2,362.22
Manure fertilizer	-0.022	3,370.86	12,316.67	398.52	500	-0.19	-2,291.95	-4.58	-86.94
Insecticide	0.019	3,370.86	12,316.67	1.83	250,000	34.91	429,959.76	1.72	3.16
Fungicide*	0.099	3,370.86	12,316.67	2.94	170,000	113.65	1,399,813.33	8.23[be]	24.18
Herbicide	-0.060	3,370.86	12,316.67	2.12	130,000	-95.36	-1,174,494.85	-9.03	-0.23
Land Cultivation Labor*	0.457	3,370.86	12,316.67	10.37	100,000	148.53	1,829,373.54	18.29[be]	189.74
Planting Labor	-0.367	3,370.86	12,316.67	2.91	100,000	-425.43	-5,239,852.01	-52.40[te]	-0.06
Maintenance Labor	-0.136	3,370.86	12,316.67	25.26	100,000	-18.15	-223,495.66	-2.23	-11.30
Harvest Labor*	0.168	3,370.86	12,316.67	9.64	100,000	58.76	723,701.93	7.24[be]	69.75
Allocative Efficiency Average								1.43	

Information: *positively and significantly affects the 95% confidence level, a = Optimum use value per hectare, be = not yet efficient, te = inefficient

that the use of land area is not efficient. These results are in line with the results of the research Sufa (2023) and Andrias *et al.* (2017), which says that the variable land area influences production, which means that the more land is used, the higher the production produced. Research on potato production across various countries indicates that land area generally positively impacts production, though its effect on yield can vary. In Indonesia, larger land areas (š1 hectare) were associated with higher technical efficiency in potato farming (Utami & Mamilianti, 2021). Similarly, in Ethiopia, land allocated for potato production positively and significantly affected output (Bukul, 2018)

2. *Seed*

This study showed that the seed variable had a positive and significant effect on potato production with the t-test results, namely a t-count value of 6.22 > a t-table of 2.00. The regression coefficient value is 0.328 with a significance level of less than 0.001, so it can be interpreted that every additional seedinput of 1% will increase potato production by 0.328% if other variables are constant. In line with several previous studies, it was also found that seed had a significant effect on agricultural production (Paul, 2017, Agatha & Wulandari, 2018 and Nugraheni *et al.*, 2022). Research has shown that using high-quality seed potato can significantly improve potato production and food security. Certified seed potato (CSP) has been found to increase yields and food security among smallholder farmers in Kenya (Okello *et al.*, 2017). Similarly, true potato seed (TPS) offers potential benefits for small-scale farmers in developing countries (KH Ababaker & Benyamin Esho, 2022). Positive selection, a method of choosing healthy plants for seed, has demonstrated yield increases averaging 12% compared to farmers' traditional selection methods in Uganda (Priegnitz *et al.*, 2020) The ratio between the NPM of seed and the price of seed is 2.02, so it can be interpreted that the use of seed is inefficient economically.

3. *Urea Fertilizer*

The urea fertilizer variable showed a positive and significant relationship with the amount of potato production. The regression results showed a regression coefficient value of 0.209 with a significance level of <0.001. It can be interpreted that every 1% addition of urea fertilizer input will increase potato production by 0.209% if other variables are constant. On the other hand, the ratio value between NPM from urea fertilizer input and the fertilizer price in question is 27.63. This value indicates that the use of urea fertilizer by respondent farmers is not efficient. This is in line with the findings of Rohman *et al.* (2021) and Rohi *et al.* (2018), which found that urea fertilizer can increase production by accelerating and optimizing plant growth.

NPK Fertilizer

The use of NPK fertilizer can positively and significantly influence potato production, with a regression coefficient value of 0.165 and a significance level of 0.006. Meanwhile, the t-test results show a t-count value of 2.77 > t-table 2.00. It can be interpreted that every 1% increase in NPK fertilizer input will increase potato production by 0.165% if other variables are constant. The ratio between NPM from NPK fertilizer and the fertilizer price is more significant than one (20.09). Based on the value of this ratio, it can be concluded that the use of NPK fertilizer is inefficient.

The results of research by Anggraesi *et al.* (2020) and Ruskandar *et al.* (2019) also found that NPK fertilizer affect production to a significant extent. The use of NPK fertilizer can spur plant generative growth and encourage the synthesis process to increase growth and production. (Quraisyin *et al.*, 2020). According to Tulung *et al.* (2021), the use of NPK fertilizer at the correct dosage can be the fresh weight of potato plants, the diameter of the tubers, and the productivity of the plants.

Fungicide

Using fungicide showed a positive and significant influence on potato production, with a regression coefficient value of 0.099 and a significance level of 0.046. It can be interpreted that every 1% increase in manure fertilizer input will increase potato production by 0.099% if other variables are constant. The t-test results showed a t-count value of 2.011 > t-table 2.00. Meanwhile, the ratio between NPM from fungicide and the price of the fungicide in question is 8.23, so it can be concluded that fungicide application is economically inefficient. The influence of fungicide that can support production is caused by the application of fungicide in the proper doses, which can inhibit the growth of diseases caused by fungi so that plants can grow better (Fitria & Diding, 2019).

Land Cultivation Labor

Land Cultivation Labor has a positive and significant effect on potato production, with a regression coefficient value of 0.457 and a significance level of less than 0.001. It can be interpreted that every 1% increase in planting labor will increase potato production by 0.457% if other variables are constant. The study also obtained similar results. (Lama & Kune, 2016) and Laksmayni (2022), which says that labor has a real effect on production. Meanwhile, the NPM ratio of the input of Land Cultivation Labor to the amount of wages provided is 18.29. A ratio value of more than one indicates that Land Cultivation Labor allocation is inefficient.

Planting Labor

The planting labor variable had a negative and significant effect on potato production with a regression coefficient value of -0.367 with a significance level of <0.001. **Table 1** shows every 1% increase in land cultivation labor will reduce potato production by 0.367%

if other variables are constant. This can be caused by the number of workers above the optimal number, so the division of labor becomes unclear, and the results of the work are ineffective. In addition, each farmer has his way of using labor inputs according to his experience and habits (Rahmasita *et al.*, 2022).

Harvest Labor

Harvest labor has a positive and significant effect on potato production, with a regression coefficient value of 0.168 and a significance level of 0.016. The t-test results also obtained a t-count value of 2.43 > a t-table 2.00. **Table 1** shows every 1% increase in harvest labor will increase potato production by 0.168% if other variables are constant. The addition of labor can optimize the implementation of potato harvesting activities so that the number of potatoes to be harvested will be more significant. This is in line with the results of the study Neonbota & Kune (2016) and Suripto & Safitri (2021), i.e., labor can positively affect production to a significant extent. The NPM ratio of harvest labor to the number of wages given is more than one (7.24), so it can be interpreted that the allocation of harvest labor is not economically efficient.

CONCLUSION

The results of this study can conclude that the variables of land area, seed, urea fertilizer, NPK fertilizer, fungicide, land cultivation labor, and harvest labor have a positive and significant effect on potato production. The Insecticide variable had a positive but insignificant effect on potato production. On the other hand, the variables of manure fertilizer, herbicide, and maintenance labor have a negative but insignificant effect. In contrast, the variable of planting labor has a negative and significant effect on potato production. Based on the allocative efficiency analysis results, the variables of seed, urea fertilizer, NPK fertilizer, fungicide, land cultivation labor, and harvest labor showed inefficient results, so these production factors must be increased in their use. Meanwhile, the land area variable shows the results of inefficient allocative efficiency, so land use must be reduced in area to achieve optimum efficiency.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest

ETHICAL STATEMENT

This article does not contain any studies with human participants or animals performed by any of the authors

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MS Received : June 06, 2024; Accepted : July 31, 2024