The Economic Impact of Carbosulfan Use on Shallot Farm
(Case Study: Brebes and Enrekang Regency)

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Abstract. Carbosulfan is one of the pesticides widely used by farmers of shallot. Excessive use of pesticides has caused controversy, particularly with regard to the environment and health, as pesticide residues can accumulate in agricultural products and pollute rivers. Even though, the use of Carbosulfan pesticide is still believed by many to benefit farmers in the economic and social aspects. This study aims to: (1) to analyse the income on shallot farming and (2) to analyse production function and production efficiency on shallot farming. The method used in this study are income analysis, linear regression analysis and efficiency analysis. Based on the results of the study, the revenue and cost ratio values is greater than 1. It indicated that the farming of shallot farming is profitable. The use of carbosulfan has positive and significant effect on shallot production. The production elasticity of carbosulfan insecticides is positive and is between 0 and 1 (0.051), indicating that farmers are rational in the use of carbosulfan for pest control. The ratio of marginal product value to the input price from the use of carbosulfan is 0.049. This means that the allocation of carbosulfan insecticide is not efficient and must be reduced in order to obtain maximum profit on shallot farming.

Keywords: Efficiency · Income · Insect · Production · Value Marginal Product (VMP)

1 Introduction

Pesticides are one of the important inputs of agricultural commodities. Pesticides including herbicides, insecticides, and fungicides have contributed to substantial increases in crop yields over the past five decades [1]. Pesticides control plant pests and diseases and therefore improve the quality and quantity of agricultural products. Excessive use of pesticides has caused controversy, particularly with regard to the environment and health, as pesticide residues can accumulate in agricultural products and pollute rivers [2]. Moreover, Uncontrol use of synthetic pesticide causes environmental pollution and leaves its residue in soil and water [3]. However, if pesticides are used rationally and carefully, along with other technologies in integrated pest management system, their use is beneficial. The benefits include increased yields and improved food security [4].

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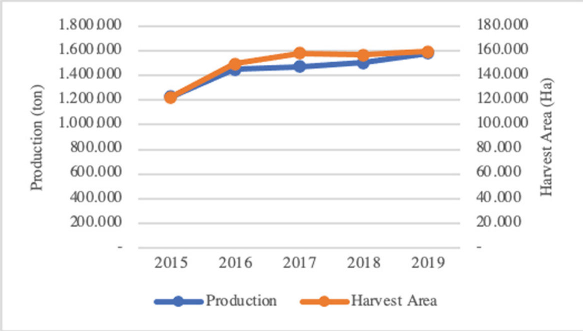

Fig. 1. Shallot production and harvest area in Indonesia (2015–2019). Source: Central Bureau of Statistics in Indonesia (2020)

Among various pesticide active substances, carbosulfan is one of the pesticides widely used by farmers [5]. Carbosulfan can be used in for most agricultural commodities cultivation, especially commodities that are vulnerable to pest attacks such as horticultural commodities. In Indonesia, carbosulfan is also used in shallot cultivation.

Shallot is the strategic commodity that are designated as staple foodstuffs apart from rice, corn and soybeans. Shallot is mainly used as basic spices and flavor in almost every Indonesian food. The consumption of shallot is mainly fulfilled by domestic production.

Shallot production in Indonesia tends to rise over years. Figure 1 shows the rise of production during 2015 to 2019. Production shallot is experiencing promising growth about 6.67% respectively. It is because the growth in production come from the expansion of harvested area.

For farmers, shallot is promising commodities because of its high return. But with this interesting prospect, high risk in production follows. It is also very vulnerable to production risk especially to pests and plat diseases. In the cultivation process, most shallot farmers use chemical pesticides to fight pest and disease and boost their production. Among many types of chemical pesticide. Carbosulfan is one active ingredient which is frequently used by farmer in their pest management. Carbosulfan is used for controlling of a wide range of soil-dwelling and foliar insect pests.

Carbosulfan pesticides play an important role in production. The use of pesticides has greatly helped keep the production of agricultural commodities in the world from losing yields of around 40–70% in the last 40 years [6]. Nevertheless, there is controversial reasons related to health and the environment. Annex III to the Rotterdam Convention in the Prior Informed Consent (PIC) procedure stated that the carbosulfan is one of Hazardous Chemicals and Certain Pesticides in International Trade. However, some countries disagreed with the recommendation and this issue will be discussed again in the next meetings. Indonesian Ministry of Agriculture has conducted some research about the impact of carbosulfan on health and environment and found that there was no serious impact of carbosulfan use in agriculture cultivation for farmer's health as well as the environment [7–9].

The use of carbosulfan as an effort to reducing plant pests and diseases is the reason for the high use of carbosulfan. In Indonesia, one of plant that uses a lot of carbosulfan is shallot. The main pests in Shallots farming in Brebes are S. exigua, Spodoptera mauritia, and Liriomyza sp. Shallots are quite sensitive to weather changes so that they also affect the types of pests that attack. In the dry season, shallots are generally attacked by pests, while in the rainy season they are more attacked by diseases [10]. Moreover, the application of pesticides by shallot fanners in Brebes generally was very intensive, either dosage or the frequency of application [11].

In this research, the economic impacts of carbosulfan use for farmers are important to be known, especially for farmer with high level of carbosulfan usage such as is shallot farming. The specific objectives of this study are as follows: (1) to analyse the income on shallot farming, and (2) to analyse production function and production efficiency on shallot farming.

2 Methodology

2.1 Study Location, Samples and Data Collection

This study was conducted on farmers who used carbosulfan pesticides. The study focused on shallot commodities. Research locations were the centres of shallot production in Indonesia and were purposively selected Brebes and Enrekang Regency for shallot. Number of samples shallot farmers are 30 people. A structured interview was constructed with questionnaire to collect the data.

2.2 Income Analysis

Income analysis was used to describe the performance of farming that has used pesticides with carbosulfan active ingredient as its production input. This method calculated the economic impacts of the use of pesticides with carbosulfan active ingredient on production costs (TC), revenue (TR) and profit margin (π). In making the income analysis, it was necessary to organize the input components of production and revenue from shallot farming. The criteria for income analysis used is the income value of farming and the value of the ratio between revenue and costs.

The income analysis was necessary to organize the input components of production and revenue. The criteria for income analysis used is farm income and the revenue-cost ratio (R/C) of shallot farm [12].

$$\pi = TR - TC, \text{ farming is profitable if } \pi > 0 \quad (1)$$

$$\frac{R}{C} = \frac{TR}{TC}, \text{ farming is profitable if } \frac{R}{C} > 1 \quad (2)$$

2.3 Production Function

Production function analysis was estimated by performing regression, a quantitative method used to estimate the relationship between dependent variables and independent variables that explain its diversity. In this study, this method was used to explain the relationship between production and production factors of each commodity analysed. Production factors that were used as the independent variables on the production (PRD_i) function included carbosulfan insecticide (INS), labour (TK), urea fertilizer (UREA), NPK fertilizer (NPK), and SP 36-fertilizer (SP36) and Kamas fertilizer (KAMAS). The production function for each commodity in this study was expressed by the following mathematical Eq. 3:

$$\ln PRD_i = \beta_0 + \beta_1 \ln (INS)_i + \beta_2 \ln (TK)_i + \beta_3 \ln (UREA)_i + \beta_4 \ln (NPK)_i + \beta_5 \ln (SP36)_i + \beta_6 \ln (KAMAS)_i + \varepsilon_i \quad (3)$$

where: β_0 is intercept; ε_i is error; and *i* is respondent number (1, 2,…, 30).

Based on the production function, the βi value obtained is the production elasticity of each production factor. The production elasticity of each production factor is expressed in three alternatives that show the scale of business: $\sum \beta i > 1$, (*Increasing Return to Scale*). $\sum \beta i < 1$, (*Decreasing Return to Scale*) and $\sum \beta i = 1$, (*Constant Return to Scale*). Marginal physical product (MPP) of a production factor was obtained from the result of multiplication of the regression coefficient of production factor related to the Average Production (AP), namely [13]:

$$MPPx_i = \beta_i \cdot AP = \beta_i \cdot \frac{y}{x_i} \quad (4)$$

Economic Efficiency (maximum profit) was obtained from the equation:

$$Py \cdot MPP = P_x \quad (5)$$

$$VMP = P_x \quad (6)$$

The efficiency rate of the use of production factors were calculated using the ratio of the Value of Marginal Product (VMP) to production factor cost (P_{xi}), which is when less than 1 it does not efficient, so the use of production factor needs to be reduced. However, when more than 1, the production factor is not yet efficient, the use of production factor needs to be increased, and when exactly 1 its mean that the production factor is already efficient.

3 Results and Discussion

3.1 Shallot Farm Income Analysis

Shallot (*Allium ascalonicum* L.) is a seasonal vegetable plant that has a high economic value, short-lived, can be propagated vegetatively using tubers, as well as generatively with seeds. The success of the development of shallot cultivation is determined by the intensity of farmers' efforts from land preparation, crop maintenance to harvest. The shallot plant is a plant that is quite susceptible to pests/diseases of many types. The effort that farmers have to make to protect their crops from pest attacks is quite large, as seen from the relatively high use of insecticides.

Table 1. Shallot farming income analysis (Rp/Ha/Planting Season)

No	Description	Total
1	Revenue	263,515,314
	a. Production (Kg)	12,132.4
	b. Price (Rp)	21,720.0
2	Cost (Rp)	122,587,698.4
3	Income (Rp)	140,927,615.9
4	R/C	2.15

Source: Primary Data (2020)

Shallot is one of the strategic horticultural commodities that have the characteristics of high cost, high risk, and high return. In running shallot farming, farmers have to have a relatively high capital compared to other commodity farming such as food crops, and must carefully care for and maintain crops so as not to suffer damage/production failure.

At the research locations in Brebes and Enrekang, the varieties of shallot cultivated are different. Brebes farmers cultivate the Bima Brebes variety while Enrekang farmers cultivate the Tajuk variety (Table 1).

The average productivity of shallot farmers in 1 planting season was 12.13 tons/Ha with an average selling price of Rp 21,720. Thus, the average revenue of farmers in 1 planting season was Rp 263,515,314. Meanwhile, the average farming cost incurred by farmers for 1 Ha of land was Rp 122,587,698 per planting season. Thus, the average income per Ha for 1 planting season from shallot farming was Rp 140,927,615. In addition, the result from the comparison between revenue and cost (R/C) is 2.15, indicating that for every Rp 1 cost spent, farmers will receive a revenue of Rp 2.15. Thus, shallot farming can be said to be profitable because it produces a profit (π) with a positive value and an R/C value greater than 1.

The biggest cost that farmers had to prepare is the cost of buying seeds (49%). Seeds are a very important production factor, so they must have good quality and conformity to the agroclimatic characteristics of each area. In addition, labour costs are also a significant component of costs (36%), especially in land cultivation and maintenance costs (Table 2).

The cost of purchasing carbosulfan insecticide was only 1.06%. However, the cost of purchasing these pesticides, most were used to purchase insecticides (50%), with details of 16% for insecticides containing carbosulfan active ingredient and 34% for other insecticides. The remaining were 30% for the purchase of fungicides and 20% for the purchase of herbicides. Thus, it can be concluded that the cost proportion to buy carbosulfan is quite small. The variation of this value is adjusted to the conditions of pests and diseases that attack farmers' shallot crops.

Insecticides with carbosulfan active ingredient are very important in eradicating fleas, caterpillars, and thrips. At the research locations, the shallot farmer respondents have always used carbosulfan active ingredient insecticides for the past few years. If at some point this carbosulfan active insecticide is no longer circulating in the market, all farmer respondents stated that they would replace it with other active chemical insecticides.

Table 2. Shallot farming cost production analysis (Rp/Ha/Planting Season)

No	Description	Total	Percentage (%)
1	Seed	60,337,047.6	49.22
2	Urea Fertilizer	499,647.6	0.41
3	SP36 Fertilizer	823,083.3	0.67
4	ZA Fertilizer	110,357.1	0.09
5	NPK Fertilizer	2,100,597.7	1.71
6	Phonska Fertilizer	1,252,381.0	1.02
7	Kamas Fertilizer	971,726.2	0.79
8	Pearl/Bee fertilizer	4,864,545.5	3.97
9	Herbicide	1,572,534.0	1.28
10	Carbosulfan Insecticide	1,303,112.1	1.06
11	Non-Carbosulfan Insecticide	2,653,323.9	2.16
12	Fungicide	2,393,966.7	1.95
13	Labor		
	a. Tillage	22,235,714.3	18.14
	b. Planting	3,262,147.9	2.66
	c. Fertilization	1,130,257.9	0.92
	d. Maintenance	9,546,274.9	7.79
	e. Spraying	4,613,293.7	3.76
	f. Harvest	2,917,687.1	2.38
14	Total Cost	122,587,698.4	

Source: Primary data (2020)

This will of course lead to changes in farmers' costs and incomes. In the case of the shallot commodity, these changes in costs and revenues cannot be calculated because there have been no case studies where farmers have replaced the role of carbosulfan active ingredient insecticides with other active insecticides.

3.2 Shallot Farmer Production Analysis

The results of production function analysis of commodity shallot showed that the determinant coefficient value (*R-squared*) is 0.9211. This can be interpreted that together all production factors namely carbosulfan insecticide (INS), labour (TK), urea fertilizer (UREA), NPK fertilizer (NPK), and SP 36-fertilizer (SP36) and Kamas fertilizer (KAMAS), are able to explain the diversities occurring in shallot production (PRD) by

Table 3. Production function estimation results of shallot faming

Variable	Koef (B)	Std. Error	T_{value}	P-*value*
Konstanta	3.082	0.827	3.726	0.001
INS	0.051	0.025	2.034	0.011*
TK	0.511	0.190	2.644	0.015*
UREA	0.092	0.032	2.894	0.008*
NPK	0.065	0.038	1.728	0.097
SP36	0.137	0.062	2.203	0.037*
KAMAS	0.075	0.051	1.457	0.158
Prob > F	0.000			
R-squared	0.9211			

Source: Primary data (2020)

92.11%. The rest is 7.89% were explained by other factors or variables the production factor studied (Table 3).

Note: *significant at 5% significance level.

F_{test} results showed that p-value F_{count} at 0.000 is smaller than the 5% significance level. F_{test} results decided to reject $H_0 = \beta_0 = \beta_1 = \beta_2 = \beta_3 = \beta_4 = \beta_5 = \beta_6 = 0$. This has brought forth the conclusion that the analysed variables namely carbosulfan insecticide (INS), labour (TK), urea fertilizer (UREA), NPK fertilizer (NPK), SP 36-fertilizer (SP36), and Kamas fertilizer (KAMAS) simultaneously have significant impact on shallot production (PRD). This has also shown that the production function model can be used for the next analysis.

The results of t-test showed that the use of production factors of carbosulfan insecticide (INS), labour (TK), urea fertilizer (UREA), and SP 36-fertilizer (SP36) partially has a significance effect on shallot production (PRD). This can be seen from the p-value of each of these production factors respectively are smaller than the 5% significance level. Meanwhile, the production factors of NPK fertilizer (NPK), and Kamas fertilizer (KAMAS) are known to not significantly affect shallot production (PRD) due to the p-value greater than the 5% significance level.

The use of carbosulfan has positive and significant effect on the level of shallot production. Other inputs such as labour (TK), urea fertilizer (UREA), and SP 36-fertilizer (SP36) also has a positive and significant impact on the production. The production elasticity of carbosulfan insecticides is positive and is between 0 and 1 (0.051), indicating that farmers are rational in the use of carbosulfan for pest control. The use of carbosulfan insecticide (INS) is increased by 10%, then shallot production will increase by 0.51%. These results are in line with several research, such as: Wayan and Nengah [14], Afrianika et al. [16], and Hasri et al. [15]. The pesticides are one of the factors that affect the production of shallots. Pesticides have an elasticity value of 0.194, which means that if there is an addition of 1% of pesticides, there will be an increase in the amount of shallot production of 0.194% with the assumption that other variables are considered zero or constant [16].

Table 4. Production efficiency analysis of shallot commodity

Var	X	B	PM	Py	PM.Py	Px	NPM/Px
INS	6.979	0.051	0.057	9.986	0.573	11.770	0.049
TK	4.725	0.511	0.849	9.986	8.474	11.513	0.736
UREA	3.139	0.092	0.230	9.986	2.297	7.568	0.303
NPK	3.538	0.038	0.084	9.986	0.842	9.105	0.092
SP36	3.561	0.062	0.137	9.986	1.364	7.749	0.176
KAMAS	2.538	0.039	0.120	9.986	1.201	9.210	0.130

Source: Primary Data (2020)

The role of pesticides on shallot production is different from other inputs. Pesticides do not increase production but save production from pests and diseases. The relationship with increased production occurs because healthy plants will be more responsive to nutrient absorption so that shallot production increases. In economic perspective, carbosulfan can continue to be used due to its significant effect on the production of shallot.

3.3 Shallot Farmer Efficiency Analysis

This ratio is an indicator of whether the production efficiency of shallot commodity has been achieved for each input use including carbosulfan active ingredient insecticides. The calculation results showed that the ratio of marginal product value to the input price from the use of carbosulfan (NPM_{INS}/P_{INS}) is 0.049 (Table 4). This means NPMx/Px < 1 and the allocation of carbosulfan insecticide is not efficient and must be reduced in order to obtain maximum profit on shallot farming.

4 Conclusions

The revenue and cost ratio values of shallot farming greater than 1 indicate that the farming of these commodities is profitable. When farming does not use carbosulfan, then revenue and cost obtained will be smaller due to the decrease in production which implies the revenue and increase in production costs. Farmers' expenditure on the use of carbosulfan around 1.06% of total production costs. The use of carbosulfan has a positive and significant effect on the level of production of shallot commodities produced by farmers. The production elasticity of carbosulfan insecticides in shallot farming is 0.051, indicating that farmers are rational in the use of carbosulfan for pest control. In shallot farming, the use of carbosulfan is not efficient and must be reduced in order to obtain maximum profit on shallot farming. Therefore, it is the recommended for the Indonesian government to have an effort to increase productivity and welfare of farmers, can still support the use of carbosulfan that have a positive effect on shallot production processes.

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References

1. United States Department of Agriculture. Pesticide Use in U.S. Agriculture: 21 Selected Crops, 1960–2008. 2014. Economic Information Bulletin Number 124.
2. D. Sofia, Pengaruh Pestisida Dalam Lingkungan Pertanian. Medan: Universitas Sumatera Utara, 2001.
3. N. Priyani, "Isolation and Degradation Study on Carbosulfan Containing Pesticide of Biosufactant-Producing Bacteria From Belawan Sumatera," International Journal of Eco-physiology, vol. 2, no. 02, pp. 92–100, 2020.
4. J. Cooper and H. Dobson, "The benefits of pesticides to mankind and the environment," Crop Protection, vol. 26, no. 9, pp. 1337–1348, 2007.
5. M.Q. Yi, H.X. Liu, X.Y. Shi, P. Liang, and X.W. Gao, "Inhibitory effects of four carbamate insecticides on acetylcholinesterase of male and female Carassius auratus in vitro," Comparative biochemistry and physiology Part C: Toxicology & pharmacology, vol. 143, no. 1, pp. 113–116, 2006.
6. E.C. Oerke, "Crop losses to pests," J of Agric Sci, vol. 144, pp. 31-43, 2006.
7. A.N. Ardiwinata, E.S.H. Sulaeman, A. Kurnia, and E. Sulaeman, "Level and Distribution of Paraquat and Carbosulfan Residues In Soil, Surface Water, And Plant From Indonesia", 2019.
8. M. Firdaus, Dampak Penggunaan Pestisida Berbahan Aktif Carbosulfan terhadap Kesehatan. Laporan Penelitian. Bogor: Institut Pertanian Bogor, 2018.
9. T. Taufikurrahman, T. Anggraeni, N.P. Aryanta, E. Mustari, Y. Setiawati, A. Rachmawati, A. Purwasena, A. Suryati, I. Fadhila, Meilisa, M. Zahra, M. Stefania, A.N. Fitriyani, and I.D. Haniefa, Pengaruh Aplikasi Pestisida Berbahan Aktif Paraquat Diklorida and Carbosulfan in Budidaya Corn terhadap Keanekaragaman Hayati Tanah and Lingkungan. Bandung: Institut Teknologi Bandung, 2018.
10. R.S. Basuki, "Farmer Knowledge and Effectiveness of Use of Insecticides by Farmers in Control of Caterpillar Spodoptera exigua Hubn. on Shallots in Brebes and Cirebon," J. Hort. vol. 19, no. 4, pp. 459–474, 2009.
11. Budigunawan, Analysis of Chlorpyrifos Residue in Alluvial Soil after Shallot Planting in Brebes. Bogor: IPB University, 2004.
12. J.P. Doll and F. Orazem. Production economics, theory with application. Second Edition. John Willey Sons IAC. Canada, 1984.
13. L.D. David, Agricultural Production Economic. Macmillan Publishing Company. Kentucky, 2012.
14. W. Wayan and Nengah, "Climate Is Very Influential to The Risk of Shallot (Allium Ascalonicum L) Farming Production," E-Jurnal Agribisnis dan Agrowisata, vol. 2, no.1, 2013.
15. V.I. Afrianika, S. Marwanti, and I. Khomah, "Analisis Faktor-Faktor yang Mempengaruhi Produksi Usahatani Bawang Merah di Kecamatan Tawangmangu," Agriecobis: Journal of Agricultural Socioeconomics and Business, vol. 3, no. 2, pp. 79–86, 2020.
16. Hasri, J. Zakaria, and Arifin. "Factors Affecting Shallot Production in East Banggae District, Majene Regency," Jurnal Ilmu Ekonomi, vol. 3, no. 4, pp. 64–72, 2020.