The Social and Economic Impact of Carbosulfan Use on Chili Farm

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Abstract. Pest management plays big role in chili production. Most chili farmer in Indonesia uses chemical pesticide, among various pesticide active substances, Carbosulfan is one of the pesticides widely used by farmers. Even though there are some controversial issues related to health and environment, the use of Carbosulfan pesticide is still believed by many to benefit farmers in economic and social aspect. This study aims to: (1) describe the social impacts of Carbosulfan use, including farmers' attitudes and motivations as well as its social benefits and (2) analyse the economic impacts of Carbosulfan. The method used in this study are descriptive analysis, income analysis and linear regression analysis. This study found that: (1) only one third of the sample agree that the use of Carbosulfan pesticide could save the working time of chili farmers. This saved working time was then used by farmers to carry out other activities such as become farmworker or labour/handyman, or rest. (2) Chili farming with carbosulfan is profitable and the use of carbosulfan pesticide is relatively cheaper than its substitute. Carbosulfan pesticide significantly and positively affects chili productivity, and if it is eliminated in production process then it can create some economic value lost.

Keywords: Income · Pesticide · Production · Profitability · Regression

1 Introduction

Red chili is one of the essential spices in every Indonesian food. Indonesian people are among the world's biggest chili enthusiasts and Indonesia was one of the world's largest chilies producing countries [1]. Indonesia chili production in 2020 reached 2.77 million tons, increased by 7.11% (183.96 thousand tons) from 2019 production with a productivity level of 9.5 tons per hectare [2]. Chili household consumption in 2020 reached 1.03 million tons, account 90.64% of total consumption. With these conditions, Indonesia has a chili production surplus of 1.63 million tons and part of this surplus was exported with export value in 2020 reached US$ 25.18 million. Chili cultivation is also an important source of cash income for small scale farmer in Indonesia.

There are several reasons for the importance of red chili production: (a) red chili are horticultural commodities with high economic value, although the prices are very

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volatile; (b) red chili is one of the national commodities that are getting serious attention from the government; (c) as a food ingredient that is widely used in Indonesian cuisine; (d) it has good export prospects and import substitution commodity; (e) it can be cultivated both in upland and wetland; (f) it absorb a lot of labour; (g) it has good strategic marketing objectives to the traditional market, modern market until processing industry [3]. But with its good business prospect, Chili cultivation is categorized as high-risk high-return commodities, due to its vulnerability to pest and climate change. According to The Chairman of the Indonesian Chili Agribusiness Association (AACI), the number of Chili Farmer has decreased in 2020 by 40% due to the uncertainty in price and production.

To maintain the sustainability of chili farming, production must be done optimally. One of the most important parts of agricultural production optimization is the control of plant-disturbing organisms. The primary method used since the 1960s to control pests has been the intensive application of chemical pesticides [4]. Most chili farmer in Indonesia tend to use chemical pesticide rather than organic or bio-pesticide. Among various pesticide active substances, Carbosulfan is one of the pesticides widely used by farmers [5]. Carbosulfan is an organic compound that belongs to the carbamate class. It is effective in eradicating pests [6], such as insects in the soil: G. hirsute [7], Gryllotalpa sp and Nematoda [8, 9], because carbosulfan is systemic, relatively durable and persistent in soil [7]. In Indonesia, carbosulfan pesticide are produced to target pest such as: thrips, army caterpillar, aphids, and red mite Tetranychus sp. Chili thrip adults and nymph lower yields by piercing and sucking sap from growing shoots, developing flowers and tender leaves, which then exhibit characteristic leaf curl symptoms. Corky tissue develops on infested fruits. Chili borer larvae move from one fruit to the next. The entrance hole develops a dark scar [10]. Damaged fruit may drop, ripen prematurely or become infected with disease. These insects not only directly reduce yield by damaging the plants but also reduce the value of chili as a result of their presence in peppers. The use of carbosulfan by farmers is one of the efforts to control pests and diseases that can cause significant losses to farmers.

Although chemical pesticides have been successful at reducing pest populations, it is well known that their application can also have negative effects on the environment and the crops itself. Due to controversial reasons related to health and the environment, carbosulfan was twice recommended at the Rotterdam conventions in 2017 and 2019 for inclusion in Annex III to the Rotterdam Convention in the Prior Informed Consent (PIC) procedure for Hazardous Chemicals and Certain Pesticides in International Trade. However, because there are still some countries that disagree with the recommendation for various reasons at the COP8 and COP9 meetings, in accordance with the rules of the convention, Carbosulfan has not been included in the PIC list and will be discussed again in 2021. Although some countries, including Indonesia, have not yet made a final decision regarding the inclusion of carbosulfan in Annex III, but when the regulation is established, then carbosulfan may not be exported without prior notice to the importing country. This, to a certain extent, can create unfavourable conditions for farmers. Farmers must make adjustments to production inputs and cultivation process. Therefore, this study aims to analyse the social and economic impact on carbosulfan use in Chili farm.

2 Methodology

2.1 Data

This study was conducted on chili farmers who used carbosulfan pesticides. Research locations were the centres of Chili production in Indonesia: Garut and Indramayu Regency. Number of sample is limited since data collection process was held during pandemic Covid-19 situation during October to November 2020. A structured interview was constructed with questionnaire to collect the data from 60 chili farmer samples.

2.2 Income Analysis

Income analysis was used to describe the performance of chili 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, revenue and profit margin. In making the income analysis, it 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) [11].

$$\pi = \mathrm{TR} - \mathrm{TC},\ \text{farming is profitable if}\ \pi > 0 \tag{1}$$

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

where: $\pi =$ income (Rp/year); TR = revenue (Rp/year); TC = cost (Rp/year)

2.3 Production Function

Production function was estimated by performing a multiple linear 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 chili production factors. Production factors that were used as the independent variables on the production function are: harvest area, use of seeds, fertilizers, pesticides, especially the use of carbosulfan, and labour. The production function in this study was expressed by the following equation:

$$\begin{aligned}\ln \mathrm{PRD_i} = {} & \beta_0 + \beta_1\, ln\, INS_i + \beta_2\, ln\, HER_i + \beta_3\, ln\, TK_i + \\ & \beta_4\, ln\, NPK_i + \beta_5\, ln\, ZA_i + \beta_6\, ln\, ORC_i + \\ & \beta_7\, ln\, UREA_i + \varepsilon_i \end{aligned} \tag{3}$$

where:

PRD_i = Chili Production (Kg/year)
β_0 = Intercept
INS_i = Carbosulfan insecticides (Litre)
HER_i = Herbicide (Litre)
TK_i = Labor (Working day)
NPK_i = NPK fertilizer (kg)
ZA_i = A fertilizer (kg)
ORC_i = Manure (kg)
$UREA_i$ = Urea fertilizer (kg)
ε_i = Error

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 product of a production factor was obtained from the result of multiplication of the regression coefficient of production factor related to the mean ratio of production, namely:

$$MPPx_i = \beta_i \cdot AP = \beta_i \cdot \frac{y}{x_i} \tag{4}$$

where:

$MPPx_i$ = Marginal physical product
AP = Average product

Economic Efficiency (maximum profit) was obtained from the equation [12]:

$$Py \cdot MPP = P_x \tag{5}$$

$$VMP = P_x \tag{6}$$

The efficiency rate of the use of carbosulfan insecticide was calculated using the ratio of Value of Marginal Product (VMP) to carbosulfan insecticide price (Pxi), which is when:

- $\frac{VMP}{Px_i} < 1$, input allocation is not efficient, number of input needs to be reduced.
- $\frac{VMP}{Px_i} > 1$, input allocation is not yet efficient, the use of production factor needs to be increased.
- $\frac{VMP}{Px_i} = 1$, the number of input used is already efficient.

Economic efficiency (maximum profit) with the combination of efficient production factors has had to meet the requirement below:

$$\frac{VMP}{Px_i} = 1 \tag{7}$$

3 Results and Discussion

3.1 Carbosulfan Use and the Social Impact

The majority of farmers used carbosulfan product during seed treatment and some farmers also used it in the maintenance of crops in a variety of ways, starting from 15 dap (days after planting), 20 dap or 30 dap with spraying time interval according to the conditions of the plants. Carbosulfan products brand that were widely purchased by chili farmers were Marshal 200 EC in 500 ml packaging size and Taurus 200 EC in 500 ml packaging size.

Most chili farmers (93%) obtained information about carbosulfan, how it is used and what pests are targeted from shops or kiosks in around farmer's residence. Most farmers also got information about carbosulfan by exchanging information with other farmers (58%). Farmers also obtained information on carbosulfan products from farmers meeting (25%) and extension conducted by producer of insecticides with carbosulfan active ingredient (5%). The main source of purchase for carbosulfan products accessed by all respondents of chili farmers was the nearest kiosk in the area where the farmers lived. But sometimes farmers could buy carbosulfan products from other sources of purchase sources such as middleman or agent from carbosulfan producer.

Almost all farmer respondents (>93%) agreed that the main reasons farmers used carbosulfan products were because carbosulfan products were effective in controlling pests faced by farmers, the products were easy to obtain and use and suitable for use in various seasons. Chili farmers also considered carbosulfan products bought by them were easy to apply in the field. In addition, the majority of farmers also stated that these carbosulfan products were relatively cheaper compared to the substitute products in controlling the pests as desired by farmers. Detailed reasons for chili farmers in using carbosulfan can be seen in Table 1.

From the results of the interviews, it is known that in the last 1–2 years, chili farmer sample had not been using insecticides containing active carbosulfan continuously. The majority of respondents of chili farmers (93.3%) did not always use insecticides containing carbosulfan active ingredient to prevent the pests from getting immunity/resistance to certain active ingredients. Thus, most farmer apply pesticide rotation in every planting season. A small proportion of farmer respondents (6.7%) did not always use insecticides with carbosulfan active ingredient because of the high price of carbosulfan insecticides. Farmer will buy cheaper insecticides when they do not have enough cash. In the situation when carbosulfan insecticides were unavailable, all farmer respondents chose to replace the carbosulfan insecticide with other active ingredients-insecticides such as synthetic pyrethroids (brand Starban), abamectin (brand Abacel), and chloranthraniliprol (brand Prevathon). The reason for choosing this alternative substitutes was the efficacy and effectiveness of these active ingredients in controlling chili pests.

Most farmers (68%) perceived that the use of carbosulfan did not necessarily reduce their working time. The high proportion of farmers who perceived that the use of carbosulfan did not save labour time was because they compared it with the alternative use of other chemical insecticides as a substitute for carbosulfan. Other farmer respondents (32%) argued that the use of carbosulfan could save the working time of chili

Table 1. Chili farmers' reasons for using carbosulfan insecticides

No	Farmers' Reasons	Number of Farmer	%
1	Effective in controlling pests	59	98
2	Cheaper than other active ingredients	48	80
3	Always available/easy to obtain	56	93
4	Easy to apply	56	93
5	Very fast in controlling pest	50	83
6	Suitable for use in various seasons	56	93
7	Safe for plants and humans	25	42
8	Environment friendly	29	48
9	Save labour cost	31	52
10	Reduce the need for water for the mixer	4	7

farmers. The use of carbosulfan helps farmers in eradicating pests compared to if farmers have to use other pest control methods such as organic pesticides which must be formulated by the farmers themselves. Based on the survey, 83% farmers stated that carbosulfan pesticide was easy to apply in the field and very fast in controlling pest. This saved working time was then used by farmers to carry out other activities, both in farming activities (becoming farmworker, rice cultivation), non-farming (becoming labour/handyman) and farmers' social activities (rest). By utilizing this saved time for productive activities, farmers can earn additional income.

3.2 Chili Farm Income Analysis

Chili is one of the leading national vegetable commodities and has a fairly high economic value. Compared to food crop farming, chili farming requires higher capital and greater production risk due to their susceptibility to pests and diseases. The varieties cultivated at the research location were quite diverse. Varieties widely cultivated at the research location in Garut were Pilar F1, JS Jayadi, Arimbi and local varieties. Meanwhile, at the research location in Indramayu, most farmers cultivated local varieties from their own nursery.

The average productivity of chili at the research location in one planting season was 11.7 tons/ha with an average selling price of Rp 10 950 per kg. In one hectare planting area, the average income of farmers was Rp. 128,473,831 and the average farming cost incurred was Rp. 73,454,857. Therefore, the average income per was Rp. 55,018,974 per ha. In addition, the comparison between revenue and cost (R/C) was obtained as 1.75, indicating that for every Rp 1 cost spent, the chili farmers will receive a revenue of

Table 2. Cost difference of carbosulfan insecticide and its substitutes

Alternatives	Cost for 1 ha (Rp)
Cost of insecticides with carbosulfan	3,047,484
Cost of insecticides substituting carbosulfan	4,057,302
Cost difference	1,009,818

Rp 1.75. Thus, chili 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. However, this value is relatively low compared to other studies with R/C values greater than 2 [13, 14].

The biggest cost that farmers had to prepare for was labour cost (62%). Among these components of labour cost, the largest costs were spent for harvesting, spraying pesticide and land cultivation stages. Meanwhile, the contribution of fertilizers, pesticides and seed to production cost were 18%, 18% and 2%, respectively. Of the total cost of pesticides, 41% was used to buy fungicides, 24% was used to buy carbosulfan insecticides, 27% was used to purchase other insecticides and 8% was for the purchase of herbicides.

Although the percentage of the pesticides cost was relatively small compared to the cost of other factors of production, the role of pesticides is very important in controlling pests and diseases that can damage crops and lead to failure of chili farming. When farmers do not use carbosulfan insecticide, farmers will substitute it with other insecticides containing active ingredient to kill insects that attack the crops. If carbosulfan is no longer available in the market, then farmers will replace carbosulfan with other insecticides sucha as Prevathon, Abacel, etc.

If the use of carbosulfan active ingredient insecticides is replaced with other active insecticides, the total insecticide cost expended will also change. Table 2 states the additional insecticide cost that must be incurred by farmers if they no longer use carbosulfan insecticides. The cost of substitute insecticides was 33.14% more expensive than carbosulfan insecticide and causes an additional cost of Rp. 1,009,818 for 1 ha in one planting season. This increase in costs will certainly reduce the income received by farmers. Therefore, the use of carbosulfan active ingredient insecticides is known to be more profitable than its substitute insecticides. Table 3 shows that the use of carbosulfan is more beneficial to chili farmers. To maintain the same production and revenue, farmers have to spend more to buy other active ingredient pesticides as a substitute for carbosulfan. This increase in cost is at 1.37% and results in a slight change in the resulting R/C value from 1.75 to 1.73.

3.3 Production and Efficiency Analysis

The results of production function analysis of chili commodity showed that the determinant coefficient value (*R-squared*) is 0.7382. This can be interpreted that together all production factors namely carbosulfan insecticide (INS), herbicide (HER), labour

Table 3. Chili farming income with carbosulfan alternatives

No	Component	Carbosulfan Insecticide (Rp)	Substitute Insecticide (Rp)
1	Total revenue	128,473,831	128,473,831
2	Total costs	73,454,857	74,464,675
3	Income	55,018,974	54,009,156
4	R/C	1.75	1.73

Table 4. Production function estimation results of chili farming

Variable	Coefficient	Std. Error	t_{count}	P-*value*
Constant	2.324	0.976	2.380	0.027*
INS	0.240	0.130	1.840	0.000*
HER	0.024	0.011	2.180	0.038*
TK	0.713	0.216	3.290	0.003*
NPK	0.057	0.026	2.170	0.042*
ZA	-0.183	0.133	-1.380	0.182
ORC	0.002	0.021	0.100	0.919
UREA	0.204	0.155	1.320	0.201
SP36	0.121	0.195	0.620	0.543
Prob > F	0.000			
R-squared	0.7382			

* significant at 5% significance level

(TK), urea fertilizer (UREA), NPK fertilizer (NPK), ZA fertilizer (ZA), organic fertilizer (ORC) and SP 36-fertilizer (SP36) are able to explain the diversities of chili production (PRD) by 73.82%. The rest 26.18% were explained by other factors or variables the production factor studied.

F-test results showed that p-value Fcount at 0.000 is smaller than the 5% significance level (Table 4). The analyzed variables namely carbosulfan insecticide (INS), herbicide (HER), labour (TK), urea fertilizer (UREA), NPK fertilizer (NPK), ZA fertilizer (ZA), organic fertilizer (ORC) and SP 36-fertilizer (SP36) simultaneously have significant impact on chili production (PRD).

The results of t-test showed that the use of production factors of carbosulfan insecticide (INS), herbicide (HER), labour (TK) and NPK fertilizer (NPK) partially has a significance effect on chili production (PRD). This can be seen in the respective p-values of 0.000, 0.038, 0.003, and 0.042 which are smaller than the significance level of 5%. Meanwhile, the production factors ZA fertilizer (ZA), organic fertilizer (ORC), urea

Table 5. Production efficiency analysis of chili farming

No	Variables	VMP/Px
1	INS	0.175
2	HER	0.022
3	TK	1.014
4	ZA	-0.415
5	ORGANIK	0.021
6	NPK	0.275
7	UREA	0.447
8	SP36	0.248

fertilizer (UREA), and SP 36-fertilizer (SP36) do not significantly affect chili production (PRD) because the p-value of each factor is bigger than the 5% significance level.

The regression coefficient of the estimated production functions indicates the elasticity of production. In this study, the production elasticity (EPi) values of production variables carbosulfan insecticide (INS), herbicide (HER), labour (TK), and NPK fertilizer (NPK) respectively are 0.240, 0.024, 0.713 and 0.057. The EPi values are between the range zero to one ($0 < EPi < 1$), that is, in region II of the production curve in this condition, marginal products will decrease with the increased use of the production factors. This condition is included in the Decreasing Return to Scale condition. EPi values close to zero as in herbicide (HER) and NPK fertilizer (NPK) show a relatively high use of production factors, but close to optimal condition.

The value of production elasticity describes the percentage increase in product/output when the amount of input is increased by 1%. For example, when the use of carbosulfan insecticide (INS) is increased by 10%, then chili production will increase by 2.40%. Conversely, if the use of carbosulfan insecticide (INS) is reduced by is 10%, then chili production will decline by 2.40%.

If carbosulfan is not used at all by large chili farmers (the use of carbosulfan insecticide is reduced by 100% then this will cause chili production to drop by 24% If it is assumed that all chili farmers in Indonesia use carbosulfan in the production process, with a national large chili production of 229,600,000 kg per year (2019) and average farmer level price is Rp. 17.383 per kg, then the amount of loss/economic value lost from the decline of chili production is Rp. 957,872,832,000 per year.

Table 5 states the condition of the ratio of marginal product value to input price in the case of chili farming in the form of natural logarithms. This ratio is an indicator of whether the production efficiency of chili commodity has been achieved for each use of inputs 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 (VMP_{INS}/P_{INS}) is 0.175. This means $VMPx/Px < 1$ and the allocation of carbosulfan insecticide is not efficient. To achieve efficient allocation of input, carbosulfan insecticide use must be reduced by 23.5% current usage.

4 Conclusions

The revenue and cost ratio value for chili farming is greater than 1, this result indicate that the farming of chili is profitable. If carbosulfan will be banned in the future, farmers will change their pesticide to other insecticides with other active ingredients that may lead to rise in chili production cost.

Farmers' expenditure on the use of carbosulfan varies around 4.2%. The use of carbosulfan has positive and significant effect on the level of chili production. Other inputs such as herbicide, labour and NPK fertilizer also has a positive and significant impact on the production. The production elasticity of carbosulfan insecticides is positive and is between 0 and 1 (0.24), indicating that farmers are rational in the use of carbosulfan for pest control. Therefore, it is 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 chili production. From the economic perspective, carbosulfan can continue to be used due to its significant effect on the production of chili and other commodities in Indonesia.

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