

Technical efficiency of pesticide application on tomato, chinese cabbage and cauliflower in simpang empat sub-district Karo Regency

Sri Fajar Ayu^{1*} and Destanul Aulia²

¹Faculty of Agriculture, Universitas Sumatera Utara, Medan, Indonesia

²Public Health Faculty, Universitas Sumatera Utara, Medan, Indonesia

Abstract. Prior research by authors on the use of pesticides and their impact on 75 vegetable farmers in Simpang Empat subdistrict, Karo district, North Sumatra showed that 60% of respondents applied pesticides in excess of the packaging instructions. Respondents were also found not to use a complete protective device. Almost 70% of respondents have mild toxicity complaints, and based on blood cholinesterase levels are also found most respondents have mild toxicity. Pesticide residue test results also found 0.728 residues of chlorpyrifos and 0.321 profenofos in vegetables produced in this area. This led to continued review by checking the technical efficiency in the use of pesticides. The method used is a quantitative method with the Data Envelope Analysis (DEA) approach to analyze technical efficiency of pesticide on each commodity. The population is the whole vegetable farmer who grew tomatoes, Chinese cabbage and cauliflower at the time of the study. The entire population is used to be a sample of 35 tomato and cauliflower farmers and 20 Chinese cabbage farmers. The results of the study indicate that the uses of pesticide as production inputs on tomato commodities, Chinese cabbage and cauliflower are not technically efficient. It is suggested to farmers to use pesticide input according to the rules, proper dosage, on target, on time, the right way so that pesticide used is technically efficient.

1 Introduction

The current pattern of pesticide use by farmers is a problem. There are many farmers, who use pesticides are incompatible with the recommended dosage and procedure, resulting innegative impacts on the economy and the environment. According to Lakitan (1995), the pesticide application can cause disturbance to the stability and balance of ecosystem. Secondary pest explosion is one of a side effect of pesticide use. The diversity of species is also sometimes reduced as a negative impact of pesticide use. Applications of pesticides can contaminate the physical environment, including soil and water. In addition, the unwise use of pesticides also directly affects farmers' income. Where the current prices of pesticides are quite expensive, and this will certainly affect the cost of production of

* Correspondent Author : srifajar.ayu@gmail.com

farmers. The fact that the rising cost of production is not always offsetted by the increased income of farmers. And this leads to inefficiency in vegetable farming in Karo District.

One of the areas in Karo Regency which became the largest horticulture producer is Simpang Empat Sub-district. In 2016, Simpang Empat Sub-district produced 10,090 tons of cabbage flowers, 8,778 tons of petsai and 9,870 tons of tomatoes [1]. Efforts to increase horticulture production continue to be done in line with the increasing demand due to population growth. These efforts are intensification and extensification programs recommended by the government. On a farmer scale, increased technical production is more inclined towards superior seed selection, planting techniques and pesticides management techniques. Scientific studies have shown that the use of pesticides may increase farm production. Increased production will have an impact on the increase in income received by farmers in every harvesting activity [2, 3, 4, 5, 6].

Increased pest attacks or plant pest organisms become one of the reasons farmers adopt pesticide application techniques that are incompatible with established standards doses on pesticide packaging. The use of excessive doses results in the presence of pesticide residues attached to horticultural products, soil and water. All pesticide chemicals in general inhibit the important metabolic processes of an organism [7]. Therefore, pesticides are considered to be toxic compounds. This statement should be a concern, especially for vegetable consumers to do right action before consuming vegetables and fruits.

Pesticide residue test conducted on samples of tomato plants, Chinese cabbage and cauliflower obtained from the study area showed varying results. The test results can be seen in the following table:

Table 1. Results of Pesticide Residue Test Using Gas Chromatography

Plant Names	Weight	Pesticide	Working System	Active Materials	Large of Land	Spot/point	Residue Detected (mg/kg)	BMR* (mg/kg)
Cauli flower	2 Kg	Dursban	Direct Contact	Klorpirifos	125 m ²	6	Metidation (0)	0
Chinese cabbage	2,5 Kg	Antracol Dursban	Direct Contact	Propineb Klorpirifos	175 m ²	7	Klorpirifos (0,728)	1
Tomato	3,6 Kg	Dursban Curacron	Direct Contact	Klorpirifos Profenofos	175 m ²	10	Profenofos (0,321)	10

*Laboratory of BPTPH Sumatera Utara 2017

Testing of pesticide residues in chinese cabbage showed different results with the cauliflower. Chinese cabbage showed positive results of pesticide residues. The residue detected was Klorpirifos of 0.728 mg/kg, with the maximum limit of residual (BMR) of 1 mg/kg (as determined by the Agriculture Service of Sumatera Utara), it was seen that the detected residue had almost reached BMR. However, the chinese cabbage which become the sample of research still save to be consumed. The pesticide residue present in the vegetable can be reduced by giving the treatment of doused with clean running water and washed with detergent or vegetable soap. The next vegetable is tomato (*Solanum lycopersicum*) which also positively contains pesticide residues. The material detected through the test is Profenofos as much as 0.321 mg/kg, with the pesticide residue limits (BMR) of 10 mg/kg then the tomato being sampled in this study is still classified in the category of save for consumption.

In addition to residual issues, excessive use of pesticides would require higher costs, resulting in inefficient management of production inputs. Efforts to increase production can

also be done using technical efficiency calculations. Increased production through technical efficiency is now an important alternative, because it can add to the potential production that is available to vegetable farmers. This study was aimed to analyze the technical efficiency of pesticide use in tomato, Chinese cabbage and cauliflower.

2 Method

This study was conducted with quantitative methods, namely technical efficiency analysis of pesticide on tomato, Chinese cabbage and cauliflower. Data analyzed using the Data Envelopment Analysis (DEA) approach. Primary data will then be processed with the help of Microsoft Excel and DEAP. DEA method is a job evaluation tool that requires one or more kinds of inputs and produces one or more output types. In a simple way, the measurement is expressed by the ratio of output to the input which is the unit of measurement of efficiency or productivity, which can be expressed partially (Cooper *et al.*, 2006). The DEA approach uses fixed weighting across all inputs and outputs of each evaluated DMU. The DEA Variable Return to Scale model approach is more appropriate to be used in this study because the farming of tomatoes, Chinese cabbage and cauliflower at the research sites barely reaches the optimal scale. The assumption of this model is that the ratio between input and output additions is different (variable return to scale). That is, the change in input and output of a DMU takes place in a linear manner, allowing increased (increasing returns to scale) and decreasing (decreasing returns to scale) value of pesticide input efficiency in each commodity. The population is the whole vegetable farmer who grew tomatoes, Chinese cabbage and cauliflower at the time of the study. The entire population is used to be a sample of 35 tomato and cauliflower farmers and 20 Chinese cabbage farmers.

3 Result and Discussion

Technical efficiency is a combination of capacity and ability of an economic unit to produce up to the maximum output level of input quantities and technologies. The results of calculations on the technical efficiency of pesticide input use in tomatoes are as follows:

Table2. Technically Efficient of Tomato

No.	CRS	VRS	RTS
1	0,001	0,001	Drs
2	0,000	0,001	Drs
3	0,000	1,000	Drs
4	0,001	0,002	Drs
5	0,001	0,001	Irs
6	0,000	0,001	Irs
7	0,000	0,001	Irs
8	0,000	0,001	Drs
9	1,000	0,001	Drs
10	0,000	1,000	-
11	0,000	0,001	Irs
12	0,000	0,002	Drs
13	0,000	0,001	Drs
14	0,000	0,000	Drs
15	0,000	0,001	Drs
16	0,000	0,000	Drs
17	0,000	0,000	Drs

No.	CRS	VRS	RTS
18	0,000	0,001	Drs
19	0,000	0,001	-
20	0,000	0,001	Drs
21	0,000	0,001	Drs
22	0,000	0,001	Drs
23	0,000	0,001	Drs
24	0,000	0,001	Drs
25	0,000	0,001	-
26	0,000	0,000	Drs
27	0,000	0,001	Drs
28	0,000	0,001	Drs
29	0,000	0,001	Drs
30	0,000	0,001	-
31	0,000	0,001	Drs
32	0,000	0,001	Drs
33	0,000	0,001	Drs
34	0,000	0,001	Drs
35	0,000	0,001	Drs
Mean	0,029	0,058	

Table 2 shows that the efficiency of pesticide use in tomatoes with Constant Return to Scale (CRS) assumption is 0,029. The technical efficiency value shows that the average sample can reach 0,29%. The average efficiency of pesticide the assumption of CRS is $0.029 \leq 1$ which means that the use of pesticide input in tomato plants is not efficient from a technical point of view. The analysis showed that 34 farmers (97, 14%) were technically inefficient in return for Scale (CRS) and only 1 farmer (2.86%) were technically efficient in the use of pesticide in tomatoes. From the results obtained only DMU 9 has an efficient value of 1,000. While using the assumption of Variable Return to Scale (VRS) obtained the average value of technical efficiency of 0.058, technical efficiency value indicates that the average sample can reach 0.58%. The average efficiency of pesticide use using VRS assumption is $0.058 \leq 1$ which means that the use of pesticide input in tomato plants is not efficient from technical point of view. Calculation of analysis with Variable Return to Scale (VRS) resulted in 33 inefficient farmers (94.28%) and only 2 farmers (5.72%) technically efficient in the use of pesticides in tomatoes. So, it can be concluded for tomatoes, only one farmer (2, 86%) found technically efficient by CRS and two farmers (5, 72%) efficient by VRS. This implies that a large number of respondents face serious problems in terms of technical efficiency.

Table 3. Technically Efficient of Chinese Cabbage

No	CRS	VRS	RTS
1	1,000	1,000	-
2	0,735	1,000	Irs
3	0,478	0,482	Drs
4	0,359	0,445	Irs
5	0,381	1,000	Irs
6	0,184	0,667	Irs
7	0,570	0,597	Drs
8	0,560	0,676	Irs
9	0,959	0,969	Drs
10	0,804	1,000	Irs

No	CRS	VRS	RTS
11	0,523	0,537	Drs
12	0,161	0,556	Drs
13	0,459	0,800	Drs
14	0,708	0,720	Drs
15	0,666	1,000	Drs
16	0,654	0,804	Irs
17	0,611	0,619	Drs
18	0,924	1,000	Drs
19	0,851	0,869	Drs
20	0,116	0,381	Drs
Mean	0,585	0,756	

Table 3 shows that at the average efficiency of pesticide used in Chinese cabbage using the assumption of Constant Return to Scale (CRS) is 0,585. The technical efficiency value indicates that the average of sample can reach 0, 585%. The average efficiency of pesticide use using the assumption of CRS is $0,585 \leq 1$ which means that the use of pesticide input is inefficient from technical point of view. The analysis showed Constant Return to Scale (CRS) as much as 19 farmers (95%) are technically inefficient and only 1 farmer (5%) is technically efficient. While using the assumption of Variable Return to Scale (VRS), the mean value of efficiency of 0.756 indicates that the average sample can reach 7.56%. The average efficiency of pesticide use VRS assumption is $0.756 \leq 1$, which means that the use of pesticide input on mustard is inefficient from technical point of view. Calculation of analysis with Variable Return to Scale (70%) found 6 farmers (30%) were technically efficient in the use of pesticides, which is the farmer or DMU samples 1,2,5,10,15 and 18 with value of 1,000. So, it can be concluded that only 1 farmer (5%) efficient by CRS and 6 farmers (30%) efficient in VRS. This implies that a large number of respondent's farmers face serious problems in terms of technical efficiency. The technical efficiency value of pesticide use on the cauliflower is presented in Table 4.

Table 4. Technically Efficient of Cauliflower

No	CRS	VRS	RTS
1	0,002	0,173	Drs
2	0,001	0,007	Drs
3	0,047	0,083	Irs
4	0,020	0,294	Drs
5	0,001	0,005	Drs
6	0,251	0,444	Irs
7	0,014	0,048	Irs
8	0,576	1,000	Irs
9	0,041	0,071	Irs
10	0,795	0,924	Irs
11	1,000	1,000	-
12	0,002	0,002	-
13	0,002	0,392	Drs
14	0,002	0,002	-
15	0,182	1,000	Drs
16	0,061	0,079	Irs
17	0,662	0,770	Irs
18	0,041	0,071	Irs
19	0,041	0,143	Irs
20	0,003	0,983	Drs
21	0,041	0,143	Irs

No	CRS	VRS	RTS
22	0,003	0,281	Drs
23	0,002	0,002	-
24	0,003	0,923	Drs
25	0,003	1,000	Drs
26	0,002	0,048	Drs
27	0,002	0,470	Drs
28	0,025	0,043	Irs
29	0,029	1,000	Drs
30	0,190	0,667	Irs
31	0,002	0,456	Drs
32	0,003	0,005	Drs
33	0,002	0,223	Drs
34	0,002	0,493	Drs
35	0,003	0,006	Drs
Mean	0,115	0,377	

Table 4 shows that the efficiency of pesticide usage using the assumption of Constant Return to Scale (CRS) is 0.115. The technical efficiency value shows that the average sample can reach 11.5% and the value ≤ 1 , which means that the use of pesticide input is inefficient from technical point of view. The analysis shows that 34 farmers (97.15%) are technically inefficient in return for Scale (CRS) and only 1 farmer (2.85%) is technically efficient in the use of pesticides in cauliflower. While using the assumption of Variable Return to Scale (VRS) obtained the average value of technical efficiency of 0.377 that the average sample can reach 3.77%. The average efficiency of pesticide use using VRS assumption is $0.377 \leq 1$, which means that the use of pesticide input on the flower crop is not efficient from a technical point of view. The calculation of analysis with Variable Return to Scale (VRS) resulted in 30 farmers (85.27%) found inefficient and only 5 farmers (14.28%) were technically efficient. From the results obtained samples (flower farmers) that are efficient use of pesticides technically are respondent or DMU 8,11,15,25 and 29 with value of 1,000. So, it can be concluded that only one farmer (2, 85%) efficient by CRS and five farmers (14, 28%) efficient by VRS. This implies that a large number of respondent farmers face serious problems in terms of technical efficiency.

4 Conclusion and Recommendation

The uses of pesticide inputs by farmers on tomato, Chinese cabbage and cauliflower are not technically efficient. With the assumption of Constant Return to Scale (CRS) is only one farmer found technically efficient use of pesticide while with the Variable Return to Scale (VRS) assumption, there are two farmers in the use of pesticides on tomatoes, six farmers on Chinese cabbage and five farmers in cauliflower. It is advised for farmers to use pesticides in accordance with the instructions given, appropriate doses, on target and on time.

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