Farmer’s behavior in using pesticides on shallots cultivation in Solok Highlands, West Sumatera

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Abstract. Pesticides are one of the main production factors needed in shallots cultivation. The appropriate use of pesticides can increase productivity, but inappropriate use of pesticides can harm farmers, contaminate crops and polluting the surrounding environment. This study aimed to describe the use of pesticides on shallot cultivation in Solok Regency, West Sumatra. Data was collected by interviewing 95 respondents of shallot farmers. Data parameters were obtained regarding pesticide technical application, pesticide application time, brand and amounts of pesticides used, and knowledge of the active ingredients used. Data was processed quantitatively descriptively, and it showed that most of the farmers mix two or more chemical pesticides for each application, and generally, farmers did not know the names and functions of the active ingredients in the pesticides, but they did not mix pesticides with the same active ingredients. In the dry season, most farmers spray every three days, while in the rainy season it increases to once every two days. This study is expected to be a reference for policymakers to be able to provide an extension program to use appropriate and correct pesticides according to the function and content of active ingredients to create a balanced agroecosystem. The government needs to conduct technical guidance on integrated pest and disease control, and disseminate environmentally friendly pest control technology.

Keywords: behavior, pesticides, shallots

1. Introduction
Shallots become an essential commodity in the Indonesian national economy because it has a role as a contributor to inflation [1]. Inflation that occurs is because the production of shallots in the production centre fluctuates, so it affects the price. Therefore, the government developed shallot areas in various locations in Indonesia, one of which is in Solok, West Sumatra. The shallot development program that has been carried out was expected to reduce domestic production and price problems.

In shallot cultivation, pesticides are the third-largest production cost and reach 9.73% of the total farming costs [2]. But instead, the research results by Nurjati et al. (2018) [3] stated that the amount of pesticide did not significantly affect the production of shallots. It showed that applying pesticides to shallot farming is inefficient because it costs a lot of money but does not affect output, because of the use of pesticides as a preventive measure against pests and diseases by spraying with frequent and higher doses. The higher farmer’s perception of risk will be followed by the higher use of chemical pesticides.

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If the pest outbreak considered will cause crop failure, farmers will increase the number of pesticides, or will even replace them with more expensive ones. For shallot farmers pest attacks are disastrous as a cause of yield loss, and can be effectively treated with pesticides [4,5].

The increasingly intensive use of pesticides can pose a risk of increasing the content of pesticide residues. Pest and disease resistance can also support an increase in the use of pesticides due to the behaviour of farmers who suspect that their farming will fail. Before all this happens, socialisation and application of control must be carried out early on, namely the provision of new pesticides when pest and disease attacks have reached the economic threshold. It because the Indonesian farmers often assume that the more pesticides used the higher the production of agricultural products [6].

The negative impacts of pesticide residues can pose health risks for farmers who apply [7,8]) and their families, and can also cause negative impacts on the environment and surrounding ecosystems [9], where it is commonly happen in developing countries. Farmers do not realise that the pesticides they use can enter their bodies through dermal, inhalation, and digestion processes, this can occur during removal, mixing, spraying, washing and storing pesticides. At the time of mixing, pesticides can be inhaled and affect the body of the farmer. Spraying process is the most prolonged exposure process. It also depends on the area of land owned. The more land owned, the longer the spray time so, the longer the process of exposure. Pesticide exposure in farmers will be higher because farmers do not use personal protective equipment and pay less attention to wind direction [10]. Previous research at the vegetable production centre in Solok Regency stated that more than half of the vegetable sprayers experienced neurotoxic symptoms due to exposure to pesticides [8]. Factors causing the high level of exposure to pesticides to farmers in the area are due to lack of knowledge about the dangers of pesticides and the safe use of pesticides, affecting the behavior of farmers such as not using personal protective equipment when spraying, spraying is not in the direction of the wind and does not maintain personal hygiene of farmers [11].

This study aims to provide an overview of the performance of the use of pesticides by shallots farmers in the highlands of Solok Regency which is a production center for new shallot development in Indonesia, where this production center is also the largest shallot production center in West Sumatra [12]. The results of this research can be the basis for controlling the use of pesticides to produce shallots with low and sustainable pesticide residues.

2. Materials and methods
This research was conducted in August 2017 at shallot production centre in highlands of Solok district, precisely in two sub-districts, namely Danau Kembar and Lembah Gumanti. The location was selected purposively, which was a new development production area outside the main production center in Solok district, West Sumatera.

Primary data was taken through an interview using a purposive sampling method to 95 shallot farmers. The interview was conducted using a questionnaire regarding; technical use of pesticides, the brand of pesticides used, and knowledge of the active ingredients contained in pesticides. The types of pesticides asked were insecticides, fungicides and herbicides. Primary data obtained will be processed descriptively in tabular form to find out the percentage of respondents who answered each question asked. To find out the number and percentage of farmers who use pesticides with the same active ingredients in shallot farming, matching between the brands used and the active ingredients of pesticides was based on the 2016 Agriculture and Forestry Pesticides book (Ministry of Agriculture 2016b) [13].

3. Results and Discussion
3.1. How to use pesticides in shallot farming in Solok Regency
To give an overview about pesticides using by shallot farmers in the Solok, several questions such as how to apply pesticides, when to apply pesticides, the time interval for spraying in the rainy season and the dry season were asked. Information from Table 1 revealed that the majority of farmers as much as 49.47% mixed two or more pesticides in one spraying tank. As many as 46.32% of farmers even mixed
insecticides, fungicides and herbicides in one container. This is in accordance with the research result of Supriadi (2013) [14], which states that mixing pesticides was commonly done by farmers even though farmers do not know whether mixing pesticides was effective or not.

Mixing pesticides is actually not a prohibited thing. Mixing pesticides if done appropriately will increase the effectiveness of pest management and increase farming profits if the combination of pesticides used was not only an effective combination in handling, it was also the cheapest price combination (Moekasan and Murtiningsih 2010 [15]; Supriadi 2013 [14]). Conversely, if mixing pesticides was done between two or more pesticides that are not right it will have a negative impact because it will reduce the effectiveness and even cause poisoning to plants (Supriadi 2013) [14].

Majority of farmers (80%) sprayed pesticides in the morning. The remaining 13.68% sprayed did not determine whether it had to be morning or evening. Budi (2009) [16] states that to ensure success, spraying of pesticides should be done when the wind is not blowing hard, the sun is not shining hot, not foggy, and when the humidity is not too high or too low. Spraying needs to be done in the direction of the wind so that farmers are not exposed to pesticides (Marisa and Arrasyid 2017) [11]. Spraying in the morning and evening is the right time, especially when the sun is not too bright shining. But keep in mind other environmental parameters such as wind speed and direction and humidity.

Table 1. How to use pesticides by shallot farmers in the highlands of Solok District in 2017.

| Parameters                                      | Number of Farmers | Percentage (%) |
|-------------------------------------------------|-------------------|----------------|
| **Pesticide Application**                       |                   |                |
| In each specific case                           | 4                 | 4.21           |
| Mix two or more pesticides in one tank          | 47                | 49.47          |
| Mixing insecticide, fungicide, herbicide in one tank | 44                | 46.32          |
|                                                | 95                | 100            |
| **Time application of pesticides**              |                   |                |
| In the morning                                  | 76                | 80.00          |
| In the afternoon                                | 13                | 13.68          |
| Anytime                                         | 6                 | 6.32           |
|                                                | 95                | 100            |

3.2. The frequency of spraying pesticides during the rainy and dry seasons

From the 95 shallot farmers interviewed, 85 farmers planted shallots in the dry season and 92 planted in the rainy season. The number of farmers who plant both in the rainy and dry seasons was 82 people. In the dry season, the majority of farmers (55.29%) spray pesticides every three days. While in the rainy season 44.57% of farmers spray every two days. Even the spraying of pesticides on shallot farming in the rainy season was generally done twice a day and will continue until the time of harvest [11,17].

From the result of t-test on farmers who plant both the rainy and dry seasons (table 3), there was a difference in the behaviour of the spraying interval between the rainy season and the dry season. It was indicated by the P-value difference between the spraying time interval between the rainy season and the dry season, which was smaller than 0.05. It indicated that the spraying behaviour of farmers was based on the season.
Table 2. Interval of spraying pesticides in the rainy and dry seasons on shallot farming in the highlands of Solok District in 2017.

| Interval | Dry Season | Rainy Season |
|----------|------------|--------------|
|          | Number of Farmers | Percentage (%) | Number of Farmers | Percentage (%) |
| 1 day    | 2           | 2.35         | 5               | 5.43          |
| 2 days   | 24          | 28.24        | 41              | 44.57         |
| 3 days   | 47          | 55.29        | 33              | 35.87         |
| 4 days   | 6           | 7.06         | 2               | 2.17          |
| 5 days   | 2           | 2.35         | 2               | 2.17          |
| 6 days   | 1           | 1.18         | 0               | 0             |
| 7 days   | 1           | 1.18         | 1               | 1.09          |
| No answer| 2           | 2.35         | 8               | 8.7           |
|          | 85          | 100          | 92              | 100           |

Table 3. The difference in the time interval between spraying pesticides in the dry and rainy season on shallot farming in the highlands of Solok District in 2017.

| Parameter | Average | P-value |
|-----------|---------|---------|
| Rainy season | 2.79 | 0.0000 |
| Dry season   | 2.30 |         |

3.3. Use of pesticide brands on shallot farming in Solok Regency

Based on the 2016 agriculture and forestry pesticide book (Ministry of Agriculture 2016b) [13] there were 3,207 registered pesticide brands in Indonesia, which registered by 343 national pesticide companies. These various pesticides were not only used for shallot plants but are also used for plants and other purposes in the agriculture and forestry sectors.

According to the results of interviews conducted with respondents, known as many as 30 brands of insecticides, 27 brands of fungicides, and nine brands of herbicides used on shallot farming. It was possible that there were still several other brands of pesticides that have not been identified in this study. The variety of pesticide brands available in agricultural shops provide an advantage for farmers to be able to choose pesticides which in accordance with their buying ability and needs [18]. The results of Basuki’s research (2009) [19] stated that the diversity of pesticide use was due to the limited knowledge of farmers in recognizing pesticides that were suitable for pest control.

The insecticide brand that had the largest market share because it was most widely used in shallot farming was Ludo (table 4). As many as 19.32% of respondents use Ludo brand insecticide. This insecticide can be used to control Spodoptera exigua (armyworm), and can be used as an insecticide on other plants such as chili, tomatoes, and cabbage [13]. The other most commonly used insecticides were the Abacel and Prevathon. Whereas other insecticides less than 10% of farmers use them. Just like Ludo, Abacel and Prevathon can also be used to control the Spodoptera exigua. The active ingredients contained in the Ludo, Abacel, and Prevathon insecticides are chlorphenapir, abamectin, chlorantraniliprole.

The three most common brands of fungicides used in shallot farming were Dithane, Folicur and Daconil. This makes the Dithane a market leader because it was the brand with the largest market share in shallot farming in Solok Regency. In herbicide type pesticides, there were nine brands known by
respondents. The three most widely used herbicide brands are Gramoxone, Zeram, and Seetop, while other herbicide brands are used by less than 10% of respondent.

| Table 4. Use of pesticide brands on shallot farms in the highlands of Solok District in 2017. |
|-----------------------------------------------|
| **Brands** | **Number of packs** | **Percentage** | **Brands** | **Number of packs** | **Percentage** | **Brands** | **Number of packs** | **Percentage** |
| Ludo | 57 | 19.32 | Dithane | 39 | 16.88 | Gramoxone | 53 | 46.90 |
| Abacel | 41 | 13.90 | Folicur | 32 | 13.85 | Zeram | 19 | 16.81 |
| Prevathon | 38 | 12.88 | Daconil | 26 | 11.26 | Seetop | 17 | 15.04 |
| Joker | 22 | 7.46 | Manzate | 22 | 9.52 | Goal | 11 | 9.73 |
| Sagribeat | 20 | 6.78 | Antracol | 22 | 9.52 | Basmilang | 7 | 6.19 |
| Rajatrin | 20 | 6.78 | Antrakol | 22 | 9.52 | Roundup | 3 | 2.65 |
| Endure | 16 | 5.42 | Cozeb | 11 | 4.76 | Metafuron | 1 | 0.88 |
| Demolish | 16 | 5.42 | Score | 11 | 4.76 | Golma | 1 | 0.88 |
| Winder | 12 | 4.07 | Ziflo | 7 | 3.03 | Bimarlon | 1 | 0.88 |
| RIP | 12 | 4.07 | Rovral | 8 | 3.46 | | | |
| Lainnya | 41 | 13.90 | Lainnya | 31 | 13.42 | | | |
| **Total** | **295** | **100** | **231** | **100** | **113** | **100** |

The number of uses of the pesticides brand on shallot farming in the Solok highlands varies considerably (table 5). Of the 95 respondents interviewed, the majority was 34.74% using three brands of insecticides in shallot farming. Only 13.68% of the respondents used more than four insecticides, both mixed and single, in one season of shallot farming. This result was lower than the use of insecticides in pest control in the production centres of Brebes and Cirebon districts where farmers mix the most up to six kinds of insecticides in one application [19]. The majority of respondents (45.26%) used two brands of fungicides and a maximum of only three brands of fungicides on shallot farming. Whereas for the use of herbicides, the majority of respondent farmers only used one brand of herbicide in shallot farming.

| Table 5. Many types of synthetic pesticides used by each farmer on shallot farming in the highlands of Solok District in 2017. |
|-----------------------------------------------|
| **Pesticides Used** | **Insecticide** | **Number of Farmers** | **Percentage** | **Fungicide** | **Number of Farmers** | **Percentage** | **Herbicide** | **Number of Farmers** | **Percentage** |
| Unused | 6 | 6.32 | 0 | 0.00 | 1 | 1.05 |
| 1 brand | 1 | 1.05 | 16 | 16.84 | 73 | 76.84 |
| 2 brands | 19 | 20.00 | 43 | 45.26 | 21 | 22.11 |
| 3 brands | 33 | 34.74 | 36 | 37.89 | 0 | 0.00 |
| 4 brands | 23 | 24.21 | 0 | 0.00 | 0 | 0.00 |
| > 4 brands | 13 | 13.68 | 0 | 0.00 | 0 | 0.00 |
| **Total** | **95** | **100** | **95** | **100** | **95** | **100** |

3.4. Use of active ingredients of pesticides

Of the many respondents who used more than one brand of pesticides both in insecticides, fungicides, and herbicides, not all of them knew the active ingredients (table 6). As many as 81% of farmers did not know at all the active ingredients contained in the insecticides used, 92.63% of farmers did not know at all the active ingredients contained in the fungicides used, and 100% of the farmers did not know the active ingredients used in the herbicide used. However, only 10.53% of the total respondents knew the active ingredients of some of the pesticides used.
Table 6. Number and percentage of farmers who knew the active ingredients of pesticides used in shallot farming in Solok Regency.

| Parameters       | Insecticide | Fungicide | Herbicide |
|------------------|-------------|-----------|-----------|
|                  | Number of Farmers | Percentage (%) | Number of Farmers | Percentage (%) | Number of Farmers | Percentage (%) |
| Not knowing at all | 81          | 85.26     | 88        | 92.63       | 95          | 100.00       |
| Knowing partially | 10          | 10.53     | 4         | 4.21        | 0           | 0.00         |
| Knowing entirely  | 4           | 4.21      | 3         | 3.16        | 0           | 0.00         |
|                  | 95          | 100       | 95        | 100         | 95          | 100          |

Table 7 showed that 75.79% of the respondents used the brand of insecticides with different active ingredients. Whereas 17.89% of farmer respondents used two or more brands of insecticides with the same active ingredients, whether they were applied individually or mixed at each application. Likewise in the use of fungicides where 14.74% of respondents used two or more brands of fungicides with the same active ingredients. Whereas in the use of herbicides, none of the farmers branded herbicides with the same active ingredients.

Table 7. Number and percentage of farmers using pesticides with the same active ingredients in shallot farming in Solok Regency.

| Parameters       | Insecticide | Fungicide | Herbicide |
|------------------|-------------|-----------|-----------|
|                  | Number of Farmers | Percentage (%) | Number of Farmers | Percentage (%) | Number of Farmers | Percentage (%) |
| Unused           | 6           | 6.32      | 0         | 0.00        | 1           | 1.05         |
| Use pesticides   | 72          | 75.79     | 81        | 85.26       | 94          | 98.95        |
| with different   |             |           |           |             |             |              |
| active ingredients|             |           |           |             |             |              |
| Use two or more  | 17          | 17.89     | 14        | 14.74       | 0           | 0.00         |
| pesticides with  |             |           |           |             |             |              |
| the same active ingredients |       |         |         |             |             |              |
|                  | 95          | 100       | 95        | 100         | 95          | 100          |

Farmers’ ignorance of active ingredients causes farmers not to choose pesticide brands based on their active ingredients. The use of the same active ingredients will cause several problems, especially in terms of cost efficiency. The use of two or more pesticides with the same active ingredient in one application will increase the dose of the use of the active ingredient in spraying, so there will be a waste especially in terms of cost, and there may also be an increase in the dose of use which will have an impact on resistance and influence negative for the environment. However, if the use of two or more pesticides with the same active ingredient is done not in one spray, the risk of loss will arise if the price of the pesticide brand is different from one another. Cost efficiency can be achieved if only using one brand of pesticides at a cheaper price.

As a new development shallot production center in Indonesia, it needs to be maintained so that the sustainability of the shallot farming carried out can still benefit farmers but also maintain the environment in optimal conditions both for plants and for people who live in the environment. Some alternatives to support sustainability can be done so that farmers do not depend entirely on the use of pesticides which in the long run can have a negative impact.

Some alternatives besides the use of pesticides can be used to support the sustainability of shallot farming in the highlands of Solok District, such as the use of sex pheromones [20] and light traps [21].
in controlling *Spodoptera exigua*, they can minimize the use of insecticides. The use of biological agents [22] and plant-based fungicides [23] can reduce the use of synthetic fungicides. On the other hand the use of vegetable pesticides and biological agents can be used together with synthetic pesticides by first choosing which ones are not in opposition to each other [14].

4. Conclusions and Recommendations
The performance of the use of pesticides on shallot farming in the highlands of Solok district varies by farmer based on the brand and active ingredients contained in each brand used. Mixing two or more brands of pesticides is a common practice even though the majority of farmers do not know and fully understand the active ingredients contained in the brand of pesticides used. It is a coincidence that the majority of farmers use several brands of pesticides with different active ingredients.

The government needs to conduct technical guidance on integrated pest and disease control, and disseminate environmentally friendly pest control technology.

The weakness of this research is that it only identifies the number of pesticides used by farmers of each brand, does not identify the mixture of brands of pesticides used in each application, and does not identify changes in pesticide use in one growing season. Suggestions for further research is to examine the mixture of pesticides used in each spray application so that the effectiveness of the mixing can be known.

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