Impact of pesticide application in high frequency on stomatal number at local shallot in Palu Valley

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Abstract. Small farmers typically produce shallot with a high frequency of pesticide application and its habit poses several ecological and environmental consequences. In this research, we evaluated the effect of pesticide application in different frequency (high, moderate and low) on shallot stomatal number and opening in Palu Valley, Central Sulawesi. By comparing in the low application, the moderate frequency with less than ten applications increased stomatal number about 1.9% and high rate with more than ten applications per two months of shallot plantation period augmented about 18.7%. While the length of stomatal opening increased about 18.2% with moderate and decreased about 32.6% with the high rate of application. Then, the width of the stomatal opening decreased about 0.6% and 17.5%, respectively. This data indicated that the application of pesticide, especially in high frequency increase stomatal number and decrease stomatal opening area with potential for inhibiting shallot growth.

1. Introduction

Palu local shallot is one of the important commercial vegetable crops and commonly widely developed in Central Sulawesi Province, especially in the Palu Valley. The morphology of Palu local shallot commonly similar to the type of shallot. They are forming tubers with a rather pink and white color but they are small size, compared to other varieties. Palu local shallot was grouped in Allium cepa L. var aggregatum and used generally as a raw material for fried shallot. The average yields are still low and accompanied by high demand. This condition forced farmers to continue planting shallot in the orchards [1-3]. Low yields production of these commodities is partly due to the application of unfavorable cultivation techniques and the presence of plant pests and diseases.

Rampant pest and disease infestation in shallot orchards [4] allows the farmers to apply a high frequency of pesticides. Pesticides are still considered by shallot farmers in the Palu Valley as a savior their production from pests and diseases [5, 6]. Increasing the total concentration was used can reach 150-200% higher than the recommended level by mixing two or three types of pesticides at once time application [7, 8]. The excessive use of pesticides results in several ecological consequences on the environment such as resistance pests and diseases, the potential decrease in soil quality and negative impacts on plants, as well as high chemical residues in the tubers of shallot [7-10]. However, other impacts on shallot is yet to be studied about the response of stomatal leaf in the use of pesticides.
According to Rohmah et al. [11] stomata is very important part for plants, where the number and size are influenced by meristematic activities. It is known that stomatal leaf is a natural hole responsible for evaporated process. Number and opening and closing of the stomata in leaf structure allow pathogen to penetrate the tissue, the more stomata, the easier infection [12,13]. The similar situation with contaminants that forming as toxic residues that are not limited to quantity and duration. They are important factor disturb the quality of the environmental system.

Based on the impact of pesticide use on plant of Palu local shallot, the aim of research was to evaluate the use of pesticides by farmers through surveys and determine the effect of the use of pesticides in high, moderate and low frequency on the number, length and width of stomatal of shallot plants in the Palu Valley, Central Sulawesi. Data obtained from this study will be useful for assessing the impact of excessive use of pesticides on the growth of Palu local shallots.

2. Material and methods

2.1. Site of research

The study was conducted in February to July 2018, located in the Palu Valley at Oloboju village, Sigi Biromaru district, Central Sulawesi. This is center cultivation of Palu local shallots in Central Sulawesi. After finished activities in the field, the study was continued at the Plant Disease Laboratory, Faculty of Agriculture, Tadulako University, Palu.

2.2. Survey and sampling of Palu local shallot

The survey in the form of an interview was conducted to determine the level of application of pesticides to farmers of Palu local shallots. According to the data from previous observations and interview with local agricultural instructors, there were about 300 families of shallots farmers in Olobuju village. Approximately ten percent or 30 farmers were taken as samples for interviews about them as owner of shallot areas, the frequency of pesticide use per season around 60 days and the type of pesticide they used.

The observation of plant stomatal was carried out on the farmer field of Palu local shallot. The stomatal samples were observed according to the frequency of application of pesticides at the farmer level. The selection of shallot leaves is carried out on different clumps of plants. Each clump of shallot plants was covered with a clear nail polish with one smear on apex, lateral and base leaf, left for 1-3 minutes, then taped on upward leaf using clear tape before applied with nail polish. The samples were then placed on the glass object. The observation under a microscope with a 400 magnification was undertaken in the laboratory Faculty of Agriculture, Tadulako University Palu.

3. Result and discussion

3.1. Pesticides used by farmers of Palu local shallot

The Oloboju village at Sigi district is the one of famous areas in Palu Valley that most of the residents are local shallot farmers. There are 300 farming families with an area around 286 ha. In the village, shallots are planted continuously, averaging four planting seasons per year. In controlling shallot pests and diseases, it shows that 46.7% of farmers used synthetic pesticides over ten times pesticide application per planting season, 43.3% of farmers applied pesticide with frequency from 5 to 10 times per season and only 10% farmers did not apply in different level (table 1). About 10% farmers used natural pesticides derived from neem to control pests, diseases and herbicides to control weeds.
Table 1. Frequency of pesticides application at the shallot farmer level

| Number of respondents | Frequency of application | Percentage | Level |
|-----------------------|--------------------------|------------|-------|
| 14                    | >10 times                | 46.7       | High  |
| 13                    | 5-10 times               | 43.3       | Moderate |
| 3                     | once (Herbicide)         | 10         | Low   |
| 30                    |                          | 100        |       |

The use of pesticides including fungicides and insecticides was showed in table 2. Commonly fungicides are classified as pesticides which do not cause acute danger in regular used or U. The insecticides used in general are classified as quite dangerous (II), and one of them is very dangerous (Ib). All pesticides were commonly used by farmers to control pests and diseases of the Palu local shallots.

Table 2. Pesticides active ingredients was used by farmers of Palu local shallot

| Type of pesticides | Active ingredients | Group  | Class |
|--------------------|--------------------|--------|-------|
| Fungicide          | Ziram              | Dithiocarbamate | III   |
| Fungicide          | Mancozeb           | Dithiocarbamate | U     |
| Fungicide          | Propineb           | Dithiocarbamate | U     |
| Fungicide          | Carbendazin        | Benzimidazole | U     |
| Fungicide          | Phosphorous acid   | Phosphonate | U     |
| Fungicide          | Thiophanate-methyl | Benzimidazole | U     |
| Fungicide          | Prochloraz         | Imidazole | III   |
| Fungicide          | Iprodione          | Dicarboximide | U     |
| Insecticide        | Chlorpirifos       | Organophosphate | II   |
| Insecticide        | Alpha-cypermethrin | Botanical | II    |
| Insecticide        | BPMC                | Carbamate | II    |
| Insecticide        | Methomyl           | Carbamate | Ib    |
| Insecticide        | Chlorantraniliprole | Antranilic dinamid | U   |
| Insecticide        | Emamectin Benzoat  | Avermectin | U     |
| Insecticide        | Chlorfenapyr       | Pyrrole | II    |
| Insecticide        | Carbosulfan        | Carbamate | II    |
| Herbicide          | Paraquat           | Piridin | II    |

Ia = Extremely hazardous; Ib = Highly hazardous; II = Moderately hazardous; III = slightly hazardous; U = Unlikely to present acute hazard in normal use; FM = Fumigant, not classified; O = Obsolete as pesticide, not classified.

The number of stomata rose once leaves were exposed with a high frequency of pesticide use, but stomatal length and width become smaller (figure 1 and figure 2). In contrast, if low and moderate frequencies (5 to 10 times) were applied number of stomata increased to about 1.9% and if a high-level frequency (over 10 times) number of stomata increased to about 18.7%. While the length of stomatal opening increased about 18.2% at moderate levels and decreased by 32.6% in high-level treatments. Then, the hole of stomatal width decreased about 0.6% and 17.5%, respectively. High application of pesticides by farmers cause the amount of stomatal to increase as a possible response to abiotic stress and pesticide residues. Marlitasari et al. [13] and Mutaqin et al. [15] stated that pollutants or residual poison attached to the stomata will accumulate. If they are in large amounts, plant stomatal cell can heavily damage. Stomatal cells are damaged and smaller will stimulating production of new more stomatal and the process of photosynthesis is proceeding normally. The ability of plant resistance is related to their ability to environmental barriers that depend on the plant genetic resistance mechanism. This condition caused presence of plant physical properties such as trichome, lenticel, stomatal and waxy layers entering the plant tissue associated with sensitivity to opening and
closing stomatal, the number of stomatal and stomatal structure [12-14] as well as contaminants that can be toxic residues that are not limited to both quantity and duration. They will be able to disrupt the quality of the environmental system.

3.2. Number, length and width of shallot stomatal plant

The results of the calculation the number of shallot stomatal in Oloboju in one growing season at various frequencies of pesticide application by farmers was showed different number, length and width of stomatal. The average number of stomatal is higher at the high frequency of pesticide application (figure 1).

![Figure 1. The average number of shallot stomata](image)

The figure 2 was showed the average of length and width of shallot stomatal in Oloboju. The use of pesticide applications by farmers, especially in high frequencies increases the amount of stomatal and reduce the areas of stomatal opening with the potential to inhibit the growth of shallots.

![Figure 2. The average of length and width of shallot stomatal](image)

Stomata functions during process of photosynthesis and transpiration in plants. Stomata exchanges CO₂ in the leaves for photosynthesis and place for evaporation of water in the process of transpiration. Therefore, the number of stomatal can increase the rate of transpiration and CO₂ absorption for photosynthesis. The available material of photosynthesis will positively influence plant growth. The presence of stomata is greatly influenced by the surrounding environment, plant stomata in the areas with greater levels of pollution will have a higher level of stomatal damage on the plant leaves [12]. Stomata can be one mechanism of plant genetic resistance. Damaging stomatal cells will stimulate to produce additional stomata and improve photosynthesis process [15-17].
4. Conclusion
The continuous application of pesticides with a high frequency of application to the Palu local shallot has an impact on the number, length and width of the stomatal. This is potentially inhibiting the growth of shallots. The use of pesticides with less than ten treatments can increase the number of stomatal about 1.9%. In the high level with more than ten applications per two months of the planting period of shallots increasing about 18.7%. While the length of the opening of the stomatal increasing about 18.2% in moderate level. There are decreasing about 32.6% in the high-level treatment of pesticides.

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