Comparison the effectiveness of the fumigant phosphine to control warehouse pest insects in soybean seed and bird feed commodities

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Abstract. The presence of insect pests of warehouses can affect the quality of commodities stored in warehouses. One of the chemicals used for pest control is phosphine. The purpose of this study was to analyze the influence of fumigation process with phosphine fumigant on soybean seeds and bird feed that can be seen from the death of pests in storage warehouses in Semarang, Central Java. Identification is carried out in animal taxonomy laboratory, State University of Semarang is carried out by calculating pest death in each type of commodity. after the data is collected, a one-way ANOVA is involved to analyze the data. Phosphine fumigants are very effective for killing warehouse pests insects especially Tribolium castaneum and Ephestia cautella in soybean seed and bird feed commodities. For future warehouse pest control it is recommended to use biopesticide to be safer for food safety.

1. Introduction

A commodity that comes from abroad is placed in the importer's warehouse before being traded. In the first article of the Trade Minister Regulation No. 48 of 2015, importer is an individual or institution or business entity, either in the form of a legal entity or not a legal entity, that carries out imports. This causes a commodity must be stored in a warehouse which can cause the commodity to be attacked by pests and reduce the quality of a commodity. One of the reasons for a commodity being exposed to pests is trading activity which is a commodity displacement from a warehouse to a warehouse [1].

The commodities contained in the importer's warehouse are soybean seeds and bird food. Pests that usually attack grains, namely Tribolium castaneum Herbst (Coleoptera: Tenebrionidae) and Ephestia cautella Herbst (Lepidoptera : Pyralidae). Metabolism in warehouse pests can increase food temperature and humidity so that fungi can grow and seed germination accurs [2].

In order to commodities free from pests, it is necessary to eradicate them by fumigation. Fumigation is a treatment action toward carrier media plant disruptor organism with fumigan in a gas-tight space at a certain temperature and pressure [3]. According to Tettey research, warehouse pests especially Ephestia cautella, can reduce commodity weight until 10.1% [4]. Initially, fumigation used methyl bromide fumigant, however, methyl bromide has been limited and replaced by phosphine over time. this is because phosphine is relatively affordable compared to methyl bromide, it is more effective at controlling pests and leaves no residue [5].

leave a taste for the commodity. Explosive when exposed to water with a temperature of 100 °C and flammable and has a flash point at a concentration above 1.8% by volume in air or 25 g / m³ at normal air pressure. Phosphine is also corrosive because phosphine reactive to materials made of copper or...
precious metals. Phosphine is already commercially used as the main fumigant in product storage [6] and fumigation in India only use fumigant phosphine [7]. Phosphine has a tablet shape and is grayish in color. Phosphin tablets when reacting with moisture in the air produce phosphine gas. Phosphine gas can penetrate the seed skin and kill pest development stadia that are inside the seed so that phosphine is effective in controlling warehouse pests. The use of aluminum phosphate is widely used in the market because of its low price, effective in reducing pest attacks, the resulting residual effect is low, and does not damage seed viability [8]. According to the Department of Agriculture phosphine comes from Aluminum Phosphide (AIP) and Magnesium Phosphide (Mg₃P) which occurs through the following chemical reactions:

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\begin{align*}
1. & \quad \text{AIP} + 3\text{H}_2\text{O} \rightarrow \text{Al} (\text{OH})_3 + \text{PH}_3 \\
& \quad \text{Aluminum} + \text{Water vapor} \rightarrow \text{Aluminum} + \text{Fosfin} \\
2. & \quad \text{Mg}_3\text{P}_2 + 6\text{H}_2\text{O} \rightarrow 3\text{Mg} (\text{OH})_2 + 2\text{PH}_3 \\
& \quad \text{Magnesium} + \text{Water vapor} \rightarrow \text{Magnesium} + \text{Fosfin} + \text{Hidroksida}
\end{align*}
\]

Mitochondria as the target of phosphine poisoning greatly influence the development of insect resistance to phosphine. mitochondrial sensitivity reduction Factors that can contribute to phosphine sensitivity and resistance include the mitochondrial membrane potential, the rate of electron flow through the mitochondrial respiration chain, and the level of ATP [9].

2. Methods

2.1. Time and research place
The research sample was conducted at ten points in the importer warehouse. The research was conducted by sampling in the field and observations was conducted at the Laboratory of Animal Ecology and Taxonomy, Biology Department, Faculty of Mathematics and Natural Sciences, Semarang State University. The time of research was conducted from January to February 2020.

2.2. Preparation of test insect
Sampling is carried out before the fumigation process takes place. All living insects are trapped in piles of commodities to be fumigated in numbers and grouped by type for use as test insects. each treatment is repeated 16 times in each commodity to obtain representative data.

2.3. Fumigation Practice
Fumigation was conducted at the importer warehouse in Semarang, Central Java, which is a routine activity to prevent commodities from being attacked by warehouse pests. Before each fumigation, commodity piles are cleaned and sealed following the agricultural quarantine agency's fumigation treatment standards. The exposure period is defined as the time between the first release of the fumigant and the beginning of the release of the seal. Animal feed commodities to be fumigated are stacked in such a way that proper gas distribution is obtained. The exposure period is determined based on the agricultural quarantine agency's fumigation treatment standards, which lasts 3x24 hours. The amount of fumigants used is calculated based on the dosage and amount of commodities to be fumigated taking into account various fumigation conditions such as estimated leak rate (half-loss time or HLT), duration of exposure, temperature, and target pest.

2.4. Identification and Mortalities Calculation
After going through the aeration process, observations on the sample are carried out and the sample is collected into ziplock plastic which will then identify the species. Identification was carried out at the
Biology Laboratory, Faculty of Mathematics and Natural Sciences, Semarang State University. One-way ANOVA is involved to analyze the data.

3. Results and Discussion
The activities of phosphine fumigant is tested against warehouse pest insects. Visible after 3x24 hours of exposure. Characterized by a mortality test of pest insects (Table 1).

Table 1. Mortality number of *Tribolium castaneum* and *Ephestia cautella* resulting from fumigation using phosphine in soybean seed commodities

| Repetition | Mortality |
|------------|-----------|
|            | *Tribolium castaneum* | *Ephestia cautella* |
| 1          | 35         | 20         |
| 2          | 40         | 14         |
| 3          | 32         | 26         |
| 4          | 42         | 14         |
| 5          | 46         | 17         |
| 6          | 46         | 9          |
| 7          | 36         | 18         |
| 8          | 36         | 19         |
| 9          | 39         | 21         |
| 10         | 43         | 16         |
| 11         | 33         | 18         |
| 12         | 39         | 12         |
| 13         | 36         | 14         |
| 14         | 38         | 16         |
| 15         | 45         | 11         |
| 16         | 43         | 15         |

Fumigant phosphine works very well in killing warehouse pests contained in soybean seed commodities. Exposure to phosphine for 3x24 hours can lead to the death of *Tribolium castaneum* and *Ephestia cautella* which are very high in soybean seed commodities. The types of warehouse pests that attack stored soybean seed commodities vary. The types of insects found are *Ephestia cautella* and *Tribolium castaneum* Herbst. *Tribolium castaneum* attacks are higher than *Ephestia cautella*. These warehouse pests can cause a decrease in the quality and quantity of stored soybean seed commodities [10]. Thus causing high economic losses.

Table 2. Mortality number of *Tribolium castaneum* and *Ephestia cautella* resulting from fumigation using phosphine in bird feed commodities

| Repetition | Mortality |
|------------|-----------|
|            | *Tribolium castaneum* | *Ephestia cautella* |
| 1          | 36         | 18         |
| 2          | 41         | 15         |
| 3          | 34         | 13         |
| 4          | 38         | 7          |
| 5          | 44         | 17         |
| 6          | 44         | 9          |
| 7          | 35         | 16         |
| 8          | 41         | 15         |
| 9          | 42         | 16         |
| 10         | 40         | 13         |
| 11         | 46         | 10         |
Based in Table 1, the types of warehouse pests that attack stored soybean seed commodities vary. The types of insects found are *Ephestia cautella* and *Tribolium castaneum* Herbst. *Tribolium castaneum* attacks are higher than *Ephistia cautella*. *T. castaneum* is one of the important insects in tropical areas, including Indonesia [11]. These insects are found in storage warehouses and become the main pests that damage commodities. Fumigant phosphine works very well in killing warehouse pests contained in bird feed commodities. Exposure to phosphine for 3x24 hours can lead to the death of *Tribolium castaneum* and *Ephistia cautella* which are very high in soybean seed commodities.

The results of statistical analysis showed that there were significant differences in the death of warehouse pest insects in soybean commodities and bird feed affected by phosphine fumigants. Phosphine fumigants are very effective for killing warehouse pests insects especially *Tribolium castaneum* and *Ephestia cautella*. Phosphine fumigants are suitable for use controlling warehouse pest insects in soy seed and bird feed commodities. Because, these two commodities have a water content of less than 22%. Phosphine is reactive to water, to maximize the effectiveness of phosphine. Ideal water content in commodities should be less than 22% [12]. During the fumigation process, piles of commodities are covered to ensure the fumigation chamber is gastight and the temperature is maintained above 10 °C. The efficacy of fumigants for killing insect pests of sheds is more determined by the conditions of the fumigation chamber and the temperature of the fumigation chamber [13]. The more impermeable the fumigation chamber, the more maximum the power of killing fumigants against warehouse pests insects. The minimum temperature for fumigation of Phosphine for the purpose of quarantine action is 10 °C [14].

Warehouse pest control uses synthetic pesticides especially phosphine, widely used to control warehouse pest insects. Because, its ability to control pests is very effective and fast. Fumigation using phosphine has an impact on the physiological processes of insects namely on the respiratory tract and neurotoxins. This effect reacts quickly to the larval and imago stages, but reacts slowly at the pupal and egg stage. Fumigation enters the body of insects mainly through the respiratory system. The entrance to the body of the insect at the stage of the larva, pupae and imago through the spiracles, which are located in the lateral part of the insect. The opening and closing of the spiracles of insects is under muscle control so that the poisoning of insects by fumigants is affected by the respiratory rate of insects [15]. Phosphine works through the inhibition of the cell respiration process. Phosphate toxicity is associated with oxidant-free radicals and inhibition of metabolic enzymes, such as cytochrome c oxidase. The production of free radicals exceeds that of antioxidant capabilities intracellular to neutralize it is very likely to cause cell damage. Often, this damage is referred to as oxidative damage. Oxidative damage caused by free radicals has implications for a variety of pathological conditions and can lead to death [16].

Insect control of warehouse pests in the future should be considered effective biological control such as using biopesticides. To be safer for food safety. Biopesticide is a pesticide made from plants and rich in active ingredients that serves as a natural defense tool against its gadfly (such as insects) [17].

### 4. Conclusion
Phosphine fumigants are very effective for killing warehouse pests insects especially *Tribolium castaneum* and *Ephestia cautella* in soybean seed and bird feed commodities. For future warehouse pest control it is recommended to use biopesticide to be safer for food safety.
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