Comparison of the effectiveness of phostoxin fumigants for controlling insect pests warehouse *Lassioderma serricorne* and *Pholcus phalangioides*

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**Abstract.** Insects warehouse pests contained in commodities, especially tobacco, can cause a decrease in the quantity and quality of commodities. The main pest insects found in tobacco storage warehouses are *Lassioderma serricorne* and *Pholcus phalangioides*. This study aims to analyze and compare the effectiveness of phostoxin fumigants to control insect pests *L. serricorne* and *P. phalangioides*. Methods used in this study include preparation of test insects, fumigation application, identification, calculation of mortality, and data analysis. The data were analyzed using one way ANOVA test. The results showed that there was a significant difference in morphility between groups of test insects. The highest mortality was in the group of test insects *L. serricorne*, which indicated that phostoxin fumigants effectively controlling barn insect pests, especially *L. serricorne*. To control insect pests warehouses in the future, it is recommended to use biopesticides to be safer for food.

1. Introduction

Cigarettes are one of the largest productions in Indonesia. According to a report from the Ministry of Finance of the Republic of Indonesia in 2019, there was a sharp increase in cigarette production, reached 365.5 billion cigarettes because there was no increase in cigarette excise compared to 2018, which is about 332.4 billion stems, made from dried tobacco, not spared the threat of warehouse pests that can multiply very quickly. Pests, such as *Lasioderma* sp, are often the biggest threat to cigarette manufacturers. Most commodities are ravaged by the time insects reach the larval phase and cause many small hole holes in the dried leaves of tobacco, which causes a decrease in the quality and quantity of the dried tobacco leaves [1].

*Lasioderma serricorne* is a Coleoptera type insect that has become one of the most prominent pests in the cigarette industry in Indonesia. Every year these insects can reduce the yield in warehouses by 10-40% [2]. *L. serricorne* damages dry tobacco by perforating the leaves, which will later reduce the mass of tobacco leaves and affect the taste, color, and smell [3]. Lasioderma has a life cycle of between 40-80 days, depending on its environmental conditions. One fertilized Lasioderma female will lay as many as 45-110 eggs, and each female can lay 2x in her life period. Larvae of *L. serricorne* are the most damaging phase of dry tobacco. The larvae have 3 instar development; the first instar measures 0.55 - 1.4 mm, the second instar is ± 3 mm, and the third instar measures 4 - 5 mm [4].

The usual precaution is to use a fumigation process or closed spraying using certain fumigants. Fumigants are often used, namely phostoxin 56 TB. It is a fumigation drug in round tablets made from
aluminum phosphide 56% and carbaman 44%. Aluminum phosphide is an active component of various mixtures that can release highly toxic phosphine gases when in contact with atmospheric moisture or hydrochloric acid in the stomach [5]. Thus, round tablets gradually lose their potency when exposed to the atmosphere as they release phosphine gas and leave non-toxic residues in the form of aluminum hydroxide [6].

\[ \text{AlP} + 3\text{H}_2\text{O} \rightarrow \text{Al(OH)}_3 + \text{PH}_3 \]

\[ \text{AlP} + 3\text{HCl} \rightarrow \text{AlCl}_3 + \text{PH}_3 \]

Phosphine gas is colorless and odorless in its pure form but, due to the presence of substituted phosphine and diphosphine, it has a foul smell that resembles rotting fish or garlic. Typically, phosphine is not detected in air or water. It is flammable and can spontaneously ignite in the air at room temperature at concentrations above the threshold range of 1.9% (v/v). It is soluble in water and organic solvents, while in the air, it reacts with OH radicals and is eliminated by this mechanism [7].

2. Materials and methods
A fumigated storage warehouse is a dry tobacco storage warehouse that comes from many domestically and abroad regions. Storage warehouses are distinguished into several parts using a specific number. Before fumigation, there is usually a trap to ascertain whether the warehouse is feasible to be fumigated or not. The storage warehouse is a tightly closed warehouse, with minimal ventilation, not exposed to direct sunlight and wind. The warehouse is moist and allows the development of tobacco pests, namely *L. serricorne* and *Pholcus phalangioides*.

2.1. Preparation of test insects
Pest sampling is done first before the closure of commodities using fumigation plastic. Sampling is done at 8 predetermined points on commodities to be fumigated at tobacco storage warehouses in Kudus, Central Java. The samples taken are living insects that are in fumigation commodities. The samples are calculated and distinguished by the type and number of insects found at each point.

2.2. Fumigation application
Fumigation conducted in this study is part of insect pest control routine measures in tobacco storage warehouses. Before the plastic closure, a volume measurement of the commodity is performed to determine the dose, and installation of the monitor hose is done first. Every 12 hours, the plastic will be opened to measure the level of phostoxin in the commodity. Commodities that have been marked and then closed using large plastics ensure that there are no holes in the plastic cover. The installation of Sand Snake at the end of the plastic cover to minimize the occurrence of gas leaks, distribution of toxins is carried out using plastic stalls according to the predetermined dose. Fumigation is carried out for 2 x 24 hours.

2.3. Identification, calculation of mortality, and data analysis
Every 12 hours, the plastic will be opened and calculate the mortality of the insect species found. Insect mortality calculation is done at a predetermined point. Some samples are taken and then inserted into 70% alcohol, identified in the Biology Laboratory, Faculty of Mathematics and Natural Sciences, Semarang State University. The data obtained were analyzed statistically using one way ANOVA test.

3. Results and discussion
The calculation of the mortality of the tested insects was carried out every 2 hours until it reached a cumulative time of 48 hours. The trend of mortality values at each time of observation can be seen in the table.
Phostoxin fumigants are very good at killing insects of *L. serricorne*. Table 1 showed the mortality percentage of *L. serricorne* after phostoxin treatments for 12 hours, 24 hours, 36 hours, and 48 hours. Table 1 shows that at 12 hours of observation, the mortality percentage of *L. serricorne* ranged from 12.75 - 16%, at 24 hours of observation, the mortality percentage ranged from 29.75–37.50%. At 36 hours of observation, the mortality percentage ranged from 73.50–86.75%, and at the end of the 48-hour observation, the mortality percentage ranged from 96.25 - 100%.

### Table 1. Mortality percentage of *Lasioderma serricorne* after phostoxin treatments

| Individual | 12 hours | 24 hours | 36 hours | 48 hours |
|------------|----------|----------|----------|----------|
| 200        | 13.75±5.75 | 29.75±7.4 | 73.5±7.5 | 96.25±10.25 |
| 200        | 16±5.5  | 37.5±4.2 | 83.5±7.56 | 97.75±6.25 |
| 200        | 14±4.5  | 31.5±7  | 86.75±7.75 | 94.25±7.25 |
| 200        | 12.75±6.25 | 34.25±8.8 | 79.25±7.25 | 100±0 |
| 200        | 16±6  | 31.75±3.8 | 85.5±10.5 | 98.25±7.75 |
| 200        | 15.75±4.75 | 35.25±6.71 | 77.75±5.75 | 100±0 |
| 200        | 12.75±7.25 | 35±6.36 | 80.75±7.25 | 100±0 |
| 200        | 13.5±5.5 | 35.75±8.83 | 71.75±5.75 | 97.75±8.25 |

Table 1 showed the mortality percentage of *P. phalangioides* after phostoxin treatments for 12 hours, 24 hours, 36 hours, and 48 hours. Phostoxin fumigants are very good at killing insects *P. phalangioides*. Table 2 shows the mortality percentage of *Pholcus phalangioides* at 12, 24, 36, and 48 hours of observation ranges from 8.5-17.85%, 11.42-17.85%, 50-59.28%, and 85-89.28%, respectively. The types of warehouse pests that attack tobacco commodities vary. The types of insects found are *L. serricorne* and *P. phalangioides*. The attack of *L. serricorne* is higher than that of *P. phalangioides*. These results are in accordance with the research that has been conducted by Ramadhan et al. [1], mention that *L. serricorne* is among the most important pests that attack tobacco commodities in storage warehouses. These warehouse pests can decrease the quality and quantity of tobacco commodities stored [8], thus causing high economic losses.

The results of statistical analysis using one way ANOVA test showed an average difference in mortality between treatments caused by phostoxin fumigant with a significance value 0.000 (P < 0.05). Also, this research showed that the average mortality percentage after phostoxin treatment was greater at *L. serricorne* than at *P. phalangioides*. Fumigation enters the body of insects mainly through the respiratory system. The entrance of the insect's body at the larval, pupae, and imago stage through the spiracles is located in the lateral part of the insect. The opening and closing of the insect spiracles are under muscle control so that insect poisoning by fumigants is affected by the respiratory speed of the
insect [9]. Aluminum phosphide is an active component of various mixtures that release highly toxic phosphine gas [5].

The further descriptive test showed that mortality caused by phostoxin fumigants was higher in the *L. serricorne* treatment group than *P. phalangioides*. Phostoxin fumigants are very suitable for controlling insect pests *L. serricorne* warehouse. Allahvaisi et al. [10] state that aluminum phosphide tablets are very suitable and effective as fumigants in controlling insect pests *L. serricorne*. Zibae et al. [11] state that the fumigant phostoxin can kill insect pests *L. serricorne* with a mortality value of 100%.

Phosphine is an indirect poison, which means the gas produced from aluminum phosphide does not cause death but reacts with oxygen to form toxic byproducts that cause death. Since phosphine is not consumed, it can act continuously, producing more toxins over time. In this way, phosphine causes the damage to accumulate like a toxic 'snowball effect' [12], which is the power of indirect poison. The more doses of phosphine tablets, the more phosphine gas is given in the room, so the airtight fumigation chamber is faster filled with phosphine gas. Phosphine is an excellent fumigant because the hydrogen phosphide has a very high molecular movement that allows the rapid penetration and distribution of gases [13]. Phosphine works through the inhibition of the cell respiration process. Phosphine toxicity is associated with free radical oxidants and inhibition of metabolic enzymes, such as cytochrome c oxidase [14]. The production of free radicals exceeds the ability of intracellular antioxidants to neutralize them, potentially causing cell damage. Often, this damage is referred to as oxidative damage. Oxidative damage caused by free radicals implicates various pathological conditions, namely damage to cells, tissues, and organs in both humans and animals. This damage can end in cell death, resulting in the onset of various degenerative diseases [15].

The field survey results showed the price of phostoxin is much cheaper than the use of Methyl Bromide, and more environmentally friendly. Phosphine is a highly toxic compound with good penetration power and length and will not leave the aroma, color, and taste, especially in fumigated dry tobacco [16]. It does not leave residues, and exhaust gases do not damage, such as Methyl Bromide, a destructive ozone layer/ozone-depleting substance (ODS) [17]. Phosphine is also a chemical compound that will turn into gas in a certain concentration at a specific temperature and can kill insects and leave no residue after fumigation is completed [18].

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) [19].

4. Conclusion

Fumigant phostoxin is very effective for controlling insect pests warehouse *Lassioderma serricorne* and *Pholcus phalangioides*. In the future, pest control warehouses are recommended to use biopesticides to be safer for food.

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