High Potential of Liquid Smoke from Coconut Shell (Cocos nucifera) for Biological Control of Rice Bug (Leptocorisa oratorius Fabricius)

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ABSTRACT

Rice bug (Leptocorisa oratorius F) is one of the most dangerous pests for paddy commodities (Oryza sativa) in the world. The use of liquid smoke was popular among local farmers to control rice bug. A coconut shell is the main source for making liquid smoke. This research aims to analyse rice bugs' mortality and antifeedant activity when dipped with coconut shell liquid smoke. The liquid smoke's effectiveness was measured by dipping paddy (5 grams in weight) that is previously soaked with coconut shell liquid for 20 seconds. The liquid smoke was prepared in various concentrations, ranging from 0% as a control; 0.50%; 0.75%; 1%; 1.25% and 1.50%. Observations were made at 24, 48, 72, 96, 120, 144 and 168 hours. Data analysis was performed by one-way ANOVA test, using SPSS program followed by a 0.05 Tukey test to determine the significance of the rice bug pest mortality. The study resulted that the mortality values from low concentrations to high concentrations were 40%, 46.67%, 60%, 70%, and 80% over seven days. The antifeedant percentage of liquid smoke increased from low concentrations to high concentrations respectively were 10.14%, 15.15%, 31.03%, 46.15%, and 68.88% during seven days. The concentration of liquid smoke that has the highest mortality was 1.50%. In conclusion, 1.50% of liquid smoke showed the highest percentage of mortality and antifeedant activity with 80% and 68.88%, respectively. In the future, it is hoped to develop this model for commercial consumption and reduce reliance on chemicals to control rice bugs. The use of pesticides can do more harm than good, especially to the environmental system.

Keywords: Coconut shell, Hemiptera, Liquid smoke, Rice bug

Introduction

Indonesia is the third country that consumed rice as a staple food after China and India [1]. The rice commodity is used as the main food for Indonesian people [2]. The nutrient content in rice is 78.9% carbohydrates, 6.8% protein, 0.7% fat and 0.6% others [3]. One of the problems with Indonesian paddy productivity is a pest. Pest is one of the consistent problems that can lower Indonesia's paddy productivity [4]. Rice Bug is a common pest that can be damaging to the grain of paddy [5]. Rice bug has a biological clock to damaging a grain of paddy in the morning and the afternoon [6]. To control rice bugs, farmers usually use chemical pesticides, but it has many negative impacts on human health, environmental pollution, and the disturbance of ecological balance [7]. Therefore, the biological control concept is one wise step to control pests and preserve the environment [8]. One way to solve the problem is to use bio-pesticide known as liquid smoke. Liquid smoke is an organic pesticide that is made of pyrolysis processing methods [9]. Liquid smoke can be derived from Coconut shells because it has a 90.75% phenol compound [10]. Activated carbon compounds can be used as an insecticide and antifeedant in insect pests [11]. After analysis using Gass Chromatography-Mass Spectrometry (GCMS), at least seven dominant compounds in the coconut shell were detected, such as 2-methoxyphenol (guaiacol), 3,4-dimetho-
Table 1. Percentage of rice bug mortality per day

| Concentration (%) | 1   | 2   | 3   | 4   | 5   | 6   | 7   |
|-------------------|-----|-----|-----|-----|-----|-----|-----|
| 0                 | 0   | 0   | 0   | 0   | 0   | 0   | 0   |
| 0.5               | 0   | 6.67| 16.67|26.67|33.33|40  |40  |
| 0.75              | 0   | 10  | 20  | 33.33|36.67|46.67|46.67|
| 1                 | 3.33| 16.67|23.33|33.33|40  |53.33|60  |
| 1.25              | 6.67| 20  | 30  | 36.67|46.67|56.67|70  |
| 1.5               | 10  | 23.33|33.33|43.33|53.33|73.33|80  |

Figure 1. Sampling location of Rice bug (*Leptocorisa oratorios* F).

Figure 2. Percentage of Rice bug mortality based on observation time (day) using Tukey test 5% significant difference
xyphenol, phenol, 2-methoxy-4 methylphenol, 4-ethyl-2-methoxyphenol, 3- methylphenol and 5- methyl-1,2,3-trimethoxy-benzene were worth exploring its usefulness in the biological control of the selected pest. Therefore, the current study’s main objective is to discover the effectiveness of liquid smoke from coconut shells in controlling rice bugs (*Leptocorisa oratorius* F).

Material and Methods

A survey was carried out on the organic agricultural area in Sumber Ngepoh Village, Lawang, Malang City, East Java (7°50’34.65”S, 112°43’17.81”T, 603 m in altitude). Rice bug sampling was done in an area of 20 m × 22 m (Figure 1). The rice bug was captured using a sweeping net. In this study, the 4th instar nymph phase was used. Rearing rice bug was carried out in the greenhouse at the Ecology and Diversity Laboratory of Mathematics and Natural Sciences Faculty, University of Brawijaya. The dimension of the insect rearing cage was 30 × 20 × 20 cm³. A wet towel was placed on the top of the cage to maintain the humidity. The rearing nymphs were carried out by placing the nymphs in a cage and giving cooked milk grains as food. The next process was acclimatization for three days to adjust to the new habitat of the stink bug. The number of insects that were used in this study was 180. It was because each treatment was repeated three times.

Liquid smoke was prepared using the pyrolysis method at the Centre of Agriculture Training, Lawang. This study applied complete randomized design (RAL) by dipping 5 grams of rice into each different concentration (0%; 0.50%; 0.75%; 1%; 1.25%, and 1.50%) and given it to the rice bug to know how the effective-ness of liquid smoke in controlling the rice bug. The rice grains to be given were soaked in liquid smoke for 20 seconds and dried. The concentration of liquid smoke was obtained by dissolving 0 ml; 0.50 ml; 0.75 ml; 1 ml; 1.25 ml, and 1.50 ml of liquid smoke in water to a final concentration of 100 ml. Observations were made at 24, 48, 72, 96, 120, 144 and 168 hours. Furthermore, pH was measured by a pH meter. Morphological insects (the ventral and lateral sides of insects) were analysed by stereomicroscope with magnification 0.63. Antifeedant activity test was carried out by calculating the weight proportion of rice given as feed. The difference in weight of leaves was calculated before eating and after eating, while mortality and antifeedant activity were calculated as a percentage. Data analysis was performed by one-way ANOVA using IBM SPSS package Statistics version 20 followed by a 0.05 Tukey test to determine the significance of the rice bug pest mortality at LC₅₀ value.

**Results and Discussions**

The mortality of rice bugs (*L. oratorios F*) (after applying liquid smoke using the feed dipping method) correlated with the amount of each treatment as mentioned in Table 1. The highest mortality percentage was shown in 1.5% of concentration with 80% mortality and the lowest mortality percentage was 0.5% of concentration with 40% mortality. The concentration at 0.5% and 0% (control), 75% showed no effective because the mortality percentage was under 50%.

The cause of death of insects applied to the liquid smoke was suggested to be due to the presence of phenol compounds in the coconut shell. The most common compounds found in coconut shell liquid smoke were reported as phenol, with a percentage reaching 90.75% [10]. The group of phenolic, acid and carbonyl compounds in coconut shells were the common compound that plays a role in influencing insect mortality [12]. Toxic compounds of liquid smoke, phenol and acetic acid, are gut poison for wood-damaging insects. The mechanism of phenol compounds entering the insect’s body would diffuse rapidly into the pore (spiracles) in the insect’s body parts to interfere with insect respiration. Disruption of insect respiration would impact the mechanism of ATP formation in the cytoplasm of cells (the process of glycolysis) and cell organelles (the Krebs cycle).

![Figure 3. The pH values at different concentration of liquid smoke](image-url)

**Table 2. The value of LC₅₀ day 6 (144 hour) and day 7 (168 hour)**

| Concentration of liquid smoke (%) | LC₅₀ (%), Day 6 (144 hour) | LC₅₀ (%), Day 7 (168 hour) |
|-----------------------------------|-----------------------------|-----------------------------|
| 0.50%                             | 1.485                       | 1.213                       |
| 0.75%                             | 6.02                        | 5.59                        |
| 1%                                | 5.97                        | 4.97                        |
| 1.25%                             | 4.65                        | 4.52                        |
| 1.50%                             | 3.40                        |                            |

**Table 2** The value of LC₅₀ day 6 (144 hour) and day 7 (168 hour)
Inhibition of ATP formation caused cells to lack energy, which inhibits the various processes of cell activity. At the same time, it can also damage the tissue and ultimately death [13]. The mortality percentage value of rice bugs from each concentration was tested with a 5% Tukey test. The difference was expressed by the letters on the bar. The more letters on the bar will be more apparent (Figure 2). The Tukey HSD test (with 5% significant) showed the different mortality percentages in each concentration were obvious at day 7.

One of the factors that can cause rice bugs’ death was acidic pH from the liquid smoke. The highest pH was at 0.5% concentration of liquid smoke, reaching 6.02 and the lowest pH was in 1.5% of concentration with a number reaching 4.52 (Figure 3). The different pH number was caused by a phenolic and acidic compound. If the phenolic compound was high, then the pH will be decreasing.

Based on analysis using SPPS software, values LC$_{50}$ were obtained starting from the 6th day (144 hours) and the 7th day (168 hours) of treatment (Table 2). The value LC$_{50}$ on the 6th day was 1.485% and the 7th day was 1.213%. Values LC$_{50}$ were used as estimates of the concentration that
was used to kill half the number of insects. The results showed that starting from the 6th day until the 7th day was decreased, which indicates the higher level of toxicity, it can kill rice bugs with a higher amount than the previous day with a death rate reached 50%. The number of LC$_{50}$ on day 6 was 1.485 and on day 7th was 1.213. It shows that on day 7th, liquid smoke was more toxic.

Rice bug that died due to the influence of liquid smoke from each concentration and its control were analyzed for morphology using a stereo microscope with magnification 0.63. Morphological analysis showed that a colour change on the ventral side of the rice bug. The control treatment has normal size and bright colour on the stomach compared to the rice bug that is affected by liquid smoke (Figure 4). Based on the lateral part of the rice bug from the control group and the treatment given liquid smoke each showed no clear difference. All lateral portions of
the control and treatment groups almost looked similar (Figure 5). Differences in dorsal, morphological differences were found between groups that were not given liquid smoke (control) and groups treated with liquid smoke. The control group had a greenish-brown back part, while the rice bug group who were given liquid smoke treatment had a darker brown back color compared to the control group. The difference was seen in the rice bug given liquid smoke treatment with a concentration of 1.25% and 1.50% (Figure 6). Changes in color of the insects that die after being given liquid smoke due to liquid smoke compounds that play their role as described before. If they react with proteins, carbonyl compounds in liquid smoke would form brown color [14]. The carbonyl compounds in liquid smoke were formed due to thermal decomposition and cellulose and hemicellulose rearrangement reactions [15].

The inhibitory activity of rice bugs feed was also observed in the study. Rice bugs given liquid smoke treatment began to show food inhibition activities that can be seen from the difference in weight of the rice that was consumed. The highest antifeedant activity showed at 1.50% concentration of liquid smoke and the lowest antifeedant activity showed in 0.5% concentration of liquid smoke. According to Park et al., (1997) [17] 0.5%, 0.75% and 1 % concentrations were classified as a very weak antifeedant activity. 1.25% was classified as a weak antifeedant activity, while 1.5% was classified as a moderate antifeedant activity (Figure 7). Liquid smoke causes antifeedants by affecting the central nervous system. It regulates the eating process, causing the food eaten by insects to be poisonous to the stomach (secondary antifeedants) [16].

**Conclusion**

Liquid smoke from coconut shells had a great potential to control rice bugs because it has a promising effect on the insects’ mortality and antifeedant activity. At 1.50% of concentration showed the highest percentage of mortality and antifeedant activity of 80% and 68.88%, respectively. The pH also functions as a good indicator of the mortality factor to rice bug, because if the pH number decreases, the phenol compound in coconut shell would increase and affect the rice bug. This technique is very promising to be developed to reduce and rely on chemicals to control rice bugs. The use of chemicals can do more harm than good, especially to the environment.

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