



The effectiveness of coconut coir liquid smoke as a natural insecticide on the mortality of *Spodoptera exigua* Hubner (Lepidoptera: Noctuidae)

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Abstract

This research was conducted at the Laboratory of Pests and Diseases, Faculty of Agriculture, University of Tadulako, Palu, from Juli 2022 to November 2022. This study used a Complete Randomized Design (CRD) which consisted of 5 treatments that were repeated 4 times to obtain 20 experimental units. The treatments were K1 = (control), K2 = liquid coconut coir smoke concentration of 2.5 ml/L, K3 = liquid coconut coir smoke concentration of 5 ml/L, K4 = liquid coconut coir smoke concentration of 7.5 ml/L, and K5 = coconut coir liquid smoke concentration of 10 ml/L. Observations included mortality and speed of death of *Spodoptera exigua*. The results showed that the concentration of coconut coir liquid smoke treatment had a significant effect on the mortality and speed of death of *S. exigua*. The K5 treatment (10% concentration) gave higher mortality and death rates, namely 65% and 3.77 respectively.

Keywords: Coconut coir liquid smoke; Natural insecticide; Shallot; *Spodoptera exigua*

1 Introduction

The beet armyworm, *Spodoptera exigua* Hubner (Lepidoptera, Noctuidae) is a cosmopolitan insect that is an important pest of shallots. *S. exigua* can spread quickly on shallot plants in the lowlands and highlands. These pests attack shallot plants throughout the year, both in dry and rainy seasons [1]. Symptoms of *S. exigua* attack are transparent spots on the leaves. Heavy attacks cause the leaves to dry and fall prematurely so the quality and quantity of crop yields decrease. *S. exigua* attacks if not controlled can cause up to 100% yield loss [2]. Control with synthetic insecticides causes various negative impacts such as environmental pollution and poisoning for users [3,4]. To reduce the use of chemical insecticides, organic pesticides can be used. One that can be used is coconut coir liquid smoke.

Liquid smoke is the result of distillation or condensation of steam resulting from indirect or direct combustion of materials containing carbon and other compounds. The raw materials that are widely used are wood, palm kernel, dregs from sawmills, and others [5]. Liquid smoke contains acetic, butyric, propionic acids, methyl esters, formaldehyde, acetaldehyde, hydrocarbons, ketones, phenols, pyridine, and methyl pyridine [6,7]. Some of the uses of liquid smoke are as weed control, anti-bacterial, anti-fungal, and insect repellent [8].

The use of coconut coir liquid smoke as a pest control agent includes rice bug *Leptocorisa oracorius* F. [9,10], army worm *S. litura* [11], diamondback moth *Plutella xylostella* [12], rice brown planthopper *Nilaparvata lugens* Stål. [13,14] and aphids *Myzus persicae* [15]. The research shows that coconut coir liquid smoke has the potential to be a rational pesticide. The aim of the study was to determine the effective concentration of coconut coir liquid smoke in controlling the beet armyworm *S. exigua* on shallot.

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2 Material and methods

2.1 Research design

This research was conducted at the Laboratory of Plant Pests and Diseases, Faculty of Agriculture, Tadulako University. This research took place from Juli to November 2021.

The study was conducted using a completely randomized design (CRD), which consisted of 5 treatments with liquid smoke concentrations and repeated 4 times and each treatment used 10 *S. exigua* larvae. The treatments were: K1: Control K2: Liquid smoke with a concentration of 2.5% (2.5 ml/100 ml water) K3: Liquid smoke with a concentration of 5% (5 ml/100 ml water) K4: Liquid smoke with a concentration of 7.5% (7.5 ml/100 ml water) and K5: Liquid smoke with a concentration of 10% (10 ml/100 ml water).

2.2 Research procedure

The study began with raising as much *S. exigua* as possible so that third-instar larvae with a uniform age could be obtained, and planting shallots as larvae feed. After the 3rd instar larvae were sufficient, namely as many as 360 individuals, then toxicity testing was carried out. Shallot leaves as feed for the test larvae were taken from the plantations, then washed thoroughly and cut into 10 cm lengths. Furthermore, the pieces of shallots were dipped for 2-3 minutes into a container containing a solution of coconut shell liquid smoke according to each treatment concentration. The leaves of the shallot plant that had been dipped were then wind-dried and put into the prepared jar, then 10 larvae were dropped on each treatment. Observation of larval death was observed starting 9 hours after application, 12 hours after application, 15 hours after application and 18 hours after application. The data obtained were analyzed by probit analysis.

3 Results

3.1 Mortality of *Spodoptera exigua*

The 5% HSD test results in Table 1 show that the K5 treatment was significantly different from all treatments with an average mortality of *S. exigua* of 30.0% (9 HAA), 35% (12 HAA), 47.5% (15 HAA) and 65% (18 HAA), but not significantly different from the K4 treatment at 12 HAA, 15 HAA, and 18 HAA observations.

Table 1 Average mortality of *S. exigua* (%) at various observation times

Treatment	Observation period (hours after application, HAA)			
	9 HAA	12 HAA	15 HAA	18 HAA
K1	0.0 (0.71 ^a)	0.0 (0.71 ^a)	0.0 (0.71 ^a)	0.0 (0.71 ^a)
K2 (2,5%)	10.0 (3.24 ^b)	17.5 (4.21 ^b)	27.5 (5.27 ^b)	37.5 (6.15 ^b)
K3 (5%)	15.0 (3.88 ^{bc})	20.0 (4.53 ^b)	32.5 (5.73 ^{bc})	40.0 (6.34 ^b)
K4 (7,5%)	20.0 (4.53 ^c)	25.0 (5.03 ^{bc})	37.5 (6.15 ^{cd})	52.5 (7.27 ^c)
K5 (10%)	30.0 (5.52 ^d)	35.0 (5.94 ^c)	47.5 (6.92 ^d)	65.0 (8.09 ^c)
HSD 5%	0.73	0.97	0.84	0.89

Note: Numbers followed by the same letters in the same column are not significantly different in the HSD test at the 5% level. The number in brackets is the value of the $\sqrt{x + 0,5}$ transformation

3.2 Larvae Death Rate

The results of the analysis of variance showed that the concentration of coconut coir liquid smoke had a significant effect on the mortality rate of *S. exigua* larvae. The K5 treatment (10% concentration) showed the highest average mortality rate of *S. exigua* larvae, namely 3.77 individuals/3 hours, and was significantly different from all other treatments (Table 2).

Table 2 Speed of death of *S. exigua* larvae at various concentrations of coconut coir liquid smoke

Treatment	Speed of death
K1 (kontrol)	0.00 (0.71 ^a)
K2 (2,5%)	2.08 (1.61 ^b)
K3 (5%)	2.34 (1.69 ^b)
K4 (7,5%)	2.94 (1.85 ^c)
K5 (10%)	3.77 (2.07 ^d)
HSD 5 %	0,12

Note: Numbers followed by the same letters in the same column are not significantly different in the HSD test at the 5% level. The number in brackets is the value of the the $\sqrt{x + 0,5}$ transformation.

3.3 The concentration of coconut coir liquid smoke on *S. exigua* mortality

The results of cumulative observations of *S. exigua* larvae mortality showed that administration of coconut coir liquid smoke had a very significant (F:0.01) effect on *S. exigua* larvae mortality in the observations of 9 HAA, 12 HAA, 15 HAA, and 18 HAA. This shows that the higher the concentration of coconut coir liquid smoke, the higher the mortality of *S. exigua* larvae, with a linear regression equation $y = 5.8x + 10$, $R^2 = 0.88$ (Figure 1). Toxicity measurements (LC₅₀) of coconut coir liquid smoke are shown in Table 3.

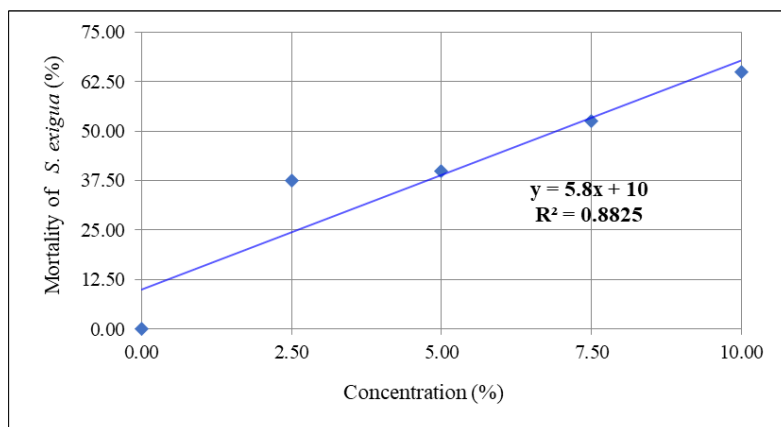


Figure 1 The relationship between the concentration of coconut coir liquid smoke and the mortality of *S. exigua* in 18 HAA

Table 3 Probit analysis of coconut coir liquid smoke on *S. exigua* larvae

Concentration (%)	Log concentration (X)	Replication	Total Test Larvae (N)	Σ Dead of larvae	Mortality (%)	Corrected Mortality (N)	Probit Value* (Y)
0,00	-	4	40	0	0,0	-	-
2,50	0,398	4	40	15	37,50	37,50	4,0814
5,00	0,699	4	40	16	40,00	40,00	4,7467
7,50	0,875	4	40	21	52,50	52,50	5,0627
10,00	1,000	4	40	26	65,00	65,00	5,3853

Note: *) The probit value is obtained from the percent-probit transformation table (Source: Priyono, 2008)

Furthermore, by using the Finney method and simple linear regression calculations using the microsoft excel, the LC₅₀ (18 HAA) value of the concentration of coconut coir liquid smoke on the *S. exigua* was obtained at a concentration level of 6.73% coconut coir liquid smoke (Figure 2).

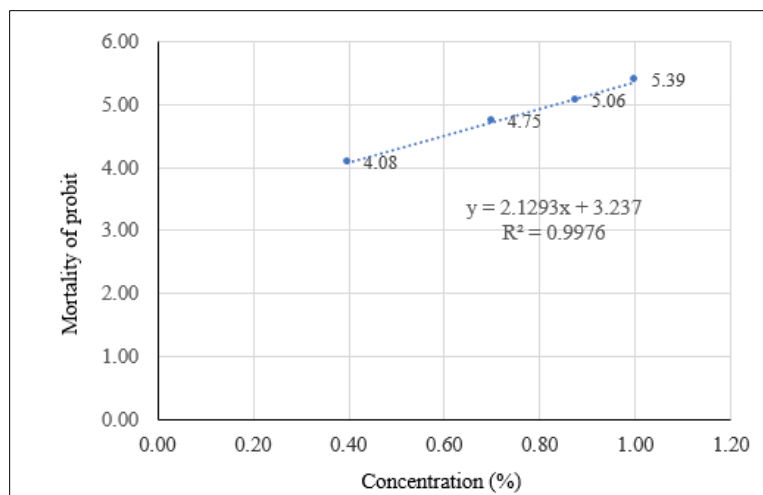


Figure 2 LC₅₀ probit analysis of coconut coir liquid smoke at the time of exposure to 18 HAA

4 Discussion

Based on the results of the study it was found that the concentration of coconut coir liquid smoke at the observations of 9 HAA, 12 HAA, 15 HAA, and 18 HAA had a significant effect on the mortality and speed of death of *S. exigua* (Table 1 and Table 2). This is presumably because coconut coir liquid smoke contains compounds that can affect the bodies of *S. exigua* larvae.

Liquid smoke is the result of condensation of steam resulting from direct or indirect combustion of materials that contain lots of lignin, cellulose, hemicellulose, and other carbon compounds [16–19]. The group of compounds that make up liquid smoke are oxalic acid by 31.41%, butanediol by 0.29%, acetic acid by 48.75%, propanone by 7.25%, propanoic by 4.01%, carboxaldehyde by 5.09%, and 3.19% phenol [20].

Based on the results of observations in the K5 treatment (10% concentration), the average percentage of mortality and mortality was higher than other treatments. This indicates that the addition of higher concentrations of coconut coir liquid smoke is directly proportional to the increase in mortality and mortality rate of *S. exigua* larvae. This is in accordance with the statement of [12], that the higher the concentration of liquid smoke given, the higher the mortality of *S. exigua* larvae produced, which is shown by the results of the linear regression equation $y = 5.8x + 10$; $R^2 = 0.88$ (Figure 1).

The correlation coefficient (r) between the concentration of liquid smoke and the mortality of *S. exigua* larvae is 88%. Based on these values it is known that the relationship between the two variables is very strong. The concentration level of coconut coir liquid smoke given is directly proportional to the number of deaths of *S. exigua* test larvae. The higher the concentration means the higher the toxicity which can cause death in the test larvae. Toxicity is a condition where there is a toxic or toxic effect on the material as a preparation or a mixture of preparations. While the toxicity test is to determine the ability of poison molecules to damage when they enter the body [4].

The LC₅₀ value of coconut shell liquid smoke was obtained at a concentration of 6.73%. The toxicity value was between the K3 (5%) and K4 (7.5%) treatments. [21] states that the workings of the active compounds in liquid smoke are stomach poisons and contact poisons. Symptoms of death of larvae exposed to liquid smoke begin with a slow appetite, over time the larvae cannot move and eventually die, which is indicated by the black and shriveled bodies of the larvae. Phenolic compounds found in coconut coir liquid smoke can act as stomach poisons in the larvae.

Phenolic compounds enter the body of the larvae through the process of eating and then enter the metabolic system and disrupt metabolic processes which eventually lead to death. Phenols can also form protein complexes that can damage cell membranes by denaturalizing protein bonds in the cell membrane so that the cell membrane becomes lytic [8].

The compounds contained in coconut coir liquid smoke in the form of oxalic acid, butadiene, acetic acid, propanone, propanoate, carboxaldehyde, and phenol caused the percentage of mortality and mortality rate of *S. exigua* larvae to increase with increasing observation time. The results of this study are in accordance with [22] which stated that giving 8.84 ml of liquid smoke could inhibit the growth of 50% of the population of *S. exigua* larvae, 33 hours after application. Furthermore [23] stated that the use of coconut shell liquid smoke at a concentration of 9% caused the mortality of *P. xylostella* by 65%.

5 Conclusion

Coconut coir liquid smoke has a significant effect on the mortality and mortality rate of *S. exigua* larvae. The concentration of 10% coconut coir liquid smoke resulted in the highest *S. exigua* larval mortality of 65.00% with a larval mortality rate of 3.77 individuals/3 hours. Coconut coir liquid smoke can be used as a botanical insecticide because it is toxic, namely at a concentration of 6.73% it can cause the death of half of the number of test insects.

Compliance with ethical standards

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Disclosure of conflict of interest

The authors declared that they have no competing interests. The authors have participated on completing this manuscript

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