ISSN 2664-4169 (Print) & ISSN 2664-7923 (Online)
South Asian Research Journal of Biology and Applied Biosciences
Abbreviated Key Title: South Asian Res J Bio Appl Biosci

| Volume-7 | Issue-2 | Mar-Apr -2025 | **DOI: https://doi.org/10.36346/sarjbab.2025.v07i02.011**

Original Research Article

Insecticidal Effect of Ethanol Extract of *Cymbopogon nardus L.* against Coffee Mealybug (*Planococcus citri* Riso.)

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Article History
Received: 11.03.2025
Accepted: 17.04.2025
Published: 19.04.2025

Abstract: In Indonesia *Planococcus citri* is a species mealybug that infects robusta coffee berries, that are very detrimental for farmers. However, the use of chemical pesticides is known to have negative impacts on health and environment so that the search for natural insecticides is continuously being carried out. This study aims to determine the insecticidal effect of citronella plant (*Cymbopogon nardus* L.) extract against the mealybugs. Citronella extract was screened for its phytochemical content and then divided into several concentration levels, namely 0% (control), 5%, 10%, 15%, 20%, and 25% sequentially. The adult females of mealybug feeding on coffee berries, were chosen as the test animal in this study. Coffee berries were soaked in treatment solution for 10 minutes. After being air-dried, the coffee berries were put into glass jars and then infested with 10 imago mealybugs. The treatment was conducted for12th, 24th, 48th and 72th hours. Lethality rate of the insect then noted and the median lethal concentration (LC_{50}) of the extract was determined using probit analysis. The results showed that plant extract of citronella contain flavonoid, tannin, alkaloid, phenolic, and terpenoid. The death rate of mealybugs increased with increasing concentration of extract. The median concentration of citronella extract on mealybugs also decreased with increasing exposure time, namely: 20.2, 12.4, 7.6, and 5.3% for exposure times of 12, 24, 48, and 72 hours, respectively. Thus, it can be concluded that citronella extract has slightly toxic properties and can be developed as a botanical insecticide for mealybug pests.

Keywords: Mealybug, *Planococcus citri*; citronella; *Cymbopogon nardus*.

1. INTRODUCTION

Planococcus. citri is polyphagous mealybug and has been recorded on over 200 host plant species belonging to 191 genera in 82 families. This pest is known to Old World origin but was accidentally spread worldwide by human trade in fresh plants [1]. Several types of cultivated plants that have been reported to be attacked by the mealybug P. citri are: *Ananas comosus* (pineapple), *Annona squamosa* (sugar-apple), *Canna* sp. (canna lily), *Citrus* sp., *Cocos nucifera* (coconut), *Codiaeum* sp. (croton), *Cucumis melo* (musk melon), *Cucurbita* sp., *Dioscorea* sp. (yam), *Ficus* sp. (fig trees or fig), *Fragaria* sp. (strawberries), *Gardenia* sp., *Ipomoea batatas* (sweet potato), *Mangifera indica* (mango), *Musa* sp. (banana), *Nicotiana* sp., *Persea americana* (avocado), *Phoenix dactylifera* (date palm), *Psidium guajava* (guava), *Punica granatum* (pomegranate), *Pyrus communis* (pear), *Pyrus malus* (apple), *Solanum melongena* (eggplant), and *Theobroma cacao* (cacao) [2].

In Indonesia, P. citri mealybug also infects robusta coffee berries, that are very detrimental for farmers, so this pest is also called coffee mealybug. The most common and effective mealybugs eradication technique is using chemical pesticides such as spirotetramate, chlorpyrifos, profenofos, methidathion, metomil. Unfortunately, the use of chemical insecticides is known to have negative impacts causing pest resistance and leaves dangerous chemical residues on coffee berries. Therefore, safe pest control based on natural ingredients (biopesticides) needs to be continuously pursued and developed [3].

Among the types of plants that are suspected of having insecticidal properties is citronella or lemongrass, *Cymbopogon nardus* (L), which in Indonesia is called serai wangi. Some previous studies have shown that citronella plant extract has insecticidal properties against mosquitoes. Lotions made from essential oil of extracted from citronella leaves showed repellent activity against *Aedes aegypti* mosquitoes using screened cage test method [4]. When citronella extract is mixed with diesel oil in the fogging technique, it is known to be effective in killing *Aedes aegypti* mosquitoes [5]. Other experiments have shown that lemongrass extract is larvicidal on the malaria mosquito larvae *Anopheles* sp. with an LC_{50} of 10.01% [6].

To test whether the citronella plant can be used as a bioinsecticide for our plant pests, we extracted this plant using ethanol solvent. The extract was tested on *P. citri* mealybug pests that infect robusta coffee berries.

2. MATERIALS AND METHODS

2.1 Plant samples and extraction

Fresh lemongrass plant samples were collected from farmers in Kemiling District, Bandar Lampung City, Indonesia. The plants were finely chopped and then dried. After drying, the plant powder was macerated using 96% ethanol. The extract was evaporated using a rotary evaporator to form a paste. The paste was diluted into several concentration levels, namely 0% (control), 5%, 10%, 15%, 20%, and 25% sequentially.

2.2 Phytochemical tests

To determine the types of phytochemicals contained in the crude extract of citronella, the following screening techniques were carried out.

- Alkaloid test. Wagner reagent is added to the citronella extract until a blackish brown precipitate is formed.
- Flavonoid test. A few drops of NaOH are added to the extract to produce a yellow color.
- Saponin test. The extract is mixed with water and then shaken, if foam forms it indicates the presence of saponin.
- Tannin test. The extract is added with $FeCl_3$ solution, the formation of a blue or green color indicates the presence of tannin.
- Terpenoid test. The extract is given Liebermann-Burchard reagent, if the color of the solution changes to red it indicates the presence of terpenoid.
- Phenolic test. The extract is added with Libermann's reagent, if a dark blue color is formed it indicates the presence of phenol.

2.3 The mealybugs and treatment

The insects tested in this study were mealybug (*Planococcus citri* Risso) that was found to infest coffee berries (*Coffea robusta* L.) in the traditional-smallholder coffee plantations of the Way Tenong district in West Lampung Regency. The insects were transferred to the laboratory and reared until reaching adult stages. The adult females, the developmental stage of mealybug feeding on coffee berries, were chosen as the test animal in this study. Six concentration levels of the citronella extract were prepared for treatment to assess lethality rates of the insect at 12th, 24th, 48th and 72th hour of exposure. Furthermore, to determine the median lethal concentration (LC_{50}) of citronella extract, probit analysis was used. Coffee berries obtained from the same coffee plantation from which the test insects are obtained were soaked in treatment solution for 10 minutes. After being air-dried, the fruits were put into glass jars and then infested with 10 imago mealybugs. Each treatment repeated three times.

2.4 Study parameters and data analysis

The parameters recorded in this study were the mortality rate of mealybugs at 12, 24, 48, and 72 hours after treatment. The mortality rate of test insect was expressed as percentage and calculated using the following formula:

$$\% \text{ mortal} = \Sigma \frac{dead\ mealaybug}{mealybugs\ population} 100\%$$

The effectiveness of extract in killing the insect was expressed as LC_{50} (lethal concentration 50%). The LC_{50} were determined using Probit EXE Analysis Program. Mean difference between parameters were analyzed using two-way ANOVA and post hoc test from Tukey at α=5%.

3. RESULTS AND DISCUSSION

The results of qualitative test of phytochemical content in citronella extract is presented in Table 1. The findings of this study are almost the same as the findings of Solekha *et al.,* (2022) who also found the presence of tannins, saponins, alkaloids, flavonoids, and terpenoids in ethanol extract of the plant. The difference is, in this study, saponins were not found. While steroids, both in this study and previous studies were also not found [7]. The difference in extraction results using the same solvent is likely caused by the nature of the plant material, its origin, degree of processing, moisture content, and particle size. Other factor may be affected by the type of extraction, time of extraction, temperature, nature of solvent, solvent concentration, and polarity [8].

Table 1: Phytochemical test result of citronella plant extract

No	Phytochemical	Existence*
1.	Tannin	+
2.	Alkaloid	+
3.	Saponin	-
4.	Flavonoid	+
5.	Steroid	-
6.	Phenolic	+
7.	Terpenoid	+
*(+) present; (-) absent		

The mortality rates of mealybugs at 12, 24, 48 and 72 hours after administration of citronella extract are presented in Table 2. Based on the data in the table, it is revealed that the higher the concentration of the extract, the higher lethality rate of the insect. The longer the exposure time, the higher the death rate, even at 72 hours an extract concentration of 25% killed all the test insects.

Table 2: Coffee mealybugs mortality rates by citronella extract at different time of exposure

Concentration	Mortality rates (%)			
	12 h	24 h	48 h	72 h
0% (control)	0.00^{a}	0.00^{a}	0.00^{a}	0.00^{a}
5%	6.6 ± 5.7^{a}	16.6 ± 5.7^{b}	33.3 ± 5.7^{b}	50.0 ± 0.0^{b}
10%	30.0 ± 0.00^{b}	50.0 ± 10.0^{c}	66.6 ± 5.7^{c}	73.3 ± 5.7^{c}
15%	40.0 ± 10.0^{b}	53.3 ± 5.7^{c}	70.0 ± 0.0^{c}	83.3 ± 5.7^{d}
20%	43.3 ± 5.7^{b}	60.0 ± 0.0^{c}	73.3 ± 5.7^{c}	90.0 ± 0.0^{d}
25%	60.0 ± 0.0^{c}	80.0 ± 0.0^{d}	96.6 ± 5.7^{d}	100.0 ± 0.0^{e}
Values in same column followed by the same superscript are not different statistically				

Probit analysis to determine the median lethal concentration (LC_{50}) of citronella extract is presented in Table 3. The value of LC_{50} in the table indicated that the plant extract of Cymbopogon nardus (L.) is toxic to mealybug P. citri. However, because the LC_{50} values of the extract at different time of exposure are all higher than 5000 ppm so that the toxicity level is categorized as slightly toxic [9, 10].

Table 3: Results of probit analysis of citronella extract against mealybugs

Duration	Nilai LC_{50} (%)	Fiducial limits (%)
12 h	20.2	16.1 – 30.0
24 h	12.4	9.6 – 15.6
48 h	7.6	5.0 – 9.7
72 h	5.3	3.1 – 7.0

The findings of this study are in line with the results of the experiment by Telaumbanua *et al.,* (2021) which used citronella extract to prevent rice pests. Rice plots given citronella extract proven not to be visited by insect pests [11]. The active ingredient in citronella extract that is suspected to have toxic properties on insects is essential oil. The use of essential oils against German cockroaches is known to have a lethal time of 90% (LT_{90}) of 4.70 to 13.93 hours in females and 0.32 to 42.82 hours in nymphs [12]. Another experiment conducted by Wicaksono *et al.,* (2023) showed that essential oil from citronella extract was effective in killing the cabbage pest *Plutella xylostella* and did not cause death to the pest's natural enemy *Diadegma eucerophaga* [13]. Predominant compounds found in essential oil of citronella are citronellal, citronellol, geraniol, elemol, δ-cadinone, and germacrene D. These compounds oil revealed to have adverse effects on the life cycle and midgut morphology of insect [14].

In addition, citronella plant extract, as proven by phytochemical screening in this study, has been proven to be rich in flavonoids [15]. Flavonoid compounds are widely known to have toxic properties against plant feeding insects [16].

4. CONCLUSION

The results of this study indicate that the ethanol extract of citronella plants can kill whitefly insects with a mortality rate that is in line with the increase in concentration. Thus, it can be concluded that citronella plants (*Cymbopogon nardus* L.) have the potential to be developed as botanical insecticides for coffee mealybugs (*Planococcus citri* Riso).

Compliance with Ethical Standards

Acknowledgments

The author would like to all laboratory staff of Zoological Laboratory, university of Lampung for their help in supporting this research.

Disclosure of Conflict of Interest: The authors declare no conflict of interest.

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