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REPELLENCY OF CITRONELLA ESSENTIAL OIL IN CONTROLLING PESTS IN PLANTS

Pupung Purnawan
Universitas Padjadjaran, Indonesia
Email: pupungpurnawan81@gmail.com

ABSTRACT

This study aims to evaluate the effectiveness of citronella essential oil as a repellency agent in controlling pest attacks on plants. The method used was systematic literature review with data collection through literature studies to collect various types of existing literature to be extracted according to the research title. The findings indicated that citronella essential oil has potential as an environmentally friendly and sustainable pest control method. However, several challenges such as the stability of the oil in the open and the need for periodic reapplication need to be addressed. With an integrated approach that takes into account relevant environmental and technical factors, the use of citronella essential oil can become an integral part of a more effective pest control strategy in agriculture.

KEYWORDS *repellency, citronella, pests, plants*

INTRODUCTION

Agriculture is an important sector in the economy of many countries, especially in Indonesia, which is known as an agricultural country. However, one of the major challenges faced in the agricultural sector is pest infestation that can cause significant losses to crops. Crop pests not only reduce crop yields but also lower the quality of agricultural products, which in turn negatively affects the welfare of farmers and the economy as a whole .

Various pest control methods have been developed and applied to reduce the negative impact of pests on crops. These methods include the use of chemical pesticides, biological control, and integrated farming techniques. However, the overuse of chemical pesticides has caused various environmental and health problems, such as soil and water pollution, pest resistance to pesticides, and negative impacts on non-target organisms including humans.

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Citronella (Cymbopogon nardus) is a plant known to contain essential oils with repellent properties against various types of insects. Citronella essential oil contains compounds such as citronellal, citronellol, and geraniol which are proven effective as insect repellents (PALONDONGAN, 2023). Therefore, stated that citronella-based essential oil (CBEO) has the potential to be developed as a novel and environmentally friendly attractant agent to control fruit flies.

Several previous studies have shown the effectiveness of citronella essential oil in controlling various types of pests. Research showed that citronella oil has the potential to control mealybugs on papaya plants. The use of citronella oil with concentrations of 0.5, 1, and 2 mL/L showed a repellent effect on mealybugs, reduced fecundity, and caused death. Showed that citronella leaf essential oil mixed with eucalyptus oil and VCO had a repellent effect on the Aedes aegypti mosquito.

This study aims to evaluate the effectiveness of citronella essential oil as a repellency agent against fruit flies. This research is expected to provide safer and more sustainable pest control alternatives for farmers. The results of this study are expected to contribute significantly to the development of environmentally friendly pest control methods. By proving the effectiveness of citronella essential oil as a fruit fly repellent, it is expected to reduce farmers' dependence on chemical insecticides, thereby creating a more sustainable agricultural system that is safe for the environment and human health.

RESEARCH METHOD

This study used a Systematic Literature Review (SLR) approach to evaluate the effectiveness of citronella essential oil (Cymbopogon citratus) in controlling pests. The SLR approach was chosen because it allows researchers to collect, assess and synthesise evidence from various published studies, resulting in a comprehensive and evidence-based understanding of the topic under study. This SLR process follows the PICO (Population, Intervention, Comparison, Outcome) framework to ensure systematicity and focus in data collection and analysis.

Once relevant studies are identified and shortlisted, the next step is data extraction. The extracted data included information on population (pests), intervention (use of citronella essential oil), comparison (other control methods), and outcome (effectiveness in reducing pest populations). The data were qualitatively analysed to assess patterns and key findings from the reviewed studies.

The final step in the SLR method is the synthesis of findings. The results of the various studies that have been analysed are compiled and presented in a structured form. This synthesis focuses on the effectiveness of citronella essential oil compared to other control methods in reducing fruit fly populations. The conclusions drawn from this synthesis provide a comprehensive understanding of the potential use of citronella essential oil as an alternative to fruit fly control, as well as recommendations for further research and practical application in the field. The following are the stages of data collection in this research.

Figure 1. Systematic Literature Review Process

RESULT AND DISCUSSION

RESULT

Table 1. Result

No.	Author & Title	Treatment	Research Result
1	Rusdi & Amalia Rusaldy (2023)	1. Ts0 = No biopesticide treatment (control). 2. Ts1 = Fertitani biopesticide 3. Ts2 = Citronella Oil Biopesticide 4. Ts3 = Biopesticide Citronella Extract 5. Ts4 = Citronella Ash Biopesticide.	The effectiveness of fruit fly control based on Abbot's formula is as follows: Ts0 = 0% Ts1 = 25.71% Ts2 = 35.88% Ts3 = 27.72% Ts4 = 19.55%
2	Juniaty Arruan Bulawan, La Mpia, (2022)	P1 = clove leaf extract, P2 = babadotan leaf extract P3 = citronella leaf extract, P4 = basil leaf extract	Based on the number of fruit flies captured P1 = 35.67 tails P2 = 29.67 tails P3 = 33.33 tails P4 = 31.33 tails
3	Gafur, G., & Anshary, A. (2022).	5 treatments namely: A0 = Control A1 = Patchouli Extract A2 = Basil Extract A3 = Lemongrass Extract A5 = Lime Extract	According to the study, lemongrass leaf extract proved to be more effective in reducing the frequency of fruit fly infestation on chilli plants. Observations showed that the highest average fruit fly attack occurred in the control group with a percentage of 6.83%, while the lowest attack occurred in the treatment group using

			lemongrass leaf extract, with a percentage of about 2.16%.
4	Jafar, A. N. (2023).	P0 (-): sterile water (control), P0(+): Decis 25 EC insecticide, P1: 4% citronella bionsecticide nanoparticles, P2: 6% citronella bionsecticide nanoparticles, P3: 8% citronella bionecticide nanoparticles, P4: 10% citronella bionsecticide nanoparticles each with three replicates.	The use of bionsecticide nanoparticles from citronella is effective in controlling B. carambolae. The application of citronella nanoparticles at a concentration of 10% (P4) succeeded in reducing the intensity of fruit fly attacks by 19.44% with an average number of larvae found as many as 2 individuals.
5	Ginting, Sumantri, & Simbolon (2021).	A1 (Synthetic Methyl Eugenol Attractant 800 g/l), A2 (Pattoouli Oil), A3 (Nutmeg Oil), A4 (Pattoouli Flower Oil) , A5 (Cinnamon Oil), A6 (Ylang Ylang Flower Oil), A7 (Citronella Oil), A8 (Lemon Oil) A9 (Vutive Root Oil).	The effectiveness of different types of attractants in terms of catchability greatly affects fruit flies. Treatment A1 showed a significant difference compared to treatment A2, and both were also significantly different from treatments A3 to A9. In treatments A3 to A9, there was no significant difference because no fruit flies were caught in the bottle, considering that the active ingredients used are repellent so that fruit flies are not interested in approaching the aroma. The average number of flies caught in treatment A1 was 11.27, while in treatment A2 the average number of flies caught was 5.55.

6	Lestari, Artayasa, & Sedijani, P. (2020)	Citronella ethanol extract, basil leaf extract or a mixture of the two (1:1) were dripped onto a piece of cotton and then placed in the trap before being placed on the tree. at concentrations of 15%, 30% and 45% were dripped onto a piece of cotton wool and then put into the trap before being placed on the tree.	Based on the observation results, the number of fruit flies caught after being treated with lemongrass stem extract was 520 individuals, with basil leaf extract was 402 individuals, and with mixed extract of lemongrass pseudo-stem and basil leaves was 376 individuals. Meanwhile, no fruit flies were caught in bottles containing only water (control).
7	Rustam, R., & Dewanti, A. (2024).	The lemongrass oil doses given to the treatments were 0 ml/trap, 0.25 ml/trap, 0.50 ml/trap, 0.75 ml/trap, and 1 ml/trap.	A dose of 0.50 ml citronella oil was the best dose as an attractant because it was able to attract fruit fly pests with an average total population of 11.75 individuals for seven days. There were 10.75 trapped B. carambolae species and 1 trapped B. umbrosa species. Overall, the 0.50 ml dose attracted 47 fruit flies for 7 days.
8	Husamah et al., (2023)	The study utilized clove leaves, lemongrass leaves, guava leaves, pandan leaves, lime leaves, pineapple, and star fruit. Two methods were employed for trapping insects: trap bottles and adhesive traps.	The findings indicated that lemongrass leaves, clove leaves, guava leaves, and pineapple were effective in trapping fruit fly pests. Lemongrass leaves proved to be the most effective individually, with 27 catches in a week. The most successful combination was fly glue with clove leaves, guava leaves, and pineapple, yielding over 100 catches in a week.
9	Hasyim, A., Setiawati, W.,	A1 : Citronella oil 10% A2 : Citronella oil 15%	The highest mean larval repellency was found in the

	Jayanti, H., & Krestini, E. H.	A3 : Neem extract 10% A4 : Neem extract 15%	15% essential oil treatment (A2) at 61.11%. The second highest larval repellency of C. cephalonica was in neem leaf extract treatment (A4) at 55.16%. The 10% essential oil treatment (A1) repelled 22.22% of larvae and the lowest repellency was found in the 10% neem leaf extract treatment A3 at 11.15%.
10	Arfianto, F. (2016).	citronella extract concentrations of 25 ml, 50 ml and 75 ml and 100 ml mixed with clean water	For the control of brown leaf insect pests on chillies, it turns out that using a concentration of citronella extract of 75 ml and mixed with 100 ml of clean water can reduce brown leaf insect pests effectively compared to other concentrations.
11	Supriyatdi et al., (2023)	P0 = Control P1 = Lemongrass Leaf Extract P2 = Noni Leaf Extract P3 = Noni Leaf Extract + Lemongrass leaf	Effectiveness based on mortality P0 = 1,52 P1 = 28,79 P2 = 24,24 P3 = 39,39
12	Tyas (2022)	A1 (Control), A2 (Citronella 1 cc/L), A3 (Citronella 3 cc/L), A4 (Citronella 5 cc/L), A5 (Insecticide made from BPMC).	The study also showed that citronella concentration of 1 cc/L already had the ability to kill leafhoppers as much as 18% on the first day and 35% on the fourth day. The concentration of citronella 3 cc/L has the ability to kill leafhoppers as much as 41% on the first day and 83% on day four. The concentration of citronella 5 cc/L has the ability to kill leafhoppers as much as 76% on the first day and 96% on day four.

13	Setiawan (2021)	1% concentration 0.5% concentration 0.25% Concentration 0.125% concentration	From the experiment of vegetable insecticide of citronella oil at the observation of 24, 48, 72 JSP, 1% concentration resulted in mortality of 53.33; 93.33 and 100%, respectively, at a concentration of 0.5% resulted in mortality of 50.00; 56.67 and 66.67, at a concentration of 0.25% produced mortality respectively 33.33; 43.33 and 56.67, and at a concentration of 0.125% produced mortality respectively 33.33; 40.00 and 56.67% in the control mortality respectively 0.00; 0.00; and 6.67. Mortality is influenced by concentration, the higher the concentration of vegetable insecticides, the greater the mortality rate, so that citronella vegetable insecticides can control / reduce brown stem leafhopper pests.
14	Salasiah et al., (2018)	White Pepper (10 g) Black Pepper (10 g) Cayenne Pepper (10 g) Lemongrass (10 g)	the highest mortality trend was found in the black pepper powder treatment, followed by white pepper, cayenne pepper and the lowest in the citronella treatment.
15	Tiana et al., (2021)	Citronella Essential Oil 0% (S0), 1.4% (S1), 1.8% (S2), 2.2% (S3) and 2.6% (S4) Kitchen Lemongrass Essential Oil	In the repellency test of citronella and kitchen lemongrass essential oils, treatments S5 and D5 (25%) were effective as repellents of T. castaneum at 24 hours after treatment.

		0% (D0), 2.6% (D1), 3.2% (D2), 3.8% (D3) and 4.4% (D4)	
16	Mugiasih et al., (2020)	0.25; 0.5; 0.75; and 1 ml per litre of water	1 ml concentration was able to killed green leafhoppers by more than 90% at 72 hours after application, significantly different from the concentration of 0.25 ml and also the control.
17	Wangi et al., (2022)	The citronella concentrations used were 0% (control), 5%, 10%, 15% and 20%.	The highest mortality was found at a concentration of 20% which caused larval mortality of up to 95%.
18	Salaki & Watung (2020)	concentrations of 10%, 25%, 40%, 55% and 70% and Controls	The results showed that for the insect spraying method, 5 treatments of Lemongrass concentration can cause 13.3-67.7% mortality, the plant spraying method 6.7-50.0%, the method of spraying insects on plants 23.3-86.7% at 72 hours after application.
19	Primanda (2022)	control, 20% soursop leaf extract, 20% citronella leaf extract, and a combination of 20% soursop leaf extract and 20% citronella.	The results showed that vegetable insecticides of soursop leaves and citronella leaves were effective and gave a very significant effect on the death of armyworms (S. litura F.) with the fastest LT_{50} value of 23 hours in the treatment of 20% citronella leaf extract,
20	Haerul et al., (2016)	A= Control, B= Garlic extract 100 ml/plant, C= Neem extract 100 ml/plant, D= Soursop extract 100 ml/plant.	the highest number of pest populations in the control treatment (A) which is 7.25 aphids and whitefly which is 5.25 pests. While

			the lowest number of pest populations in the treatment of 100 ml neem extract (C), namely 3.25 aphids and whitefly, namely 2.75 pests on red chilli plants.
21	Raunsay (2021)	Lemongrass stem extract 25%, 20%, 15%, 10% and 0% (control)	With the conclusion that lemongrass stem extract has the effectiveness in killing aphids at a concentration of 20% which can be used as a natural pesticide because it is close to 50% mortality at LC50.
22	Sari et al., (2022)	lime leaf extract (Citrus aurantifolia), lemongrass leaf extract (Cymbopogon citratus), clove leaf extract (Syzygium aromaticum L.) and pandan wangi leaf extract (Pandanus amaryllifolius).	The results showed that the concentration of lemongrass leaf crude extract of 4% was the best concentration with repellent effect on rice ticks.
23	Bate (2019)	E1 (tobacco extract) E2 (clove extract) E3 (citronella extract) E4 (neem extract) E5 (red chilli extract).	Effect of plant-based pesticide types on mortality of Spodoptera litura F armyworm pests in field mustard plants E1 = 7625 E2 = 66.75 E3 = 63.5 E4 = 61.5 E5 = 64
24	4th and Octiyanti (2021)	0.125 ml per trap, 0.250 ml per trap, 0.375 ml per trap, 0.500 ml per trap, and 0.625 ml per trap. trap, and 0.625 ml per trap.	The results showed that the species that attack citrus plants are B. carambolae, B. papaye and B. umbrosa. The dose of lemongrass oil that was most capable in trapping the most fruit flies was the 0.625 ml trap with an average fruit fly population of 18.5 for seven days.

25	Hastuti & Hasan (2015)	P0 = Control, PL = Galangal Rhizome 100 g/l, PB = Babadotan Leaf 100 g/l, PS = Lemongrass Leaf 100 g/l and this was repeated four times.	The application of lemongrass leaf solvent can suppress pest populations, while babadotan leaves act as an attractant to Helopeltis sp. in cocoa.

Discussion

Types of Plants Applied with Citronella Essential Oil

Citronella essential oil has been used in pest control for chili plants (*Capsicum annuum*), which are susceptible to various pests such as thrips, aphids, and fruit flies. The use of citronella essential oil as a natural repellent helps reduce the population of these pests, which often cause damage to chili leaves and fruits. In addition to reducing the use of chemical pesticides, the application of citronella essential oil also has the potential to improve the yield and quality of chili harvests.

Cocoa (*Theobroma cacao*) is a highly valuable plant often attacked by pests such as cocoa pod borer (*Conopomorpha cramerella*). These pest attacks can decrease the quality of cocoa beans and cause economic losses for farmers. Citronella essential oil, with its repellent properties, can help prevent these pests from approaching and damaging cocoa pods. Using this essential oil not only protects the plants but also contributes to more environmentally friendly cocoa production.

Onion storage facilities (*Allium cepa*) can also benefit from citronella essential oil to control storage pests such as warehouse beetles and mites. These pests often cause significant damage to stored onions, reducing their shelf life and quality. Applying citronella essential oil as a repellent in onion storage can reduce pest infestations and maintain the quality of onions during storage.

Starfruit (*Averrhoa carambola*) and papaya (*Carica papaya*) are tropical fruit plants frequently attacked by fruit flies and aphids. Pest attacks can cause fruit damage, reduce market value, and lower harvest yields. Citronella essential oil can be used as a repellent agent to prevent these pests from approaching starfruit and papaya plants. Thus, the use of this essential oil can help farmers reduce losses due to pest attacks and increase fruit productivity.

Rice (*Oryza sativa*) and corn (*Zea mays*) are major food crops that often face pest problems such as brown planthoppers, stem borers, and armyworms. Pest attacks on rice and corn can cause significant yield reductions and impact food security. The use of citronella essential oil as a natural pest control agent for rice and corn can reduce pest attacks and support sustainable agricultural practices. Additionally, citronella essential oil can also be applied to citrus plants (Citrus spp.) to control whiteflies and other sucking pests that can cause diseases and damage to citrus fruits.

Types of Pests Controlled

Fruit Flies and Spodoptera frugiperda

Fruit flies (*Bactrocera spp*.) are one of the main pests attacking various types of fruits, including chili, starfruit, and papaya. Fruit fly attacks cause significant fruit damage and reduce the economic value of the harvest. Citronella essential oil has effective repellent properties to prevent fruit flies from approaching plants, thus reducing fruit damage. Spodoptera frugiperda, also known as the fall armyworm, is a pest that damages corn and various other crops. This pest causes damage to corn leaves and ears, resulting in reduced yields. The application of citronella essential oil can repel this pest, reducing the damage caused by Spodoptera frugiperda.

Armyworms and Whiteflies

Armyworms (*Spodoptera litura*) are pests that attack various crops, including vegetables and staple crops like rice. These caterpillars cause extensive leaf damage, which can hinder plant growth. Citronella essential oil can be used as a repellent agent to reduce armyworm attacks, thereby protecting plants and improving yields. Whiteflies (*Bemisia tabaci*) are pests that attack horticultural crops and cause various plant diseases, including viruses. The use of citronella essential oil can help control whitefly populations, reducing the risk of disease spread, and maintaining plant health.

Mealybugs and Aphids

Mealybugs (*Pseudococcus spp*.) and aphids (*Aphididae*) are pests that suck plant sap, causing leaf curling, stunted plant growth, and the spread of viral diseases. Citronella essential oil has repellent effects against mealybugs and aphids, which can prevent them from attacking plants. Controlling these pests with citronella essential oil not only protects plants but also reduces the use of chemical pesticides that negatively impact the environment and human health.

Fruit Suckers (Helopeltis spp.) and Aphids

Fruit suckers (*Helopeltis spp*.) are pests that attack cocoa plants and cause significant fruit damage. Pest attacks can reduce the quality of cocoa beans and decrease yields. Citronella essential oil can be used to control fruit sucker populations by repelling these pests from cocoa plants. Additionally, aphids (*Aphididae*) are common pests that attack various types of plants, including vegetables and fruit crops. Applying citronella essential oil can help reduce aphid attacks, maintain plant health, and increase productivity.

Rice Weevils, Sitophilus zeamais, and Brown Planthoppers

Rice weevils (*Sitophilus oryzae*) and Sitophilus zeamais are storage pests that damage grains such as rice and corn during storage. These pests cause significant economic losses by reducing the quality and quantity of stored harvests. Citronella essential oil can be used as a natural repellent to control these pests in storage facilities. Brown planthoppers (*Nilaparvata lugens*) are important pests in rice plants that cause damage to stems and reduce yields. Applying citronella essential

oil to rice plants can help reduce brown planthopper populations, protect rice plants, and increase rice production.

Comparison Plant Extracts

1. **Ageratum conyzoides and Clove Extracts**

   The extracts of *Ageratum conyzoides* (goatweed) leaves and cloves (*Syzygium aromaticum*) are often used as natural pest control agents. Goatweed leaves contain compounds like coumarin and flavonoids, which have insecticidal and repellent properties, effective in controlling pests such as aphids and caterpillars. Clove contains eugenol, a compound known for its strong insecticidal activity. Clove essential oil can repel pests like fruit flies and whiteflies, thus protecting plants from the damage caused by these pests.

2. **Neem and Noni Extracts**

   Neem (*Azadirachta indica*) and noni (*Morinda citrifolia*) extracts are also popular in pest control. Neem extract contains azadirachtin, which is highly effective in disrupting the life cycle of pests and acts as a repellent, antifeedant, and growth inhibitor. Noni leaves have antimicrobial and insecticidal compounds that help control pests such as aphids and whiteflies. These extracts provide natural and sustainable solutions for pest control in crops.

3. **Citrus and Pandan Leaves Extracts**

   Extracts of citrus leaves (*Citrus spp*.) and fragrant pandan leaves (*Pandanus amaryllifolius*) are also used as pest control agents. Citrus leaf extract contains limonene, a compound with repellent and insecticidal activity against various pests. Fragrant pandan leaves contain natural compounds like alkaloids and flavonoids that are effective in repelling insects. The use of these extracts can help control pest populations without harming the environment.

4. **Chili and Garlic Extracts**

   Chili (*Capsicum spp*.) and garlic (*Allium sativum*) extracts have long been used in pest control. Capsaicin in chili acts as a strong repellent against insects, while allicin in garlic has insecticidal and fungicidal properties. These extracts can be used to control pests such as aphids, caterpillars, and whiteflies, as well as protect plants from disease attacks.

5. **Soursop Leaves, White Pepper, Black Pepper, and Basil Extracts**

   Extracts from soursop leaves (*Annona muricata*), white pepper (*Piper nigrum*), black pepper (*Piper nigrum*), and basil (*Ocimum basilicum*) offer various benefits in pest control. Soursop leaves contain acetogenins, compounds with strong insecticidal activity against various pests. White and black pepper extracts contain piperine, which is effective in repelling insects. Basil extract has natural repellent properties that can help control pests such as aphids and whiteflies.

6. **Synthetic and Other Essential Oils**

   In addition to these plant extracts, various synthetic substances and other essential oils are used as comparators in pest control. These include

Synthetic Methyl Eugenol Attractant 800 g/l, Patchouli Oil, Nutmeg Oil, Patchouli Flower Oil, Cinnamon Oil, Ylang Ylang Flower Oil, Citronella Oil, Lemon Oil, and Vetiver Root Oil. Methyl eugenol is a strong attractant for fruit flies, while essential oils from patchouli, nutmeg, patchouli flower, cinnamon, ylang ylang, citronella, lemon, and vetiver have various insecticidal and repellent properties that can be used to effectively repel and control pests. The use of these various extracts provides farmers with a range of options for sustainable and environmentally friendly pest management.

The use of essential oils as pest control agents faces various challenges that need to be addressed to ensure their effectiveness and sustainability. One of the main challenges is the consistency of chemical composition where variations in plant sources, growing conditions, and extraction methods can affect the quality and effectiveness of essential oils. In addition, rainfall also affects the effectiveness of citronella essential oil as the content may be reduced by rainwater.

Other challenges including the instability of essential oils in the environment such as degradation by sunlight or oxygen may also limit their use. Finally, the economic burden of essential oil production and application on a large scale can be a significant constraint, covering the costs of extraction, processing, and distribution (Hao, 2019). Therefore, although essential oils have potential as a natural and environmentally friendly pest control solution, these challenges need to be addressed through further research and development.

CONCLUSION

Overall, this research demonstrates that the use of citronella essential oil has the potential to be an effective method for controlling pest attacks on crops. With its repellent properties, citronella essential oil can drive pests away from plants, making it a potential environmentally friendly and sustainable alternative for pest control. However, this research also highlights some challenges that need to be addressed, such as the stability of essential oils in the open environment and the need for frequent reapplication. Therefore, while citronella essential oil offers promising potential in controlling fruit flies, an integrated approach that considers relevant environmental and technical factors is necessary to maximize its effectiveness on a larger agricultural scale. Thus, this research provides an important foundation for the development of more sustainable and environmentally friendly pest control strategies in agriculture.

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