The potency of Citronella oil and Clove oil for pest and disease control in tropical fruit plants

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Abstract. One of the main obstacles in tropical fruit cultivation is pests and diseases. It is necessary to apply safe pest control for consumers and the environment. Indonesian Tropical Fruit Research Institute (ITFRI) studies the potency of several essential oils for pests and disease control on tropical fruit for many years. These studies aimed to evaluate the effectiveness of Citronella and clove oils in controlling pests and diseases. These studies were conducted in laboratory and field conditions by comparing the development of pest and disease symptoms on essential oils treated plants and untreated control or among several essential oils treated plants. The results showed that clove oil could inhibit the development of powdery mildew in rambutan and Phytophthora palmivora that caused diseases in durian. Citronella oil decreased ant attack and scarring symptoms on mangosteen fruits. Research activities to test the effectiveness of these two essential oils in field conditions need to be intensified so that this technology is truly effective, efficient, and right on target.

1. Introduction
Tropical fruit is one of the agricultural products that has a major contribution to people's lives, especially in relation to health and the economy. In terms of health, fruit is an important source of vitamins, minerals and other health elements that are needed in human life. Meanwhile, in terms of the economy, farming or fruit agribusiness makes a real contribution to improve the welfare of these business actors. However, in the production process there are several obstacles that are often encountered and can become obstacles to produce optimal products both in quantity and quality. In fact, these obstacles are also an obstacle in trade for foreign markets (exports). One of the main obstacles is the presence of pests and plant diseases. Decreasing on fruit quality and quantity that mainly caused by plant pests and diseases directly affects farmer’s income [1].

Currently, the efforts to suppress horticultural plant pests and diseases are still based on chemical pesticides. Several advantages of using chemical pesticides such as quick response on pest mortality, easy application and easy found on the market. The side effects of using this kind of pesticides such as environment harmful, human health problem [2], pest resistance, killing of non-target insects, and the presence of residues in fruit products [3] are not considered in the process of crops cultivation in general, especially fruit.

For this reason, research efforts are needed to obtain pest and disease control technology by taking into account developing national and international issues. One of these issues is the demand for food products that are safe for consumers and the environment, technology based on local resources, the need for organic technology and optimization of the bio-industry. Based on the development of the latest issue, one technology that needs to be intensified in research is the use of essential oils as a
control agent for pests and plant diseases including fruit trees. The results of the research that had been done informed that essential oils have the potential to control pests and plant diseases [4,5].

Essential oils of citronella and cloves have the ability to inhibit or suppress the development of pathogens that cause plant diseases and pests. Clove oils and their vapors had fungicidal activity against the dermatophytic fungus *Candida albicans*, *Epidermophytion floccosum*, *Microsporum audouinii*, *Trichophytion mentagrophytes*, and *Trichophytion rubrum* [6]. Citronella oil has the ability to kill eggs and to *repel Helicoverpa armigera* [7]. Furthermore, citronella oil kill and repel egg laying on the host plant of *Bemisia tabaci* [8]. In addition, the essential oil mixture of citronella and clove has antifungal activity which inhibit the development of disease pathogens. Essential oil mixture of clove and citronella is effective to inhibit mycelium growth and sporulation of pathogenic Fov. F117. An organic fungicide containing mixture of clove oil and citronella oil shows high effectiveness in reducing the intensity of the attack of BBV pathogens, especially at the application dose of 5 ml/l [9].

Based on these results, Indonesia Tropical Fruit Research Institute (ITFRI) followed up to test the effectiveness of several essential oils, especially clove and citronella oils, in controlling pests and diseases on tropical fruit plants. These essential oils were considered as potential plant pest and disease control materials because of their effectiveness and cheaper prices compared to most chemical pesticides.

2. Materials and methods

2.1. Materials

Materials used in this study were plant materials (mangosteen and rambutan), *Phytophthora* isolate, citronella and lemongrass oils, potato dextrose agar media and other supporting materials.

2.2. Methods

2.2.1. *Citronella oil to control scarring symptom on mangosteen fruit*. A research to control *Thrips* causing scarring symptom on mangosteen had been done in farmer field at Bogor (West Java) and Payakumbuh (West Sumatera) on January to December 2015. The mangosteen plants used were approximately 6 years old. The treatments were control (without citronella oil application) and weekly application of Citronella oil at dose 2 cc/l. Each treatment was repeated 8 times. Citronella oil was applied when the flowering stage started until one week before harvesting time. Observations were made on the percentage of the number of fruits with scarring symptom severity >10%. Observations were conducted at harvesting time.

2.2.2. *Citronella oil for ant control in mangosteen*. The study was carried out on 6 years old mangosteen plants in farmer fields at Bogor (West Java), Payakumbuh (West Sumatera) and Sijunjung (West Sumatra) on January-December 2015. The application of citronella oil spray was carried out weekly at a dose of 2 cc/l starting from fruitset up to 1 week before harvesting time. The treatments were control (without citronella oil application) and weekly application of Citronella oil at dose 2 cc/l. Each treatment was repeated 8 plants. Observations were conducted at harvesting time on the total number of fruits and number of fruits attacked by ants per plant. The t-test was carried out to find out the significant difference between both treatments.

2.2.3. *Essential oils vapour to inhibit the growth of Phytophthora palmivora on a laboratory condition*. The research aimed to check the effect of several essential oils on the growth of *P. palmivora* isolate was carried out at Laboratory of Plant Protection, ITFRI. A complete randomized design with 5 treatments and 5 replications was used in this study. The treatments were: a. clove oil, b. citronella oil, c. patchouli oil, d. vetiver oil and control (without essential oil). The isolate was cultured on PDA media and it was not in direct contact with essential oil but it was only affected by essential oil vapour. Each petri dish added with 18 ul of essential oil based on treatment used. Observation was made on growth diameter of isolate after treated with several essential oils.
2.2.4. Clove oil to control powdery mildew of rambutan fruits. The study was conducted in Aripan experimental station of ITFRI, West Sumatra, Indonesia on July-August 2020. The rambutan plants used in this study were 4 years old. The treatments were doses of clove oil application that consisted of 0 (control), 1, 2 and 4 cc/l. The applications were started when fruit set until one month later. Each treatment was repeated 4 times. Observations were performed every three days on number of fruits and number of fruits attacked by powdery mildew.

3. Results and discussion

3.1. Citronella oil to control scarring symptom on mangosteen fruit

The scarring symptom on mangosteen rind is caused by thrips. To suppress this pest attack, citronella oil was applied at a dose of 2 cc/l which was applied once a week. Based on the test result, it could be seen that the percentage of the number of mangosteen fruits with scarring symptom more than 10% on plants applied with citronella oil was 20% lower compared to untreated control (Table 1). Probably, application of citronella oil reduced population of thrips causing scarring symptom.

Table 1. Percentage of mangosteen fruits with scarring symptoms on the skin more than 10%

| Treatments                      | Bogor  | Payakumbuh |
|---------------------------------|--------|------------|
| Citronella oil application      | 30.7   | 63.7       |
| Without citronella oil application | 50.0   | 88.4       |

![Fruits without citronella oil application (a) and with citronella oil application (b)](image)

3.2. Citronella oil for ant control in mangosteen

Application of Citronella oil to control ant on mangosteen had been carried out at Leuwiliang, Payakumbuh and Sijunjung. The results showed that the percentage of the fruit attacked by ants on the mangosteen plant which was applied with citronella oil was lower than mangosteen plant without application of citronella oil (Table 2). This fact is seen in testing at the location of Leuwiliang, West Java and Payakumbuh, West Sumatra. This can happen because citronella oil had insect repellent properties due to the presence of citronellal compounds and irritation properties on the skin so that it can damage the ant integument causing death.

Table 2. Percentage of mangosteen infected by ants in the blocks that received treatment of citronela oil and without citronela oil treatment

| No  | Locations              | Percentage of fruits attacked by ants (%) | Citronella oil application | Without citronella oil application |
|-----|------------------------|------------------------------------------|-----------------------------|-----------------------------------|
| 1.  | Leuwiliang, Bogor (West Java) | 14,7 a*                                 | 54,4 b                      |
| 2.  | Payakumbuh (West Sumatra)     | 6,2 a                                    | 65,6 b                      |
| 3.  | Sijunjung (West Sumatra)      | 0,57 a                                   | 0,65 a                      |

*Numbers followed by the same letters on the same row are not significantly different each other based on DNMRT α 5%.
Figure 2. Mangosteen fruits attacked by ants (a) dan Mangosteen fruits that were free from ants (b)

3.3. Essential oils vapour to inhibit the growth of Phytophthora palmivora on a laboratory condition
The result was that the vapor of clove and citronella oil was able to inhibit the development of *P. palmivora* fungi. The growth of this fungus was slower in the clove oil (C) and citronella oil (S) treatment compared to the untreated (K), patchouli oil (N) and vetiver oil (A) during the observation (Figure 3).

Figure 3. Diameter of *P. palmivora* in Potato Dextrose Agar media with addition 18µl of several essential oils. Note: K = control, N = patchouli oil, S = citronella oil, C = clove oil and A = vetiver oil.

3.4. Clove oil to control powdery mildew of rambutan fruits
Powdery mildew on rambutan fruit treated with clove oil 1 and 2 cc/l was lower of compared to untreated control. Whereas higher damage of the fruits was observed at treatment of clove oil 4 cc/l. It was possibly due to phytotoxicity of high dose of clove oil applied (Figure 4). The rambutan fruits that were free and attacked by powdery mildew were shown at Figure 5. The mechanism of clove oil in inhibiting the development of disease-causing fungi was reported by inhibiting spore germination and mycelium development, deleterious morphological changes in cellular structures and cell surface alterations.
Figure 4. Fluctuation of powdery mildew disease percentage attacked on rambutan fruits treated with 1, 2, 4 cc/l clove oil and untreated control (K).

Figure 5. Rambutan fruits were free from powdery mildew attacked (a) and attacked by powdery mildew (b).

3.5. Discussion

The mode of actions of citronella oil in controlling pests were as a contact repellent, feed deterrent, and killer. The main components of citronella oil were citronellal, citronellol, and geraniol. These three compounds have potential as insect repellents [10]. Vapour from citronellal compounds has been well recognized as a repellent for the presence of mosquitoes [11]. Geraniol has a higher repellent activity against mosquitoes than citronella and linalool [12]. Citronella oil was repellent against the sucking pests of *Helopeltis antonii* [13]. Vapour of citronella oil was also known to be repellent against larvae of shallot warehouse pest *Ephesia cautella* [14]. Citronella oil which has high insect repellent power has also been shown against the mealybug *Bemisia tabaci* which attacks chili plants [8].

The ability of citronella oil to cause death in insects is also confirmed by several previous research results including *Helopeltis antonii* [13], *Diconocoris hewetti* (pepper flower-sucking pest) [15], *D. piperis* [16]. Citronella oil has an irritating effect, causing damage to the integument and a high transpiration process. This can result in the death of the insect. The results of other research also informed that citronella compounds are stomach poisons that can kill thrips in jatropha plants [17].

Citronella oil as a feed deterrent has been proven in several research results. Spraying application of citronella oil had an effect on the ability of *P. marginatus* mealybugs to produce progeny. Mealybugs treated with citronella oil produce fewer progeny than without citronella oil treatment. This is because the citronellal contained citronella oil is antifeedant, which causes a reduction in insect appetite, which causes insect consumption on host plants to be reduced, thus disrupting growth and reducing insect reproduction. Citronella oil was repellent, antifeedant and deterrent oviposition for insects [18,19].
Lemongrass (*Cymbopogon citratus*) essential oil exhibited the strongest antifungal effect followed by peppermint (*Mentha piperita*) and eucalyptus (*Eucalyptus globulus*) essential oil. *Candida albicans* cells treated with lemongrass essential oil at MIC level in liquid and vapour phase showed prominent shrinkage and partial degradation. Lemongrass essential oil is highly effective in vapour phase against *C. albicans*, leading to deleterious morphological changes in cellular structures and cell surface alterations [20]. Both clove essential oil and its volatile vapour strongly inhibit spore germination and mycelial growth of the dermatophytic fungi tested. The volatile vapour of clove essential oil showed fungicidal activity whereas direct application of clove essential oil showed fungicidal activity [6]. *In vitro* study revealed that lemongrass oil vapour at all concentrations tested (33, 66, 132, 264 and 528 μl/l) suppressed the mycelial growth and conidial germination of *Colletotrichum gloeosporioides* [21].

Recently, agriculture sector is mainly directed towards sustainable agriculture. Selection of environment friendly pesticides is one of components to reach sustainable agriculture. Utilization of essential oils as pests and diseases control agents is one of options that can be chosen. It provides safe food products for both consumers and environment, technology based on local resources, organic technology and optimization of bio-industry.

4. Conclusions

Based on the results of both laboratory and field studies, citronella and clove oils could be considered as good alternative control agents for tropical fruit pests and diseases. Citronella oil decreased scarring symptoms of mangosteen fruit causing by thrips and controlled the ant attack on mangosteen. Whereas clove oil inhibited the growth of *P. palmivora*, a pathogen on durian, and powdery mildew on rambutan.

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