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The Effect of Citronella Essential Oil on Controlling the Mango Red-Banded Caterpillar, *Noorda albizonalis* Hampson (Lepidoptera: Pyralidae)

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Abstract

Mango fruit borer (red-banded caterpillar) *Noorda albizonalis* is one of the important pests detrimental to the cultivation of mangoes. A control measure to reduce the level of attacks is necessary in order to prevent a high loss of yield. Plant based pesticides (as citronella essential oil) are potential pest control agents that are environmentally friendly and are safer than the currently used pest-control agents. The present paper was conducted at the Cukurgondang Research Station, Pasuruan-East Java, Indonesia. The experiment was arranged in a randomized block design with 8 replications in which the treatments were concentrations of essential oil 2, 4, 6 cc/l and control (untreated). The parameters observed were the intensity of fruit borer attack and the economic profit obtained from the application of citronella oil. The results showed that the application of citronella essential oil could reduce the rate of fruit borer attack and the production loss on mango, mainly at a concentration of 6 and 4 cc/l. The profit per hectare gained from its application at a concentration of 6 and 4 cc/l was IDR 3,596,000 and IDR 2,864,000, respectively (US$1 = IDR 9,700).

Keywords: Mango, *Noorda albizonalis*, Citronella Oil.

1. Introduction

Mango plays an important role in the life of Indonesian people in terms of health and economy. Mango fruits contain the nutrients required to support human health. These nutrients are protein, fat, calcium, phosphorus, iron, water, vitamins A, B, C, and E. From an economic perspective, mango farming is promising because it can provide high profits due to the benefit/cost ratio of 3.96. In Indonesia, the production of mangoes has steadily risen from year to year. During the years 2007-2011, mango hectarage continuously increased in all the 33 provinces (Agricultural Statistics, 2012). In terms of production and the export value of fruit crops, mango ranks second in production next to banana and second in export value next to mangosteen.

Despite the increase in the total number of production and area, the productivity of mango per area unit has not increased yet. The average productivity per hectare is approximately 5 tons, much lower compared to other mango growing countries that have reached 12 tons/ha. The main reason behind the low yield is the presence of pests and diseases. One of the important pests affecting mango production is the fruit borer (Red-Banded Caterpillar), Noorda albizonalis Hampson. The yield losses caused by this pest are approximately 10-15% (Anonymous, 2002). This pest should be controlled (Royer, 2009). To date, the control measures used to suppress the pest still mainly depends on the use of pesticides.

The control techniques applied should be safe and environment-friendly to support the program of generating agricultural products that are safe for both the consumers and the environment. One of them is the use of the potential natural pesticides that have short persistence and no residual negative effects but are effective to control pests. Citronella essential oil is one of the natural ingredients, contained in Lemongrass, that have a potential as control agents of pests and diseases. This is based on the results of previous studies revealing that the citronella essential oil has properties as a bactericidal, fungicidal, and insect repellent (Isman, 2000; Kazuhiko *et al.*, 2003; Zaridah *et al*., 2006; Van Tol *et al.*, 2007; Catherine and Hamraoui, 1995). However, to date, there is no information about the use of citronella essential oils for controlling mango fruit borer. Therefore, the current study is intended to evaluate the effectiveness of using citronella essential oils in controlling mango red-banded caterpillar in mango orchard. It is expected that citronella essential oil can reduce mango fruit borer attacks due to its repellent properties.

2. Materials and Methods

The study was carried out at the Cukurgondang Research Station, Pasuruan - East Java from July to December 2011. The problem of red-banded caterpillar almost always occurs in every fruit season in

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Cukurgondang and the surrounding areas. Therefore, the study was carried out in that area. There were four treatments of citronella oil concentration for controlling red-banded caterpillar, i.e., 2 cc/l, 4 cc/l, 6 cc/l, and 0 cc/l (control). An adhesive material, methyl chlor, was added to the water in order to form an emulsion of citronella oil with water. As citronella oil was added with an adhesive material to dissolve into the water, the control treatment was just water with an adhesive material. A concentration of an adhesive material added into water was 3 cc/l. Essential oil was extracted from the leaves and stems of *Cymbopogon nardus* Rendle by a steam distillation process. The main active constituent is citronellal. Mango plants used were Arumanis variety of 20 years old with the height of approximately 8 m. The study was arranged in a randomized block design with 8 replications. Spraying application was at 6 days interval. This interval was based on the results of a preliminary test indicating that the persistence of citronella essential oil ranged from 5 to 7 days. Spraying began when the fruits were 3-5 mm (soybean size) up to 1 week before harvest. A power sprayer that has an extension stick (3 m in length) was used to spray the entire plant canopy (up to 7 m). The maintenance covering fertilization, irrigation, and weeding was steadily conducted to keep the optimum plant growth.

The parameters measured were red-banded caterpillar attack rate, yield loss, and profits of spraying the citronella oil. Since the mango trees were high, the attack rate was determined by counting the fallen fruits caused by red-banded caterpillar per tree sample. Observations were made every week starting from one week after the first application of citronella oil to harvest. The yield loss was calculated using the formula:

$$\text{Percentage of yield loss} = \frac{A}{B} x100\%$$

where **A** = accumulated number of attacked fruits per mango tree since one week after the first application of citronella oil to harvest, **B** = total number of fruits per tree derived from the number of harvested fruits plus the number of fallen fruits since one week after the first application of citronella oil to harvest. All the percentage data collected were subjected to one-way analysis Of variance (ANOVA). The means were separated using the Least Significant Difference (LSD) test at the 5% significance level (Gomez and Gomez, 1984).

The economic profit was assessed by calculating the difference of production, revenue, and additional costs involved in the application of citronella oil compared with no treatment (control). Additional cost of citronella oil applications includes the cost of labor and citronella oil. Labor cost per day was IDR 50,000 (Indonesian Rupiah) and the citronella oil price was IDR 80.00/cc. Revenue was calculated under the assumption of mangoes Arumanis price of IDR 5,000/kg.

3. Results and Discussion

The results of this study indicate that the use of citronella essential oil could reduce the level of the attack intensity of *N. albizonalis* on the mango crop. This could be seen in the data on the number of fruits attacked on all observation dates, especially at a concentration of 6 cc/l citronella (Figure 1).

Figure 1 shows that *N. dorsalis* began attacking mango fruits when fruits are at the young phase until the fruits ripened. Periods of severe attacks took place at the beginning of the young fruit and at the fruit development phase until fruits matured.

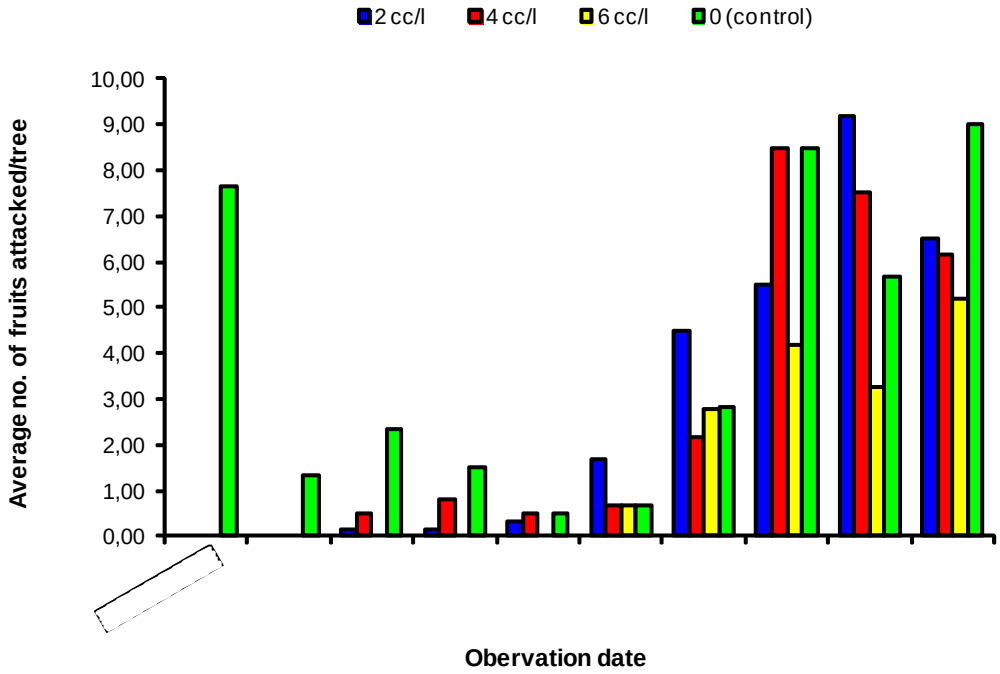


Figure 1. Fruit borer attack rate at each concentration treatment of citronella oil

Therefore, the period when the arumanis fruits are still at a medium size to the period of their maturity is a critical phase for pest attacks. In the young fruit period, from the date of 11/7/2011 to 19/08/2011, citronella

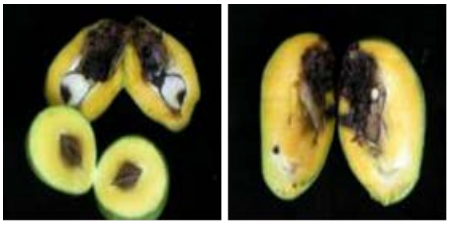
essential oil showed high effectiveness in suppressing the attack of mango fruit borer. This is demonstrated by the fact that, in general, the fruit borer attack in this period was always lower in the treatment of citronella essential oil compared to the control.

The effectiveness of citronella decreased in suppressing the pest attack when fruits were in the middle phase of development up to harvest (from August 25th to October 19th, 2011). This was indicated by the rates of the fruit borer attack that continued to increase until harvest. Nevertheless, the application of citronella essential oil, particularly for the 6 cc/l concentration was still more effective to lessen pest attack rate compared to control.

Different from the treatment of 6 cc/liter citronella, the treatment of 2 and 4 cc/liter had the relatively unstable effectiveness to suppress pest attack that was indicated by a higher attack rate than control treatment only on several observations (August 15th, September 8th and October 10th). Although the effectiveness of citronella essential oils was less stable in suppressing borer infestation, the total percentage of infected fruits, when young to harvest at application of citronella essential oil, was lower than that at the control treatment. Yield losses due to fruit borer attack at application of citronella essential oil at concentration of 2, 4, and 6 cc/l were 20.18%, 18.93%, and 14.77%, respectively, while the control was 26.16% (Table 1). Symptoms of mango fruit borer attacks are shown in Figure 2.

Table 1. Yield losses of Arumanis mango fruits at citronella essential oil treatments

No.	Concentration of citronella (cc/l)	Percentage of yield losses (%)
1	2	20.18 b
2	4	18.93 b
3	6	14.77 c
4	Control (*untreated*)	26.16 a



Means in a column followed by the same letter are not significantly different (P >0.05, LSD)

Figure 2. The attack of the fruit borer on mango fruit cv. Arumanis

The reasons why the essential oils can reduce mango fruit borer attack are that the essential oil of citronella has some negative properties against insects, namely:

1. Repellent Properties**:** citronella essential oil has an insect repellent effect, making the insect unwilling to come to the host. The scent of citronella causes fruit pests less likely to attack the mango fruit. This explanation is based on several previous studies ascertaining that the citronella oil has a repellent effect on some insects, such as fruit piecing and sucking moths *Calpa emarginata* (F.), *Othreis materna* (L.), *O. fullonia* (Cl.), *Cyligramma latona* (Cram.), *Sphingomorpha chlorea* (Cram.) in an apple orchard (Bosch, 1971) and fruit sucking moth *O. materna* on pomegranate and guava fruit (Jayanthi *et al.*, 2010).
2. Insecticidal Properties**:** Even though it is not as strong as some synthetic and botanical pesticides, citronella essential oil can also kill Spodoptera litura, a noctuid moth that attacks tobacco (Hummelbrunner and Isman, 2001), the aphid *Hyadaphis foeniculi* Passerini (Abramson *et al.*, 2006), as well as some stored product insects (Issa et al., 2011) like *Callosobruchus maculatus* (Raja *et al.*, 2001; Raja and William, 2008) and *Sitophilus oryzae* (Paranagama *et al.*, 2004). The citronellal compound contained in the essential oil of citronella is responsible for this property and has an insecticidal property against insects (Koul *et al.*, 2008).
3. Inhibitory Properties (Antifeedant): This antifeedant makes the insects unwilling to eat the plant because of its the chemical compound that is not preferred upon initial biting. As a result, the insect keeps away from its host without making any damage. A good example was shown on *S. litura* (Isman, 2000), and *Ostrinia nobilalis*, a pyrallid moth attacking corn (Lee *et al.*, 1999).
4. Ovicidal Properties: These properties lead to reducing the rate of egg hatching. The compound that acts as a cause of this nature is citronellal. Setiawati *et al.* (2011) reported that the egg hatchability of *Helicoverpa armigera* on chili pepper, treated with citronella oil, was reduced up to 95%. Earlier studies also reported that citronella oil signifcantly reduced the hatchability of eggs laid by *C. maculatus* on fresh batches of cowpea seeds (Raja *et al.*, 2001; Raja and William, 2008).

From Figure 1, it appears that the high attacks occuring during the time period of fruit development up to harvest might be attributable to the weak insecticidal and ovicidal effects against the moth. Hence, of the four properties above, antifeedant or repellent activities seem to be more dominant in suppressing moth attacks.

The data show that the attack rate of mango fruit borer fluctuates following the critical phase of the mango crop. Critical phase of mango fruit borer attack takes place when the fruit is in the development stage until harvest (Figure 1). This can occur when the fruit is in the condition favored most by the pest, such as the strong attractant scent or the presence of eating stimulants (*kairomones* action). The strength of repellent and eating inhibitors (*allomones* action) will also fluctuate depending on the strength of the attractant scent and the availability of materials stimulants. Such interaction causes the fluctuation on the effectiveness of citronella essential oil in suppressing the attack of mango fruit borer. In this study, the use of citronella essential oil as a repellent and/ or antifeedant against the mango fruit borer was more effective at a concentration of 6 cc/l rather than at a concentration of 2 and 4 cc/l. This is because the concentration of 6 cc/l can reduce the attractant scent released by mango fruit or make the fruit borer dislike eating the mango fruit.

The results of the profit analysis show that the use of citronella essential oil, particularly at concentration of 6 cc/l and 4 cc/l, is profitable and increased revenues despite the additional costs of the essential oil materials and spraying labors (Table 2).

Table 2. Profit analysis of citronella oil application in controlling mango fruit borer per hectare

Concentration of citronella (cc/l)	Cost of citronella oil (IDR ,000)	Cost of labor (IDR ,000)	Average of production (Kg)	Gross Revenue (IDR ,000)	Net Revenue (IDR ,000)
2	768	1,100	4,700	23,500	21,632
4	1,536	1,100	5,700	28,500	25,864
6	2,304	1,100	6,000	30,000	26,596
Untreated	-	-	4,600	23,000	23,000

As shown in Table 2, the additional benefits (profit) of citronella essential oil application can be determined by calculating the difference between net revenue of citronella oil treatment and control. Based on these calculations, the profits gained from the application of citronella oil at a concentration of 4 and 6 cc/l were IDR 2,864,000 and IDR 3,596,000 per hectare. Even though the use of citronella essential oil could only suppress the attack rate up to 11.39%, when converted into IDR, it gave a high enough profit. Further studies on the commercial scale should be carried out in order to confirm these findings.

4. Conclusion

Citronella essential oil could effectively reduce the attack rate of mango fruit borer *N. albizonalis*, especially at a concentration of 4 and 6 cc / liter of water. The yield loss could be avoided as much as 7.23% and 11.39%, as a result from the application of 4 and 6 cc/l, respectively; whilst the profits gained were IDR 2,864,000 and IDR 3,596,000 per hectare.

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