

Attraction of Cocoa Pod Borer to Non-Host Plant Carrot Leaves Extract

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ABSTRACT--Carrot leaves are included as agricultural waste and have not been widely used especially as insect attractants. Carrot leaves content is known, including fatty acids, chlorogenic acid, and gallic acid which serves as a stimulant for Lepidoptera. Cocoa pod borer (CPB) is a moth of the Lepidoptera order that attacks cocoa plants and losses due to its attack can reach 82.2%. Control is difficult because CPB larvae are in the pod, therefore control is directed at adult insects. One alternative to control CPB by utilizing plant extracts as attractants. Therefore, this study aims to determine the ability of carrot leaves extract as an attractant of CPB. Carrot leaves are extracted by soaking the leaves with methanol 70% in stages with a comparison between the plants and solvents respectively (4:1,2:1,1:1). The results of the marinade are then evaporated with a rotary evaporator machine and then crude extract is made into several concentrations of 7%, 5%, 3%, and 1% for use in bioassays. Bioassay uses 2 cylinder cages; the first cylinder cage is made of 5 holes to be connected to the second cylinder through clear plastic pipes. 20 CPB imago consisting of 10 males and 10 females were inserted in the first cage cylinder, then carrot leaf extract was inserted in the second cage cylinder. Observations are made every 3 hours for 24 hours. The most visited extract was a concentration of 7%. Indications of interest in the CPB imago are based on the percentage of interest with a value of 82% or the "very high" category. The amount of imago is 43.75% and is significantly different from other treatments. The number of female CPB imago was more at an average value of 7.00 and significantly different from all concentrations and controls. While the number of male imago was not significantly different in all treatments. Imago CPB visited all extract treatments during the first 3 hours since the bioassay was carried out and conversely, no CPB was seen in the control.

Keywords--cocoa pod borer, attractant, plant extract, carrot leaves.

I. INTRODUCTION

Carrot is a vegetable crop that is harvested at the age of 3 months and the by-product of carrot leaf waste. Wiqar (2009) calculated that the weight of one carrot plant was an average of 162.3 grams, the weight of a carrot tuber 135.1 grams and the leaves of a carrot 27.2 grams, so the percentage of carrot leaves against a carrot bulb was 20.13%. For example, if a carrot production of 488,979 quintals/year would produce 9,843,147 kg of leaf waste (Muryanto et al., 2019). Although the amount is large, so far the researchers have only looked at the antioxidant content of carrot leaves (El-shehawy, 2011; Burri et al, 2017), but its use as a vegetable insecticide has not been examined.

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Cocoa pod borer (CPB; *Conopomorpha cramerella* Snellen) is the main pest of cocoa plants in the South-East Asia region (Day, 1989), and what causes damage is the larval stage (Anshary, 2002). CPB larvae eat fruit flesh and food channels leading to the seeds (Wahyudi et al, 2008) so that the seeds stick to each other, harden and turn black so as to reduce the quality and quantity of cocoa beans to reach 82.2% (Wardoyo, 1980). The larval stage is difficult to control because it is in the pod, so control is directed to CPB adult.

CPB control has been carried out in various ways, such as implementing GAP (Good agriculture practice) such as sanitation, pruning and frequent harvesting (Depparaba 2002), to spraying insecticides whose results are not so significant. Alternative control by utilizing plant extracts has not been done much, especially using carrot leaves as attractants. Carrot leaves themselves contain crude protein 18.71%, crude fiber 15.69% (Sartika, et. Al, 1988), minerals in the form of potassium and some secondary metabolites in the form of gallic acids (El-shehawy, 2011), chlorogenic acid, β - myrcene, α -asarone, methyl isoeugenol, β -caryophyllene, (E) - β -farnesene, limonene, and sabinene (Habegger and Schnitzler, 2000). With all of these secondary metabolites, there is the potential for making insecticides (Ergina et al., 2014), especially as insect attractants. According to Renwick and Chew (1994), the phenol content in carrot leaf extract can attract insects from the Lepidoptera order. Therefore, this study aims to determine the ability of carrot leaf extract as an attractant for cocoa pod borer or natural insecticide in the form of a lure.

II. MATERIALS & METHODS

Plant and insect material

Carrot leaves were obtained from Biringpanting Village, Malino plateau, South Sulawesi, Indonesia in February. The criteria for the leaves used are the old ones, with rather thick leaf texture, dark green and has a stem length of \pm 20cm (the top leaves used).

Imago CPB is obtained by covering the cocoa pods that have been harvested with dried cocoa leaves for 4 days. After 4 days, each strands leaf is examined to see the pupa formed. CPB's pupa is cylindrical, there is a thin transparent white layer, and there is a larva in the middle. The formation of CPB imago ranged from 7-9 days. Imago CPB that has just emerged from its pupets is directly used in bioassay.

Plant extraction

Carrot leaves are washed thoroughly using distilled water, then placed on a plastic tray lined with filter paper and then air-dried at room temperature. After drying the leaves are thinly sliced and weighed 250gr and then soaked with 70% methanol solvent. Soaking carrot leaves is done in stages, using a ratio (solvent: plant) 4: 1, 2: 1, and 1: 1 (Pertiwi, 2015). It takes 24 hours for each stage of immersion so that the total methanol extract of carrot leaves obtained 1.75 liters. The extract was then evaporated at a speed of 7rpm at a temperature of 40oC (Pristina et al, 2017) using a rotary evaporator Stuart RE 300. Crude extracts of carrot leaves that have been evaporated and then used in bioassays.

Bioassay

In this bioassay two types of a plastic cylinder, containers are used. In the first cylinder (33cm long, 30cm diameter) five holes were made with the same distance. The holes are connected to the second container cylinder (13.3cm long, 14cm diameter) to place the carrot leaf extract treatment (1%, 3%, 5%, 7%) and control (methanol). The two cage cylinders are connected by clear plastic pipes (20cm long, 5cm diameter). 0.5 ml of carrot leaf extract was dropped on sterile cotton, then the cotton was allowed to stand for 10 minutes, then the cotton was put into the second container cylinder. Then 20 CPBs (10 males and 10 females) were inserted in the first cylinder, then observations were made every 3 hours for 24 hours with the observation parameters were (1) percentage of imago attraction based on the formula of Sighamony et al. (1984), (2) the number of CPB imago in each treatment, (3) comparison of the number of male and female CPB in each treatment and (4) the arrival time of CPB imago in each treatment. Data analysis using a completely randomized design then conducted Further Tests with the Least Significant Difference method (LSD).

Percentage of attractiveness formula by Sighamony et al. (1984)

$$P = \frac{A - N}{A} \times 100\%$$

Information;

P = Percentage of attractiveness

A = Number of insect in each treatment

N = Number of insect in control

Category

Class 0 = Not attractive (Negative)

Class 1 = 0 – 20% (Low)

Class 2 = 20,1% - 40% (Medium)

Class 3 = 40,1% - 60% (Moderate)

Class 4 = 60,1% - 80% (High)

Class 5 = 80,1% - 100% (Very High)

III. RESULT AND DISCUSSION

Percentage of CPB imago interest in Carrot Leaf ExtractBased on the results of bioassays that have been carried out, all treatments of the concentration of carrot leaf extract managed to attract CPB with different levels, while the control (methanol) was negative or not attractive. The highest percentage of interest in CPB imago in the treatment of 7% concentration with a value of 82% or the category of "very high" (Table 1).

Table 1: Percentage of interest of adult CPB in some concentrations of carrot leaf extract

Percentage of interest	Concentration of carrots leaves extracts				
	1%	3%	5%	7%	Control
Value	14%	50%	60%	82%	0%

Level	Class 1	Class 3	Class 3	Class 5	Class 0
Category	Low	Moderate	Moderate	Very High	Negative

Note: Percentage of interest formula based on Sighamony *et al.* (1984)

The interest of insects in plant extracts is based on the factor of chemical compounds they contain. Carrot leaf is known to contain a number of important minerals such as iron, zinc, copper (Pereira *et al.*, 2003), chlorogenic acid (Renwick and Chew, 1994) and essential fatty compounds (Leite *et al.*, 2010) which are very important for insects. Minerals are needed by insects for their growth, reproduction and energy sources, then lipids such as fatty acids as building blocks of cell walls (Bala *et al.*, 2018). It is suspected that one of the reasons for the CPB imago to move to the carrot leaf extract is because of this. The CPB Imago used in the bioassay is just coming out of the pupa. The tendency of newly hatched insects is to find food or habitat that provides food. Like a moth, the main food of CPB is nectar, and fatty acids are one of the macronutrient constituents of nectar (Levin *et al.*, 2016; Nepi, 2014). Imago CPB Amount in Several Concentrations of Carrot Leaf Extract

Statistical analysis showed that the 7% concentration of carrot leaf extract attracted the most CPB imago with a percentage of 43.75% (table 2) and was significantly different from all other treatments. This shows that carrot leaf extract contained plant chemical compounds that act as attractants.

Although different plants, 7% concentration of coffee bean extract also proved to be attractive towards CPB (Firmansyah, 2012). Both coffee and carrots are not hosting CPB but have an attractive effect on this pest. This can be developed as a way of controlling CPB. Such as the *Bactrocera dorsalis* flies interested in leaf extract *Ocimum sanctum* L. (Oktaviani *et al.*, 2015) or the interest in *Lobesia botrana* moth on essential oils of rosemary plants which do not host plants (Katerinopoulos *et al.*, 2005). The ability of plant extracts to attract insect pests can be used as an alternative to the use of synthetic pesticides (Franck *et al.*, 2009).

Table 2: The average number of CPB imago in several concentrations of carrot leaf extract

Concentration of carrot leaves extracts	Number of CPB adults (%)
7%	43.75a
5%	18.75b
3%	15.00c
1%	8.75d
Control	7.50d
NP BNT	3.51

Note: Numbers followed by the same letter (abcd) in the same column mean not significantly different in the 5% LSD test.

Number of CPB Male and Female Imago in Some Concentrations of Carrot Leaf Extract

From the calculation of the number of CPB imagos in each treatment, sex was identified. The treatment of carrot leaf extract concentration of 7% gets the highest number of female CPB imago with an average value of

7.00 and is significantly different from all concentrations and controls (methanol). While the number of male imago was not significantly different in all treatments.

The interesting fact that CPB females are more interested in visiting carrot leaf extract due to chemical factors. In addition to the fatty acid factors previously discussed, carrot leaves also contain phenol compounds such as chlorogenic acid. Renwick and Chew (1994) identified chemical compounds in carrot leaves that stimulated *Papilio polyenes* to come laying eggs with chlorogenic acid. Female insects are known to have higher mobility than males because they need a suitable place to lay eggs. The arrival of males is the influence of chemicals released by female insects.

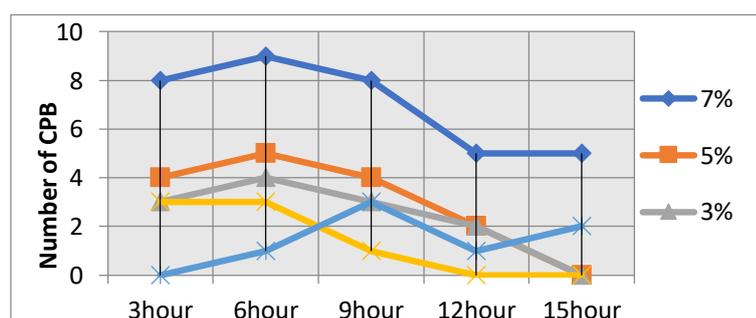
Table 3: Comparison of male and female CPB imago numbers in carrot extract

Concentration of carrot leaves extracts	Sex	
	Male	Female
7%	2.40	7.00a
5%	0.40	2.60b
3%	1.00	2.20b
1%	1.00	2.00b
Control	2.20	1.40b
NP BNT		2.15

Note: the numbers followed by the same letter in the column (abc) mean that they are not significantly different in the LSD level 0.05. Arrival Time of CPB Imago in Several Concentrations of Carrot Leaf Extract

During the observation, it was seen that adult CPB insects had come to the carrot leaf extract in the first 3 hours after the bioassay was carried out and conversely no CPB was seen in the control (methanol). For the next few hours, the number of CPB imago that came to the extract began to fluctuate and stopped coming 15 hours from the time the observation began. The arrival of CPB in the treatment was influenced by chemical stimulation from carrot leaf extract. At a concentration of 7%, it was found that the CPB was the most since the first and second 3 hours, then dropped in the following hours. Another phenomenon is shown by control (methanol) where there is a CPB imago at 9 hours after the bioassay begins because it is suspected that the CPB has a disruption in its olfactory system. In addition, another factor causing fluctuation in the number of CPB is because this pest is a nocturnal insect (Susanto, 1994) and has a weak flying ability and a limited active period. It is known that moths/moths are only active a few hours since sunset (Suparno, 2000) as well as adult CPB insects. Whereas during the day, CPB is also not very active, only flying around horizontal branches to find shelter until dusk.

Figure 4: CPB imago arrival time at several concentrations of carrot leaf extract



IV. CONCLUSION

The results obtained by carrot leaf extract are attractive to CPB imago. This is based on the highest percentage of interest in the treatment of 7% concentration with a value of 82% or the category of "very high", then the number of imago is 43.75% and is significantly different from other treatments. The amount of female CPB at a concentration of 7% was also more with an average value of 7.00 and was significantly different from all concentrations and controls. While the number of CPB males was not significantly different in all treatments. Imago CPB had visited the carrot leaf extract in the first 3 hours after the bioassay was done and conversely no CPB was seen in the control.

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