The Used of Attractants From Coffee at Various Heights Traps to Control Coffee Berry Borer and Quality Test of Coffee Berry

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Abstract. The coffee plant is a commodity that is widely grown in Toba Regency, Province of North Sumatera. Coffee berry borer (CBB) Hypothenemus hampei (Coleoptera: Scolytidae) is an essential pest in coffee plants which can reduce the quantity and quality of coffee fruit up to 50%. This research was to study the use of attractants derived from extract coffee bean and outer skin (pericarp) at various height traps to control CBB in Parsaoran Sibisa Village, Lumban Julu District, Toba Regency. This research method uses a factorial randomized block design with two treatments and three replications. For the first factor is the type of attractants (aqua-des, coffee beans and pericarp). The second factor is the height of the trap (0.5; 1.0 and 1.5 m). The results showed that the interaction of attractant type and trap height had no significant effect, but the attractiveness of coffee beans significantly affected CBB population trapped. The attractant of coffee beans caught 16.40 adults, 6.57 adults pericarp and 0.04 adults of distilled water. The best trap height is at 0.5 m with 8.50 adults followed by a height of 1.0 m and 1.5 m each with 8.28 adults and 6.24 adults.

Keywords: coffee, Hypothenemus hampei, attractant

1. Introduction
Coffee is one of the most widely consumed plantation commodities in the world and traded globally. Indonesia is the fourth largest coffee producer in the world after Brazil, Vietnam, and Colombia [13], while North Sumatra Province is the largest producer of Arabica coffee in Indonesia, reaching 50,405 tons in 2016 [25]. Coffee productivity in Indonesia is still very low when compared to other coffee producing countries [29]. Coffee production in Toba Regency in 2016 was 3398.45 tons with a land area of 3558.83 ha, but in 2017 it decreased by 2741.139 tons even though the land area increased to 4576.36 ha [3].
One of the causes of decreased coffee productivity is the attack of coffee berry borer (CBB) *Hypothenemus hampei* Ferr. CBB is the primary pest that attacks coffee plants around the world [14]; [22]. Currently, farmers still depend on chemical control which is insecticides with active *organochlorine endosulfan*. It could damage the environment and the food chain in the ecosystem, as well as leave a residue on coffee [8]. Coffee planters in Indonesia have implemented several CBB controls utilizing sanitation (picking powder, booty, melting), using biological agents with the fungus *Beauveria bassiana*, chemicals and using vegetable pesticides. However, it is still less effective [5]. Fernandes et al.[12] explained that the economic injury level (EIL) due to CBB in conventional coffee cultivation is around 7.9-23.7%, and organic coffee is around 24.4-47.6%. Furthermore, Aristizábal et al. [1]; [2]; Escobar-Ramírez et al.[11] explained that CBB pest control must be carried out in an integrated manner, namely combining scientific, biological, physical and natural culture control techniques. Physical control is to use trapping containing attractant compounds because it is environmentally friendly in suppressing the CBB population. The results of research by Wiryadiputra et al., [31] explain that control using Hypotan's attractant trap can reduce CBB attacks by up to 80%. Coffee waste in the form of coffee husks can be used as a trap to control CBB, yet its use is not optimal.

Based on the above background, it is necessary to research CBB control using attractant traps by utilizing extracts from coffee beans and pericarp and determining the best trap height in the field.

2. Materials and method

The research has conducted in a coffee plantation which owned by local farmers in Parsaoran Sibisa Village, Lumban Julu District, Toba Regency. The research was starting from March to May 2019. GC-MS analysis of coffee beans and pericarp has carried out at the Organic Chemistry Laboratory of the Faculty of Mathematics and Natural Sciences, Gadjah Mada University, Yogyakarta.

The materials used are Arabica coffee plants, attractants, distilled water, alcohol, detergent solution, label paper, nylon rope, raffia rope, and clear plastic. The tools used were a 1.5 l mineral bottle, a 12 ml plastic bottle, a collection bottle, tweezers, iron wire, zinc plate, loop, microscope, meter, hygrometer, hand counter, filter, bamboo and 10 ml syringe.

This study used a factorial randomized block design (RBD) with two factors, factor 1: type of attractant (aquades, beans and pericarp) and factor 2: trap height (0.5, 1.0 and 1.5 m) and -three repetitions each. The observed variables in this study were the number of trapped CBB population, the percentage of affected fruit and other insects caught in the trap bottle. Two sample trees have determined for each treatment, four branches selected with a position in the middle of the tree and the direction of the wind (east, west, north and south). The total number of fruits and the number of affected fruits calculated and then the percentage of fruit attacked was calculated for each treatment with the formula:

\[
I = \left(\frac{a}{b}\right) \times 100 \%
\]

Explanation:
- \(I\) = Percentage of fruit affected
- \(a\) = The number of coffee berry attacked by CBB.
- \(b\) = Total number of cherries

3. Results

3.1. Volatile compounds GC-MS analysis results

The highest volatile compounds obtained from the results of GC-MS analysis for Arabica coffee bean extract were 9,12 Hexadecadienoic acid, methyl ester (Table 1). In contrast, the highest volatile compounds obtained from Arabica coffee husk extract were 9,12-Octadecadienoic acid methyl—esters (Table 2).
The interaction of attractant type and trap height had no significant effect.

3.2. Number of imago CBB trapped
The results of observations and analysis of variance showed that the type of attractant treatment had a significant effect on the number of CBB for eight consecutive weeks while the height treatment was not significant. The interaction of attractant type and trap height had no significant effect.

The highest average number of CBB per week obtained in the A1 treatment (coffee bean attractant) with an average of 16.40 individuals followed by A2 (pericarp attractant) of 6.57 and A0 (aqua des) of 0.04 (Table 3).
Table 3. The average number of CBB during eight weeks of observation

| Observation Week | Types of attractants | Height of Trap | Average |
|------------------|----------------------|----------------|---------|
|                  |                      | T1 (50 cm)    | T2 (100 cm) | T3 (150 cm) |
| 1                | A0 (Aqua des)        | 0             | 0          | 0          | 0.00c    |
|                  | A1 (Coffee bean)     | 15.67         | 15.33      | 7.33       | 12.78a   |
|                  | A2 (pericarp)        | 8             | 4.33       | 3          | 5.11b    |
|                  |                      | Average       | 7.89       | 6.56       | 3.44      | 5.96     |
|                  | A0 (Aqua des)        | 0.67          | 0          | 0          | 0.22b    |
| 2                | A1 (Coffee bean)     | 12.67         | 6          | 5          | 7.89a    |
|                  | A2 (pericarp)        | 8.33          | 3.67       | 3          | 5.00a    |
|                  |                      | Average       | 7.22       | 3.22       | 2.67      | 4.37     |
|                  | A0 (Aqua des)        | 0             | 0          | 0          | 0.00c    |
| 3                | A1 (Coffee bean)     | 26.67         | 22         | 30.33      | 26.33a   |
|                  | A2 (pericarp)        | 10            | 8          | 9          | 9.00b    |
|                  |                      | Average       | 12.22      | 10         | 13.11    | 11.78    |
|                  | A0 (Aqua des)        | 0             | 0          | 0          | 0.00c    |
| 4                | A1 (Coffee bean)     | 19            | 19.67      | 12         | 16.89a   |
|                  | A2 (pericarp)        | 9.33          | 5.33       | 3.33       | 6.00b    |
|                  |                      | Average       | 9.44       | 8.33       | 5.11     | 7.63     |
|                  | A0 (Aqua des)        | 0             | 0          | 0          | 0.00b    |
| 5                | A1 (Coffee bean)     | 4.67          | 3.33       | 6.33       | 4.78a    |
|                  | A2 (pericarp)        | 1             | 1.33       | 0.33       | 0.89b    |
|                  |                      | Average       | 1.89       | 1.56       | 2.22     | 1.89     |
|                  | A0 (Aqua des)        | 0             | 0.33       | 0          | 0.11c    |
| 6                | A1 (Coffee bean)     | 44.33         | 54         | 34.67      | 44.33a   |
|                  | A2 (pericarp)        | 19            | 22.67      | 10         | 17.22b   |
|                  |                      | Average       | 21.11      | 25.67      | 14.89    | 20.56    |
|                  | A0 (Aqua des)        | 0             | 0          | 0          | 0.00c    |
| 7                | A1 (Coffee bean)     | 10.33         | 13.67      | 9.67       | 11.22a   |
|                  | A2 (pericarp)        | 4.67          | 4.67       | 3.67       | 4.33ab   |
|                  |                      | Average       | 5          | 6.11       | 4.44     | 5.19     |
|                  | A0 (Aqua des)        | 0             | 0          | 0          | 0.00b    |
| 8                | A1 (Coffee bean)     | 4.67          | 7.67       | 8.67       | 7.00a    |
|                  | A2 (pericarp)        | 5             | 6.67       | 3.33       | 5.00a    |
|                  |                      | Average       | 3.22       | 4.78       | 4        | 4        |

3.3. Percentage of affected berry
The observations on the percentage of affected berry showed that for eight consecutive weeks, the interaction of attractant type and trap height had no significant effect on the percentage of fruit affected (Table 4). The treatment of trap height to the percentage of infected coffee pods was not significantly different, at the height of T3 (1.5 m), T2 (1.0 m) and T1 (0.5 m) the mean percentage of attack was 23.02%, 23.74% and 29.96%, respectively.

Table 4. The average percentage of infected berry during the eight weeks of observation

| Observation Week | Types of attractants | Height of Trap | Average |
|------------------|----------------------|----------------|---------|
|                  |                      | T1 (50 cm)    | T2 (100 cm) | T3 (150 cm) |
|                  |                      | %             |           |            |
| Beginning        | A0 (Aqua des)        | 30.56         | 42.03      | 36.86      | 36.48    |
|                  | A1 (Coffee bean)     | 37.91         | 35.37      | 36.79      | 36.69    |
|                  | A2 (pericarp)        | 31.33         | 29.78      | 26.09      | 29.07    |
|                  |                      | Average       | 33.26      | 35.73      | 33.25    | 34.08    |
| 1                | A0 (Aqua des)        | 28.8          | 32.72      | 25.45      | 28.99    |
3.4. Other Insects Caught in Bottle Traps
Observations on other types of insects caught in bottle traps for eight consecutive weeks in the coffee plantation of Parsaoran Sibisa Village, Lumban Julu District, Toba Regency, consisted of 8 orders and 23 families with an insect population of 1739 individuals (Table 5).

Table 5. The number of other insects trapped during the eight observations.

| Order  | Family          | Total | Status/Role |
|--------|-----------------|-------|-------------|
|        | Coccinelidae    | 125   | Predator    |
| Coleoptera | Nitidulidae 1   | 315   | Decomposer  |
|        | Nitidulidae 2   | 4     | Decomposer  |
|        | Crytaphagidae   | 42    | Pest        |
|        | Elateridae      | 2     | Predator    |
|        | Pentatominae 1  | 1     | Pest        |
| Heteroptera | Pentatominae 2  | 2     | Pest        |
|        | Pentatominae 3  | 3     | Pest        |
|        | Formicidae 1    | 31    | Predator    |
|        | Formicidae 2    | 154   | Predator    |
| Hymenoptera | Formicidae 3    | 18    | Predator    |
|        | Formicidae 4    | 90    | Predator    |
|        | Braconidae      | 2     | Parasitoids |
|        | Apis            | 4     | Pollinator  |
|        | Acrididae       | 3     | Pest        |
|        | Tettigonidae    | 73    | Pest        |
4. Discussion

The results showed that the volatile compounds from the coffee bean extract could trap more CBB imago than the volatile compounds from the pericarp extract. It is in line with that described by Ramli et al. [24]; M. Sinaga et al. [17] who explained that coffee bean extract was better at trapping CBB imago than pericarp extract. Dufour and Frérot [9]; Rasiska et al. [26] also explained that the volatile compounds from the coffee bean extract trapped more CBB female imago than the attractant compounds from a mixture of ethanol and methanol as well as distilled water from other coffee plant parts.

Volatile compounds have widely used in plant pest control. Volatile compounds can act as repellents or as attractants for insects Castro et al. [6]. Jaramillo et al. [14] stated that the coffee fruit contains approximately 50 types of volatile compounds which can attract CBB insect pests. Most of the volatile compounds obtained from the extract of coffee beans and Arabica coffee shells are derivative compounds of carboxylic acids, which can attract imago to lay eggs. Cruz-López et al. [7] obtained that volatile compounds from robusta coffee are mostly terpenes and ester compounds, ketones, alcohols and pyrazines. Roblero and Malo [27] explain that various volatile compounds produce responses to CBB imago. N. tabacum, L. camara, C. officinalis plants produce volatile compounds to repel the presence of CBB, while E. sonchifolia plants produce attractive compounds for CBB [6].

At the 4th week of observation, there was a decrease in the caught CBB population. The decrease in the number of CBB caught in the field is closely related to climate effects. The high rainfall at the time of collecting the CBB imago in the field has thought to have influenced the number of imago trapped. Jaramillo et al. [15]; Mendesil et al. [20] stated that population dynamics and CBB infestation patterns are strictly related to climatic factors such as rainfall and relative humidity, as well as coffee plant physiology. The height of the trap also affects the number of the population caught, although it does not significantly affect it. The results showed that the height of the T1 trap (0.5 meters) obtained the highest average number of CBB imago followed by T2 (1.0 m) and T3 (1.5 m), namely 67.99, 66.23 and 49.88 individuals. Traps can be placed at the height of 0.5-1.5 m because the coffee cherries are still available at that height. It is similar with the results of research by Rostaman and Prakoso [28] which states that insects can still catch in trapping up to a height of 1.4 meters because at that height, there are still coffee cherries.

The highest CBB population in the third and sixth observations have considered as the highest peak of CBB female imago activity. It is related to the CBB life cycle, starting from laying eggs to imago, which takes 22 days depending on climatic factors. Erfan et al. [10] also stated that changing eggs to imago takes 25-35 days while Damon [8] stated that the CBB life cycle ranges from 28-34 days depending on weather conditions, especially temperature. The lower the temperature, the higher the place, and the life cycle will be getting longer. In the last two weeks of observation, the number of caught CBB imago began to decline. It was due to the decline in the quality of the volatile compounds used as traps.

4.1. Percentage of Affected Berry

The results of the observation on the percentage of affected fruit showed that for eight consecutive weeks, the interaction of attractant type and trap height did not significantly affect the percentage of

| Orthoptera | Gryllidae | 1 | Detritivor |
|------------|----------|---|-----------|
| Ectobiidae |          | 450 | Decomposer |
| Blatodea   | Blattidae | 11 | Decomposer |
|            | Blattidae 2 | 39 | Decomposer |
| Dermaptera | Carcinophoridae | 162 | Predator |
| Diptera    | Drosophilidae | 28 | Pollinator |
| Hemiptera  | Miridae | 179 | Pest |

**Total**: 1739
fruit affected (Table 4). The highest percentage of the attack by the imago CBB was in the A0 treatment (aqua des) with an average of 27.45%. It happened because aqua des were not able to attract CBB pests in the field where the distilled water did not contain attractive compounds such as volatile compounds which functioned as attractants for CBB female imago. So that CBB attacked more coffee beans in the aqua des treatment plot. It is similar to the statement of Mendesil et al. [21] stated that various vapours from volatile compounds could give different responses to the amount of interest in the female CBB imago in the field. The percentage of attacks decreased from the beginning to the end of the observation on the A0 (aqua des) treatment. It might be CBB in this plot were interested in the attractiveness of the coffee beans and seed coat around them so that they were trapped. It is supported by Baker statement [4] which stated that CBB could fly up to a radius of 500 meters assisted by wind and the smell of CBB imago is influenced by the level of berry’s maturity physiologically in the field. CBB preferred the ripe (red) coffee berry than the unripe (green) coffee berry [19].

The treatment of trap height on the percentage of affected coffee cherries was insignificantly different. However, the distance between traps affected the percentage level of infected fruit. It is different from Uemura-Lima et al. [30] description, which explained that the height of the trap affected the number of CBB trapped. The lowest traps (0.5 m) trap more CBB imago than 1.0 m and 1.5 m height traps.

4.2. Other Insects Trapped in The Bottle

The results of observations of other types of insects trapped in the bottles for eight consecutive weeks at the coffee plantation in Parsaoran Sibisa Village, Lumban Julu Subdistrict, Toba District, consisted of 8 orders and 23 families with a population of 1739 insects (Table 3). The most trapped insects are from the type of cockroach (Blattodea: Ectobiidae) with a total of 450 insects. It is presumably because the insect has an interest in volatile compounds similar to the sex pheromones contained in the coffee bean extract and pericarp. As stated by Lihoreau et al. [16] that cockroach species use chemical signals such as volatile sex pheromones to attract the opposite sex.

The presence of insects influenced by the environment and available food sources. Besides coffee commodities, various plants also grow around the research area such as oranges, soursop, bananas, maize and Leucaena glauca. Drosophilidae family from the order Diptera trapped is the primary pest of fruit. It is supported by Maesyaroh et al. [18] research which stated that the order Diptera is small and soft-bodied is an essential pest for fruit plants.

The results showed that only two parasitoids from the Braconidae family trapped in the bottle. The reason for the low parasitoid population might be due to the coffee plantations around which the farmers use insecticides. Also, the parasitoids were undeveloped due to the unavailability of feed for adult parasitoids. According to Morgan et al. [23], environmental factors and the appropriate quality and quantity of feed influenced the success of parasitoids to survive.

5. Conclusion

The type of attractant significantly affected the amount of CBB trapped, the attractiveness of coffee beans better than pericarp and aqua des, capturing with an average of 16.40, 6.57 and 0.04 CBB insects, respectively. The height of the trap against the number of insects and the percentage of berry attacked by CBB had no significant effect.

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