Consistency of attack level of coffee berry borer (Hypotenemus hampei Ferr.) on organic and conventional arabica coffee plantation in Aceh Tengah District, Aceh Province, Indonesia

H Husni*, J Jauharlina, M Sayuthi, E Mulyadi, P Yulianda, N Maulidia

Plant Protection Department, Universitas Syiah Kuala, Jalan Tgk. Hasan Krueng Kalee 3, Darussalam-Banda Aceh 23111, Indonesia

*Email: husnimusannif@unsyiah.ac.id

Abstract. A study has been conducted for 3 consecutive years since 2019 to 2021 to investigate the influence of cultivation system of Arabica coffee against the attack of the coffee berry borer (Hypothememus hampei Ferr.) in Arabica coffee plantations in Aceh Tengah District, Aceh Province, Indonesia. We observed the attack level of H. hampei on Arabica coffee plants that were cultivated both organically and conventionally. The results showed that for three years observation, in general, the attack level of coffee berry borer (CBB) on organic and conventional coffee plantations was not significantly different. Observations in 2019 showed that the attack level of CBB on organic coffee plantations ranged from 27-34 % and on conventional coffee plantations ranging from 33-49 %. Observations in 2020 showed that the attack rate of CBB on organic and conventional coffee ranged from 20-40 % and 28-41%, respectively, while observations in 2021 were 25-26 % and 27-28 %. The results of these studies indicate that the level of CBB attack on organic coffee plantations is no different from conventional coffee plantations that routinely use synthetic pesticides. This indicates that in organic coffee plantations, natural enemies have played an important role in suppressing the development of CBB populations. Although the use of synthetic pesticides in conventional coffee plantations can suppress pest populations, it is suspected that these pesticides also play a role in reducing the population of natural enemies of pests. Therefore, organic coffee cultivation is much more profitable, especially it can reduce the cost of buying synthetic pesticides and fertilizers, besides ensuring the safety of coffee farmers, workers, and consumers from harmful chemical contamination from pesticides.

1. Introduction

The Gayo Highlands is a mountainous area located in the central part of Aceh Province, which consists of Bener Meriah, Central Aceh and Gayo Lues Districts. Because it is located in high mountains, almost the entire Gayo Highlands has a cool climate throughout the year. Because it has a cool climate, since the Dutch colonial era this region has been considered suitable for Arabica coffee cultivation.

Arabica coffee originating from this area has received international recognition for its distinctive aroma and taste, so today Arabica coffee originating from this region is often called Gayo Arabica coffee. The area for planting Gayo Arabica coffee is getting wider day by day, so that currently the Gayo Highlands have become the largest arabica coffee planting area in Indonesia. The largest Arabica coffee growing areas are in two districts, namely Aceh Tengah and Bener Meriah districts. The latest data
shows that the area of Arabica coffee plantations in these two districts has reached approximately 100,000 hectares [1].

In recent years, coffee farmers in the Gayo Highlands, especially in Aceh Tengah District, have started cultivating Arabica coffee plants organically. One of the reasons farmers want to cultivate coffee organically is because the selling price is much higher than inorganic coffee. The price of organic coffee beans on the market ranges from 150,000 – 200,000 rupiah per kg, while the price of inorganic coffee ranges from 18,000 – 75,000 rupiah per kg [2]. Arabica organic coffee has been named the best coffee in the world according to the cupping score that has been done by the world coffee test cup expert. Meanwhile, the organic system in cultivating Gayo Arabica coffee can make Gayo coffee as the coffee with the highest selling value in the world [1]. Although the selling price of organic Gayo Arabica coffee is very high in both local and international markets, in general coffee farmers in Aceh Tengah District still prefer conventional coffee cultivation, because this method is considered more practical and effective in controlling various pest organisms on coffee plants.

One of the important obstacles in the cultivation of arabica coffee plants in Aceh Tengah Regency is the attack of the coffee berry borer (*Hypothenemus hampei* Ferrari). As a result of this pest attack has significantly reduced the production of coffee beans, while also reducing the quality of coffee beans. CBB pests have been considered the most dangerous coffee plant pests in all coffee producing countries. There are many reports, scientific journals and literature studies that report on the dangers and adverse economic impacts of this pest attack [3, 4, 5, 6].

The large-scale expansion of the Arabica coffee planting area in Aceh Tengah Regency has caused the spread of this CBB pest attack area. In fact, according to the confessions of several coffee farmers in this district, CBB pests have often been found in coffee fields located at an altitude above 1,300 m. Whereas previously this pest attack was reported only to occur in coffee fields which were below an altitude of 1,200 m. According to the coffee farmers we interviewed, the number of coffee berries that were attacked by this pest was increasing over time. To find out the development of this pest attack from year to year, observations of this pest attack were carried out for 3 consecutive years since 2019 to 2021. Observations were made both on organic and conventional coffee plantations to see whether there was an influence of cultivation techniques on the level of CBB pest attack.

### 2. Research methods

#### 2.1. Selection of research plot location

For both organic and conventional coffee plantations, two research plots were selected, each with an area of 1 Ha. Twenty coffee trees from each research plot were randomly selected as sample plants, so that the total sample plants were 80 coffee trees.

The research location is an arabica coffee plantation which is located at an altitude of 1100-1300 m. Gayo Arabica coffee is generally grown and grows very well at this altitude. Sample plants taken for both organic and conventional coffee plantations are Arabica coffee plants that are 10-15 years old. Organic coffee plantations are certified organic plantations issued by coffee exporters who develop Arabica coffee farmers in Aceh Tengah District. While conventional coffee plantations are the Arabica coffee plantations that are not certified organic and still use various chemical compounds such as pesticides and synthetic fertilizers.

#### 2.2. Observation

The attack rate of CBB was observed for three consecutive years, from 2019 to 2021. In each year, 4 (four) observation periods were carried out, namely once before harvest, twice during harvest and once after harvest. To calculate the level of CBB attack, in each observation period, 100 coffee berries were taken randomly from each sample plant.
3. Results and discussion
The results of statistical analysis using the T test showed that, for three years observation, in general, there was no significant difference in the level attack of CBB pests between organic and conventional coffee plantations.

Observations in 2019 showed that the attack rate of CBB on organic coffee plantations ranged from 27-34% and on conventional coffee plantations ranging from 33-49% (Figure 1). Observations in 2020 showed that the attack rate of CBB on organic and conventional coffee ranged from 20-40% and 28-41%, respectively (Figure 2), while observations in 2021 were 26-28% and 27-31%, respectively (Figure 3).

**Figure 1.** Research in 2019. The level of coffee berry borer attack in conventional and organic coffee plantations for each observation time. **:** p<0.01; ns: p>0.05 by paired t-test. Error bars represent standard error of mean (n = 20).

**Figure 2.** Research in 2020. The level of coffee berry borer attack in conventional and organic coffee plantations for each observation time. ns: p>0.05 by paired t-test. Error bars represent standard error of mean (n = 20).
Based on the data above, it is suspected that in organic coffee plantations there are more abundant and more diverse populations of natural enemies, so that these natural enemies can reduce the CBB pest population to a position below the economic threshold. Whereas in conventional coffee plantations, although pesticide applications have been carried out routinely, they have not been able to reduce the pest population significantly. This is presumably because these pesticides have played a role in reducing the population of natural enemies of CBB pests, as well as the possibility of causing pest resistance. According to [7] there were some broad-spectrum pesticides such as organophosphate which have caused a decline in the population of various beneficial species and also have caused secondary pest outbreaks.

In organic coffee plantations, in addition to natural enemies, many other biological components, such as animals, wild plants, microorganisms and others, are synergistically involved in maintaining environmental balance. Stoleru and Sellitto [8] stated that one of the negative impacts of conventional plant cultivation practices is a change in the balance between beneficial organisms and harmful pests. On the other hand, research conducted by Velmourougane [9] on coffee plantations in India shows that the biodiversity of macrofauna and microorganisms both on the surface and below the soil surface in organic coffee plantations is higher than conventionally managed coffee plantations.

Our previous research (Husni et al., unpublished) also showed that the abundance and diversity of arthropods in organic coffee plantations was much higher than in conventionally managed coffee plantations. The arthropods found were found to act as plant pests, natural enemies, pollinators, decomposers, and so on. One very important component of the Arthropod group is that it acts as a natural enemy. We found several species of Arthropods which are predators and parasitoids, as well as entomopathogenic fungi that play a very important role in controlling CBB pests in coffee plantations.

The decrease in the level of CBB pests on organic coffee plantations is certainly not only due to the role of natural enemies, but also cannot be separated from the presence of various wild plant species in coffee plantations, both of which function as refugia for natural enemies of CBB and which function as repellents against CBB pests. Piatto et al. [10] reported that organically managed robusta coffee plantations were able to reduce CBB and brown twig beetle attacks by 7% lower than conventionally managed coffee plantations. Piatto et al. [10] suspect that one of the causes of the high incidence of CBB on coffee plantations that are managed conventionally is the intensive herbicide spraying on the land, causing the extinction of several weed species that act as CBB pest repellants. Due to the extinction of...
these repellent-producing plant species, the population of CBB in conventionally managed coffee fields has increased.

Johnson et al. [6] has reviewed many articles related to distribution patterns, CBB, the impact of CBB attacks on the economy, and CBB pest control strategies. One of the important points they concluded was that in addition to garden sanitation, the use of various natural enemies, such as the fungus B. bassiana and parasitoid insects, was able to keep the level of CBB pests below the economic threshold. Meanwhile, Montañez and Amarillo-Suárez [11] have reviewed various scientific articles related to the influence of organic farming systems on insect diversity, and they concluded that on land managed by organic farming systems, insect population are higher than those managed with conventional systems.

Our recent study also showed that the level of species diversity and the number of Arthropods that are potential as natural enemies on organic coffee fields were much higher than conventionally managed coffee fields (Husni et al. unpublished). The results of the study showed that the number of insect species suspected as natural enemies in CBB pest was found more in organic coffee plantations than conventional ones. There are several insect species that are suspected of acting as parasitoids in CBB pest found in Arabica coffee plantations in Aceh Tengah District and also found more ant species and other predatory insects that were potential predators of coffee plant pests in organic coffee plantations. In another study (Husni et al. unpublished) we found a parasitoid species that had been released by the Aceh Tengah District Plantation and Forestry Service several years ago to control CBB pest, namely Phoropo nasuta (Hymenoptera: Bethylidae). This species is only found in organic coffee plantations at an altitude of 900-1,100 m and 1,100-1,300 m.

It is suspected that this parasitoid species has played a role in suppressing the CBB population in Arabica coffee plantations in Aceh Tengah District, especially in coffee plantations that are managed organically. Further research is urgently needed to find natural enemy species that have the most potential for controlling CBB pest. This research has been able to answer the benefits of organic coffee plantation management, especially in suppressing CBB attacks.

4. Conclusions
The results of research for three consecutive years (2019 – 2021) on Arabica coffee plantations in Aceh Tengah District show that in general the attack level of Coffee Berry Borer was not significantly different between organically and conventionally managed coffee plantations. Thus, the management of coffee plantations organically is economically much more profitable because it can cut the cost of purchasing synthetic fertilizers and pesticides.

When viewed from a broader perspective, organic coffee plantation management is far more profitable. Some of these advantages, for example, are more economically profitable because of the higher selling value of organic Arabica coffee beans, safer from contamination of harmful chemical compounds to coffee farmers, workers, and consumers, safe against non-target organisms and microorganisms, safe for the environment, and in accordance with the principles of sustainable agriculture.

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