Overview of the use of biocontrol agents in the control of Indonesian sugarcane borers

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Abstract. Sugarcane-borer complex in Indonesia consists of a shoot borer (Scirpophaga excerptalis) and four stem borers (Chilo sacchariphagus, C. auricilius, Sesamia inferens and Tetramoera schistaceana). Control of these borers is carried out biologically through the release of egg parasitoid Trichogramma spp. There are four species of mass-produced egg parasitoids and are used in the borer control program, namely Trichogramma japonicum, T. chilonis, T. nanum, and T. minutum. During this time, to measure the level of effectiveness of egg parasitoid releases was through the level of stalk damage. The effectiveness of the release of egg parasitoid should be measured through the mortality rate of borer eggs or parasitization level by the parasitoid. The observations in sugar cane plantations with release and without release of the Trichogramma spp. showed that releases of T. japonicum and T. chilonis were not effective in causing borer egg mortality. The level of parasitization of the borers’ eggs in both plantations was not significantly different, and the parasitization of sugarcane borer eggs was observed mostly due to natural egg parasitoid species, such as Tetrastichus sp., Telenomus sp., and T. chilonis. Biological control of the sugarcane borer complex by mass release of egg parasitoid needs to be reviewed.

Keywords: Trichogramma, Telenomus, Tetrastichus, egg parasitoid

1. Introduction

Infestation of sugarcane-borer complexes in sugarcane plantations in Indonesia consist of five species, namely Chilo auricilius, C. sacchariphagus, Scirpophaga excerptalis, Sesamia inferens and Tetramoera schistaceana [1]. Crop damage caused by the sugarcane borer complex infestation reached 8-10% in South Sumatra and less than 5% in East Java. In sugar cane plantations at PT Gunung Madu Plantation (GMP) in Central Lampung, crop damage due to infestation of the stem borer complex reached 14%. For certified sugarcane seed production, it is required that the stem borer infestation is not more than 5%. Based on the current condition of sugarcane borer infestation, the sugarcane borer control technique and the factors related to the control technique applied are aspects that need attentions.

Sugarcane borer control is generally carried out biologically by augmentation of egg parasitoids from the genus Trichogramma (Trichogrammatidae: Hymenoptera) and larval parasitoids from the genus Microplitis (Braconidae: Hymenoptera) and Sturmiopsis (Tachinidae: Diptera). The selection of egg parasitoids is based on the assumption that Trichogramma is a generalist egg parasitoid, so that it can be mass produced using alternative hosts. Microplitis and Sturmiopsis are used as biological agents with the consideration that they are parasitoid larvae found in sugarcane agroecosystems in Indonesia.
Mass release of egg parasitoid has been carried out on sugarcane plantations infested by sugarcane borer in Pakistan [2], Philippines [3], Thailand [4], and Brazil [5]. In general, the success of the release of the biological agent is stated by the reduction of sugarcane borer larvae infestation after the releases. For example, the release of \textit{T. chilonis} by 12,000 parasitoids /acres per month for 5 months (April-September) could reduce the intensity of borer complex attacks by 35\% and 45\%, and increase production of 19\% and 14\%, respectively in new plated and ratoon sugarcane in Pakistan [2]. Measuring the effectiveness of biological control agents in controlling target insect pests should be by observing the mortality that occurs in the target insect, namely the mortality of eggs or larvae of the target insect in the form of parasitization by released biological control agents (BCA). Evaluation of the effectiveness of the BCA used in the biological control program for sugarcane borers by observing the mortality of the target insects because of the released BCA has not been done much. Therefore, this study aims to review the effectiveness of BCA released in the sugarcane-borer-biological-control program, especially the release of egg parasitoids genus \textit{Trichogramma}.

2. Materials and Method

2.1. Parasitization level of parasitoid eggs by augmentation and naturally occurrence.

Augmentation of egg parasitoids in the biological control program of sugarcane borer complexes is carried out by mass releasing egg parasitoids from the genus \textit{Trichogramma}. Mass production of parasitoid \textit{Trichogramma} spp. conducted using factitious hosts, namely \textit{Corcyra cephalonica}, the rice moth eggs using a method developed by [6] and [7]. Observation of the parasitization level of the eggs of sugarcane borer complex was carried out on sugarcane plantation with released \textit{Trichogramma} spp., namely in Situbondo, East Java with the release of \textit{T. japonicum} and in Central Lampung, Lampung with the release of \textit{T. chilonis}.

Observation of naturally parasitization level of \textit{S. excerptalis}, the shoot borer, and \textit{Chilo} spp., the stem borer, by egg parasitoids are carried out by collecting eggs in sugarcane plantations without \textit{Trichogramma} spp. Augmentation. These observations were made in Pati (Central Java), Malang and Situbondo (East Java).

Observation of the level of parasitization of sugarcane borer eggs is carried out by collecting eggs of sugar cane shoots and stem borers, observing the parasitization level, and emerging parasitoid species are identified based on an identification key developed by [8] for \textit{Trichogramma}.

2.2. The level of stem and shoot borers infestation after \textit{Trichogramma} releases.

This research was conducted on sugarcane plantation in Pakis District, Malang (7° 57’ 33” South, 112° 43’ 10” East). The released egg parasitoid is \textit{T. chilonis} which is mass-reared using factitious host, \textit{Corcyra sephalonica} eggs according to the method developed by [9]. The study was conducted on a sugarcane 20 m x 20 m plot size, arranged in a Randomized Block Design with 4 replicates. The treatment consists of:

1. Control – without parasitoid releases
2. 25,000 parasitoid per ha
3. 50,000 parasitoid per ha
4. 75,000 parasitoid per ha
5. 100,000 parasitoid per ha

Parasitoid release is carried out every 2 weeks starting at 1 - 4 month after planting. Observation variables to assess the effectiveness of using egg parasitoids in controlling sugarcane borer consist of visual observation of larvae and egg borer populations, symptoms of borer infestation, and level; of egg parasitism. Observations on borer population were made on 5 sample units, each sample unit consisting of 5 rows of plants. Minimum distance of the sample unit is 5 m from the edge of the plot. Each row in the sample unit was observed on 6 rows taken from different clumps in the row. Distance of sample plants between clumps in rows is 2 m.
Observation of the shoot borer infestation was done by observing the symptoms of infestation (on the leaves and shoots) and eggs’ population which are observed in all samples. Observation of stem borer infestation was done by observing the symptoms of infestation and the number of larvae which is done by splitting the stem by observing the number of stem segments and the number of damaged segments the larval stage. This destructive observation is carried out on 2 bars in each row. Collection of shoot and stem borer eggs to be observed for mortality due to parasitoids or predators. Observations were carried out with 2 week intervals, starting at 4th weeks to 24th weeks after planting.

3. Results and discussions

3.1. Parasitization level of parasitoid eggs by augmentation and naturally occurrence.

Table 1 shows that the released egg parasitoids, both *T. Chilonis* and *T. Japonicum* did not parasitize the stem-borer eggs, but *Telenomus* sp. And *Tetrastichus* sp. Natural populations that cause high levels of parasitization. Likewise, in conditions without *Trichogramma* release, the two parasitoid species of the *Platygastridae* and *Eulophidae* family which dominate the naturally parasitization of sugarcane borer eggs.

| Location          | Egg parasitism (%) by | T. chilonis | Telenomus sp. and Tetrastichus sp. |
|-------------------|-----------------------|-------------|----------------------------------|
| With released     |                       |             |                                  |
| *Trichogramma*    |                       |             |                                  |
| Central Lampung1  | 33                    | 67          |                                  |
| Situbondo2        | 16                    | 84          |                                  |
| Pati2             | 26                    | 74          |                                  |
| Without released  |                       |             |                                  |
| *Trichogramma*    |                       |             |                                  |
| Situbondo         | 13                    | 87          |                                  |
| Malang            | 50                    | 50          |                                  |
| Pati              | 34                    | 66          |                                  |

1 Species *Trichogramma* released: *T. chilonis*  
2 Species *Trichogramma* released: *T. japonicum*

Parasitization of stem borer eggs was dominated by *Telenomus* sp. and *Tetrastichus* sp. with a higher percentage of parasitization compared to parasitization by *T. Chilonis* in released sugarcane fields (Central Lampung). This results showed that although the quality of the parasitoids produced is relatively good [10], mass-produced of *T. chilonis* species using factitious hosts and were released, contributed to lower mortality compared to the natural population of *Telenomus* sp. and *Tetrastichus* sp.

In sugarcane plantation with *Trichogramma* released, we did not find *S. Excerptalis* eggs, so it can be said that the parasitization in shoot borer is caused by natural population egg parasitoids.

Table 2 shows that shoot borer eggs are not parasitized by *Trichogramma* spp. But parasitization was caused by *Telenomus* sp. And *Tetrastichus* sp. With 100% parasitism level. This condition confirmed the research results of [11], which reported that the parasitization of shoot borer eggs in sugarcane plantations in Java generally by *T. Schoenobii* and *T. Rowani* with parasitization level of 34.59% and 24.07%, respectively; and [12] who reported that in sugarcane plantations without wild plants found 2 species of stem and shoot borer egg parasitoids, namely *Telenomus dignoides* and *Tetrastichus schoenobii*. In addition, [13] reported that *S. excerptalis* eggs were generally parasitized by *Telenomus beneficiens*. 
Table 2. Natural parasitism level of shoot borer eggs

| Location | Egg parasitism (%) by | Trichogramma | Telenomus sp. |
|----------|-----------------------|--------------|---------------|
|          |                       | 0            | 100           |
| Situbondo|                       | 0            | 100           |
| Malang   |                       | 0            | 100           |
| Pati     |                       | 0            | 100           |

Measurement of effectiveness of mass released *T. chilonis* to control sugarcane shoot borer in previous studies was carried out by measuring parameters indirectly. For example, [14] reported that *T. chilonis* released at a dose of 150,000-300,000 parasitoids/acres could control the population of the *S. nivella* and sugarcane borer complex, *C. infuscataellus*, *Emmalocera depressella* Swin, and *Acigona steniella* (Hampson) with a decrease in damage due to borers by 35-43% compared to controls. Thus, the role of *T. chilonis*, both from the released population and the natural population, in suppressing the shoot population of *S. excerptalis* remains unclear.

3.2. The level of stem and shoot borers infestation after *Trichogramma* releases.

The release of *T. chilonis* in this study was to control the population of shoot borer and sugarcane stem borers. Damage to plants caused by shoot borers is relatively higher compared to damage caused by stem borers (Table 3). Infestations of sugarcane borer complex in all treatments were not significantly different and categorized in the low infestation rate (less than 5%), including in control plots that were not treated with parasitoid release. This result showed that the release of *T. chilonis* at various doses applied did not show significant effectiveness.

Table 3. Damage to sugarcane shoots and stem caused by the stem and shoot borer infestations, as well as predator complex populations (ants, spiders, Coccinellid beetles) in the treatment of *T. chilonis* release.

| Treatments       | Cane stem damage by borer (%) | Cane shoot damage by shoot borer (%) | Predator population/plant |
|------------------|-------------------------------|-------------------------------------|---------------------------|
| Control          | 0.3                           | 2.3                                 | 3.0                       |
| 25,000 parasitoid per ha | 0.2                           | 3.3                                 | 2.8                       |
| 50,000 parasitoid per ha | 0.0                           | 3.0                                 | 3.0                       |
| 75,000 parasitoid per ha | 0.0                           | 1.5                                 | 2.5                       |
| 100,000 parasitoid per ha | 0.0                           | 4.0                                 | 3.3                       |

In all treatments and control plots, predator populations were not significantly different (Table 3). The release of *T. chilonis* in this study showed less effectiveness because of the role of predatory insect communities as active predators of shoot-borer and stem borer eggs which are easily found by predators. *Solenopsis saevissima* (Smith) was reported as a potential predatory ant in preying on *C. sacchariphagus*, the sugarcane borer in Brazil [15]. In Louisiana, *S. invicta* was reported to play a role in reducing damage by *D. saccharalis*, the sugarcane stem borer [16]. In general, natural enemy populations, including predators, have the potential to protect phytophagous populations that causing damage in cultivated crops in stable agroecosystems. The agroecosystems that are not disturbed by the intervention of toxic compounds from aerial sprays of chemical pesticides or burning practices carried out before harvest. The role of predators in causing the mortality of sugarcane borer egg complexes needs to be considered in the biological control program through the mass release of *Trichogramma* species egg parasitoids.
4. Conclusion
Biological control of the sugarcane borer complex by mass release of egg parasitoid needs to be reviewed for its effectiveness. Biological control programs in sugarcane plantations in Indonesia need to consider conservation of natural enemies by avoiding burning of sugarcane, and aerial sprays of cane ripener substances or insecticides.

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