Field evaluation of *Bacillus thuringiensis* product to control *Metisa plana* bagworm in oil palm plantation

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**Abstract.** *Metisa plana* is widely known for its destructive impact on oil palm plantations. *M. plana* infestation could reduce the oil palm productivity by 40% if it remains untreated over two consecutive years. The application of insecticide has become a well-known method of controlling *M. plana* infestation. The experimental design used was a Randomized Block Design with six treatments and six replications. Four doses of *Bacillus thuringiensis* and selected green-labelled insecticides (active ingredient: clorantraniliprole) were evaluated for their toxicity based on initial population of *M. plana*. The foliar spraying bioassay technique was used to expose six replications to the designated treatments. *M. plana* mortality was observed for 2, 7, 14, and 28 days after application. The results showed that both *B. thuringiensis* and clorantraniliprole could cause 96-99% mortality in seven days. Based on these field evaluation, the use of insecticide products with active ingredients Bt with soluble concentrate formulation recommended for the control of *M. plana* bagworms was carried out using concentrations of 0.625-1.25 ml/l or 250-500 ml/ha. Field experiments are needed to provide more accurate results when the insecticides are exposed to natural environment.

**Keywords:** bagworm, *B. thuringiensis*, *M. plana*, foliar spray

1. Introduction

One of the important pests in oil palm plantations is the group of caterpillars that eat oil palm leaves consisting of caterpillars, caterpillars, and caterpillars. Of the three groups of caterpillars, bagworms are the most difficult pests to control. The damage caused can trigger stress on plants to reduce productivity. In general, minor damage to the fronds of 10-13% led to a decrease in production of 33-40% [1]. Priwiratama *et al.* reported that *Pteroma pendula* bagworm attacks were able to reduce production by 36.35% [2]. Meanwhile, *Metisa plana* caterpillar attacks in Malaysia caused yield losses of up to 43% [3]. *M. plana* (Lepidoptera: Psychidae) bagworm develop its life cycle from 80 to 113 days consists laying the eggs, take up to five and seven instar stages. The pupa develop always hanging at the back of oil palm leaves. The male will hatch from the casing as a imago while the female stay inside the casing [4].

Control techniques with insecticides are the main choice when the population reaches the economic threshold or when there is an explosion of pests in the field. It is common because it can quickly reduce the pest population. Due to the high intensity of the *M. plana* attack on oil palm plantations in Peninsular Malaysia, insecticides have become a popular means of controlling *M. plana* infestation when the
economic threshold is reached. It can provide a rapid reduction in the number of pests. Chemical-based has become the major control mechanism in managing bagworm outbreaks in most plantations compared to smallholdings [5].

So far, control techniques that have been carried out in the field include applying insecticides with various active ingredients ranging from synthetic chemicals to biologics. The application of insecticides with the active ingredients methamidophos and monocrotophos effectively controlled the *M. plana* bagworm by stem injection [6]. In another experiment, the active ingredient insecticides cypermethrin and flubendiamide could cause 100% mortality four days after application in the laboratory [7].

However, overreliance on chemical insecticides to control agricultural pests has often led to the development of other more persistent problems such as resistance of pests to treatment, the abundance of harmful chemical residues in the environment, and the disruption of beneficial insects populations. Biological control is a method of controlling pests in agriculture that relies on natural agents rather than chemicals [8].

Applications of biological insecticides such as *Bacillus thuringiensis* (Bt) have been started to control *M. plana* bagworm. The use of the active ingredient Bt does not cause toxic effects on non-target organisms such as freshwater fish, humans, livestock, and other vertebrate species [9]. *Bacillus thuringiensis* is a gram-positive bacterium that upon sporulation produces protein gem harmful to creepy crawlies in Lepidoptera, Diptera, Coleoptera, and different orders. The insecticidal protein of Bt, target-explicit, is delivered vigorously during the slack period of its development cycle. The proteins are effectively gathered and detailed. The δ-endotoxins, when ingested by defenseless creepy crawlly hatchlings, the δ-endotoxins were actuated by gut proteases [10], which causes osmotic lyses and passing of passing hatchlings. In this study, efficacy tests were carried out on several levels of Bt formulation dosages from commercialized products, and synthetic insecticides, the active ingredient chlorantraniliprole, were used as comparisons. Chlorantraniliprole is a narrow-spectrum insecticide with less harmful to mammalian [11].

2. Materials and methods

The field evaluation was conducted at one oil palm plantation in Labuhan Batu Selatan Regency, North Sumatra Province (1°38'58" N, 100°24'46" E). The experimental design used was a Randomized Block Design with six treatments and six replications. The treatment plot consisted of twelve trees with four in the middle being used as sample trees (Figure 1). The types and doses of insecticides used in this test are listed in Table 1.
Figure 1. The experimental design for each treatment (⊙: the sample tree).

Table 1. The active ingredient, dose, and concentration of insecticides used in the experiment.

| Treatment | Active Ingredient     | Dose    | Concentration | Spraying Volume |
|-----------|-----------------------|---------|---------------|-----------------|
| Bt 1      | *Bacillus thuringiensis* | 500 ml/ha | 1.25 ml/l    | 400 l/ha        |
| Bt 2      | *Bacillus thuringiensis* | 375 ml/ha | 0.9375 ml/l  | 400 l/ha        |
| Bt 3      | *Bacillus thuringiensis* | 250 ml/ha | 0.625 ml/l   | 400 l/ha        |
| Bt 4      | *Bacillus thuringiensis* | 125 ml/ha | 0.3125 ml/l  | 400 l/ha        |
| KL        | Chlorantraniliprole   | 625 ml/ha | 1.5 ml/l     | 400 l/ha        |
| Control   |                       |         |               |                 |

The arrangement of the treatment plots was determined based on the results of preliminary observations of the initial population of 2nd-3rd larval stages in the sample plants (Figure 2). Each sample tree was observed for the initial population of *M. plana* bagworms on the leaf midribs at the leaf canopy’s top, middle, and bottom. Foliar spraying was only carried out once, a day after preliminary observations, using a Maruyama MD180DX mist blower with a spray volume of 1 tank per 6 plants or 400 liters per ha (Figure 3). This mist blower is capable of spraying a suspension of insecticides up to a height of 11 m.
To determine the effect of treatment on insect pests, the surviving bagworm populations were observed at 2, 7, 14, and 28 days after application, then the percentage of bagworm mortality was calculated. The data obtained were then analyzed for variance and Duncan's multiple range test at a 5% significance level. Data on mortality was corrected using the Abbots formula [12]:

\[ M' = \frac{(C_a - T_a)}{C_a} \times 100\% \]

- \( M' \) = Corrected mortality
- \( T_a \) = Pest populations or damage percentage in insecticide treatment plots after insecticides application.
- \( C_a \) = Pest populations or damage percentage in control treatment plots after insecticides application.

3. Results and discussion

The preliminary observations on the \( M. \) plana populations of each sample palm were observed. The average population of \( M. \) plana in all samples reach 56.61 larvae per frond (Table 2). In this experiment,
the population of bagworms in the control plot experienced a mortality of 14.95% at 2 days after application until it reached 35.57% at the end of the observation (Figure 4). The death of the bagworm was caused by various natural enemies of *M. plana* already in the field, especially *Eucanthecona* sp. Based on field observations, the application of Bt did not kill these predators, so the way this insecticide worked was more specific in controlling oil palm leaf-eating pests. The long-term use of *B. thuringiensis* every two weeks for nine months did not harm natural enemies of insect pests in oil palm plantations [13].

**Table 2.** The initial population of *Metisa plana*.

| Treatment | Active ingredient | Dose       | Concentration | Initial population |
|-----------|-------------------|------------|---------------|--------------------|
| Bt 1      | *Bacillus thuringiensis* | 500 ml/ha | 1.25 ml/l    | 83.33              |
| Bt 2      | *Bacillus thuringiensis* | 375 ml/ha | 0.9375 ml/l  | 41.67              |
| Bt 3      | *Bacillus thuringiensis* | 250 ml/ha | 0.625 ml/l   | 69.17              |
| Bt 4      | *Bacillus thuringiensis* | 125 ml/ha | 0.3125 ml/l  | 40.67              |
| KL        | Chlorantraniliprole | 625 ml/ha | 1.5 ml/l     | 56.20              |
| Control   |                   |           |               | 48.67              |

Insecticide treatment with concentrations of 1.25, 0.9375, and 0.625 ml/l of the active ingredient Bt and Chlorantraniliprole could produce mortality above 95% at 1.5 ml/l seven days after application. Meanwhile, the active ingredient Bt insecticide with a concentration of 0.3125 ml/l achieved a mortality of above 90% for the larvae of the bagworms tested at 14 days after application (Figure 5). Based on these field evaluation, the use of insecticide products with active ingredients Bt with soluble concentrate formulation recommended for the control of *M. plana* bagworms was carried out using concentrations of 0.625-1.25 ml/l or 250-500 ml/ha. Field experiments are needed to provide more accurate results when the insecticides are exposed to the natural environment.

*Bacillus thuringiensis*, a bacterium that produces protein crystals with the name δ-endotoxin which kills insects during the sporulation process [14]. The microbes is a gram-positive bacteria measuring 1-1.2 micron rod-shaped and facultative anaerobic and can form spores. Until now, Bt is widely used in agriculture as a baby pesticide. In integrated pest control programs, Bt has reduced the use of chemical pesticides and has been successfully applied to various crops, including vegetables, cotton, maize, potatoes, and soybeans [15]. In addition, Bt has been very effective in controlling bagworms by spraying on oil palm plants [16]. It is characterized by the production of parasporal inclusion body crystals, which constitute one or more types of insecticidal protein (ICP) crystals or δ-endotoxin or Cry protein [17].
The level of effectiveness of Bt is strongly influenced by the feeding activity of the target pest. Therefore, Bt must be eaten by the target insect, and usually, Bt is highly recommended to be applied to insects or larvae that are actively feeding. Insects infected with Bt are usually pale in color, become flaccid and have reduced mobility. These bacteria will cause the insect’s body contents to become brownish-black, red, or yellow when rotting [18]. Visual observations of all sample oil palm plants after being sprayed with Bt product did not show any symptoms of phytotoxicity in these plants. The use of biological insecticides such as the active ingredient Bt is highly recommended to support sustainable oil palm development.
Chlorantraniliprole is the most potent insecticide against *M. plana* in oil palm plantations. The relative susceptibility of the *M. plana* larvae to chlorantraniliprole was 7.3 times higher than cypermethrin. The best time to control *M. plana* is 1<sup>st</sup> to 3<sup>rd</sup> instars larval period by using chlorantraniliprole on oil palm. Chlorantraniliprole is a alternative as strategies for the insecticide resistance management of *M. plana* in oil palm plantation [11].

4. Conclusion
Based on the study showed that *B. thuringiensis* cause 96-99% mortality in seven days. Meanwhile, the insecticide (active ingredient: chlorantraniliprole) which used as comparasion reached the same result as Bt. Based on these field evaluation, the use of insecticide products with active ingredients Bt with SC formulation recommended for the control of *M. plana* bagworms was carried out using concentrations of 0.625-1.25 ml/l or 250-500 ml/ha. Field experiments are needed to provide more accurate results when the insecticides are exposed to natural environment.

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