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Bioefficacy of Selected Insecticides on Late Stage Instars of Bagworm, *Metisa Plana* (Walker)

Mohammad Daniell Mat[1], Siti Noor Hajjar Md Latip[1, 2*]
Che Ahmad Hafiz Che Manan[1], Ayman Che Razali[3]

[1]Faculty of Plantation & Agrotechnology, Universiti Teknologi MARA Cawangan Melaka Kampus Jasin, 77300 Merlimau Melaka, Malaysia
[2] Sustainable Crop Protection Research Group, UiTM Shah Alam, 40450 Shah Alam, Selangor, Malaysia.
[3] Plantation Business Management, Agricultural Chemicals (M) Sdn. Bhd., 13600 Perai, Penang, Malaysia.

**Corresponding author's e-mail: noorhajar@uitm.edu.my*

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ABSTRACT

Metisa plana is a significant oil palm pest in South East Asia and are well recognized for its devastating impact on oil palms in Malaysia. Due to the high intensity of the M. plana assault on oil palm plantation in the peninsular, Malaysia. The use of insecticides has become a famous means of controlling M. plana infestation when the economic threshold is reached. Three selected insecticides are Cypermethrin, Flubendiamide, and Bacillus thuringiensis tested for their toxicity toward M. plana. Late-stage instar of M. plana was collected at Felda Serting Hilir 4, Bahau, to be tested on three different pesticides, including one control treatment. For each treatment, five replications were exposed to the selected chemical by using the leaf dip bioassay method. The mortality of M. plana was recorded for eight consecutive days. Results showed that both Cypermethrin and Flubendiamide could achieve a 100% mortality rate within four days while it takes eight days for Bacillus thuringiensis and control treatment. Further study should be done in the field to obtain more accurate results when exposed to natural conditions and the environment.

Keywords: *Bagworm, M. plana, Cypermethrin, Flubendiamide, Bacillus thuringiensis, leaf dip bioassay*

INTRODUCTION

Bagworm *(M. plana)* is an important oil palm pest in South East Asia [1]. It is well recognised for its devastating impact on oil palms in Malaysia [2] and Indonesia [3]. Continuous use of chemical insecticides to manage outbreaks of *M. plana*, lack of alternate host plants were identified as possible causes to outbreaks of *M. plana* [4].

Due to the high intensity of the *M. plana* attack on oil palm plantation in Peninsular Malaysia, the use of insecticides has 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. In the oil palm plantation, various forms of insecticides are effective against *M. plana*, when applied using various spraying techniques, such as spraying with mist blower, turbomyzers, aerial spraying, fogging, etc. Recently, for the control of *M. plana* in the infested area of oil palm plantations, several organophosphate, carbamate, and synthetic pyrethroids have been recommended [5]. Indiscriminate and prolonged use of excessive chemical insecticides to control *M. plana* outbreak also affected natural enemies of larvae of *M. plana*, such as predators and parasites, which is one of the key factors for the population growth.

M. plana larvae prefer upper leaf surface for feeding and lower surface for resting and molting [6]. The damage on oil palm leaves could significantly reduce the production since 50% defoliation of oil palm leaves could result in a yield loss of 10 tons/ha of fresh fruit bunch (FFB). Pesticides are designed to kill and because their mode of action is not specific to one species, its effect or harm organisms other than pests, including humans. The WHO estimates that there are 3 million cases of pesticide poisoning each year and up to 220,000 deaths, primarily in developing countries. Though the pesticide industry in the developed world has made good progress in the field of development and production of low risk/low volume user and environment-friendly pesticides formulation, pesticides in the developing countries still now are mainly available in conventional formulations such as dust, wettable powder, emulsifiable concentrates and solutions

Cypermethrin is a broad-spectrum pyrethroid type II [7]. This pesticide is highly photostable and with excellent stability in acidic pH, besides having low volatility and solubility in water [8]. Cypermethrin is marketed as an emulsifiable concentrate, a liquid soluble concentrate, and as a wettable powder; has low toxicity to birds and mammals, but is extremely toxic to insects and aquatic organisms, presenting high bioaccumulation potential [9]. Flubendiamide belongs to the phthalic acid diamide group of insecticide [10]. Flubendiamide is mainly effective for controlling lepidopteron pests, including resistant strain in rice, cotton, corn, grapes, other fruits, and vegetables [11]. It has larvicidal activity as a stomach poison and is an oral intoxicant, fast-acting (rapid cessation of feeding), long-lasting (rain fast), and has limited plant penetration and systemicity. It is a foliar-applied insecticide with a lipophilic character [12].

Meanwhile, *Bacillus thuringiensis* (Bt) is a soil bacterium that forms spores during the stationary phase of its growth cycle. Various Bt strains synthesize Crystal (Cry) and cytolytic (Cyt) toxins, (also known as δ-endotoxins), during sporulation and during the stationary growth phase as parasporal crystalline inclusions, which are known to have insecticidal activity against a narrow taxonomic group of insects. Therefore, Bt toxins have been used as topical pesticides to protect crops, and more recently, the proteins have been expressed in transgenic plants to confer inherent pest resistance [13].

During population outbreaks, chemical control is the fastest and most effective method of suppressing and maintaining *M. plana* populations below the action threshold [14]. Although the chemical is the best choice, most of it was harmful to untargeted insects. Hence, this study aimed to determine the effect of two chemical insecticides, which are Cypermethrin and Flubendiamine, and a biopesticide, *Bacillus thuringiensis*, against late instar larvae of bagworm *M. plana*.

METHODOLOGY

Sample Preparation

Late-stage (5th instar) of *M. plana* were collected at Felda Serting Hilir 4 in February from ten randomly selected palm fronds. Approximately 400 – 450 samples were collected from the acquired leaflets. Samples were then maintained at room temperature at 25 – 28°C for acclimatisation purposes. A total sample of 200 samples of M. plana was needed during this study. One control treatment also had been set up to minimise the effects of variables other than the independent variable.

Bioassay Test

Leaf-dip bioassay method was used for assaying *M. plana* susceptibility in this study. Oil palm leaves were collected from healthy oil palm seedling under insecticide-free conditions. These leaflets were prepared by briefly soaking and then rinsing three times with running tap water. The midrib was removed, and the leaf lamina was retained. Rectangular leaf pieces were cut from the leaf lamina. The rectangular pieces were individually dipped for ten seconds in the insecticide solutions, air-dried in the laboratory for one hour, and placed in a plastic container-each container consisting of 10 *M. plana* (sample).

Meanwhile, distilled water was used to treat the control leaf cut. The larvae were sealed with transparent plastic lids. The mortality of these larvae was recorded for eight consecutive days, and the mortality rate was recorded. The bioassay was conducted in an ambient room temperature environment of 24°C–29°C. The *M. plana* were considered dead when it did not respond to prodding. Flubendiamide, *Bacillus thuringiensis* & Cypermethrin were the insecticides used in this experiment. *Bacillus thrurigiensis subspecies Kursaki* has been used in the study. The selected insecticides solution were prepared inside three different, 900 ml container rectangular container. The rate and formulation of the prepared insecticides were as shown in (Table 1) and based on the recommendation label stated at the insecticide bottle. For each treatment, there is five replication. A total sample of 200 samples of *M.*

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Table 1: Rate of Insecticides Used

TREATMENT	INSECTICIDE RATE
Cypermethrin	0.072 L / 900 ml
Flubendiamide	0.2g / 900 ml
Bacillus thuringiensis	2g / 900ml

Statistical Analysis

The mortality rate of *M. plana* is calculated from observed and corrected mortality by using the formula below:

$$\text{Observed mortality} = \frac{Total\ no.of\ dead\ Metisa\ plana}{Total\ no.of\ sample\ size} \times 100\%$$

$$\text{Corrected mortality} = \frac{(\%\ Observed\ mortality - \%\ Control)}{(\ 100\% - \%\ Control)} \times 100\%$$

The collected data were analysed by using SPSS version 16 for analysis of variance (ANOVA) and independent *t*-test. Data on mortality was corrected using the Abbots formula [15].

RESULT AND DISCUSSION

Cumulative mortality

Cumulative mortality of *M. plana* toward different insecticides (Cypermethrin, Flubendiamide, *Bacillus thuringiensis*, including control), as shown in Figure 1. Mortality of *M. plana* has been recorded since Day After Treatment (DAT) 1 when exposed toward Cypermethrin and Flubendiamide.

Bacillus thuringiensis treatment only recorded *M. plana* mortality on DAT 3 while control treatment last until DAT 4 before recording the mortality. The highest percentage of cumulative mortality registered throughout eight days after treatment was 100% shown by all the four treatments, while the lowest cumulative mortality recorded was 4% by Flubendiamide and control treatment.

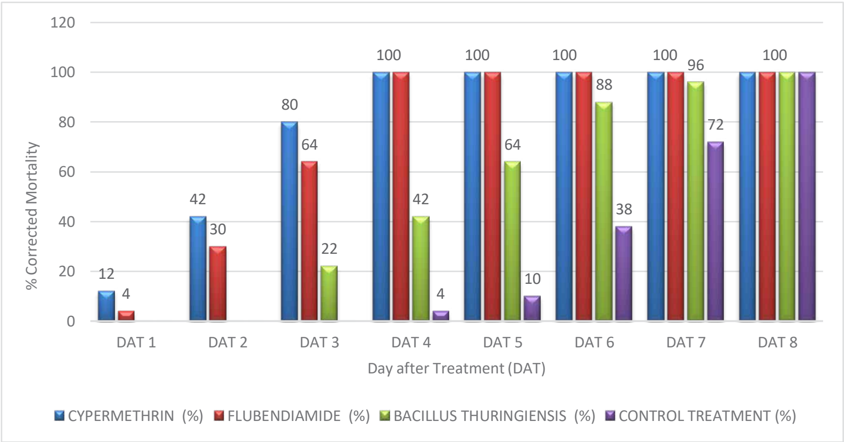

Figure 1: Cumulative Mortality of *M. plana* for Eight Days After Treatment (DAT)

Corrected mortality

Corrected mortality for both Cypermethrin and Flubendiamide treatment recorded the same value as the observed mortality. Cypermethrin maintained the highest corrected mortality for three consecutive days from DAT 1 until DAT 3, while *Bacillus thuringiensis* enlisted for the lowest corrected mortality for every recorded day (Figure 2). This result showed that both insecticides suffered minimum error to none in the mortality rate calculation when being compared with the control treatment. Anyhow, *Bacillus thuringiensis* had different corrected mortality ass compared with observed mortality. The value was slightly decreasing, which indicated that this treatment experienced external factor involvement regarding the mortality rate.

From DAT 1 until DAT 5 can be said that mortality recorded for *M. plana* were caused by the treatments applied. The observed mortality can prove it for control treatment, which not exceeds 10%. Starting from DAT 6 to DAT 8, causes of mortality cannot be said solely for the treatment as the observed mortality recorded more than 10%. It reflects that *M. plana* mortality influenced by other factors. To obtain the best result for the mortality rate, the experiment should be conducted within 96 hours to 120 hours of observation. Both Cypermethrin and Flubendiamide exhibit mortality since DAT 1, which means that both insecticides have a faster mode of action. However, Cypermethrin was the better insecticides between the two in terms of its mode of action as it kills more *M. plana* compare to Flubendiamide on the first day. Overall performance for both Cypermethrin and Flubendiamide can be said similarly as it recorded 100% in DAT 4, which considered to be the fastest in this experiment. *Bacillus thuringiensis* manifested a slower toxicity effect toward *M. plana* as the mortality can only be recorded on DAT 3. The slower effect can be assumed as the component of *Bacillus thuringiensis* is the bacteria itself. Biological components are known to have slower consequences toward *M. plana* compared to the chemical substances.

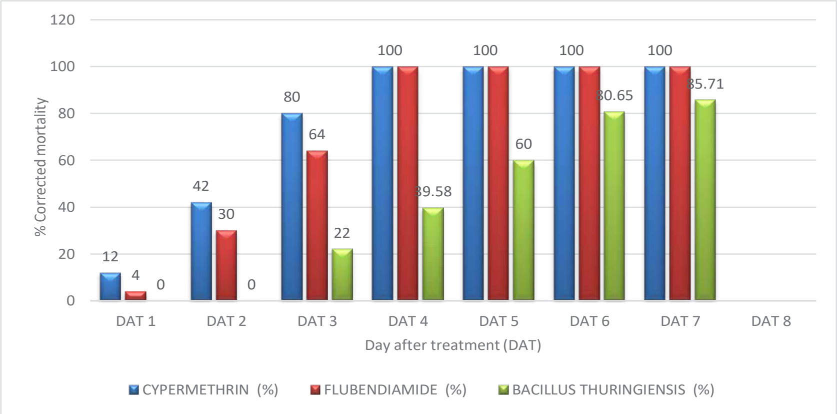

Figure 2: Corrected Mortality of *M. plana* for Eight Days After Treatment (DAT) One Way ANOVA

The result shows that there is a significant difference between the type of insecticides used toward the mortality rate of *M. plana* for eight days of observation. The *p*-value shows can prove it in the table below. The *p*-value is ($p < 0.05$) for every data collected on eight consecutive days (Table 2). However, some differences can be found between the effectiveness periods of insecticides toward *M. plana*. Both Cypermethrin and Flubendiamide were recorded for 100% of the mortality rate within four days after treatment is done. *Bacillus thuringiensis* only recorded 100% mortality for the full duration of eight days the same as the control treatment.

Table 2: Mean ± SE (Homogenous Subset) Mortality of M. plana toward Different Usage of Insecticides

TREATMENT	1 DAT	2 DAT	3 DAT	4 DAT	5 DAT	6 DAT	7 DAT	8 DAT
CYPERMETHRIN	1.2 ± 0.37a	3.0 ± 0.44a	3.8 ± 0.48a	2.0 ± 0.63a	0.0 ± 0.00b	0.0 ± 0.00b	0.0 ± 0.00b	0.0 ± 0.00b
FLUBENDIAMIDE	0.4 ± 0.24a	2.6 ± 0.67a	3.4 ± 0.67a	3.6 ± 0.50a	0.0 ± 0.00b	0.0 ± 0.00b	0.0 ± 0.00b	0.0 ± 0.00b
BACILLUS	0.0 ± 0.00b	0.0 ± 0.00b	2.2 ± 0.37a	2.0 ± 0.31a	2.2 ± 0.37a	2.4 ± 0.24a	1.0 ± 0.44b	0.2 ± 0.20b
CONTROL	0.0 ± 0.00b	0.0 ± 0.00b	0.0 ± 0.00b	0.4 ± 0.24b	0.6 ± 0.40b	2.8 ± 0.73a	3.4 ± 0.74a	2.8 ± 0.48a
ANOVA *F*-VALUE	6.40	16.00	13.89	8.33	14.40	15.20	13.54	26.81
***P* VALUE**	0.005	0.000	0.000	0.001	0.000	0.000	0.000	0.000

Note: Mean within the column with the different letters are significant at $p<0.05$ level by Tukey's test between treatments.

DAT: Day after treatment

DISCUSSION

From DAT 1 until DAT 5 can be said that mortality recorded for *M. plana* were caused by the treatments applied. The observed mortality can prove it for control treatment, which not exceeds 10%. Starting from DAT 6 to DAT 8, causes of mortality cannot be said solely for the treatment as the observed mortality recorded more than 10%. It reflects that *M. plana* mortality influenced by other factors such as natural death. To obtain the best result for the mortality rate, the experiment should be conducted within 96 hours to 120 hours of observation.

Both Cypermethrin and Flubendiamide exhibit mortality since DAT 1, which means that both insecticides have a faster mode of action. However, Cypermethrin was the better insecticides between the two in terms of its mode of action as it kills more *M. plana* compare to Flubendiamide on the first day. Overall performance for both Cypermethrin and Flubendiamide can be said similarly as it recorded 100% in DAT 4, which considered to be the fastest in this experiment. *Bacillus thuringiensis* manifested a slower toxicity effect toward *M. plana* as the mortality can only be recorded on DAT 3. The slower effect can be assumed as the component of *Bacillus thuringiensis* is the bacteria itself. Biological components are known to have slower consequences toward *M. plana* compared to the chemical substances.

In terms of environmental control, Flubendiamide is a better insecticide compare to cypermethrin as it gave minimum impact to other species. However, the disadvantage of this insecticide is its high price. *Bacillus thuringiensis* is a bio-insecticide. The main component of this insecticide is the living organism, which is bacteria. It is the best insecticide in terms of environmental control between the three insecticides. However, *Bacillus thuringiensis* has a slower mode of action, which caused the insecticide to take a little while; it can manifest its effectiveness. *Bacillus thuringiensis* also has a high price tag due to the bio-substances. All the insecticide had a different effect on *M. plana.* One of the factors is due to the mode of action of the insecticide. For Flubendiamide mode of action, it is a foliar-applied insecticide that has larvicidial activity as a stomach poison and is an oral intoxicant, fast-acting (rapid cessation of feeding), log lasting (rain fast) and has limited plant penetration and systemicity [10]. Although the photolysis of Flubendiamide is the main route of degradation, soil surface gave calculated half-lives of 11.56 days [10] longer than Btk half-life. The longer half-life of Flubendiamide will increase it is effective to both early and late instar. At pupae instar, no chemical was proven effective due to no chemical penetration into the bag.

CONCLUSION

This study has been carried out to determine the toxicity of different pesticides, namely Cypermethrin, Flubendiamide, and *Bacillus thuringiensis,* toward *M. plana* mortality. Based on the study, all the insecticides used will be resulting in the mortality of *M. plana*. Cypermethrin is the most effective insecticide for controlling the *M. plana* infestation, followed by Flubendiamide and *Bacillus thuringiensis*, respectively. Even the insecticides application in the plantation is the easiest way for resolving this insect pest problem; every procedure must follow on the recommendation of Insect Pest Management (IPM) to make sure the chemical substances from the pesticides will not affect non-target organism and environment.

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