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POPULATION ASSESSMENT AND APPROPRIATE SPRAYING TECHNIQUE TO CONTROL THE BAGWORM (*METISA PLANA* WALKER) IN NORTH SUMATRA AND LAMPUNG

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ABSTRACT

Over the last few years, the bagworm *Metisa plana* Walker (Lepidoptera: Psychidae) has become an important pest of oil palm, especially in North Sumatra. Recent report suggested that the bagworm has also been found in Lampung. The report requires preliminary survey to assess *M. plana* status and to prepare an effective control measure for the pest. This study was conducted to determine the relative density of *M. plana* in North Sumatra and Lampung and to compare the effectiveness of the spraying versus fogging application to control *M. plana* in oil palm fields. The observation confirmed that in 2010 *M. plana* colonies have developed in Lampung with an average relatively similar to that in North Sumatra during 2005. The finding implies that monitoring should be taken routinely to anticipate further development of the bagworm population in Lampung. Overall results of carbosulfan treatments suggested that the fogging insecticide technique was potentially as effective as spraying technique. This finding could be beneficial for bagworm control program due to the extensive areas of oil palm and the large size of canopy. A more thorough experiment is required to explore the most economical doses and to select effective insecticides to control *M. plana.*

Keywords: *Metisa plana* Walker (Lepidoptera: Psychidae), bagworm, oil palm, spraying vs. fogging application

INTRODUCTION

Indonesia is the largest oil palm producing country in the world. Indonesia oil palm plantation is increasing significantly over the last 10 years with an average of 8.7% per year, ranging from 3.9 million ha in 1999 to 7.3 million ha in 2009. The current data indicate that Indonesia crude palm oil (CPO) production increased from 19.2 million tons in 2008 to 19.4 million tons in 2009 (Data Consult, 2009). With the current rapid development of oil palm plantations in Indonesia, serious efforts have to be taken to minimize factors that disrupt the oil palm production. A vast expanse of the plantation also causes enormous potential losses when production disruption occurs, whether it is caused by climatic aberrations, disruption of ecosystems, as well as by outbreaks of plant pests and diseases.

One of important pests that could seriously disrupt oil palm production in Indonesia is the bagworm, *Metisa plana* Walker (Lepidoptera: Psychidae), a sessile insect feeding on the oil palm leaves. *Metisa plana* or bagworm has been reported as an important pest of oil palm in Southeast Asia (Wood, 1968; Basri and Kevan, 1995). In Malaysia, *M. plana* is the most serious and dominant pest of oil palm (Norman *et al*., 1994; Norman and Basri, 2007) and it has sometimes caused large losses since 1956 (Wood, 1968). During the period of 1981 to 1985, this pest caused a serious yield loss to 10,000 ha of oil palm estates in Malaysia where oil palm trees were heavily damaged (Basri *et al*., 1988). A recent survey conducted by Norman and Basri (2007) maintains that *M. plana* is the most widely distributed species in oil palm areas.

Metisa plana larvae damage oil palm by eating foliage for body maintenance and growth as well as for bag construction. Bagworm larvae prefer upper leaf surface for feeding and lower surface for resting and molting (Basri, 1995). 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) as simulated by Wood *et al.* (1973). *Metisa plana* undergoes seven larval instars each of which is protected within larval bag in different size and color. Length of *M. plana* bag varies from 1.3 –2.5 mm for the first instars to 9.3 – 11.0 mm for the seventh instars (Basri and Kevan, 1995). The population of *M. plana* exhibits cycles of 70–80 days with discrete generations in which females emerged before males during all generations. In a controlled environment, eggs of *M. plana are* pale and barrel-shaped with 19.7 days of incubation period. Laboratory reared bagworm produces ca. 158.3 eggs/female whilst fecundity of wild females is 99.9 eggs/female (Basri, 1995).

Over the last few years, *M. plana* has developed as a threatening pest of Indonesia oil palm industry, especially in northern Sumatra. In the region, the pest population has started to develop since the 1990s and has yet to be overcome satisfactorily. Similarly alarming population of *M. plana* has recently started in Lampung where colonies of the bagworm were informally reported in oil palm plantation at the Bekri Unit of PTPN VII Lampung in early 2010 (personal communication). Up to this date, however, no serious measure has been taken to anticipate the development of the bagworm population in Lampung. Due to seriousness of bagworm destruction on oil palm plantation, the informal report has initiated our team of the Department of Plant Protection, University of Lampung, to conduct an initial survey at Bekri Unit in Lampung to access early development of *M. plana* population in the area. Data of pest densities are also needed as baseline information in studying the population dynamics of *M. plana* in the future and to anticipate the necessary control measure when the outbreak occurs.

On the outset of population outbreak, natural control of *M. plana* does not suppress the bagworm population even though pathogens, parasitoids, and predators are available as natural enemies of the bagworm such as: *Cotesia* (*Apanteles*) *metesae* (Sankaran and Syed, 1972), *Cosmelestes picticeps* (Hemiptera: Reduviidae) and *Dolichodenidea metasae* (Hymenoptera: Braconidae) (Cheong *et al.,* 2010). In the group of insect pathogens, entomopathogenic fungi *Peacilomyces fumosoroseus* and *Metarhizium anisopliae* were isolated from fungal-infected bagworms. However, their resultant impact in controlling the bagworm populations in the field was still far from desirable (Cheong *et al*., 2010). Utilization of pathogens of the bagworm such as *Bacillus thuringiensis* have also been tested against the bagworm with variable success. *Bacillus thuringiensis* subspecies *kurstaki* or *aizawai* are shown to be effective on the bagworm *M. plana* under the condition of the experiment (Tan *et al.*, 2008). Another report, however, did not recommend *Bacillus thuringiensis* (B.t.) for controlling the bagworm because of variable success with its use (Basri *et al.*, 1996). The variable success of the bagworm may be attributed to facts that larval control by *Bt* was generally slow and it normally takes two to three days for the larvae to die (Knowles, 1994) and sometimes it even extended beyond one week for larger larvae (Glare and Callaghan, 2000).

To obtain a rapid and effective control of the *M. plana* in large areas, chemical application is sometimes needed as the control measure for the pest despite its potential for environmental hazards. Cases in Malaysia revealed that on a commercial scale, narrow-spectrum insecticide applications or stem injection of the oil palm trees with insecticide were the main option (Wood *et al*., 1974; Chung, 1988) although it was realized that the use of insecticide could significantly disrupt populations of *M. plana* natural enemies and cause pest resistance to insecticides (Ali *et al*., 1993). A similar action is probably also inevitable to control the bagworm in Indonesia oil palm plantations when outbreaks does occur in large scale. The situation requires most appropriate chemicals, equipments, and techniques best suited for oil palm plantation.

One of the most common techniques to apply insecticide to control agricultural crop pests is spraying application. Spraying application for large areas of oil palm plantations combined with large canopy of oil palm trees, however, is financially expensive as they are time and labor consuming. An alternative insecticide application technique that could be utilized to control *M. plana* is the fogging technique, a chemical application now commonly applied to control mosquitoes. Assuming that the fogging application of insecticide is as effective as spraying application, the fogging technique could save money substantially. The technique is likely less expensive and more practical to be implemented with sessile (immobile) insect such as *M. plana* bagworms which naturally spend most of their lifetime stay inside their larval bags. The effectiveness of the two techniques, however, has not been examined in oil palm plantations. Comparing the effectiveness of the two application techniques for controlling *M. plana* in oil palm fields, therefore, is important and could minimize the expense of pest control operation for the bagworm.

Based on the above background and consideration, this study was conducted with two main objectives: (1) to determine the relative population density of *M. plana* at two locations where colonies of the pest have been reported (Tanjung Morawa, North Sumatra and Bekri, Lampung); and (2) to compare the effectiveness of the spraying versus fogging insecticide application in controlling *M. plana* bagworm in oil palm fields.

MATERIALS AND METHODS

Location and Schedule

The survey and the experiment were conducted at two locations during two periods of the *M. plana* population outbreaks, i.e. May of 2010 at Bekri Unit of PTPN VII Lampung and April-May of 2005 at Tanjung Garbus Unit of PTPN II Tanjung Morawa, North Sumatra. Survey of the bagworm conducted in Lampung was an early observation and was intended to identify the initial population of *M. plana* bagworm in oil palm field as well as to confirm the status of the pest colonies in the area. Survey in Lampung was carried out in 3-4 years old palm fields where colonies of *M. plana* have been spotted while the North Sumatra observation was conducted in 6-7 years old oil palm fields.

Methods and Implementation

Observation of *M. plana* Density.

Population assessment for *M. plana* in Lampung was slightly different from that in North Sumatra. Population survey of the bagworm in Lampung was considered an early assessment and the data were intended as a quick outlook of *M. plana* status in Lampung oil palm plantation. The survey was, therefore, not as intensive as that in North Sumatra where the bagworm population has been reported for the last few years. Furthermore, the North Sumatra survey was conducted as part of the spraying experiment in which population of *M. plana* prior treatments and after treatments had to be recorded in a similar sampling methods.

Observation of the *M. plana* density in Lampung was carried out in 3-4 years old oil palm trees at three locations where colonies of the pest have been found at the Bekri Unit of PTPN VII. From each location, 80 samples of oil palm leaflets were cut from 20 trees. From each selected tree, four samples were taken for observation (1 sample from each direction: north, east, south, and west). Each sample (containing five leaflets or five oil palm ribs) was placed in a transparent plastic bag for later inspection at the laboratory. Samples were randomly selected from blocks of oil palm trees that have been identified to be infested by *M. plana* colonies. From each block, trees at diagonal position were taken randomly as samples. At the time of observation, larvae were identified to ensure that the species obtained were *M. plana* bagworms. The insect was identified based on morphological characteristics as described and pictorially depicted in Kalshoven (1981) and Rhainds *et al*. (2009). Inspection of the oil palm leaflets was conducted by counting the number of *M. plana* larvae on each leaflet. Data of larvae number were averaged and variances and standard of errors were calculated to determine the variability of the data.

Bagworm densities at Tanjung Garbus Unit of PTPN II Tanjung Morawa (North Sumatra) were observed in five years old oil palm trees. A number of 33 blocks or sampling plots from three locations were observed every 2-3 days from April to May of 2005. From each plot, three oil palm trees were chosen randomly. Out of each selected tree, leaves were then taken from different part of the tree canopy, i.e. lower, middle, and upper canopy. A number of 10 leaflets were cut from each sample point. Leaflets were then placed into transparent plastic bags and brought to the laboratory for later inspection. *M. plana* larvae found on each leaflet were counted and examined to determine the status of the bagworms whether there were alive or dead.

Dose Effectiveness and Insecticide Application Techniques

The experiment to compare the effectiveness of insecticide application techniques to control *M. plana* was conducted in Tanjung Garbus Unit of PTPN II Tanjung Morawa, North Sumatra. The insecticide used in this experiment was formulated as 200 EC (Emulsifiable Concentrate containing 195.6 g/l of carbosulfan as the active ingredient). The experiment was conducted in a randomized complete block design with three replications (blocks were used as replications). Each block had seven units of 50 x 100 m oil palm tree plots. The treatments of experiment were: three doses of spraying application (with 100, 200, and 400 g of a.i./ha), three doses of fogging insecticide application (with 100, 200, and 400 g of a.i./ha), and a control.

Spraying application was carried out using a Cifarelli's knapsack powered mist sprayer capable of generating 10-11 meters of spray that could reach oil palm leaves (Figure 1). Before application, the equipment was calibrated to determine the accurate spray volume required to treat each plant complying with the treatment doses. Fogging application was conducted with a Superfog Fogging Machine capable of blowing ca. 10 m smokes through oil palm trees. The machine was a thermal fogger that produced a range of droplet sizes including a large number of very small droplets that could easily reach air spaces in areas highly obstructed by vegetation such as oil palm trees. Diesel fuel was mixed and added to insecticide tank prior to the operation of the fogging machine. To obtain the maximum effect of insecticide smokes, the fogging application was conducted at midnight when the dew had begun to fall. The falling dew was expected to limit the upward movement of the insecticide smokes in the surrounding blocks of oil palm. During the application, all of field applicators and supervisors wore masks to prevent insecticide contamination.

The insecticide tested in this experiment was applied three times at seven days interval. The first, second, and third application was held on 13, 20, and 27 April 2005, respectively. As previously carried out in larval density observation, *M. plana* mortality was examined by counting the number of dead and surviving bagworm found on sampled leaflets. From each sampled oil palm tree, a number of 10 leaflets were cut from three positions: lower, middle, and upper part of the tree (therefore a total of 30 leaflets were collected from each tree). Sampled leaflets were placed in transparent plastic bag for later determination of the insects. Effectiveness of spraying vs. fogging techniques was determined by comparing the averages of larval mortality percentages from each technique. Larval mortality was observed every 2-3 days for a-18 day period. A similar method was applied in examination of the bagworm larvae for efficacy comparison of the insecticide doses. Analysis of variance and a set of contrast comparisons were applied to analyze the effectiveness of application techniques and dose efficacy. The contrast comparison was calculated to determine the effectiveness of the treatments on: (1) spraying application at 100 g of a.i./ha vs. fogging application at 100 g of a.i./ha; (2) spraying application at 200 g of a.i./ha vs. fogging application at 200 g of a.i./ha; (3) spraying application at 400 g of a.i./ha vs. fogging application at 400 of a.i./ha; (4) spraying application vs. fogging application; (5) spraying application vs. control; and (6) fogging application vs. control. The contrast comparisons and their coefficients are summarized in Table 1.

Data were analyzed using SAS Software Version 8.0 (SAS Institute, 2000). Percentages of *M. plana* mortality in treated plots were corrected with the percent mortality at control plot with Schneider-Orelli's formula (1947 in Püntener, 1981) as follows:

$$CM\ \% = \frac{(Mortality\ \%\ \ in\ T - Mortality\ \%\ \ in\ C)}{(100 - Mortality\ \%\ \ in\ C)}$$

Remarks: CM = corrected mortality; T = treated plots; C = control plots.

Table 1. The Contrast Comparisons to the effectiveness of the treatments

Comparisons of Treatments	Contrast Coefficients						
	S1	**S2**	**S3**	**F1**	**F2**	**F3**	**C**
Spraying 100 g/ha Vs. Fogging 100 g/ha	-1	0	0	1	0	0	0
Spraying 200 g/ha Vs.Fogging 200 g/ha	0	-1	0	0	1	0	0
Spraying 400 g/ha Vs. Fogging 400 g/ha	0	0	-1	0	0	1	0
Spraying Vs. Fogging	-1	-1	-1	1	1	1	0
Fogging Vs. Control	0	0	0	-1	-1	-1	3
Spraying Vs. Control	-1	-1	-1	0	0	0	3

Remarks: S1 = Spraying application at 100 g a.i./ha dose; S2 = Spraying application at 1.0 g a.i./ha dose; S3 = Spraying application at 2.0 g a.i./ha dose; F1 = Fogging application 100 g a.i./ha dose; F2 = Fogging application 1.0 g a.i./ha dose; F3 = Fogging application 2.0 g a.i./ha dose

Figure 1. Powered sprayer machine used to apply insecticide on the experiment of spraying Vs. fogging application.

RESULTS AND DISCUSSION

Density of *Metisa plana*

Field observations of *M. plana* density on three locations at Bekri Unit of PTPN VII Lampung confirmed the previous report that the bagworm colonies have developed in the area. Numbers of the bagworm larvae found on oil palm trees ranged from 3.54 to 4.14 larvae per leaflet with an average of 3.78 larvae per leaflet (Table 2). Data from the 1600 leaflets collected from the field revealed that almost all of oil palm leaves have been infested by larvae of *M. plana*. This condition implies that the bagworm population has sufficiently developed in the area, particularly at Bekri Unit of PTPN VII Lampung.

The density level of the bagworm found in Bekri Unit was relatively similar to that observed in Tanjung Morawa, North Sumatra during April – May of 2005 which ranged from 2.67 to 4.29 larvae per oil palm leaflet and averaging 3.63 larvae per leaflet (Table 3, Figure 2). Up to this date, however, no reduction of CPO production due to the *M. plana* population had been reported from Lampung area. Oil palm trees in Bekri seemed to be in better condition than those observed in Tanjung Morawa five years ago when *M. plana* population was about at the same level. This condition was probably due to the fact that *M. plana* colonies found in Lampung were relatively new (initial population was informally reported around March of 2010). Another factor that kept oil palm trees in Bekri Unit was in better condition was probably the more intensive crop growing practices applied to oil palm in PTPN VII in Lampung. Oil palm crops in Bekri Unit of Lampung were more intensively treated with fertilizers and pest control measures those in Tanjung Morawa of North Sumatra.

Table 2. Density of *M. plana* larvae per oil palm leaflet in Bekri Unit of PTPN VII Lampung (May 2010)

Locations	**Number of *M. plana* per leaflet (± SE)**
Field 1	4.14 ± 0.38
Field 2	3.66 ± 0.33
Field 3	3.54 ± 0.52
Average	3.78 ± 0.26

Despite no official report of CPO yield reduction were claimed in Indonesia, the oil palm damage caused by *M. plana,* especially in Tanjung Morawa, was severe. *Metisa plana* larvae attack caused serious damage to oil palm leaves. Leaf injuries after the bagworm feeding become permanent holes (Figure 2) and consequently could affect the photosynthesis process of the oil palm crops. Rhainds and Ho (2002) suggested that the intensity of leaf holes is proportional to the level of population density of the bagworm. It is estimated that the bagworm attacks at mild to moderate levels could cause a reduction of 33% to 47% of oil palm yield within the next two years (Basri and Kamarudin, 2005). This information suggested that precautious monitoring should be taken regularly to anticipate further development of the bagworm population both in Lampung and North Sumatra. The densities of *M. plana* in the two locations were probably also higher than the available economic thresholds for the pest. Wood (1971) stated that the economic threshold of *M. plana* was 10 larvae per frond while Basri (1993 in Darus and Basri, 2000) set the threshold at 8 – 47 larvae per frond. Considering that a frond of oil palm has ca. 200 leaflets (depend on the age of the tree), densities of *M. plana* found in our surveys most likely exceeded the economic threshold and a chemical application was probably justified.

Records of *M. plana* status in Tanjung Morawa showed that out of the collected bagworms, percentages of alive and dead larvae were 83.59% and 16.41%, respectively. Overall pattern during the observation showed that *M. plana* field mortality fluctuated variably. The percentage of alive *M. plana* in the area was relatively high compared to that in Perak Malaysia observed at the same period. Cheong *et al*. (2010) reported that in 2005 only 71.0% out of 4,377 individual bagworms surveyed in Melintang (Perak, Malaysia) were alive. In the following year (March-April of 2006), the percentage of alive *M. plana* was relatively at similar rate (70.1%). Since we did not survey the causal factors that led to *M. plana* mortality in the field, we could not determine why the number of *M. plana* found alive in Tanjung Morawa was higher than that in Perak, Malaysia. Several factors could lead to mortality of the bagworm in the field, namely predators, parasitoids, fungi, and other environmental factors. Survey by Cheong in Perak Malaysia (2010) revealed that predators caused the highest percentage (37%) of mortality affecting to bagworm population in the plantation. About 35.9 and 27.2% of mortality were contributed by parasitoids and fungal infection, respectively.

Based on the *M. plana* population development and crop damages experienced by PTPN II Tanjung Morawa during 2005, the current population of the bagworm in Bekri (Lampung) should alert the management to prepare for the control program when the pest outbreak develops. We consider that as newly established colonies, the Bekri population of the bagworm could potentially develop at larger scale when the environmental factors are favorable for the pest development. More structured observations of the bagworm may be required to monitor the population development of the pest. No less importance is the availability of control measures, techniques, and equipment for the task. Results of our experiment in comparing the effectiveness of spraying Vs. fogging applications in Tanjung Morawa could be considered if less expensive measures are to be exercised.

Table 3. Average number of *M. plana* per oil palm leaflet during April-May 2005 in Tanjung Garbus Unit of PTPN II Tanjung Morawa, North Sumatra

Date	Number of *M. plana* per leaflet			% Alive	% Dead
	Total	Alive	Dead		
13/04/05	2.67	2.29	0.38	85.65	14.35
15/04/05	4.23	3.40	0.83	80.51	19.49
19/04/05	3.09	2.47	0.62	79.91	20.09
22/04/05	3.67	3.05	0.62	83.09	16.91
26/04/05	4.29	3.62	0.67	84.34	15.66
28/04/05	3.67	2.97	0.70	80.84	19.16
03/05/05	3.91	3.41	0.50	87.29	12.71
07/05/05	3.86	3.14	0.72	81.30	18.70
11/05/05	4.06	3.48	0.58	85.65	14.35
15/05/05	2.88	2.51	0.37	87.32	12.68
Average	3.63	3.03	0.60	83.59	16.41

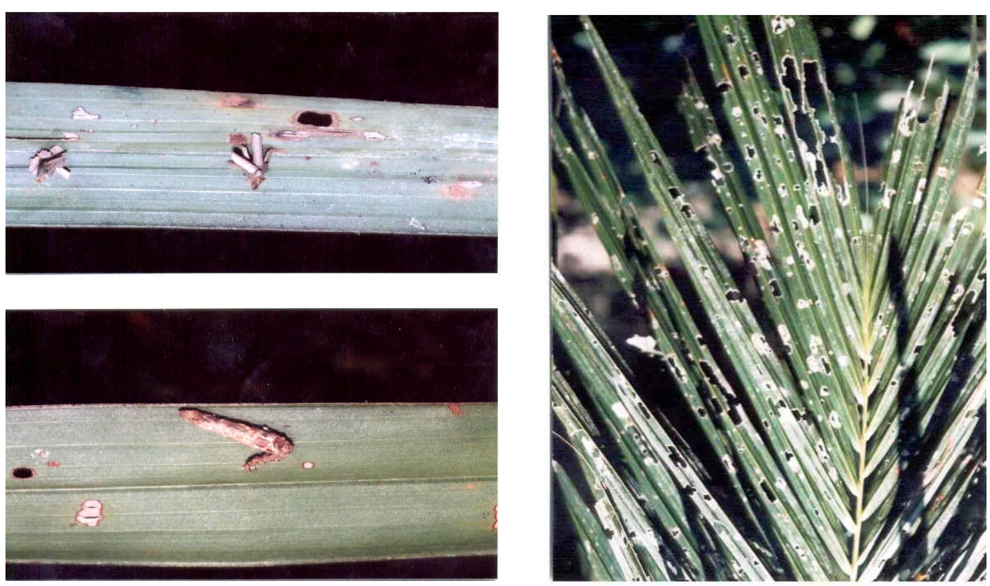

Figure 2. *Metisa plana* Walker (Lepidoptera: Psychidae) on oil palm leaves found at Tanjung Garbus Unit of PTPN II (North Sumatra) in 2005 (left). Impacts of *M. plana* feeding on the destruction of oil palm leaves (right) (Photos: Hamim Sudarsono).

Effectiveness of Insecticide Doses and Application Techniques

Our observation indicates that overlapped cohorts of *M. plana* larvae existed in oil palm trees and multiple instars of larvae were found. Due to the large number larvae found in the field and the difficulty of larva separation based on their instars, our experiment did not differentiate the instars of *M. plana* exposed to insecticide application. The data show that two days after the first application of carbosulfan, mortality rates of *M. plana* at oil palm trees varied from 39.96 to 79.46% while the control plot had only 19.49% mortality. Relatively similar patterns were recorded after the second and third application of insecticide. While mortality rates of *M. plana* were recorded at 12.68% to 20.09% in control blocks, the mortality percentages of the bagworm in treated plots were significantly higher ranging from 39.96% to 79.89%. Analysis of variances and individual contrast comparisons of the experimental data indicated that there was no different mortality percentage between spraying and fogging application of carbosulfan at each dose level. Out of 27 individual contrast comparisons confronting *M. plana* mortality after spraying Vs. fogging application on each dose level (100, 200, and 400 g a.i./ha), a significantly different mortality of *M. plana* was only found on the 26th April 2005 data at the 100 g a.i./ha dose level (Tables 4 and 5). Meanwhile, contrast comparisons for the combined means between spraying and fogging resulted in slightly different mortality rates. Out of nine contrast comparisons, four results (23 April, 26 April, 3 May, and 7 May) indicate that spraying applications caused higher *M. plana* mortality than those of fogging applications. Five averages, however, indicate that *M. plana* mortality on sprayed and fogged blocks were not significantly different.

Despite some mixed results on the combined data, the majority of overall mortality data indicated that *M. plana* mortality after fogging treatment were not significantly different from those after spraying treatments (26 out of 27 data for the individual contrasts comparisons; 5 out of 9 data for the combined contrast comparisons. It is important to emphasize that the fogging was conducted at midnight when the dew had begun to fall to limit the upward movement of the insecticide smokes in the surrounding blocks of oil palm. Since the test was conducted in an open field of relatively large oil palm blocks, it was impossible to measure how much insecticide drift or smokes was wasted from the spraying as well as from the fogging application. However, how much insecticide drift produced by each techniques should not affect the conclusion of this experiment because the spraying and fogging techniques compared in this test used the same amount of insecticide.

Based on the results of our experiment, it is reasonable to conclude that the application of insecticide through fogging technique is potentially as effectives as the spraying technique in controlling *M. plana* in oil palm fields. This conclusion, however, requires further studies to determine the more effective dose levels and to select better insecticides. A more precise effective dose is necessary because the thermal fogging uses heat to produce fog or smaller insecticide droplets which may shorten the residual effect of the insecticide. Another important consideration in *M. plana* control is the timing of the insecticide application. Darus and Basri (2000) suggested that the insecticide application should be done at the beginning of generation, as soon as bagworm eggs hatch. This is because the younger larvae are more susceptible to chemicals than the older ones. The correct timing is therefore the utmost importance for effective control.

Even though further experiment has to be conducted at larger scales, this finding could be beneficial for the bagworm control program due to the extensive areas of oil palm fields and the large size of oil palm canopy. One of the advantages of fogging technique is the relatively simple and fast process of application but with large coverage of treated areas. When the effective insecticide is selected and optimum dose has been determined, the fogging application technique could be as effective and at the same time more economical than spraying or even trunk injection reported by Chung (1988).

Table 4. Percent of *M. plana* mortality after three times of carbosulfan treatments (200 EC formulation) at several dose levels with spraying Vs. fogging application

Date of Observation	Dose of Active Ingredient (Carbofuran) and Application Techniques						Spraying	Fogging	Control
	100 g/ha		200 g/ha		400 g/ha				
	Spraying	Fogging	Spraying	Fogging	Spraying	Fogging			
15-Apr	63.65	39.96	62.75	43.17	72.37	79.46	66.26 a	54.2 a	19.49 c
19-Apr	57.15	57.98	73.99	67.76	53.49	61.98	61.54 a	62.57 a	20.09 c
23-Apr	77.58	59.92	75.58	57.28	79.59	60.07	77.58 a	59.09 b	16.91 c
26-Apr	79.89 a	59.83 b	76.14	60.09	66.63	62.73	74.22 a	60.89 b	15.66 c
29-Apr	75.92	55.79	69.67	63.12	72.61	62.23	72.73 a	60.38 a	19.16 c
3-May	72.9	59.26	75.71	56.24	77.05	63.33	75.22 a	59.61 b	12.71 c
7-May	77.54	59.58	76.05	68.16	79.84	68.65	77.81 a	65.46 b	18.70 c
11-May	74.33	60.96	76.4	62.76	79.64	69.58	76.79 a	64.43 a	14.35 c
15-May	64.31	63.52	73.09	65.64	77.53	72.03	71.64 a	67.06 a	12.68 c

Remarks= (1) Average of *M. plana* mortality percentage at the same dose level followed by different characters are significantly different
(2) Average of *M. plana* mortality percentage among spraying, fogging, and control followed by different characters are significantly different
(3) Insecticide was applied on 13, 20, 27 April 2005

Table 5. P-value of six contrasts comparing % of *M. plana* mortality following three time applications of carbosulfan to oil palm tree canopies.

Date of Observation	Contrast 1	Contrast 2	Contrast 3	Contrast 4	Contrast 5	Contrast 6
15-Apr	0.1801	0.2622	0.6775	0.2334	0.0253*	0.0049*
19-Apr	0.9672	0.7592	0.6765	0.9298	0.0224*	0.0252*
23-Apr	0.0728	0.0643	0.0505	0.0039*	0.0001**	0.0001**
26-Apr	0.0259*	0.0648	0.6304	0.0127*	0.0001**	0.0001**
29-Apr	0.0508	0.4935	0.2849	0.0882	0.0001**	0.0001**
3-May	0.0582	0.0113	0.0670	0.0014**	0.0001**	0.0001**
7-May	0.0656	0.3911	0.2308	0.0328*	0.0001**	0.0001**
11-May	0.2873	0.2783	0.4186	0.1000	0.0003**	0.0001**
15-May	0.9167	0.3295	0.4677	0.3007	0.0001**	0.0001**

Remarks= Insecticide was applied on 13, 20, 27 April 2005; C1=Spraying 100 g a.i./ha Vs. Fogging 100 g a.i./ha; C2 = Spraying 200 g a.i./ha Vs. Fogging 200 g a.i./ha; C3 =Spraying 400 g Vs. Fogging 400 g a.i./ha; C4 = Spraying Vs. Fogging C5 = Fogging Vs Control C6 = Spraying Vs. Control

CONCLUSIONS AND SUGGESTION

Our field observation confirms that *M. plana* colonies were found in Bekri Unit of PTPN VII Lampung during 2010 with an average density relatively similar to those in Tanjung Morawa, North Sumatra during 2005. The data implies that the bagworm population has sufficiently developed in Lampung and precautious monitoring should be taken regularly to anticipate further development of the bagworm population.

The majority of overall mortality data indicate that *M. plana* mortality after fogging treatment were not significantly different from those after spraying treatments (26 out of 27 data for the individual contrasts comparisons; 5 out of 9 data for the combined contrast comparisons). Application of insecticide through fogging technique is potentially as effectives as the spraying technique in controlling *M. plana* in oil palm fields. This finding could be beneficial for the bagworm control program due to the extensive areas of oil palm fields and the large size of oil palm canopy. A more thorough experiment is required to explore the most economical and effective doses and insecticides to control *M. plana.*

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