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EFFECT OF BAGWORM *Pteroma pendula* Joannis ATTACK ON THE DECREASE IN OIL PALM PRODUCTIVITY

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ABSTRACT

***Effect of bagworm* Pteroma pendula *Joannis attack on the decrease in oil palm productivity*.** Outbreak of oil palm bagworm *Pteroma pendula* has been reported within the last few years in several plantations in North Sumatra. A study was conducted to determine the impact of *P. pendula* attacks on oil palm productivity. Aerial photograph was taken in November 2016 and analyzed to determine the level of damage on each palm canopy. The damage symptoms were classified onto healthy palms as control plants (score 0), mild (score 1), moderate (score 2), severe (score 3), and very severe (score 4). The sample palms were randomly selected and observed for the sex ratio, bunch number and bunch weight at 18 months after defoliation. The attack of *P. pendula* at the highest level (score 4) caused a significant effect on sex ratio and the number of bunches produced. The fresh fruit bunches production was declined 21.02–36.35% on palms with moderate to very severe attack (score 2–4). Similar palms also have a potential case of inflorescences abortion 18.41–32.54%. However, the average bunch weight was not influenced by *P. pendula* attack.

Key words: bunch number, bunch weight, *Pteroma pendula,* sex ratio

INTRODUCTION

Pest attack is one of the limiting factors in the cultivation of oil palm. Damage due to pest attacks have a negative impact on the production of oil palm fresh fruit bunches (FFB), both directly and indirectly. Direct yield loss can occur due to pests on flowers and fruit bunches, such as the oil palm bunch moth *Tirathaba ruvifena* Walker and mice (Corley & Tinker, 2015; Masijan *et al*., 2015). Decreased FFB production can also occur indirectly as a result of severe damage to oil palm leaves (Chung, 2015; Woittiez *et al.,* 2017). Damage to the leaves will cause disruption of the photosynthesis process so that the supply of assimilates for fruit development is reduced (Ajambang *et al.,* 2015; Apichatmeta *et al.,* 2017). Damage to the leaves can also cause palm to become stressed so that they tend to form male flowers.

In general, pest attacks on oil palm plantations in Indonesia are dominated by leaf defoliating pests, especially from the Lepidoptera such as nettle caterpillars, tussock moths, and bagworms (Susanto *et al.,* 2015). Of the three caterpillars, bagworm is the most difficult to control in the field. Some of the dominant species of bagworms in oil palm plantation are *Metisa plana* Walk.*, Pteroma pendula* Joannis*, Mahasena corbetti* Tams., and *Clania tertia* Temp. (Susanto *et al.,* 2015; Priwiratama *et al.,* 2018). Among these, *P. pendula* has the smallest size and it is quite rare to report its population explosion in the field. However, since the last five years the *P. pendula* attack has been reported in several plantations in Deli Serdang Regency, North Sumatra (Pangaribuan *et al.,* 2017) and until now the attack can still be found in the field.

There have not been many studies on the impact of *P. pendula* attacks on the productivity of oil palm. Knowledge on the correlation between attack intensity and crop productivity is very useful for predicting potential yield losses due to *P. pendula* attacks. This study aimed to determine the level of decline in oil palm productivity due to *P. pendula* attacks.

MATERIALS AND METHODS

The study was conducted at one of oil palm plantations in Deli Serdang Regency, North Sumatra (3°21’01.3"N, 99°07’01.5"E). The type of soil in the most of the experimental sites was red-yellow podzolic with an average rainfall of 1,900–2,482 mm/month. The observation site was a 10 ha block of mature oil palm planted in 2013. Photographs of bagworm attacks at the observation site were carried out using drones in November 2016, while the calculation of the sex ratio of oil palm was carried out in April to May 2018.

Scoring of the Level of Oil Palm Damage Due to *P. pendula.* Scoring of the level of oil palm damage due to bagworm *P. pendula* was carried out based on the symptoms of the attack on the oil palm canopy seen in aerial photographs taken on November 2016. Scoring criteria used are presented in Table 1. The map of damage intensity was then arranged based on the results of the scoring to see the distribution of each category of damage in the field. After the map was obtained, verification in the field was performed to ensure the accuracy of the scoring that has been carried out on affected palm.

Determination of Sample Plots. After the verification, 120 palm samples for each scoring category (Table 1) were randomly selected by considering the similarity between palms. Upkeep for all plot samples including fertilization, pests and diseases control, weeding, frond pruning, and FFB harvesting activities were carried out according to local estate standards and policies.

Observation of Sex Ratio and FFB Production of Oil Palm Infected by *P. pendula*. An evaluation of the impact of leaf eating caterpillars on the sex ratio of oil palm was carried out 18 months after defoliation. This is based on the process of sex differentiation that occurs in the period of 18–30 months before the appearance of the oil palm inflorescences (Harahap, 2008). Observation of sex ratio was conducted by counting all male and female inflorescences, and FFB produced by each sample. The value of sex ratio is calculated by the following formula (Corley & Tinker, 2016):

$$\text{sex ratio} = \frac{\text{female flowers} + \text{fruit bunches}}{\text{female flowers} + \text{fruit bunches} + \text{male flowers}}$$

Furthermore, during the rotation of the harvesting (five times), each ripe FFB on each sample was harvested and weighed to investigate the impact of *P. pendula* attack on the FFB production of the affected palm.

Data Analysis. The resulting data were analyzed for variance using GenStat 12th edition software (VSN International UK). If there are significant differences between the attack categories, the data is further tested by Duncan's multiple range test with a confidence level of 5% (α=0.05).

RESULTS AND DISCUSSION

Attack Intensity and Distribution Pattern of Bagworm *P. pendula*. Based on field observations, 87.45% of oil palms were attacked by bagworm *P. pendula* with intensity reaching 58.04%. The composition of the attack was dominated by palm with very severe attack (score 4) with a proportion of 30.09%, and higher than unattack palm plants (12.55%).

Bagworm *P. pendula* attacks can occur at any age of the palm, but the highest intensities is generally occur in palms with overlapping fronds (≥8 years old) (Susanto *et al.,* 2015). Early instar larvae feed on the leaf's upper epidermis (Figure 1F), while the late instar larvae feed on the leaf's lower epidermis. Damage to this part of the epidermis causes the leaves to dry out and look like a burning appearance (Figure 1D-E). The attack of *P. pendula* generally starts from the lower frond and continues to the upper frond (Kamarudin & Wahid, 2010).

The pattern of bagworm attacks in the experimental block tends to be in cluster (Figure 2). The cluster occurs because generally the bagworms move from the affected palm to another through the frond that have already overlap (Kamarudin & Wahid, 2010; Susanto *et al.,* 2012). This happens because the adult

Table 1. Scoring criteria to determine the level of damage to the oil palm canopy due to *P. pendula* attacks

Score	Remarks
0	Healthy palm with canopy of leaves that still look green without any symptoms of bagworm attack
1	Palm with mild symptom which means the symptoms of burning-like leaves have reached the canopy of leaf circumference > 4 (32nd leaf below) from above
2	Palm with moderate symptom which means that the symptoms of burning-like leaves have reached the canopy of leaf circumference 3 –4 (24th to 32nd leaves) from above
3	Palm with severe symptoms, which means that symptoms of burning-like leaves have reached the canopy of leaf circumference 2 –3 (16th to 24th leaves) from above
4	Palm with very severe symptoms, which means that the symptoms of burning-like leaves have reached the canopy of the leaf circumference <2 (first leaf to 16th leaf) from above

Figure 1. Aerial photographs of bagworm *P. pendula* attacks in various attack categories. (A) unattacked palm (score 0); (B) palms with mild symptoms (score 1); (C) palms with moderate symptoms (score 2); (D) palms with severe symptoms (score 3); (E). palms with very severe symptoms (score 4); (F) *P. pendula* attacks cause damage to the leaf epidermis.

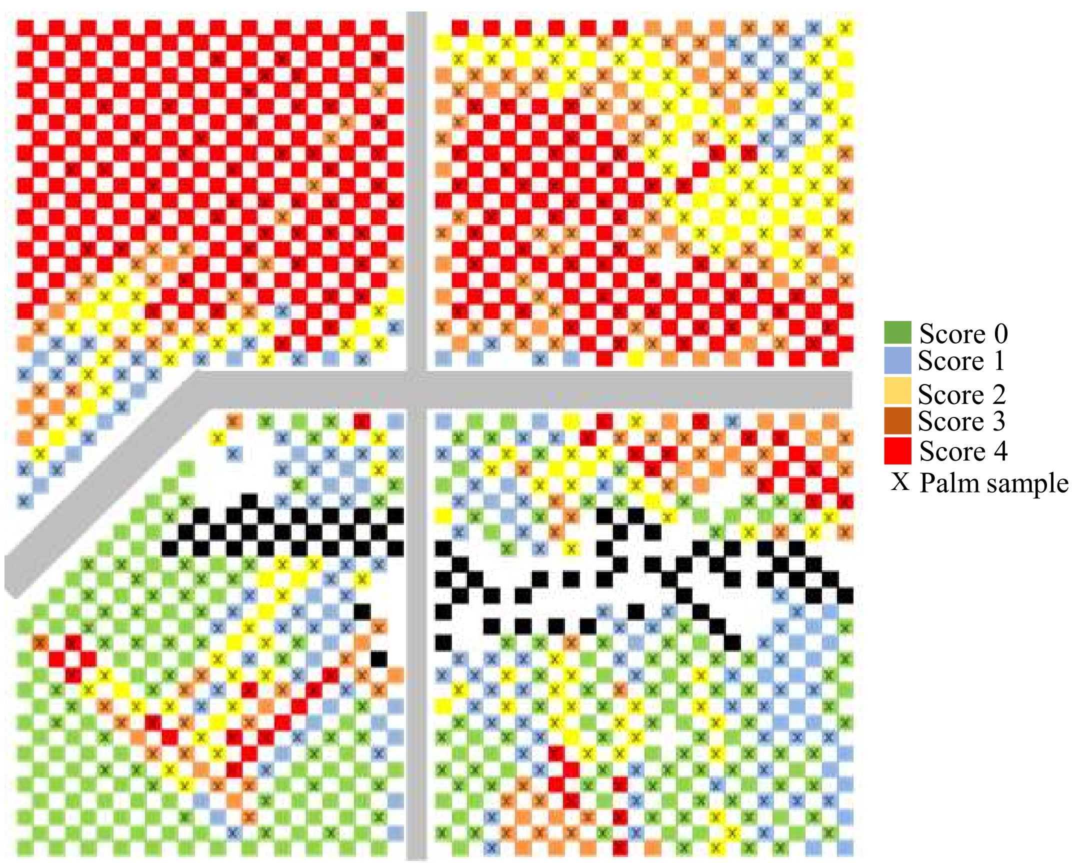

Figure 2. The map of *P. pendula* attack with various attack level categories (scores) on November 2016 at the oil palm observation block of planting year 2013.

female bagworm has no wings and will remain in the bag until they lay eggs and die. The absence of these wings causes the distribution of bagworms to be slower and more limited around the initial point of attack. Based on this behavior, it can be assumed that the attack of the bagworm in the experimental block starts in the northwestern part.

Sex Ratio of the Oil Palm. Field observations showed that the sex ratio of plants was affected by the severity of *P. pendula* attacks. Palms with the highest attack intensity (score 4 or very severe symptoms) had the lowest sex ratio and were significantly different from healthy palms (Table 2). This shows that oil palms with very severe attack (score 4) produce more male inflorescences than the healthy palms (score 0). Meanwhile, palms with a score of 1–3 were not significantly different from healthy palms, although there was a tendency for a lower sex ratio.

The value of sex ratio was closely related to the process of sex differentiation that occurs long before the appearance of the inflorescences, which was between 18–24 months before (Djufry *et al.,* 2000; Harahap, 2008). Normally, one male or female inflorescence can be formed on each frond (Corley & Tinker, 2016). The formation of male or female oil palm inflorescences was strongly affected by the condition of the palm and the environment when the process took place. Palms experiencing stress due to environmental stresses such as mismatches in climatic and nutrient conditions or defoliation will produce more male inflorescences (Wood *et al.,* 1973; Djufry *et al.,* 2000; Adam *et al.,* 2011; Darlan *et al.,* 2016; Harahap *et al.,* 2017). Marcelino & Diaz (2016) has previously demonstrated the effect of defoliation on the number of female inflorescences produced by eight-year-old oil palm. Palms with less than 32 fronds/palm produce fewer female inflorescences or FFB than palms with normal number of frond (between 40–48 fronds/palm).

Production of FFB of Oil Palm Affected by *P. pendula.* The productivity of oil palm is determined by the number and weight of the FFB produced. Palms with moderate to very severe symptoms (score 2–4) had significantly less bunches than palms with healthy or mild symptoms (score 1) (Table 3). Although there were differences in the bunch number produced, there was no significant difference in the average of bunch

Table 2. Value of sex ratio of oil palm in various categories of *P. pendula* attacks

Attack category (score)	Sex ratio (%)	Difference of sex ratio (%)
0	98.23 ± 0.48 a	-
1	97.38 ± 0.91 a	0.79
2	96.35 ± 1.01 a	1.90
3	96.43 ± 1.05 a	1.74
4	92.54 ± 1.61 b	5.53

Values followed by the same letters is not significantly different based on Duncan's multiple interval test at significance level of 5% (α=0.05).

Table 3. Average of bunch number, bunch weight and estimated FFB production of oil palm within various categories of *P. pendula* attacks

Attack category	Bunch number	Bunch weight (kg)	FFB production * (kg/palm/semester)	Decreased production (%)
0	12.14 ± 3.86 a	8.52 ± 1.54 a	103.49 ± 3.01 a	-
1	11.39 ± 3.48 a	8.29 ± 1.73 a	94.43 ± 2.64 b	8.75
2	9.88 ± 3.60 b	8.28 ± 1.36 a	81.74 ± 2.72 c	21.02
3	9.04 ± 3.02 b	8.15 ± 1.39 a	73.68 ± 2.25 d	28.80
4	8.18 ± 3.14 c	8.05 ± 1.27 a	65.87 ± 2.31 e	36.35

Values in the same column followed by the same letters are not significantly different based on Duncan's multiple interval test at significance level of 5% (α=0.05). * Estimated FFB production for 6 months obtained from the bunch number x bunch weight.

weight between palms attacked by *P. pendula* and healthy palms. The average bunch weight in all palms was in the range of 8.0–8.5 kg, similar to the potential of bunch weight produced by five-year-old palms (Lubis, 2008). These results indicate that the effect of bagworm *P. pendula* or other defoliator pests was more clearly expressed in the bunch number than the bunch weight. Variations in the bunch number have also previously been reported to occur in palm under stressed conditions due to environmental cues or decreased photosynthetic activity because of defoliation (Henson, 1997; Henson, 1998; Henson & Dolmat, 2004a). On the other hand, the bunch weight variable is generally not much affected by palm conditions or environmental stress (Lim & Chan, 1998; Henson & Dolmat, 2004b).

The attack intensity of *P. pendula* was negatively correlated to FFB production per palm (Figure 3). The higher the level of damage caused by *P. pendula*, the lower the FFB production per palm. The palms with the most severe level of damage (score 4) caused a loss of FFB yield of 36.35% (Table 3). The yield loss was affected by the lower bunch number produced due to defoliation in the affected palms.

Various studies have shown that the attack of leaf eating caterpillars with defoliation rates between 30–50% can cause a decrease in production of up to 40% in the first and second years after defoliation occurs (Wood *et al.,* 1973; Basri *et al.,* 1995; Syed & Saleh, 1998; Kamarudin & Wahid, 2010; Potineni & Saravanan, 2013). The decrease in current year production was generally caused by the decreasing ability of palms to photosynthesize thereby disrupting the intake of assimilates for the development of flowers and fruit, while the decrease in production in the second year after defoliation was more due to the effect of a lower sex ratio (Corley & Tinker, 2015; Woittiez *et al.,* 2017). According to Henson & Dolmat (2004a) as well as Cros *et al.* (2013) the number of bunches produced depends on the condition of the plant and the environment, especially during the process of flower formation.

When viewed from the total production of flower and FFB, healthy palms produce an average of 12.6 bunches per palm (Table 4). According to Turner & Gillbanks (2003), the position of the anthesis or receptive flower is in the frond number 17 while the ripe FFB is in the frond number 31. Meanwhile, Corley & Tinker (2016) stated that the receptive inflorescences are in the frond position number 20 while the ripe FFB is in the frond number 30. This means that every healthy palm has the potential to produce 11–15 inflorescences or FFB. In the category of mild attack (score 1), the number of inflorescences and FFB production is not different from healthy palms. Conversely, palms with moderate to very severe attack categories (score 2–4) have a smaller bunch number. This indicates the existence of flower abortion on palms attacked by *P. pendula*.

Combres *et al.* (2013) predicted that the abortion process occurs 10 months after the stress on the oil palm. One of the triggers for flower abortion is the occurrence of stress on the palm which can be caused by defoliation in the palm canopy or unsuitable environmental conditions during the flower formation (Djufry *et al.,* 2000; Corley & Tinker, 2015; Harahap & Lubis, 2018). From Table 3 it can be seen that in general the higher the level of damage of palm canopy, the greater the potential for flower abortion. Flower

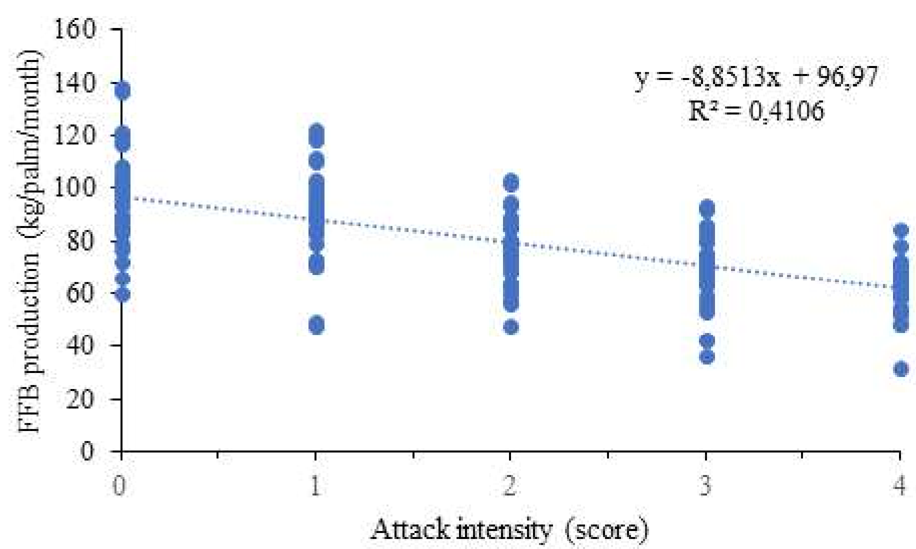

Figure 3. Relationship between *P. pendula* attack intensity and FFB production.

Table 4. The number of flower and FFB produced by oil palm plants at various stages of *P. pendula* attack

Attack category (score)	Number of flowers and fruit	Difference (%)
0	12.6 ± 0.34 a	-
1	11.86 ± 0.32 a	5.87
2	10.28 ± 0.34 b	18.41
3	9.38 ± 0.28 c	25.56
4	8.5 ± 0.30 d	32.54

Values followed by the same letters is not significantly different based on Duncan's multiple interval test at significance level of 5% ($\alpha = 0.05$).

abortions that occur in palms that are moderately (score 2), severely (score 3), and very severely (score 4) attacked are 18.41%, 25.56%, and 32.54%, respectively.

The above results have shown that attack of bagworm *P. pendula* can cause significant yield losses on oil palm. Potential decrease in production is also similar to those which has been reported in the attack of other species of bagworm, for instance, *M. plana* which ranges from 10–44% (Basri & Kevan, 1995; Sudharto *et al.,* 1997; Pamuji *et al.,* 2013). This shows that *P. pendula* is an important pest in oil palm plantations so that its presence in the field must be controlled to minimize yield losses.

CONCLUSION

Bagworm *P. pendula* tend to have a clustered attack pattern and caused defoliation of more than 50% in the canopy of an oil palm. The attack of *P. pendula* at moderate to very severe intensity (score 2–4) causes a decrease in production of FFB by 21.02% to 36.35% and potential flower abortion from 18.41% to 32.54%. The attack of *P. pendula* does not affect the average bunch weight of affected palms.

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