Parasitoid Population in Beneficial Plant Areas of Oil Palm (*Elaeis guineensis* Jacq.) Plantations at Torgamba Plantation

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Abstract

Bagworms (Lepidoptera: Psychidae) are among the most damaging defoliating pests in oil palm plantations, and parasitoids are key natural enemies for their biological control. Beneficial (flowering) plants are expected to enhance parasitoid activity by providing nectar, pollen, and shelter that support parasitoid survival and reproduction. This study assessed the effect of beneficial plants on bagworm populations and the associated parasitoid activity at Torgamba Plantation, South Labuhanbatu Regency, North Sumatra, Indonesia. A survey method was applied to two observation blocks a beneficial-plant block and a control block without beneficial plants each comprising 25 sample palms, observed monthly from October to December 2025. Data were analyzed using descriptive statistics and an independent-samples t-test at the 5% significance level. The mean bagworm population was markedly lower in the beneficial-plant block (0.73 individuals per palm) than in the control block (4.25 individuals per palm), and the difference was statistically significant ($p < 0.05$). The higher parasitoid activity observed in the beneficial-plant block coincided with this reduction, indicating that beneficial plants provide suitable habitat for parasitoids and thereby strengthen biological control. Beneficial plants are therefore recommended as a component of sustainable, environmentally friendly pest management in oil palm plantations.

Keywords: *parasitoids; beneficial plants; bagworm; oil palm; biological control*

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Introduction

Oil palm (Elaeis guineensis Jacq.) is one of Indonesia's leading plantation commodities, playing a significant role in generating foreign-exchange earnings, creating employment, and supporting national economic growth [1]. Sustaining and improving its productivity is therefore central to national industrial needs and the competitiveness of the plantation sector.

One of the major constraints in oil palm cultivation is infestation by bagworm pests (Lepidoptera: Psychidae). Severe infestations cause extensive defoliation, reduce the effective leaf area available for photosynthesis, and consequently lower crop productivity [2]. Pest management in oil palm plantations still relies heavily on chemical insecticides, which may lead to several adverse effects, including pest resistance, suppression of natural-enemy populations, and environmental contamination [3].

Consequently, more environmentally friendly strategies are required through Integrated Pest Management (IPM). One such approach is the conservation of natural enemies through habitat management, in particular the establishment of beneficial plants that provide nectar, pollen, shelter, and alternative food resources for parasitoids and predators, thereby enhancing the abundance and effectiveness of natural enemies in suppressing pest populations [4]. Parasitoids are among the most effective biological control agents against bagworms because they develop within or on the host insect, eventually causing its death [5].

Despite these recognized benefits, information on the effect of beneficial plants on bagworm populations in Indonesian oil palm plantations remains limited. This study was therefore conducted at Torgamba Plantation to determine the bagworm population in areas with and without beneficial plants, to analyze the differences between the two areas, and to evaluate the effect of beneficial plants on bagworm populations, as a contribution to environmentally friendly, effective, and sustainable pest management.

Bagworm infestation is one of the major constraints affecting oil palm productivity in Southeast Asia. Severe infestations reduce the effective leaf area available for photosynthesis, resulting in significant yield losses. Conventional control methods rely heavily on chemical insecticides, which may cause pest resistance, reduce natural enemy populations, and negatively affect environmental sustainability.

The conservation of natural enemies through habitat management has become an important component of Integrated Pest Management (IPM). One effective approach is the establishment of *beneficial plants*, which provide nectar, pollen, shelter, and alternative food resources for parasitoids and predators. These ecological resources enhance the abundance and effectiveness of natural enemies in suppressing pest populations.

Parasitoids are among the most effective biological control agents against bagworm pests because they develop within or on the host insect, eventually causing host mortality. Therefore, understanding parasitoid populations associated with *beneficial plants* is essential for developing environmentally friendly pest management strategies in oil palm plantations.

Literature Review

Oil palm (*Elaeis guineensis* Jacq.) is a strategic plantation commodity in Indonesia, playing a vital role in foreign exchange earnings, employment, and national economic growth [3]. One of the main obstacles to its cultivation is the attack of bagworms (Lepidoptera: Psychidae), the most destructive group of leaf-eating pests in Southeast Asian oil palm

plantations. Heavy infestations cause severe defoliation, reducing the effective leaf area for photosynthesis, and ultimately suppressing plant productivity [6]. Because the damage is cumulative, plant recovery after a population explosion can take up to two years [1].

Among several commonly encountered bagworm species such as Mahasena corbetti, Pteroma pendula, and Metisa plana M. plana is known as the most serious defoliator. The larvae live in protective pouches, making contact control difficult, and their populations can explode (outbreak) beyond economic thresholds. Various studies report that M. plana population explosions can cause yield losses of up to 40–44% and significant economic losses [1][6]. Environmental factors such as temperature also influence population dynamics, making regular monitoring crucial in managing this pest [1].

Parasitoids are key natural enemies of bagworms. These small, wasp-like insects from the order Hymenoptera develop inside or on the host by laying eggs through an ovipositor; the parasitoid larvae then feed on the host from the inside until the host dies [2]. Parasitoids from the family Braconidae are among the most abundant and effective at suppressing bagworms, with Dolichogenidea metesae being one of the dominant species; overall, dozens of Hymenopteran parasitoid species have been recorded emerging from M. plana in oil palm plantations [1][6]. The reported high parasitization rates underscore the role of parasitoids in regulating pest populations at low levels. The abundance and survival of parasitoids are highly dependent on the availability of shelter and food sources in the form of nectar and pollen [2].

Beneficial plants are flowering plants intentionally planted to provide nectar, pollen, and habitat for natural enemies. Some species commonly used in oil palm plantations are Cassia (Senna) cobanensis, Turnera subulata, Antigonon leptopus, and Euphorbia heterophylla [2]. Among these plants, C. cobanensis is considered the most effective due to its easily accessible, sucrose-rich nectar in its stem stipules; a field study showed that this plant attracted over 300 bagworm parasitoids, far surpassing comparison species, which attracted fewer than ten individuals [2]. Other studies have shown that most parasitoids, such as Brachymeria carinata and D. metesae, prefer C. cobanensis and Turnera spp. compared to Antigonon leptopus, and planting these plants coincided with a decrease in bagworm outbreaks [8]. In Indonesia, efforts to conserve parasitic insects through planting flowering plants also showed that parasitoid populations were related to their distance from the flowering plants [7].

Providing resources for natural enemies through habitat management is known as conservation biological control and has been recognized as an important component of Integrated Pest Management (IPM). This approach aims to increase the abundance and effectiveness of natural enemies by providing nectar, pollen, shelter, and alternative hosts/prey, thereby ecologically suppressing pest populations [4][5]. Within the IPM framework, planting beneficial plants is combined with cultural, physical, and when necessary chemical tactics, with the aim of reducing reliance on synthetic insecticides, which risk developing pest resistance and killing natural enemies [4][5][6].

Based on the above review, the presence of beneficial plants has the potential to increase parasitoid populations and activity, thereby sustainably suppressing bagworm populations. Evidence regarding the role of these flowering plants is well established in oil palm plantations in Malaysia, but field evidence in Indonesia particularly directly comparing beneficial plant areas with control areas at the plantation scale is still limited [7]. Therefore, this study aimed to determine parasitoid populations and their effects on bagworm populations in beneficial plant areas compared to control areas at the Torgamba Plantation, as a basis for developing effective and environmentally friendly biological control strategies.

Methods

The study was conducted at Torgamba Plantation, South Labuhanbatu Regency, North Sumatra, Indonesia, from October to December 2025. Two observation blocks were selected:

a *beneficial plant* block and a control block without *beneficial plants*. Each treatment consisted of one block containing 25 sample oil palm trees. Parasitoid populations were monitored using visual observations and sweep net sampling around *beneficial plants*. Simultaneously, bagworm populations were recorded on each sample tree during monthly observations. Data were analyzed using descriptive statistics, and differences between treatments were evaluated using an independent *t*-test at a 5% significance level.

Result and Discussion

The beneficial-plant block supported a higher level of parasitoid activity than the control block. This was attributed to the availability of nectar and pollen from flowering plants, which are essential for the survival and reproduction of adult parasitoids. The greater parasitoid activity coincided with a substantial reduction in the bagworm population. The mean bagworm population was 0.73 individuals per palm in the beneficial-plant block, compared with 4.25 individuals per palm in the control block (Table 1). An independent-samples t-test indicated a highly significant difference between the two blocks ($p < 0.05$), confirming that beneficial plants contributed to suppressing the bagworm population.

Table 1. Independent-samples t-test of the bagworm population between the beneficial-plant and control blocks

	Beneficial-Plant Block (individuals/palm)	Control Block (individuals/palm)
Mean	0.73	4.25
Variance	0.19	2.23
Observations	25	25
Hypothesized Mean Difference	0	
df	28	
t Stat	-11.29	
P(T<=t) one-tail	0.00	
t Critical one-tail	1.70	
P(T<=t) two-tail	0.00	
t Critical two-tail	2.05	

Note: bagworm population expressed as individuals per palm; observation period October–December 2025.

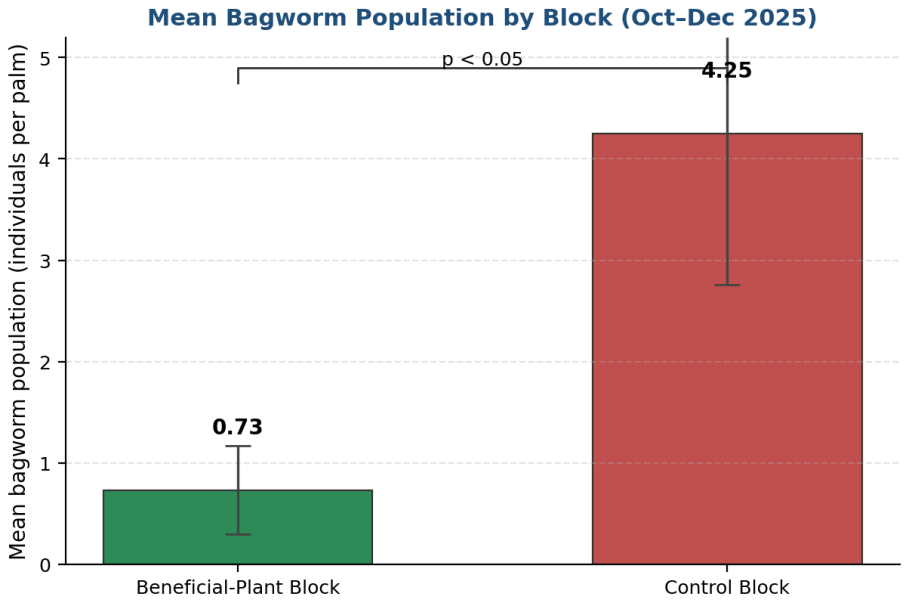

Figure 1. Mean bagworm population (individuals per palm) in the beneficial-plant and control blocks; error bars denote standard deviation.

The magnitude of the difference between the two blocks was substantial. The mean bagworm population in the beneficial-plant block (0.73 individuals per palm) was approximately 83% lower than in the control block (4.25 individuals per palm), equivalent to roughly a six-fold difference. This indicates that the presence of beneficial plants was associated with strong suppression of the bagworm population rather than a marginal effect.

Beyond the difference in means, the two blocks also differed markedly in variance (0.19 versus 2.23). The much lower variance in the beneficial-plant block shows that infestation there was not only lower but also more uniform, whereas the control block contained trees with widely varying—and occasionally high—bagworm loads. This heterogeneity of variance is consistent with the reduced degrees of freedom reported in Table 1 (df = 28), which reflect a Welch (unequal-variance) t-test; applying this correction is appropriate given the roughly twelve-fold difference in variance. The resulting t-statistic (−11.29) far exceeded the two-tailed critical value (2.05), with a p-value well below 0.05, indicating a highly robust difference between treatments.

Ecologically, this suppression can be explained by the resource subsidies that flowering beneficial plants provide to adult parasitoids. Nectar and pollen are important carbohydrate and protein sources that extend parasitoid longevity, increase fecundity, and raise parasitism rates, so that a plant community offering these resources tends to sustain larger and more active parasitoid populations. In oil palm, beneficial plants such as Turnera subulata, Cassia cobanensis, and Antigonon leptopus are widely used for this purpose, and their association with enhanced natural-enemy activity against bagworms is well documented [1]. The higher parasitoid activity observed in the beneficial-plant block is therefore a plausible mechanism linking habitat management to the observed decline in bagworm numbers.

These findings are consistent with previous studies reporting that flowering beneficial plants increase parasitoid abundance and improve the efficiency of biological control in oil palm plantations. Habitat management through flowering plants has been recognized as an effective conservation-biological-control strategy that promotes sustainable pest management while reducing dependence on chemical insecticides [3][4]. From a management perspective, keeping the bagworm population below one individual per palm, as achieved in the beneficial-plant block, maintains infestation well below the levels at which chemical intervention is normally warranted, thereby reducing control costs and the ecological side effects associated with insecticide use, such as the loss of natural enemies and the development of resistance [5].

Several limitations should be considered when interpreting these results. Because each treatment was represented by a single block, the 25 sample palms are subsamples rather than independent replicates of the treatment; consequently, block-level environmental differences cannot be fully separated from the effect of the beneficial plants, and the findings are best regarded as strong indicative evidence rather than definitive proof of causation. In addition, parasitoid presence was assessed as activity rather than quantified as population density or parasitism rate, and the observation period covered only three months. Future studies using replicated blocks, direct quantification of parasitoid abundance and parasitism, and a longer monitoring period would allow the causal role of beneficial plants to be established more conclusively.

Conclusion

The establishment of beneficial plants in oil palm plantations supports parasitoid activity and contributes to the suppression of bagworm populations. Therefore, beneficial plants can be recommended as an important component of Integrated Pest Management (IPM) programs to promote environmentally sustainable oil palm production.

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