Faculty of Resource Science and Technology

Occurrence of Bagworm and Nettle Caterpillar with its Natural Enemies in Oil Palm Plantation Planted with *Turnera ulmifolia*

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Bachelor of Science with Honours
(Plant Resource Science and Management)
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This report is submitted in partial fulfillment of the Requirement for The Degree of

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SUPERVISOR: MOGERET BINTI SIDI

Plant Resource Science and Management

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Occurrence of bagworm and nettle caterpillar with its natural enemies in oil palm plantation planted with *Turnera ulmifolia*

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ABSTRACT

A study entitled occurrence of bagworm and nettle caterpillar with its natural enemies in oil palm plantation planted with *Turnera ulmifolia L.* was carried out in Felcra Samarahan Jaya Oil Palm Plantation in Kota Samarahan, Sarawak. The main objective of this study was to evaluate the effect of *T. ulmifolia* on the population of bagworm and nettle caterpillar and its natural enemies in oil palm plantations. Results of the study showed that there was significant difference in the number of alive bagworms between plot T0 (Without *T. ulmifolia*) and T1 (With *T. ulmifolia*). The mortality of bagworm was more significant in area T1 compared to T0. The results of this study also revealed that the presence of natural enemies was effective in controlling number of bagworms. The most common bagworm species recorded from this study were *Pteroma pendula* Joannis and *Metisa plana* Walker. Other defoliate insect found in the oil palm plantation from this study was nettle caterpillar which were *Susica* sp., unknown species and *Birthosea* sp, and *Darna* sp. Based on the finding of this study, planting beneficial plant, *T. ulmifolia* give good result in controlling defoliate insect; bagworm and nettle caterpillar and enhance the occurrence of its natural enemies.

Keywords: Bagworm, Nettle caterpillar, Natural enemies, Beneficial plants.

ABSTRAK

Kajian bertajuk kejadian ulat bungkus dan ulat bulu dengan musuh semula jadi di ladang kelapa sawit yang ditanam dengan Turnera ulmifolia L. telah dijalankan di Ladang Kelapa Sawit Felcra Samarahan Jaya di Kota Samarahan, Sarawak. Objektif utama kajian ini adalah untuk menilai kesan T. ulmifolia terhadap populasi ulat bungkus dan ulat bulu serta musuh semula jadinya di ladang kelapa sawit. Keputusan kajian menunjukkan terdapat perbezaan yang signifikan dalam bilangan ulat bungkus yang hidup antara plot T0 (tanpa T. ulmifolia) dan T1 (dengan T. ulmifolia). Kematian ulat bungkus adalah lebih ketara di kawasan T1 berbanding T0. Hasil kajian ini juga mendedahkan bahawa kehadiran musuh semulajadi berkesan dalam mengawal bilangan ulat bungkus. Spesies ulat bungkus yang paling biasa dijumpai direkodkan daripada kajian ini ialah Pteroma pendula Joannis dan Metisa plana Walker. Serangga perosk daun lain yang ditemui di ladang kelapa sawit daripada kajian ini ialah ulat bulu iaitu Susica sp., spesies tidak dikenal-pasti dan Birthosea sp, dan Darna sp. Berdasarkan dapatan kajian ini, penanaman tumbuhan bermanfaat, T. ulmifolia menunujukan keberkesanan dalam mengawal serangga perosak daun; ulat bungkus dan ulat bulu serta menarik kedatangan musuh semulajadi.

***Kata kunci**: Ulat bungkus, ulat bulu, musuh semulajadi, tumbuhan bermanfaat*

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List of Abbreviations

cm	Centimetre
ETL	Economic Threshold Level
Felcra	Federal Land Consolidation and Rehabilitation Authority
FFB	Fresh Fruit Bunches
GPS	Global Positioning System
IPM	Integrated Pest Management
Btk	*Bacillus thuringiensis subsp. kurstaki*

CHAPTER 1

1.0 Introduction

Oil palm is one of the main crops and now play a significant role in Malaysia's economy. According to Amiruddin (2003), Malaysia is the world's second-largest producer and exporter of palm oil products in the world after Indonesia, where both countries contribute 83.5% of production and 89.6% of palm oil trade in the world in 2002. Unsurprisingly, it is one of the main drivers of the nation's agro-industry and has drawn attention from all around the globe for a number of successful attempts in reducing poverty and distributing wealth fairly (Alam et al., 2015). However, oil palm plantations may also encounter difficulties that would have an impact on crop production and quality because they are a potential host for a variety of pests due to their extensive planting area, which creates a mono-crop environment that is perfect for pest infestation (Jamian, 2017).

Bagworm and nettle caterpillar are common pests in oil palm plantation which causes significant damage to the oil palms. Bagworm is one of the major pests which can cause a crop loss of around 33% to 40% from moderate defoliation of 10% to 13% in 2 years (Basri, 1993). A bagworm is a caterpillar that eats leaves and wanders around while carrying a thick silken bag" for its protection from other predators as reported by Kamarudin et al. (2010). They also stated that the larvae cause significant damage, which gets worse as they develop to maturation (from larvae to pupae into a moth). In addition, mature flightless females can also utilize their pheromone to attract males for reproduction and reproduce on a large scale within their sack (Kamarudin et al., 2010). Thus, the larvae defoliation will worsen as the population develops affecting the yield.

Next, nettle caterpillars are a Lepidopteran of the family Limacodidae. It was considered the defoliator which causes serious problems to oil palm in Malaysia (Chung, 2012). According to Chung (2012), the four most common types of nettle caterpillar in Malaysia are *Darna trima* (Moore), *Darna diducta* Snellen, *Setora nitens* Walker, and *Setothosea asigna* (van Eecke). The larvae of nettle caterpillar consist of rows of bumps with stinging spines called scoli and they act as protection (Cock et al., 1987). The adults of the nettle caterpillar are small, hairy moths with wings (Chung, 2012).

There are various techniques to control the bagworm in the oil palm plantation. Firstly, chemical control is the primary and one of the most common techniques used to suppress the population of bagworms in oil palm plantations (Hasber, 2010). However, chemical control such as pesticides has the potential to harm other useful insects such as pollinators and predators (Cheong et al., 2010). They also mentioned pesticides were ineffective against the bagworm while it's in the egg stage as they were protected inside the bag (Jeffers, 2019). Other methods including biological control, such as using predators and parasitoids are highly recommended since they are more ecologically friendly and more sustainable (Debach, 1964). Beneficial plant also plays an important role in the implementation of Integrated Pest Management (IPM) where it has the capability in attracting predator insects that prey on the bagworm population (Wratten et al., 2002; Jamian et al., 2017). Beneficial plants such as *Turnera ulmifolia* L. may have the traits in attracting the insects which serve as target biocontrol agents for bagworms (Abdullah & Rahim., 2018).

Therefore, the objective of this study was to evaluate the effect of *T. ulmifolia* on the number of bagworm and nettle caterpillar and its natural enemies in oil palm plantations.

CHAPTER 2

2.0 Literature Review

2.1 Pest in Oil Palm Plantation

2.1.1 Bagworm

The bagworm family (Lepidoptera: Psychidae) contains around 1000 species and 300 genera that are found all over the world (Rhainds, 2000; Rhainds & Sadof, 2009). Bagworm is a leaf-eating pest that has infested Malaysian oil palm plantations. Bagworm larvae typically, prefer to feed on the upper side of the leaf and rest and develop on the bottom surface (Basri et al., 1994; Basri & Kevan, 1995). Overlapping palm fronds (> 8 years old) have the most intense attack by bagworms (Susanto et al., 2015) where attacks usually begin on the lower frond and progress to the upper frond (Kamarudin & Wahid, 2010). The upper epidermis of the leaf is fed to early instar larvae, whereas the lower epidermis is fed to late instar larvae. The leaves dry out and appear to have a burning appearance when this region of the epidermis is damaged (Priwiratama et al., 2019).

Bagworms can defoliate oil palm trees by up to 50%, resulting in a significant production loss of up to 10 tonnes of fresh fruit bunch (FFB) per acre (Wood et al., 1973). Bagworms in Malaysia which including *Pteroma pendula* Joannis, *Metisa plana* Walker, *Mahasena corbetti* Tams, *Brachycyttarus griseus* Joannis, *Manatha albipes* Moore, *Amatissa cuprea* Moore, *Cryptothelea cadiophaga* Westwood, *Dappula tertia* Templeton, *Pteroma* sp., and *Clania* sp. (Sankaran, 1970; Syed, 1977; Norman et al., 1994; Robinson et al., 1994). In addition, *M. plana* and *P. pendula* are known to be problematic in Peninsular Malaysia, with *M. plana* being more harmful, whereas *M. corbetti* is the predominant bagworm pest in Sabah and Sarawak (Basri et al., 1988; Chung, 1998). However, several research conducted over the previous decade has concluded that *M. plana* are the most problematic and widespread pest of oil palms in Malaysia (Norman & Basri, 2007).

2.1.2 Nettle caterpillar

The nettle caterpillar is a Lepidoptera that came from Limacodidae family and is another example of a leaf-eating caterpillar that is also considered a serious pest in oil palm in Malaysia (Chung, 2012). According to Cock et al. (1987), the lack of abdominal prolegs and the larva's ability to adhere to surfaces via an adhesive ventral surface that likely functions similarly to a sucker were characteristics that made the Limacodidae family distinctive. They also stated that, as a result of a wave being sent forward along the foot, the larvae move in a peristaltic manner that resembles slugs (Cock et al., 1987). According to Chung (2012), *Darna trima* (Moore), *Darna diducta* Snellen, *Setora nitens* Walker, and *Setothosea asigna* (van Eecke) are the four most prevalent species of nettle caterpillar in Malaysia. Nettle caterpillar larvae were equipped with a row of protuberances with stinging spines termed scoli, that provide additional protection (Cock et al., 1987). The adults of the nettle caterpillar are a winged moth that are small and hairy (Chung, 2012).

2.2 Tactics to control bagworm

2.2.1 Chemical control

Chemical management is the fastest and most efficient way to suppress and keep *M. plana* populations below the action threshold during population outbreaks (Yap, 2000). Salim et al. (2015) discovered that the application of trichlorfon, cypermethrin, and lambda-cyhalothrin in a ground spraying technique against *M. plana* larvae in an oil palm plantation in Malaysia was an effective chemical insecticide at suggested dosages. They also stated that using *Bacillus thuringiensis subsp. kurstaki* (*Btk*) to reduce the larval population of *M. plana* below the economic threshold level (ETL), produced unsatisfactory results and is not recommended. In addition, the implementation of chemical treatment like pesticides by farmers to the plantation as a standard way to exterminate bagworms shows significant environmental contamination (Zhou et al., 2014). Other than that, according to Margni et al. (2002), pesticides that are used on agricultural fields also harmed to non-target species and contaminate soil and water. Furthermore, insecticides control of bagworms is regarded as unsuccessful, especially in the later larval stages, since it is less effective when the bagworms shut their bags (Rhainds & Sadof, 2009). Moreover, the plant's height poses an issue for spraying pesticides, since they reach a height of more than 20 feet in 15 years in irrigated plantations, despite root feeding and stem injection are being practiced (Kalidas, 2012). Additionally, the use of tractor-drawn air-blast sprayers, which would theoretically be the most effective method of control, is also prohibited due to the region's uneven terrain, swamps, and huge boulders. Moreover, shoulder-mounted mist-blowers only provide enough coverage for palms under six years old (Halim et al., 2018).

2.2.2 Biological control

Biological control is described as the action of parasites, predators, or pathogens in controlling the population density of another organism at a lower average than it would be without them (Debach, 1964). Furthermore, in the biological management of bagworm populations, the goal is to maintain local habitat complexity and agriculture biodiversity (Jamian et al., 2017). Moreover, according to Chung et al. (1995), natural enemies generally keep the leaf-eating caterpillar of the oil palm under control. Other than that, Huffaker et al.

(1971) also suggest, good natural enemies, not only serve as a significant mortality factor that results in limiting or reducing the pest population size but is also likely to stabilize both the pest density and their density. Finally, parasitoids have been widely used in biological control programs and have proven to be an efficient weapon in the battle against Lepidoptera pests (De Oliveira et al., 2017).

The Hemiptera is mostly phytophagous, with Miridae, Rudiviidae, Pentatomidae, and Anthocoridae being examples of predaceous families (Nayar et al., 1976; New, 1991; Khoo, 1992). The Assassin, a subfamily of the huge terrestrial Rudiviidae, does not appear to 'capture' prey, instead, it walks up slowly to possible prey items, mostly caterpillars and bagworms, then pierces them with a stylet without more elaboration (Desmier et al., 1989; Syari, 2010). Based on Sulaiman & Talip (2021) studies, a few numbers of natural enemies have been found in oil palm plantations such as *Dolichogenidea metesae* Nixon, *Goryphus bunoh* Gauld, *Autosaphes psychidivorus* Muesebeck, *Brachymeria carinata* Joseph, *Tetrastichus* sp., *Pediobius* sp., and *Elasmus* sp. In addition, according to Zulkefli (1996), *Sycanus dichotomus* Stal plays an important role in the biological control program in oil palm because it has a longer rostrum than other hemipteran predators, allowing it to successfully attack larger late instar bagworms and other larger sized oil palm caterpillars, thereby reducing the number of bagworms. As a result, Berndt et al. (2002) argue that biological control and other habitat management techniques must be preserved to meet the needs of natural enemies.

2.3 Beneficial plants in oil palm plantation

Beneficial plants were commonly planted in oil palm plantations to provide nectar, seed, and pollen for the survival of insects, particularly natural enemies (Ghazoul, 2005).

Beneficial plants must be able to meet the criteria where they are easily manageable as well as to be able to adapt to local climate and soil types, needing minimum trimming, watering, and fertilizing. Not only that, but beneficial plants must be able to attract potential natural enemies, which helps to reduce the need for chemical pesticides to manage the bagworm population, especially in oil palm plantations. *Cassia cobanensis* (Britton) Lundell, *Antigonon leptopus* Hook. & Arn., and *Turnera ulmifolia* L. are examples of beneficial plants.

C. cobanensis belongs to the Leguminosae family, and its flowers are typically yellow orange (Jamian, 2017). It takes little maintenance except during the early stages of development, grows well in open areas, and is hence suitable for planting along roads and drains where sufficient sunlight is available. *C. cobanensis* is a nectar-producing plant that attracts a wide range of parasitoids linked to bagworms, but no current observational study on the biodiversity of insect predators in the crop has been done (Jamian, 2017). According to Basri & Norman (2002), the *C. cobanensis* impact might take up to a year to manifest once the bagworm parasitoid has established itself on the plant. The low population of *Metisa plana* demonstrated the benefits of this plant in sustaining the life duration of parasitoids (Basri et al., 2001). Parasitoid activity appears to be more prominent in the presence of *C. cobanensis*, resulting in a lower number of bagworms in the vicinity. Meanwhile, the lack of *C. cobanensis* in the control block led to an increase in the live larval population of bagworms because parasitoid emergence was substantially lower. However, parasitoids are often detected on *C. cobanensis* plants, but predatory activity appeared to be more prevalent in the ground covers. As a result, only parasitoids prefer to live in the food sources on the *C. cobanensis* plants themselves rather than in the ground coverings, which are primarily ferns (Kamarudin & Wahid, 2010). In addition, *C. cobanensis* plants are not perennial species resulting in frequently planting after the growing season last.

A. leptopus, a fast-growing climbing vine with tendrils, belongs to the Polygonaceae family. It is also known as an invasive species in natural regions, yet it is highly recommended for large-scale planting in oil palm farms (Raju et al., 2001). The *A. leptopus* flower is pink or white. It forms underground tubers and large rootstocks and is a prolific seed producer, producing seeds that float in the water as well as fruit and seeds that are eaten and dispersed by a variety of animals (Kamarudin & Wahid, 2010). *A. leptopus* are utilized as caterpillar control due to the liquid or nectar required by pest control agents as parasitoid hosts and predators for palm leaf-eating caterpillars or as alternative prey hosts for palm leaf-eating caterpillars (Guritno & Sitompul, 1995; Fageria, et al, 2011). However, *A. leptopus* is a perennial vine and climber species that will thrive on ledges.

T. ulmifolia is a member of the Turneraceae family, which includes 205 species from ten genera (Schlindwein & Medeiros, 2006). It is non-native to Malaysia, and it is found mostly in the New World's tropical and subtropical regions, Africa, Madagascar, and Mascarene Island (Heywood, 1978). Not only that, *T. ulmifolia* is also widespread in the disturbed areas of the Jamaica archipelago, according to a researcher (Schappert & Shore, 2000). Furthermore, *T. ulmifolia* has a yellow blossom with a width of 2.5 to 5 cm (Ismail, 1977). It is perennial species that blooms from early morning until late afternoon (Henderson, 1961). Moreover, *T. ulmifolia* is currently cultivated as one of the beneficial plants in oil palm plantations, where it supplies food resources for parasitoids (Noor Hisham et al., 2013). The parasitoid then works as a biological control for insect pests of oil palm trees (Desmier et al., 2002). However, the potential of *T. ulmifolia* plant species as beneficial plants in oil palm farms and its effect on natural enemies and bagworm populations are not well studied.

CHAPTER 3

3.0 Materials and Methods

3.1 Study Area Description

This study was carried out on a ten-year-old oil palm farm in the Felcra Samarahan region which experienced moderate infestation caused by *Metisa plana*. The oil palm was planted in a triangle arrangement with a 10 x 10 x 10 m spacing throughout the field. The coordinates of the plantation had been taken with the Global Positioning System (GPS) which was positioned at 1°28'05.4"N, 110°32'25.3"E (Figure 3.1).

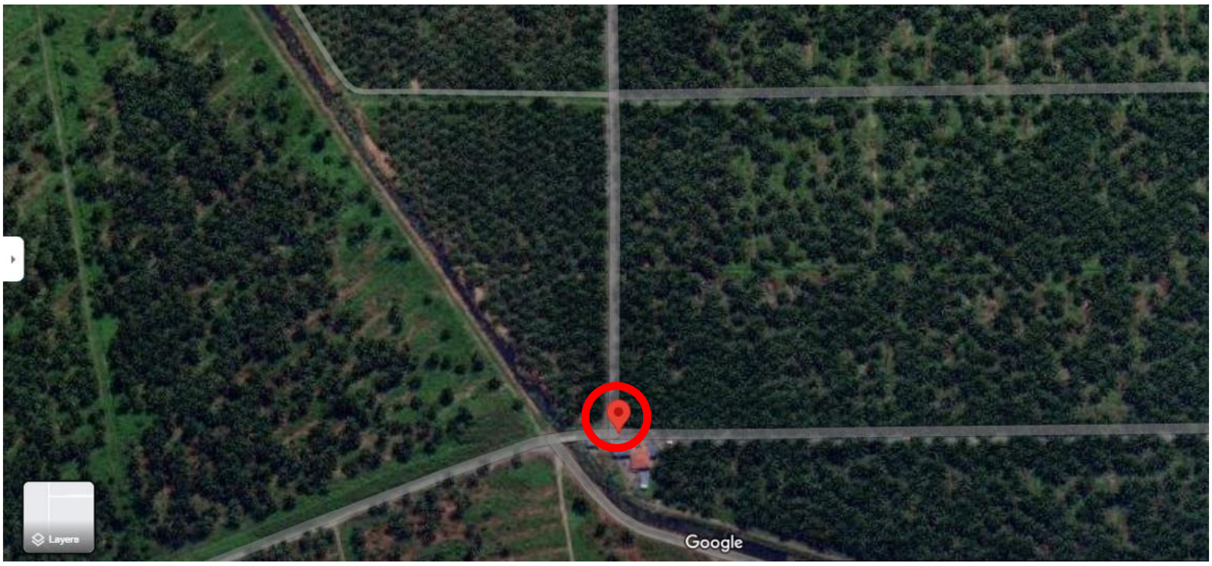

Figure 3.1 Sampling location map

3.2 Research Method Design

For this research, 2 treatments were separated based on the presence of *Turnera ulmifolia* and without *T. ulmifolia*. Each treatment consists of 3 plots that act as replicates which were arranged followed by Plot with *T. ulmifolia* 1 (PT1), Plot with *T. ulmifolia* 2 (PT2), Plot with *T. ulmifolia* 3 (PT3), Plot without *T. ulmifolia* (PNT1), Plot without *T. ulmifolia* 2 (PNT2), and Plot without *T. ulmifolia* 3 (PNT3). Each replicate was separated

100 meters as a barrier. Within each replicated plot, 50 trees were chosen and tagged with plastic tape. In each plot, there were two subplots which were divided into Row 1 (R1) and Row 2 (R2). R1 consists of trees tagged from the first to the fifth row, while R2 consists of trees tagged from the sixth to the tenth row (Figure 3.2). Throughout the research, there was no insecticidal application intervention. History of insecticides application cypermethrin have been applied two years before the study was conducted. The *T. ulmifolia* was located along the edge of the field.

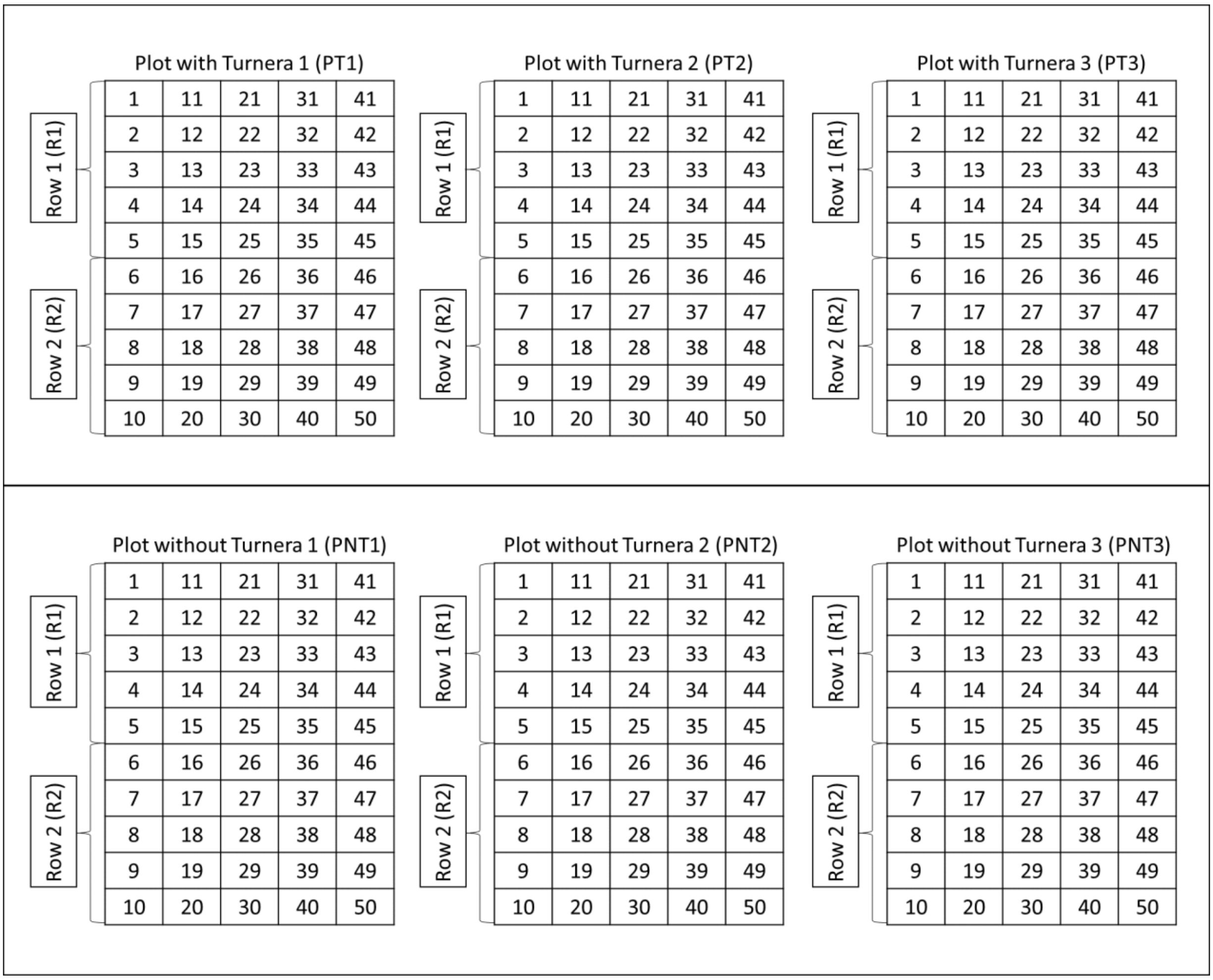

Figure 3.2 Plot design

3.3 Data Sampling

The sampling took place weekly for one month and a total of 12 oil palm trees is randomly selected on every sampling date. Two palm trees were randomly selected in each subplot with one coming from each R1 and R2. Leaf samples from each palm had been collected using a random sampling method. Samples of bagworms and nettle caterpillars on the palm were taken to determine the number of bagworms and their natural enemies (damages). Leaflets with pests from selected frond palms were cut with scissors and collected using hand-picking. The pests were stored in cages and transferred to the laboratory to record their numbers and to observe the emergence of natural enemies. The occurrence of damages and ants was recorded with a photo camera. The total number of bagworms and their life stage were recorded.

All live and dead larvae and pupae of bagworms were divided into various life stages to be counted and recorded. The bag was measured to identify the stages of live larvae. Each stage of live bagworms larvae was kept separately in a clear plastic container (11.8 cm wide x 8.5 cm base x 6.0 cm height) and was provided daily with fresh leaves of oil palm till pupation. The female pupae were separated from the adult by examining the posterior end of pupal bags; female pupae-no opening, with adult opening. Live pupae will be kept in plastic containers for observation of parasitoid emergence (75 cm wide x 25 cm base x 76 cm height). Nettle caterpillars were kept in a separated glass container to record their occurrence in the oil palm. Nettle caterpillars were provided with fresh leaves of oil palm until pupation.

Samples of natural enemies were collected with a sweep net. Natural enemies were kept in plastic containers.

3.4 Determination of parasitism, predation, and fungi attack on bagworm

A post-mortem was performed on all dead bagworm specimens to determine the actual level of mortality caused by natural enemies (Figure 4a-4c). Dead bagworms with small holes in their bags were separated and monitored to observe (similar) the emergence of parasitoids. Adult parasitoids that emerge were transferred individually into glass vials using an aspirator and were supplied with 50% honey as a food source. Using the keys, manual, and descriptions of Norman et al. (1996, 1998) and Parator Software, all parasitoids were counted, recorded, and identified.

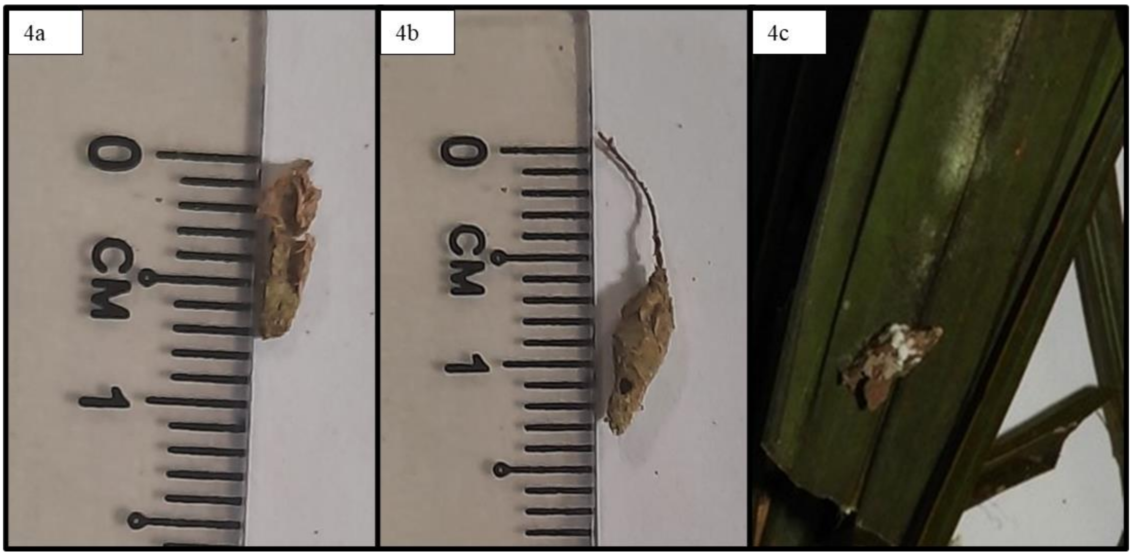

Figure 3.3 Categorise of bags' content: 4a) bags were torn or with a large hole, 4b) small hole at the side of the bag, 4c) fungus at the side of the bag.

3.5 Data Analysis

Dependents T-tests were used to compare the means differences alive and mortality of bagworm species in this experiment. SAS Version 13.0 were used to conduct all analyses.

CHAPTER 4

4.0 Results

4.1 T-test (SAS Analysis)

Table 4.1 shows that plots with *Turnera ulmifolia* (T1) have a greater number of bagworms in week 3 (31) compared to plots without *T. ulmifolia* (T0) (12). However, higher number of alive bagworms at plot T0 were recorded in week 2 and week 4 with the differences in number of alive bagworms were 18 and 31, respectively (Table 4.1). Plot T0 has a significantly higher number of alive bagworms compared to plot T1 (Pr> |t| = 0.5402 is greater than alpha level, 0.01 and 0.05, and t-value, -0.69) (Table 4.2).

Table 4.1 Number of alive bagworm

Weeks	Turnera (T1)	No Turnera (T0)	D
1	21	21	0
2	15	33	-18
3	31	12	19
4	32	63	-31

Table 4.2 T-test result of alive bagworm

Analysis Variable : D	
t Value	**Pr > |t|**
-0.69	0.5402

The highest number of mortalities in T1 was recorded in week 3 with total number was 40, and the different number of mortality bagworms between T1 and T0 was 25 (Table 4.3). The number of mortality bagworm were significantly higher in plot T1 compared to plot T0 (Pr> |t| = 0.8118 is greater than alpha level, 0.01 and 0.05, and t-value, 0.26) (Table 4.4).

Table 4.3 Number of mortality bagworm

Weeks	Turnera (T1)	No Turnera (T0)	D
1	8	21	-13
2	12	26	-14
3	40	15	25
4	23	11	12

Table 4.4 T-test result for mortality bagworm

Analysis Variable : D	
t Value	**Pr > |t|**
0.26	0.8116