

Effectiveness of yellow traps baited with different fruit peels for capturing adult bagworm (*Pteroma pendula*) in an oil palm plantation

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ABSTRACT

The bagworm (*Pteroma pendula*) is an important defoliating pest of oil palm, and practical alternatives to insecticide-based management are needed. This study evaluated yellow traps baited with different fruit peels for capturing adult *P. pendula* and identified the bait associated with the highest capture rate. The field experiment was conducted from December 2025 to January 2026 at PT Nusantara IV Regional I, Rambutan Estate, Serdang Bedagai Regency, North Sumatra, Indonesia. A Randomized Block Design was used with six treatments and four replications: an unbaited yellow-trap control (P0), durian peel (P1), mango peel (P2), pineapple peel (P3), jackfruit peel (P4), and banana peel (P5). Adult captures were observed over 21 days and analyzed using ANOVA followed by Duncan's Multiple Range Test at the 5% level. Banana peel produced the highest mean capture (3.42 adults per trap), followed by jackfruit (2.50), pineapple (1.75), mango (1.67), durian (0.67), and the control (0.33). The results indicate that fruit-peel bait can increase adult *P. pendula* captures in yellow traps, with banana peel showing the greatest potential under the conditions of this experiment. Because volatile compounds were not chemically analyzed, the chemical mechanism underlying attraction remains to be confirmed in further studies.

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1. INTRODUCTION

Bagworms are major pests that cause significant damage to oil palm foliage. Three bagworm species that frequently attack oil palms are *Pteroma pendula*, *Metisa plana*, and *Mahasena corbetti*. These pests belong to the family Psychidae within the order Lepidoptera. Ikhsan et al. (2024) note that there are numerous species of leaf-eating caterpillars affecting oil palms, including nettle caterpillars, bagworms, and hairy caterpillars.

The bagworm (*Pteroma pendula*) is a major pest of oil palm that can reduce crop productivity. Upon hatching, the bagworms begin feeding on oil palm fronds by scraping the upper leaf surface. This causes the leaves to dry out and develop holes; severely damaged leaves turn gray, leading to reduced yields. Infestations can result in 10–13% defoliation and a reduction in oil palm production of approximately 33–40% (Thaer et al., 2021). Although they do not directly kill the

plant, the damage caused by bagworms disrupts the photosynthetic process. The most difficult pest to control in the field is the bagworm (Basri et al., 2022). A critical stage in the bagworm life cycle is the presence of the female moth, which plays a role in egg-laying and the population development of the next generation. Moths are insects belonging to the order Lepidoptera; they are characterized by darker coloration and shorter wings, and they are primarily active at night (Murgianto et al., 2022).

The control of bagworm pests that has been carried out is by applying insecticides, however, this control technique is still unable to eradicate the caterpillars directly, so it becomes a delay and the bagworms turn into imago. Therefore, it is necessary to develop other control techniques that are more effective and efficient for controlling bagworms in the imago phase. In controlling pests that occur in oil palm plantations, plantations have their own methods of control such as using chemical insecticides, botanical insecticides, introducing natural enemies and using traps (Hasibuan et al., 2024).

One control alternative implemented at PT Nusantara IV (Rambutan Estate, Division 1) involves the use of yellow traps utilizing fruit waste. The use of colored traps relies on the attraction of insects to contrasting colors. Yellow traps are particularly effective at attracting insects because they resemble young leaves or ripe fruit natural food sources for these insects (Mustakim et al., 2024). This method is environmentally friendly and capable of trapping adult *Pteroma pendula* because the fruit waste acts as an attractant (releasing volatile compounds). These volatile compounds draw insects toward the resulting scent; the compounds disperse widely when ambient temperatures are high or upon exposure to direct sunlight, making it easy for insects to detect and locate them (Ikhsan et al., 2024). Furthermore, organic waste in the form of fruit peels is abundant in Indonesia, as the country is one of the world's largest producers of tropical fruit, with annual production reaching millions of tons (Nur and Khairi, 2020).

Yellow traps exploit insect responses to visual cues, while plant-derived volatile compounds may provide an additional olfactory stimulus. Fruit peels are abundant organic residues and can release volatile compounds during ripening and decomposition. However, comparative field information on the ability of different fruit peels to increase adult *P. pendula* captures in yellow traps remains limited. In particular, it is not yet clear whether commonly available fruit peels differ in their attractiveness under oil palm plantation conditions. Therefore, this study compared yellow traps baited with durian, mango, pineapple, jackfruit, and banana peels against an unbaited yellow-trap control. The study aimed to determine whether fruit-peel bait increased adult *P. pendula* captures and to identify the fruit peel associated with the highest capture rate under the conditions of the experiment.

2. METHOD

2.1 Time and Place

The Final Project (TA) activities were carried out from December 2025 to January 2026 located in blocks 240 and 250 at PT Nusantara IV Regional I Rambutan Plantation, Serdang Badagai Regency. This location selection method was carried out by survey or direct review, it was found that the intensity of bag caterpillar attacks in the oil palm plantation area on the crops producing (TM) for the 2014 planting year at PT Nusantara IV Regional I Rambutan Plantation, so that it can answer the purpose of this study.

2.2 Tools and Materials

The equipment used in the process of making *Yellow Trap* is used plastic bottles, neat ropes, brushes, markers, matches, irons, knives/cutters, books to record data, cameras/cellphones for documentation. The materials used are pineapple, banana, and jackfruit peel waste, mango, durian and rat glue.

2.3 Research Stages

2.3.1 Identify Garden Potential

In the process of identifying the potential of the garden to find the problem to be researched, the researcher found a problem, namely the high attack of bagworm pests which can result in the obstruction of the photosynthesis process. The main characteristic of the bag caterpillar pest attack is characterized by leaves on the palm fronds that are hollow and dry like burning.

2.3.2 Location Selection

The location selection in this study has several characteristics such as in the affected area. There are not many hylopetis or ferns and are close to toll roads.

2.3.3 Determination of Sample Territory

The determination of the sample area is carried out through *the judgement sampling method Judgement sampling* (also known as *purposive sampling*). *Judgement sampling* is a sample determination technique by selecting samples among the population according to the researchers' wishes (objectives/problems in the research), so that the samples can represent previously known population characteristics (Mushofa *et al*, 2024).

The determination of the sample area was carried out through direct observation in the field. The selected sample area was the block that was attacked in the field. The selected area was based on a direct review by the researcher, namely in the Rambutan plantation in blocks 240 and 250.

2.4 Data Collection Techniques

The primary data consisted of the number of adult bagworms captured in each trap at each observation time. Field documentation and plantation information were used only to describe the study site and infestation context; they were not included as response variables in the statistical analysis. Adult captures were recorded directly from each experimental trap. Field observations and photographic documentation were used to support data recording and verification.

2.5 Statistical Analysis

This study uses a field experiment method with a group random design (RAK) according to the conditions in the field by using a group random design using Rand in *excel*, the results of this RAK use 6 treatments and 4 replications, the research design is as follows:

Table 1. Treatment Used

Code of Conduct	Types of Treatment
P0	Yellow trap without fruit (control)
P1	Yellow trap + Durian skin
P2	Yellow trap + Mango peel
P3	Yellow trap + Pineapple peel
P4	Yellow Trap + Jackfruit Skin
P5	Yellow trap + Banana peel

Source: Primer

Observations were carried out over a 21-day period, and data were analyzed using ANOVA and the Duncan's Multiple Range Test (DMRT) at the 5% significance level. Each treatment was replicated four times, resulting in a total of 24 experimental units.

2.6 Research Implementation

2.6.1 Preparation of the Research Area

Land preparation is carried out by selecting the area of oil palm block that is infested by bag caterpillar pests, by conducting a direct survey and looking at the level of attack on oil palm trees. Oil palm trees that were damaged by bag caterpillars were found in 2 blocks, namely block 240 with an area of 29.47 and block 250 with an area of 28.41 which will be installed as a sample test.

2.6.2 Sample Point Determination Technique

The experiment consisted of six treatments (P0–P5) and four replications. Replications 1 and 3 were established in Block 240, whereas replications 2 and 4 were established in Block 250. Within each replication, the six treatments were randomly assigned to trap positions.

Replication arrangement:

Replication 1: Block 240

Replication 2: Block 250

Replication 3: Block 240

Replication 4: Block 250

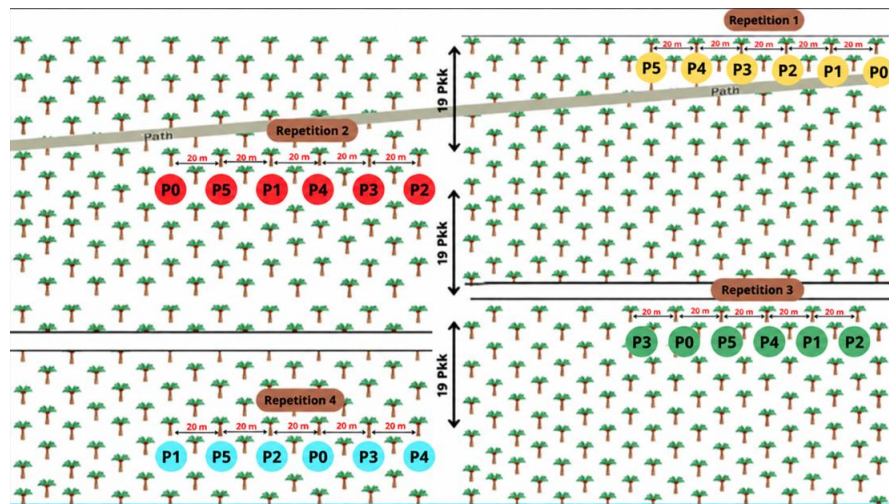


Figure 1. Recurrence Point
Source: Primary (2025)

In research Rhainds *et al.*, (2002) The Man Who Invented the Bag (*Metisa plana*) has a limited flying behavior and only moves around the crown of the plant. Males usually fly low near the leaf surface where the female settles in her pouches. According to Askyla & In, (2004) The male imago has a very limited dispersal ability and can only fly at short distances, i.e. between 10 to 100 meters.

In research Kamarudin *et al.*, (2012) The height of the installation of the bag caterpillar imago trap is about 2 meters from the ground level and the distance between traps in one transect is about 20 meters. Meanwhile, the results of the research conducted (Yusuf Dibisono *et al.*, 2022), the distance used between repeats 19 rows to the side with the distance between plots 10 rows back, for height level *Fruit Staircase* The most effective in trapping fireworm pests is 1.6 meters. The height of the trap used by the rambutan garden is 1.5 meters.

Based on some of the results of the study, the imago flying activity is generally located on the crown of the lower and middle fronds of oil palm plants because the imago of the bag caterpillar will fly upwards to mate with female moths, so the placement of traps is placed on blocks that are heavily attacked with a height of 1.5-2 m with a distance between traps of 20 meters and a distance between repeats of 19 trees to the side of part of the sample area in a zig-zag manner.

2.6.3 Trap Making

The steps to make a yellow trap device are: The trap is made of aqua plastic bottles that are dyed with yellow; Aqua bottles in small holes as air filtration so that the aroma of the fruit can evaporate out; on the outside of the bottle is glued as the adhesive; Put the fruit peel waste bait into a filter bag weighing 200 grams (Novi, 2022); Then put the bag in the aqua bottle that has been made by the window to make it easier to enter the bait; Hang the fruit that has been put in a sieve bag using nylon thread; Equalization of the dosage is carried out so that the difference in the catch of the bagworm imago is only caused by the type of fruit peel waste used.

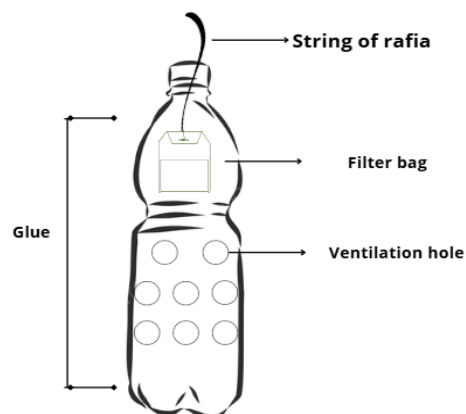


Figure 2. Trap Design
Source: Primary (2025)

2.7 Observation Parameters

Adult captures were recorded at 7-day intervals for 21 days, giving three weekly observations. Fruit-peel bait was replaced at 7-day intervals to standardize bait age among treatments. Fruit-peel exchange aims to ensure that the results of observations can be processed using data analysis techniques, as well as to determine the effectiveness of each fruit peel waste treatment.

The parameters observed in this study were the number of bagworm moths trapped and the number of non-target insects that were trapped in each treatment. The observation of the number of bagworm moths was carried out to determine the effectiveness of *yellow traps* with natural pheromones in attracting the image of bagworms, while the observation of non-target insects aimed to see the influence of traps on other insects that were not the main target of the study. The more bagworm moths caught, the more effective the treatment was considered, while the non-target insect data was used to determine the level of trap selectivity to the surrounding environment.

3. RESULTS AND DISCUSSION

3.1 Observation of Bagworm Adults

Based on weekly observations (Table 2), each treatment had a significantly different effect on the number of adult bagworms (*Pteroma pendula*) captured. In the first week (W1), treatment P5 (banana) yielded the highest number of captured adults (6.00a), differing significantly from all other treatments; treatment P4 (jackfruit) also showed a high result (3.50b) but differed significantly from P5 (banana). Meanwhile, treatments P2 (mango) and P3 (pineapple) did not differ significantly from each other but differed significantly from the other treatments. Treatments P1 (durian) and P0 (control) yielded the lowest capture numbers and did not differ significantly from one another.

Table 2. Average Number of Adults Trapped per Week

Treatment	Observations in Week			
	1	2	3	Total
P0 (Control)	0,25 ^d	0,25 ^d	0,50 ^c	0,33
P1 (Durian)	0,50 ^d	0,50 ^d	1,00 ^b	0,67
P2 (Mango)	2,25 ^c	1,25 ^c	1,50 ^{ab}	1,67
P3 (Pineapple)	2,00 ^c	1,75 ^{bc}	1,50 ^{ab}	1,75
P4 (Jackfruit)	3,50 ^b	2,25 ^b	1,75 ^a	2,50
P5 (Banana)	6,00 ^a	2,50 ^a	1,75 ^a	3,42
Total	14,50	8,50	8,00	10,33

Note: Figures followed by different letter notations in the same column are significantly different according to the DMRT test at the 5% level.

DMRT results indicate that treatment P5 (banana) trapped the highest mean number of adult bagworms throughout the observation period (7, 14, and 21 days), whereas the P0 control yielded the lowest mean number. Differences in letter notation across the replicates indicate that the treatments differed significantly from one another in their effect on adult bagworms; the notation indicates instances of both significant and non-significant differences among the treatments.

Based on Figure 2, the effectiveness of trapping adult bagworms indicates that treatment P5 (banana peel) yielded the highest catch, with a mean total of 3.42 individuals per trap over the 21-day observation period. These results demonstrate that the type of fruit peel waste used as an attractant influenced the number of adult bagworms captured. This variation is likely attributable to the types and quantities of volatile compounds present in each fruit peel. These volatile compounds evaporate into the air, producing a distinctive aroma detectable by insects via their antennae, thereby influencing their behavior and drawing them toward the scent source. Fruit types containing volatile compounds can attract insects through the aromas they emit; under conditions of high ambient temperature and direct sunlight, insects are readily stimulated to approach and locate these volatile compounds (Ikhsan et al., 2024).

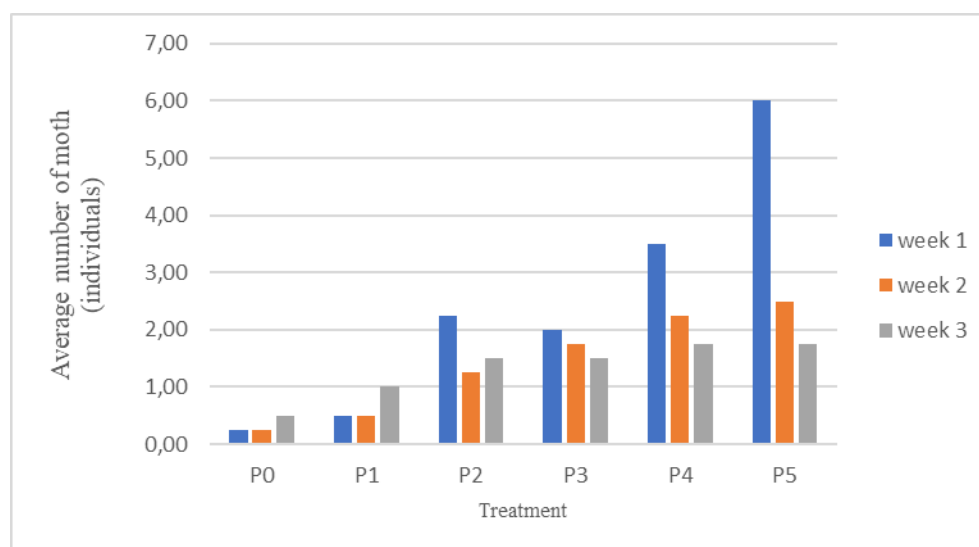


Figure 3. Graph of trapped *Pteroma pendula* adults

The P5 treatment (banana peel) demonstrated the highest effectiveness throughout the entire observation period. In the first week, this treatment captured an average of 6.00 adult insects; the number subsequently dropped to 2.50 in the second week and 1.75 in the third week. Despite this decline, the catch count for this treatment remained higher than that of the other treatments. The high attractiveness of banana peel is attributed to the presence of ester compounds, which produce the strong, sweet aroma characteristic of ripe fruit. These results align with research by Dharmawati (2025), which reported that banana-based attractants yielded the highest moth catches compared to other fruits.

The aroma of these ester compounds is thought to resemble the chemical compounds insects use to communicate and locate mates. One of the compounds found in banana peels is a chiral ester containing a methylbutyl component. This compound shares chemical characteristics with certain components of the female moth sex pheromone. This aligns with research by Leonhardt et al. (1983), which identified (R)-1-methylbutyl decanoate as a component of the female sex pheromone in bagworms. Sex pheromones are chemical compounds released by female insects to attract males for mating. In bagworms, the pheromone is produced by glands located in the female's thorax and dispersed via fine hairs shed from her body. The presence of compounds resembling these pheromone components is believed to make male adults more responsive to the scent produced by banana peels compared to other treatments.

Therefore, volatile compounds found in banana peels are thought to trigger behavioral responses similar to those elicited by natural sex pheromones, thereby attracting male moths to the scent source and into the trap. This hypothesis is supported by research conducted by Kamarudin and Arshad (2006) and Kamarudin et al. (2010), which reported that sex pheromones produced by female *Metisa plana* effectively attract males and have been utilized for monitoring and control purposes via mass trapping techniques. The use of pheromone-based traps is known to reduce mating success, thereby offering the potential to decrease pest populations in the field.

The P4 treatment (jackfruit peel) yielded the second-highest average catch, at 2.50 individuals per trap. The catch reached 3.50 individuals in the first week, then declined to 2.25 in the second week and 1.75 in the third week. These results indicate that jackfruit peel is also effective at attracting adult bagworms. The P4 treatment (jackfruit) contains volatile compounds the primary components responsible for the characteristic aroma of organic materials with esters being the dominant compounds in fruit aromas, including that of jackfruit (Ong et al., 2008; Grimm and Steinhaus, 2019). Esters are highly volatile and produce a sweet aroma resembling ripe fruit, making them highly effective at attracting insects (Lim et al., 2023). In bagworms (family Psychidae), the primary attractant used for reproductive communication is a sex pheromone dominated by ester compounds. This is supported by other research indicating that the majority of bagworm species utilize esters as the main component of their pheromones (Rahmani et al., 2020). Therefore, the high catch rate observed with the jackfruit treatment is likely linked to the prevalence of ester compounds in the aroma of the fruit peel.

The P3 treatment (pineapple) yielded an average catch of 1.75 individuals per trap, with catch numbers remaining relatively stable throughout the observation period. This treatment demonstrated an ability to attract adult bagworms, albeit at a moderate level compared to the

banana and jackfruit treatments. Pineapple peel is known to contain volatile compounds similar to those found in the fruit pulp specifically esters, alcohols, aldehydes, and organic acids (Asikin et al., 2022). These compounds produce a distinctive aroma that can serve as a natural insect attractant. The presence of these volatile compounds is believed to be the factor enabling the pineapple treatment to attract adult bagworms, even though its effectiveness was lower than that of the banana and jackfruit treatments.

The P2 treatment (mango) yielded an average catch of 1.67 individuals per trap. The catch count reached 2.25 individuals in the first week, dropped to 1.25 individuals in the second week, and rose slightly to 1.50 individuals in the third week. The ability of mango peel to attract adult bagworms is thought to be influenced by the presence of volatile compounds such as terpenoids, esters, alcohols, and aldehydes that contribute to the fruit's characteristic aroma (Oliver and Simancas et al., 2020). The most dominant compounds in mango peel are terpenoids, including limonene, α -pinene, and myrcene (Maldonado et al., 2019). These compounds act as semiochemicals capable of influencing insect behavior; however, they are believed to lack a strong structural resemblance to bagworm sex pheromones, resulting in lower attractiveness compared to the banana and jackfruit treatments.

Treatment P1 (durian) yielded an average catch of only 0.67 individuals per trap, making it the least effective treatment after the control. The low catch rate is thought to stem from the dominance of volatile sulfur compounds, which produce a sharp, pungent odor. Treatment P1 (durian) contains various volatile compounds; the fruit's distinctive, pungent aroma is primarily attributed to the dominance of volatile sulfur compounds—specifically thiols such as ethanethiol, methanethiol, and 1-(ethylsulfanyl) ethane-1-thiol. These compounds generate the sharp, strong, sulfuric scent that characterizes ripe durian. Although sulfur compounds are dominant, durian also contains esters like ethyl 2-methylpropanoate, which impart a subtle sweet, fruity aroma (Osman et al., 2022). The excessively strong sulfur odor is believed to be less suitable as an attractant for adult bagworms, resulting in lower catch numbers compared to the other treatments.

Treatment P0 (control) yielded the lowest catch numbers throughout the observation period. This is because the traps relied solely on the color yellow, without the addition of volatile compounds derived from fruit peel waste. Nevertheless, some adult insects were still captured, as the color yellow is known to attract insects. This aligns with the findings of Mustakim et al. (2024), who stated that yellow traps are more effective at attracting insects because they resemble the color of young leaves or ripe fruit—common food sources for these insects. It is also consistent with research by Sitorus and Azwana (2025), which demonstrated that the use of the color yellow resulted in a higher catch of adult bagworms compared to white or green. However, in the absence of additional attractants in the form of volatile compounds, trapping effectiveness was significantly lower than in treatments utilizing fruit peel waste.

3.2 Observation of the Effective Duration of the Attractant

The durability of the fruit peel acting as an attractant is a crucial factor in determining the bait replacement schedule to ensure optimal capture of adult bagworms. In this study, observations were carried out for 3 weeks and showed that the effectiveness of the aroma decreased over time due to evaporation on the fruit skin, so routine monitoring was needed to know when the bait needed to be replaced.

The use of attractants across the different treatments demonstrated varying effects on the persistence of the resulting aroma; despite identical dosages, the specific type of fruit peel used played a role. During the initial observation period (M1–M2), all treatments—particularly P4 and P5 tended to elicit a relatively strong response; however, over time, the effectiveness of the attractants diminished or altered, eventually rendering them ineffective due to evaporation and the emergence of the fruit peel's natural scent.

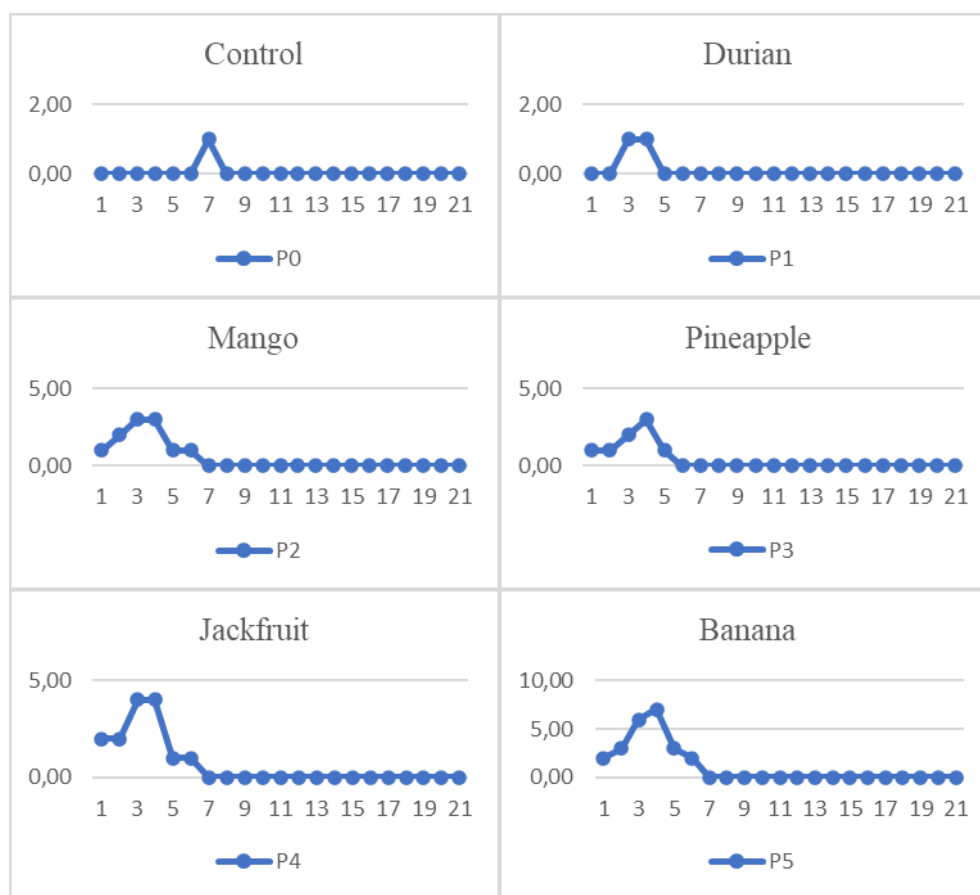


Figure 4. Duration of yellow trap attractant efficacy per treatment

Observations on the durability of fruit peel waste were carried out to determine the effectiveness of each type of fruit peel as a natural attractant in attracting bagworm imago (Figure 4). This test was carried out by adding 1 more replication to test the durability of fruit peel waste in winning bagworm imago consisting of 6 treatments, namely P0 (control), P1 (durian peel), P2 (mango peel), P3 (pineapple peel), P4 (jackfruit peel), and P5 (banana peel). Observations were made every day for 21 days by recording the number of bagworm imago trapped in each treatment. This daily observation aims to determine changes in the effectiveness of each type of fruit skin over time and determine the durability of the aroma produced by each treatment.

The effectiveness of fruit peel waste in attracting adult bagworms tended to decline over the course of the observation period. Initially, the aroma emitted by the fruit peels was potent, successfully attracting a larger number of adult bagworms. However, after several days, the number of captured insects began to drop, indicating a diminishing olfactory attraction. This decline in effectiveness is likely attributable to the evaporation of volatile compounds, chemical degradation, and the influence of environmental factors such as temperature, humidity, and microbial activity. Consistent with the findings of Zhang et al. (2021), the release rate of volatile compounds from plant-based attractants is significantly influenced by daily fluctuations in temperature and humidity within the plantation; these conditions induce chemical degradation of aromatic molecules, thereby reducing their attractiveness.

In addition to environmental factors, trap design and construction play a crucial role in determining the persistence of the fruit peel waste aroma in the field. In this study, the fruit peel waste was wrapped in a mesh fabric before being placed inside the trap. This mesh wrapping served to minimize rapid evaporation while maintaining the bait's integrity throughout the observation period. Furthermore, the number and size of the trap's ventilation holes influenced the rate at which the aroma was released from the fruit peel waste. A greater number of ventilation holes facilitated a faster release of volatile compounds into the environment; while this allowed insects to detect the scent more quickly, it also shortened the bait's active lifespan. Conversely, fewer ventilation holes slowed evaporation, allowing the aroma to persist longer within the trap. Using a barrier medium such as gauze or mesh when placing organic bait acts as a slow-release matrix that inhibits evaporation, thereby extending the duration of the aroma's activity in the field (Nielsen et al., 2019). Thanks to this gradual release system, the fruit peel waste continued to emit

an aroma capable of attracting adult bagworms for a certain period, although its effectiveness tended to decline over the course of the observation. Therefore, periodic bait replacement is necessary to maintain optimal volatile compound concentrations and ensure the trap remains effective at attracting adult bagworms throughout the control period.

4. CONCLUSION

The use of yellow traps combined with fruit peel waste proved effective in trapping adult bagworms (*Pteroma pendula*). The yellow color of the trap served as a visual lure, while the aroma from the fruit peel waste acted as a chemical attractant that increased the catch rate. Based on a 21-day observation period, banana peel (P5) was the most effective type of fruit peel waste used as a natural attractant on yellow traps for catching adult bagworms (*Pteroma pendula*), yielding an average catch of 3.42 individuals per trap. This result surpassed those of the jackfruit peel (2.50 individuals), pineapple peel (1.75 individuals), mango peel (1.67 individuals), durian peel (0.67 individuals), and control (0.33 individuals) treatments. The high catch rate observed with banana peels is attributed to the presence of ester compounds, which produce a distinctive aroma capable of attracting adult bagworms. These ester compounds are believed to resemble the sex pheromones used by female adults to attract males during mating. Over the three-week observation period, the number of captured adults showed a downward trend, decreasing from 14.50 individuals in the first week to 8.50 in the second week and 8.00 in the third week.

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