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A Comparative Study of Blue and Yellow Sticky Traps for Insect Monitoring on Tomato Organic Farm in Mardi Cameron Highlands

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Abstract: Sticky traps are widely used tools in insect monitoring and pest management strategies. These traps are useful tools for monitoring insect populations and eradicating pests because they use a sticky adhesive surface to capture and immobilize insects upon contact, especially flying insects. This study focuses on investigating insect preferences in a tomato plot regarding their attraction to either blue or yellow sticky traps. The research was conducted over three sampling periods from October to November 2022. A total of 12 sticky traps were deployed in the tomato plot for each sampling time, with six blue and six yellow sticky traps. Results of t test indicated a significant difference between the insects captured using Yellow Sticky Traps (YST) and Blue Sticky Traps (BST) with p value < 0.05 (t value = 2.94). The data indicated that YST was better at capturing a greater variety of insects, enhancing diversity coverage. On the other hand, BST demonstrated its significance in monitoring thrips and aphids, pests crucial to tomatoes, making it valuable for insect surveillance. In conclusion, YST demonstrated higher overall insect capture rates, BST remained valuable for specific insects like thrips and aphids. The findings from this study provide valuable insights for optimizing insect trapping methods in tomato cultivation and potentially in other agricultural settings

Keywords: *Solanum lycopersicum,* insect population, trap color

1. Introduction

Solanum lycopersicum, also known as tomato, is a widely cultivated plant that is in high demand both locally and internationally. Although the Solanaceae family classifies tomatoes as botanical fruits, people often refer to them as vegetables. Malaysia widely grows round, oblong, and angular tomato cultivars (DOA, 2023). Malaysia primarily concentrates tomato cultivation in high-altitude regions such as Cameron Highlands and Kundasang, with the threat of pests posing a significant challenge. Whiteflies, aphids, leaf miner and thrips are among the major pests that require careful attention. These insect pests have the ability to cause significant harm to tomato plants, leading to decreased yields and reduced quality of the crop. The pests can inflict both direct and indirect damage. Thrips and aphids can destroy plant tissue by scraping and extracting sap, leading to the appearance of scars on the tissue, curling, punching a hole and the depletion of the plant's resources, while whiteflies may lead to development of black sooty mould on the plant surface which will lead to immature and irregular ripening in some vegetable crop (Ssemwogerere et al., 2013; Gantyada & Sarkar, 2021). Indirect damage may include transmission of virus causing contamination during or after feeding. The leaf miner larvae directly injure the leaf tissue through mining, resulting in desiccation, premature leaf-fall, and cosmetic loss.

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According to a survey conducted by Nur Liyana et al. (2012) leaf miner was the highest pest infesting tomato with 56% infestation and yield losses was recorded up to 30% in Cameron Highlands, Malaysia.

Sticky traps are widely used tools in insect monitoring and pest management strategies. It is regarded as one of the most straightforward methods for understanding and monitoring insect populations within a plot, given its cost-effectiveness and ease of management. It represents one of the simplest methods for understanding and tracking insect populations within a plot, as it is both cost-effective and straight forward to manage. These traps consist of a sticky adhesive surface that captures and immobilizes insects upon contact (Bashir et al., 2014). They are designed to attract and trap flying insects, making them an effective and environmentally friendly method for monitoring insect populations and controlling pests. In a monitoring program, sticky traps serve as an essential tool for providing early warnings of pest presence even before damage to plants is observed. This valuable early detection aids in decision making and mass trapping of flying pests as part of Integrated Pest Management for the development of environmentally friendly and safer pest control strategies (Sampson & Kirk, 2013; Böckmann et al., 2015). Effective insect monitoring requires a thorough understanding of insect behavior, including their preferences for color, light, and other factors. Such knowledge serves as a fundamental basis for developing precise and targeted control techniques (Mazzoni & Anfora, 2021). Several types of traps are commercially available of which sticky traps are a popular and cost-effective option. They are available in various colors, with yellow and blue being the ones most commonly recommended to growers as many pest insects have been shown to be attracted to either of those colors. Therefore, in this study, our main objective is to investigate the preference of insects in a tomato plot regarding their attraction to either blue or yellow sticky traps. By comparing the effectiveness of these two trap colors, it will provide valuable information on the relative attractiveness of these trap colors to different insects present in the tomato plot.

2. Material and method

2.1 Research plot

The research was carried out at the tomato plot, MARDI Organic Farm located in Cameron Highlands, Pahang (4°28′5.16″N, 101°23′ 6.11″ E). The experimental setup consisted of four rows of tomato plants, each row comprising 36 tomato plants (Figure 1).

2.2 Monitoring and insects sampling

The study was conducted over three sampling periods, from October to November 2022. For each sampling time, a total of 12 sticky traps were deployed in the tomato plot, with six blue sticky traps and six yellow sticky traps obtained from KOPPERT. The traps were held in place using poles. Blue and yellow sticky traps were placed adjacent to each other on the pole and the distance of the pole is 2 meters apart from each other. All sticky traps were exposed for 24h. At the time of collection, the traps were covered with a transparent plastic sheet and brought back to the lab for identification purposes. Comparison between mean was tested by t-test (p=0.05) using Minitab Version 18.

Fig. 1: Sampling plot in MARDI Organic Farm, Cameron Highlands with collected blue and yellow sticky trap

3. Results and Discussion

The total number of insects observed, as presented in Table 1, varied during the three observations in the Yellow Sticky Trap (YST). In the first observation, 451 insects were recorded, followed by 1,203 in the second observation, and 606 in the third, resulting in a combined collection of 2,260 insects. On the other hand, in the Blue Sticky Trap (BST), a total of 257 insects were collected in the first observation, followed by 721 in the second, and 425 in the third, making the total number of insects collected in BST was 1,403. Results of t test indicated a significant difference between the insects captured using Yellow Sticky Traps (YST) and Blue Sticky Traps (BST) with p value < 0.05 (t value = 2.94) (Table 1).

Table 1: Total of insect collected from total sampling

Colour	Number of Insect per observation			Total
	1st	2nd	3rd	
Yellow	451	1203	606	2260
Blue	257	721	425	1403
t value:2.94 p value: 0.009				

In YST, the insects were categorized into 5 orders, with the highest number belonging to Diptera at 80.58%, followed by Hymenoptera (13.72%), Hemiptera (2.30%), Coleoptera (2.12%), and Thysanoptera (1.28%) (Fig. 2a). In BST, a total of 6 orders were identified, with Diptera being the most prevalent at 85.60%, followed by Hymenoptera (4.99%), Thysanoptera (4.42%), Coleoptera (2.99%), Hemiptera (1.92%), and Dermaptera (0.07%) (Fig. 2b). More species was captured using YST(S=62) compared to BST(S=54). The t-test results for all Orders indicated no significant difference between the number of YST and BST insects caught, except for Hymenoptera and Thysanoptera. For Hymenoptera, we observed a higher number of hymenopterans including parasitic wasps from the family of Encyrtidae, Platygastridae and Braconidae collected in the yellow sticky trap (YST) (n=310) compared to the blue sticky trap (BST) (n=70), with $t(2) =7.91$, $p=0.016$ (Figure 3). In contrast, the order Thysanoptera exhibited a higher number of captured thrips on BST (n=62) compared to YST (n=29), with a $t(2)=-7.2$, $p=0.019$ (Figure 3). Upon evaluating the detailed results, specifically focusing on the Aphididae (aphids), Agromyzidae (leaf miners), Aleyrodidae (whiteflies), and Thysanoptera (thrips) families, it was found that there were no significant differences in the number of insects captured between both traps, except for the thrips family, as previously reported (Figure 4).

a

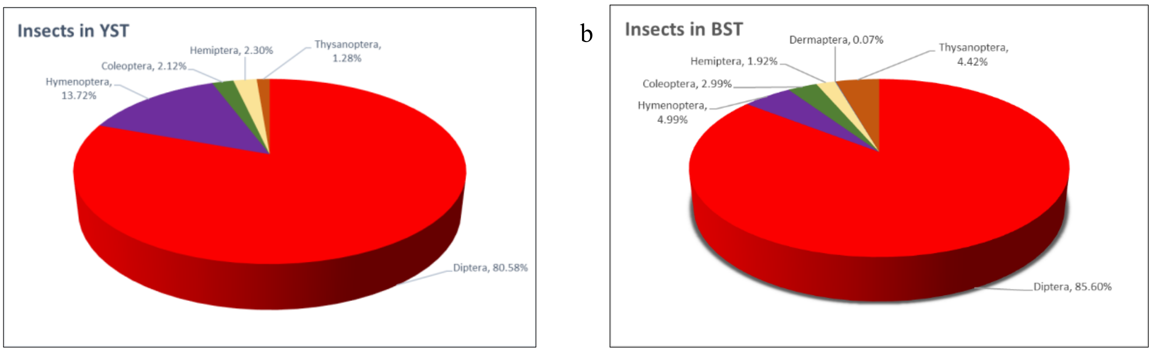

Fig. 2: (a)Total of insects collected using yellow sticky trap (YST); (b)blue sticky trap (BST).

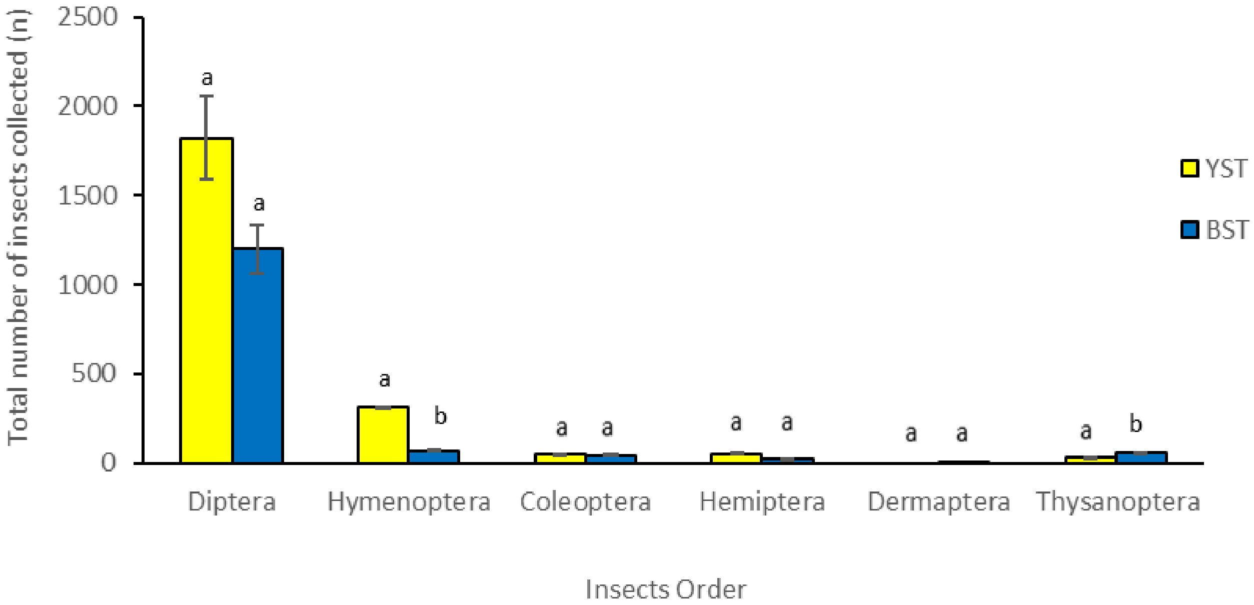

Fig. 3: Total number of insects collected in yellow and blue sticky traps according to insects Order recorded in Mardi Organic Farm, Cameron Highlands *(means that do not share a letter are significantly different*).

Yellow sticky traps are efficient for monitoring a wide range of pest species on a single trap due to their perceived light green color by most insects. This color resembles young shoots of host plants, which explains their attractiveness to a diverse array of insects (Sétamou et al., 2014; Paris et al., 2015). Generally, colors play an important role for insect's pest to locate their host (Prokopy & Owen, 1983; Lopez-Reyes, 2022). Insects are attracted to a high reflectance in the long wave region from green to red (about 500-640 nm) and low reflectance in the short-wave region from UV to blue (300-500nm). The choice of the optimal trap color is contingent upon the trapping purpose (Sampson et al., 2021). Nevertheless, additional research has indicated that the responsiveness of insects to various wavelengths and levels of reflectance seems to alter based on the specific insect species and sex (Domingue et al.,2016; Van der Kooi et al., 2021). The research conducted by Shi et al. in 2015 revealed that male adults of the Cicadellidae family have a greater inclination towards being attracted to yellow sticky traps as opposed to females. In another study conducted by Goretti et al. in 2011, it was shown that female chironomids exhibit a significantly higher attraction towards white light in comparison to males.

Furthermore, yellow sticky traps are frequently used for capturing coleopteran, hemipteran, and hymenopteran insects due to the advantage that most insects are more visible against a yellow setting compared to darker trap colors (Kelber et al., 2003; Idris et al., 2012; Carrillo-Arámbula et al., 2022). Additionally, these traps have been found to be effective in capturing parasitic hymenopteran as shown in this study. Atakan (2015) also noted that employing white and yellow sticky traps attracted more beneficial insects, such as parasitoids and coccinellids. Despite these positive outcomes, concerns have been raised about the use of Yellow Color Traps (YST) potentially reducing the population of beneficial insects and leading to an increase in pest populations. However, it is important to note that the extent of these worries remains uncertain. The few studies on the effect of trap color on capture of beneficial insects suggest a variable response. Clare et al. (2000) and Wallis and Shaw (2008) conducted assessments on the impact of red, green, white, yellow, and blue traps on capturing beneficial species in New Zealand apple orchards. Their findings revealed that white traps were more appealing to honey bees (*Apis mellifera*) and native bees (*Lasioglossum*, *Hylaeus* spp.), blue traps attracted a higher number of bumble bees (*Bombus* spp.) according to Clare et al. (2000), while yellow traps proved more effective in attracting parasitic wasps, as observed by Wallis and Shaw (2008).

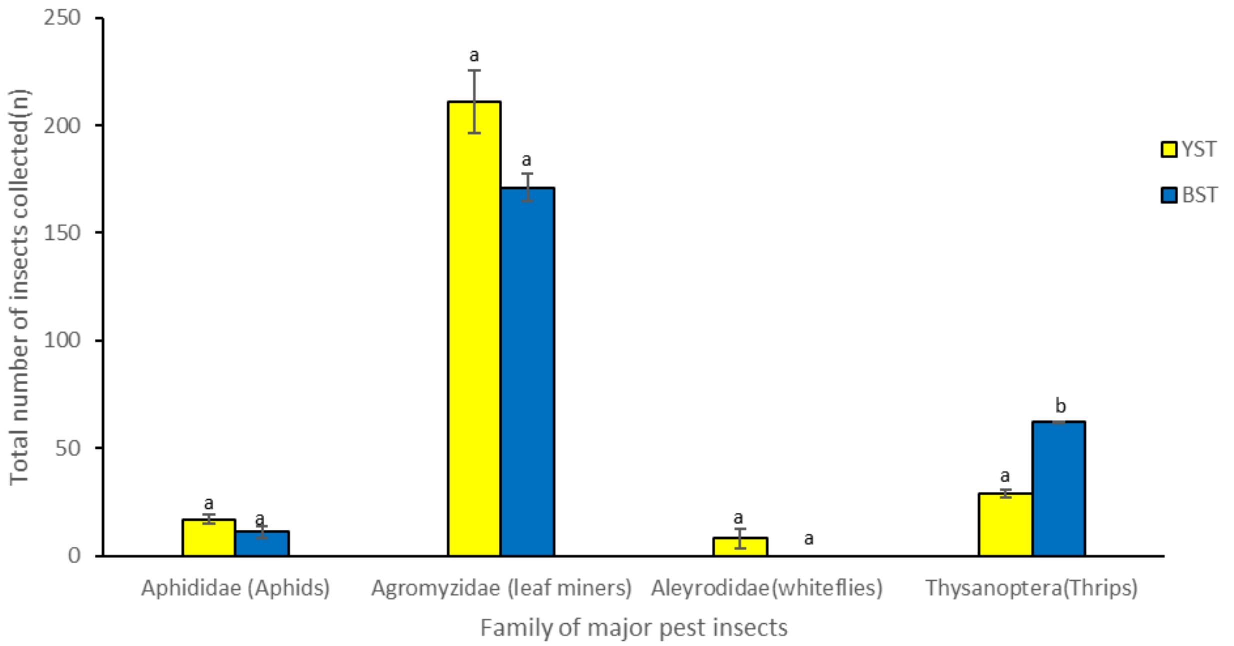

Fig. 4: Total number of insects collected in yellow and blue sticky traps according to a family of major pests recorded in Mardi Organic Farm, Cameron Highlands (*means that do not share a letter are significantly different*).

Moreover, among the different sticky traps assessed, the yellow color demonstrated superior effectiveness compared to other colors (blue and silver) in combating aphids and whiteflies infesting tomatoes. This is also consistent with our finding where more whitefly and aphid from the order of Hemiptera has been captured more using YST compared with the BST but no significant difference was recorded (Figure 2). In general, Hemiptera are not attracted to visual targets that reflect or emit light < 400 nm or > 600 nm as reported by Doring (2016). Alate whiteflies (WF), specifically *Bemisia tabaci*, showed the highest attraction and efficiency to the yellow color compared to other colors (blue, green, red, white, and black) as it influences the movement and host choice (Idris et al., 2012; Johnston & Martini, 2020). Rajabpour and Yarahamadi (2012) additionally documented that yellow sticky traps exhibited the highest efficiency in detecting early infestations and sampling the *Aphis gossypi* population. The findings on leaf miner align with the study conducted by Hamza et al. (2023). Their research, which collected samples from 2017 to 2022, demonstrated that tomato leaf miner was most attracted to yellow sticky cards compared to blue sticky cards.

Alternatively, distinct trap colors prove more effective when growers seek to enhance captures of particular species, such as using blue traps for thrips and red traps for Spotted Wing Drosophila (SWD), as indicated by the findings of this study where more thrips were captured using BST compared to YST. Given the elusive nature of thrips and the challenge of tracking their population for control measures, employing a targeted color trap can effectively monitor their numbers. Study done by Pobozniak et al. (2020) showed that blue sticky traps are the most effective trap color compared to yellow and white traps to capture thrips however it depends on the thrips species, cultivar of the crops and also growing seasons. In the study conducted on the color preference of *Scirtothrips dorsalis* to sticky traps in rose, Sridhar and Naik (2015) found that thrips are attracted to different colors in the following order: blue, yellow, pink and white. This was observed both in field and polyhouse environments. This method can assist farmers in safeguarding their crops during the initial stages of thrips infestation. The primary emphasis was on selecting the precise hues that would attract the thrips.

4. Conclusion

The efficacy of controlling pests in tomato cultivation is affected by numerous factors such as implementation of biopesticides, bioagents, planting systems and also trapping for insect monitoring. Considering all of the facts, both traps are currently recommended in insect monitoring. However, YST demonstrated overall insect capture rates by 24% higher compared to BST which remained valuable for specific insects like thrips and aphids. The findings from this study provide valuable insights for optimizing insect trapping methods in tomato cultivation. However further studies are required to elucidate the factors contributing to this sequence of events and to refine the effectiveness of insect monitoring strategies in agriculture focusing on diverse traps color.

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Conflict of Interest

The authors declare no conflicts of interest.

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