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Preference of Insects for Different Colors of Sticky Traps in Rose Apple (*Syzygium aqueum*) Orchards

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ABSTRACT

Sticky traps are used to monitor various types of insects as one of the effective Integrated Pest Management (IPM) strategies. Integrated Pest Management provides an easy method for estimating the population density of pests that require low-cost, less skilled work and helps develop an environmentally friendly control strategy. However, different colors of sticky traps may have different preferences for insects collected in a specific area. Therefore, a study was conducted to determine whether the different colors of sticky traps influenced the diversity of insects collected in the UiTM Perlis farm. Sampling was performed each month in the *Syzygium aqueum* plot, four for each color of the sticky trap, from January to February 2019. A total of six different colors of sticky traps (red, blue, yellow, green, brown, and white) were randomly hung under the tree's canopy at 1 m height above ground level. The diversity of insects was collected every three days. The result shows a significant difference between the color of the sticky trap and the insect's diversity, in which the yellow sticky trap attracts the highest number of insects. Diptera was found to be the most abundant insect on a yellow sticky trap, while Mantodea was the lowest and only trapped on the white sticky trap. However, an in-depth study is needed to determine the relationship between insect diversity and rose apple production.

INTRODUCTION

Syzygium aqueum belongs to the Myrtaceae family, also known as the water jambu or water apple. This tropical fruit has been widely cultivated and grown throughout Malaysia due to the climate, which is suitable for its year-round production. It is cultivated mainly as smallholdings ranging from 1 to 5 ha, with its hectare age estimated at 1,500 ha in 2005 [1]. However, in 2012, Malaysia's total area of land planted with this crop was approximately 150-170 hectares based on crop equivalent hectares [2]. *Syzygium aqueum* can be eaten raw, making many people plant it alone.

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According to Sagala et al. [3], *S. aqueum* has crispy fruit flesh, a honey taste, and much water. Then, it is sweet and refreshing when eaten and has diversity in appearance [4]. According to Panggabean [5], various parts of this plant have been used in traditional medicine and in particular as an antibiotic. Osman et al. [6] reported that Malaysian people used powdered dried leaves to treat cracked tongues, and preparation of its root has been used to relieve itching and reduce swelling.

Integrated Pest Management (IPM) is a combination of control methods to control the pest population in agriculture sectors [7]. It is an economically justified and sustainable crop protection system consisting of cultural, biological, genetic, and chemical control aimed at maximum productivity with the least possible adverse environmental effects. This statement was supported by Bashir et al. [8], who reported that IPM is an eco-friendly control strategy to estimate the pest population at a low cost. According to Rahman et al. [9], adopting IPM significantly reduced the number of pesticide applications for vegetable crops, such as eggplants, bitter gourds, and tomatoes. They also stated that IPM is the key and will reduce pesticide usage, which is very costly to control the pest population.

Good control management of insect pests and diseases will enhance the quality of products. Then, pest attacks must be prevented from damaging the fruit before it matures. Integrated pest management was applied in the production of vegetable crops by monitoring insect pests and identifying the uses of physical, mechanical, and biological control during plant growth and development [10]. One of the IPM methods is mechanical control, such as using yellow sticky traps. It is a standard method to monitor insect pest populations. However, Devi & Roy [11] reported that the blue sticky trap attracts the most significant number of thrips over the crop growth period than the white, yellow, and fluorescent green sticky trap, while Rosa et al. [10] stated that the red color trap showed the highest level of insects being captured followed by blue, green, and yellow color traps at all height level in chili crops. According to Bess [12] it has been long observed that there is a difference in how insects interact with different colors. A compound eye typically contains three kinds of spectrally sensitive photo-receptor cells peaking in ultraviolet, blue, and green wavelength regions, as shown in honeybees [13]. In order to control the pest, IPM was applied by using several control methods. One of the steps before applying IPM was monitoring. According to Lu et al. [14] a sticky trap is a standard method for monitoring the population of pests, and the cost of applying this method was cheap and affordable.

This study aimed to evaluate the effectiveness of different colors of sticky traps in capturing insects and to classify the order of insects that were intercepted by the sticky trap in the *Syzygium aqueum* orchard at UiTM's Plantation Unit Perlis Branch. This study's significance is finding out the most effective colors of sticky traps that can attract insects. Furthermore, the result of this study can help farmers choose the best color of the sticky trap to control the insect pests and know the insects' order before applying suitable control methods.

MATERIALS AND METHODS

Study Site

The study of insect preference towards the different colors of sticky traps was carried out in the *S. aqueum* plot at Universiti Teknologi MARA (UiTM) Perlis Branch, Arau Campus. The plot was located at the longitude and latitude of N 6.45874 and E 100.28264. The area of the plot is one acre with a planting distance of six meters × six-meter. The *S. aqueum* plot is five years old, and all the plants are five meters tall.

Sampling Procedures

The sampling was conducted at four different plots. A total of six different color sticky traps (red, blue, yellow, green, brown, and white) were set up in each *S. aqueum* plot to find out the attraction of the insect (Figure 1). The treatments were arranged in a randomized complete block design (RCBD) with four replications. The shape of each sticky trap is rectangular, with a size of 16 cm x 23 cm. The colored papers were laminated, covered with clear plastic, and sprayed with sticky glue (IAT Spay Brand) on both sides of the traps (Figure 2). The traps were hung vertically with the branch by a rope under the canopy of *S. aqueum* trees around 1 meter above ground level, while the distance for each treatment was 0.8 meters around the canopy of the plant and a 20-meter distance between replications [15 - 16] Colored sticky traps were replaced with fresh sticky traps every three days at 6:00 p.m. in the *S. aqueum* plot from

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January to February 2019. The collected samples were then taken to UiTM's laboratory for data recording, preservation, and future concerns.

T1R1	T3R1	T1R2	T3R2
T6R1	T5R1	T6R2	T5R2
T2R1	T4R1	T2R2	T4R2
T1R3	T3R3	T1R4	T3R4
T6R3	T5R3	T6R4	T5R4
T2R3	T4R3	T2R4	T4R4

Figure 1. Experimental plot layout for four plots in which each sampling site had six different colors of sticky traps.

Figure 2. The laminated sticky trap sprayed with sticky glue (IAT Spay Brand) was hung under a canopy.

Data Analyses

The orders of insects were identified using a dissecting microscope at the UiTM's laboratory with the reference from the CSIRO online invertebrate key. Then, the data of insects attracted to different colored sticky traps and the orders captured were presented in percentage before being analyzed using Kruskal-Wallis at IBM SPSS version 21. The mean was compared by using Microsoft Excel at $P < 0.05$.

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RESULTS AND DISCUSSION

This study captured 1443 individuals and 12 orders using six different sticky trap colors. Hymenoptera (31%), Diptera (29%), and Coleoptera (29%) had the highest number of individuals captured, while Ephemeroptera (0.2%), Blattodea (0.2%), and Mantodea (0.07%) had the least number of individuals captured using colored sticky traps (Table 1). It showed that some insects attract colored traps as suggested by other researchers [17 – 19]. Yellow sticky traps collected higher insect abundance, followed by white, green, blue, brown, and red, which collected the most minor insect abundance (Table 2).

Table 1. The total abundance of insects was collected in 6 different colors of sticky traps.

Order	Total Abundance	Percentage
Hymenoptera	441	30.56
Diptera	422	29.24
Coleoptera	421	29.18
Lepidoptera	55	3.81
Hemiptera	37	2.57
Odonata	26	1.80
Orthoptera	26	1.80
Homoptera	8	0.55
Ephemeroptera	3	0.21
Blattodea	3	0.21
Mantodea	1	0.07
Total	**1443**	**100**

Table 2. Mean ± SE Abundance of Insects for six colors of sticky traps

Sticky trap	Mean ± SE of Abundance of Insects
Yellow	99.25 ± 2
White	81.25 ± 5
Green	75.25 ± 1.2
Blue	68.5 ± 1
Brown	55.5 ± 6
Red	47.5 ± 4

Yellow sticky traps attracted the highest number of insects with a mean value of 99.25 (Figure 3). This result was similar to the result of Yesica et al. [20] who reported that the yellow sticky trap captured a more significant number of *Frankliniella occidentalis* in Mexico. Lidia et al. [21] reported that the yellow glycol trap captured the highest number of *Dendrolimus pini* (Hymenoptera). According to Vernon & Gillespie [22] and Aragón et al [23] yellow is the most intensely reflective color in the spectrum, and that might be important for food location by foliar feeding insects. This was due to the color hue, intensity, and saturation of the yellow color.

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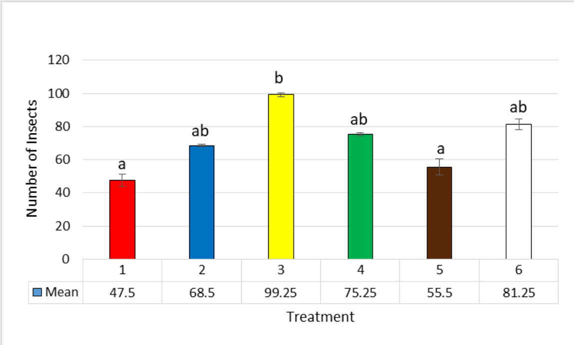

Figure 3. Total insects collected on different colors of sticky traps. Note: Different letters indicate a significant difference at the 0.05 level.

From the various colors of sticky traps used, Diptera, Hymenoptera, Homoptera, and Hemiptera had the highest number of individuals captured on yellow-colored sticky traps (Figure 4). Yellow color is very effective in attracting male Ethiopian fruit fly (Diptera) [24] and *Eristalis tenax* (Diptera) [25] adult *Diaphorina citri* (Hymenoptera) [26], Ichneumonids (Hymenoptera) [27] *Idioscopus clypealis* (Homoptera) [16]. In addition, Suzan [28] also captured the highest number of Hemiptera individuals using a yellow sticky trap. Another study by Shen and Ren [29] and Gu et al. [30] showed that combining yellow-colored sticky traps with parasitoids effectively controlled *B. tabaci* in a greenhouse. The yellow color might also resemble the colors of flowers, thus attracting more insects.

Meanwhile, Coleoptera had the highest number of individuals captured on the green sticky trap (Figure 4). Jolivet & Verma [31] stated that the green color may be related to the green coloration of the plant part that attracted ladybirds to visit them. In addition, the white sticky trap also captured the highest number of Lepidoptera individuals. Knight & Miliczky [32] also identified that green attracted more codling moths. Meanwhile, Odonata and Mantodea were highly attracted to white sticky traps. Tarwotjo et al. [33] captured Odonata using white color traps.

Moreover, the result also showed that brown sticky traps were identified to be effective in capturing a high number of Orthopteran individuals (Figure 4). According to Richard [34] Orthopteran was attracted to brown as they lay their eggs in soil which is brown in coloration. Blue sticky traps also attracted a fair (the fourth highest) number of insects. A study by Brødsgaard [35] & [22] showed that blue sticky traps were often influential in attracting thrips insects. Besides insects, spiders were captured most from blue sticky traps. However, there is limited information on why spiders were attracted to the blue color. Sticky traps are an easy method to estimate the population density of pests. Due to the less human disturbance/presence when using sticky trap methods, a great diversity of insect pests can be observed. This method should be studied more to increase the efficiency of integrated pest management (IPM).

CONCLUSION

This study identified that different colors attracted different insect orders. From the six sticky-colored traps used, yellow proved the most effective in attracting different orders and numbers of insect individuals, while red was the least effective.

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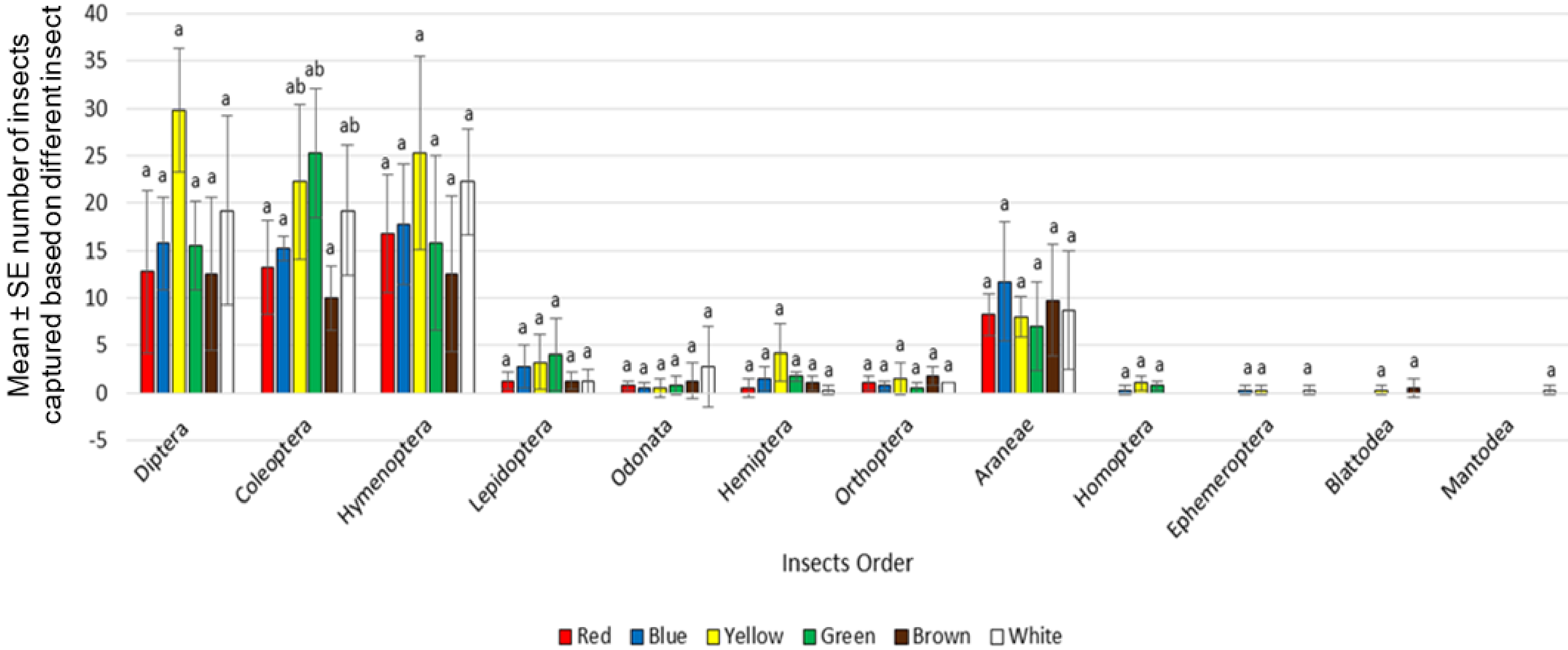

Figure 4. A total number of individuals from 12 orders was captured using six different sticky trap colors.

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AUTHOR CONTRIBUTIONS

Conceptualization, M.A.Z.; Data curation, M.A.Z., M.A.A., and N.F.A.L.; format analysis, M.A.Z., M.A.A., and N.F.A.L; Investigation, M.A.Z., and M.A.A.; Methodology, M.A.Z., and M.A.A.; Project administration, M.A.A., and N.F.AL.; Resources, M.A.A., and N.F.A.L; Supervision, M.A.A. and N.F.AL.; Validation, D.M.N., and N.A.H.; Visualization, M.I.A.R.; Writing-original draft, M.A.Z.; Writing-review and editing, M.A.A., N.F.A.L, D.M.N, M.I.A.R.; All authors contributed to the design of the research and the write-up. All authors collaborated to edit and polish the study, then read and approved the final manuscript.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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