Number of fruit flies (*Diptera: tephritidae*) trapped in various combinations of methyl eugenol dosages and trap colors

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Abstract. The fruit fly (*Diptera: tephritidae*) is one of the pests affecting chilies. This pest can cause yield losses that vary between 30% to 100%. An effective and environmentally friendly technique which could be applied to control this pest is the use of methyl eugenol attractant combined with the color of the trap. This research was carried out in Muaro Jambi District and aimed at testing the effectiveness of a combination of several attractant doses of methyl eugenol and color traps on a number of fruit flies trapped in the red chili plantations. This study used a split plot design. Methyl eugenol doses were used as the first factor, consisting of two levels namely 0.5 ml, 1.5 ml., and trap color was used as the second factor, consisting of three levels namely red, yellow, and blue. There were six treatment combinations with 4 replications in total. The result showed that the amount of fruit flies trapped with methyl eugenol at 1.5 ml dose and yellow color are higher than other treatment combinations. However, the attractant dose of methyl eugenol has a stronger effect than the color, this study shows that effective control of fruit flies must involve both elements.

1. Introduction

Red chilies are a horticultural commodity holding high economic value and are consumed by most people as a cooking spice. Jambi Province is one of the producers of red chilies in Indonesia. The productivity of red chilies in Jambi Province in 2016 was 7.27 tonnes per hectare [1]. This data is considered low when compared to the potential yield which is actually capable of reaching 10 tonnes per hectare. The low productivity is caused by various factors, including attacks by plant pests.

One of the plant pests in red chilies is fruit flies (*Diptera: tephritidae*). Fruit flies are classified as polyphagic pests, which means they spend most of their life cycle in a fruit and they can have many generations per season (multivoltine). They also spread faster and have a high reproduction rate, making them difficult to manage [2] The controls that have been carried out include the application of insecticides, fruit wrapping, and male insect sterilization. It has been acknowledged that application of insecticides can have a negative impact on natural enemies of pests, the environment and consumers. The wrapping technique for controlling fruit flies in red chilies cultivation is thought to be inefficient.
Meanwhile, male insect sterilization technique requires high technology input which is difficult for traditional farmers to do.

One effective and environmentally friendly technique is the use of methyl eugenol attractant. Methyl eugenol is a phenylpropanoid chemical from the phenolic class which is used to attract male fruit flies [3]. This chemical is volatile, and the aroma released in the air affects the behavior of male fruit flies attracting them to a radius of the aroma of up to 20 m to 100 m [4].

Information on the use of synthetic attractant methyl eugenol (PT. Petrokimia Kayaku) doses on the effective number of trapped fruit flies has been studied [5]. However, the use of synthetic methyl eugenol attractant combined with color traps against the number of trapped fruit flies is unknown. This study is aimed at the effectiveness of synthetic attractant methyl eugenol dosage and trap color on the number of fruit flies trapped in red chili plantations.

2. Materials and methods
This research was conducted on chili plantation areas owned by farmers in Tangkit Muaro Jambi. The geographic location of the research area is located at the coordinates of 1.633543 ° S 103.677316 ° E with an altitude of 25 meters above sea level. This research was carried out from February to July 2019.

The research was carried out using a split plot with the Completely Randomized Design (CRD) with 6 treatment combinations with four replications so that there were 24 experimental plots. The types of treatment tested are as follows:

- **main plot, namely methyl eugenol dosage:**
  - a1 = 0.5 ml of methyl eugenol
  - a2 = 1.5 ml of methyl eugenol

- **sub plot namely the color of the trap:**
  - b1 = red colored trap
  - b2 = yellow coloured trap
  - b3 = blue coloured trap

The experimental plot size was 5 m x 6 m (30 m²) consisting of five planting beds. Chili plants were planted in a double row planting system with a spacing of 50 cm x 60 cm, each experimental plot consisted of 100 plants in total.

Seeding was done using a seed tray. Each seedling tray unit consisted of 200 planting holes with a size of 2.3 x 2.3 cm. The seedling medium consists of a mixture of black soil (topsoil) and fine sand with a ratio of 1: 1. Every single seed of chili was planted in the hole in the seedling tray. Watering was done twice a day, morning and evening. The research area was cleared of grass or weeds, then the soil was cultivated by hoeing and flipping it flat. The planting hole was measured with a length of 15 cm, 10 cm wide, and 15 cm high. The application of manure (cow dung) was done 2 weeks before planting. Seedlings were transferred to the field following 30 days after sowing (DAS). The seeds were planted in the planting hole to the root neck, then watered and finally maintained.

The maintenance included watering, replanting, fertilizing and weeding. Further fertilization was carried out 2 weeks after planting (WAP), which was as much as 200 grams of NPK (15: 15: 15), and 50 grams of ZA dissolved in 20 liters of water. The diluted fertilizer was given as much as 100 ml per plant. The next fertilizer was given at 8 WAP in the form of NPK. (15:15:15) with a dose of 10 grams per plant. Watering was done every day in the morning when a water pump was not used.

Applying the treatment of methyl eugenol and color traps, the traps were made of plastic bottles measuring 29 cm high and 8.5 cm in diameter. To get red, yellow and blue traps, the plastic bottles were sprayed with a paint accordingly. Next, the bottom of the plastic bottle was cut. The capless pieces were attached back to the body of the bottle in an upside-down position to provide entry for fruit flies. Then, a cotton swab was put inside and hooked onto a bonding wire and was injected with methyl eugenol according to the treatment dose and 1 ml of the insecticide Cypermethrin.

The traps were placed horizontally in the center of the experimental plots with a height of 80 cm when the plants were 8 to 13 WAP. The distance between the traps and the experimental plots was 20 m, while the distance between the traps in the experimental plots was 6 m. Every week, the cotton swabs...
in the traps were replaced with new ones that had been injected with methyl eugenol and the insecticide Cypermethrin.

Observations were made on the number of fruit flies trapped, and their attack rate. The number of fruit flies trapped was calculated every week at 9 to 14 weeks after treatment (WAT). Fruit flies trapped in each treatment were collected into a labeled 10 oz collection glass and then counted.

Observation of attack rate was done to 10 sample plants in each treatment plot. The Observation was carried out simultaneously with the observation of the number of fruit flies at 9 to 14 WAT. The fruits attacked by fruit flies were recorded into a rotten category when they were split open and contained fruit fly larvae inside. The attack rate formula used is [6] as follows:

\[ I = \frac{a}{b} \times 100\% \]  

(1)

I: Attack rate (%)

a: The number of fruits attacked by fruit flies

b: Total number of fruits

The research data was analyzed by the analysis of variance (ANOVA) using IBM SPSS Statistics 22 software and followed by Duncan's Multiple Range Test (DMRT) at 5% level.

3. Results and discussion

3.1. The number of fruit flies trapped

The average number of fruit flies trapped in each treatment combination at each observation time (9 - 14 weeks after transplanting) is presented in Figure 1. The mean at each dose of methyl eugenol is presented in Figure 2, and the mean for each color of the trap is presented in Figure 3. Figures 1, 2 and 3 show that the number of fruit flies trapped has fluctuated and the highest number is found in 9 WAT. The data in Figure 1 shows that the most trapped fruit flies at 9 WAP were found in the treatment combination of 1.5 ml methyl eugenol and red color, while in each subsequent observation the number of trapped fruit flies was the most in the combination of 1.5 ml methyl eugenol treatment and yellow color. Based on Figure 1, it can also be seen that the number of fruit flies trapped in the combination of 1.5 ml methyl eugenol with any color (red, yellow, blue) is always higher than the combination of 0.5 ml methyl eugenol with any color in every observation with the exception of observation 9 WAT. This is in line with the data in Figure 2 that shows the number of fruit flies trapping in 1.5 ml methyl eugenol is always higher than that in 0.5 ml methyl eugenol in each observation. Figure 3 shows that the number of fruit flies trapping in the yellow trap is always higher than the red and blue traps in every observation except for the 9 WAT.

The methyl eugenol attractant is one of the food sources needed by male fruit flies to increase their fitness level before copulation. After the chemical is consumed, the metabolic process takes place in the male fruit fly to change the methyl eugenol compound into 2-allyl-4,5-dimethoxyphenol and (E) - coniferyl alcohol. These metabolites are then carried to the rectal glands of male fruit flies and released when copulation occurs at dusk. Male fruit flies that consume methyl eugenol compounds have stronger competitiveness and are able to copulate with more female fruit flies than those who do not [7].

The difference in the number of fruit fly catches in methyl eugenol treatment is due to differences in the chemical content of these compounds. The 1.5 ml dose of methyl eugenol has a stronger aroma than the 0.5 ml dose, so that the number of trapped fruit flies is greater. Methyl eugenol compounds include volatile chemicals that can fill the air at room temperature. When the smell of methyl eugenol from a source evaporates up to several meters and spreads in the air, it will be picked up by the fruit fly olfactory system in the form of a signal to their antenna. These signals will be transmitted and processed into information in the fruit fly's brain [8]. The higher the dose of methyl eugenol given, the greater the chemical content of methyl eugenol used and the stronger the aroma of methyl eugenol released in the air so that it can attract greater amounts of fruit flies. More fruit flies were trapped in the methyl eugenol treatment with a concentration of 1.5 ml compared to the methyl eugenol treatment with a concentration
of 0.5 ml. According to [9] male fruit flies are more attracted to and trapped in the trap containing methyl eugenol than a trap added with fruit juice. The use of methyl eugenol compounds is part of integrated pest control techniques that are safe and environmentally friendly. The control of fruit flies with methyl eugenol compounds can be done in several ways, including (a) detecting or monitoring the number of fruit flies, (b) attracting fruit flies into traps then sterilizing or turning them off, and (c) disrupting fruit flies in mating, gathering, and eating.

![Figure 1](image1.png)

**Figure 1.** The mean of fruit flies trapped in each treatment combinations of methyl eugenol doses and trap color at n weeks after transplanting.

![Figure 2](image2.png)

**Figure 2.** The mean of fruit flies trapped at each dose of methyl eugenol at n weeks after transplanting.
Color is one of the main visual stimuli to fruit flies besides size and shape. Red has a wavelength between 630 to 700 nm, yellow has a wavelength between 560-590 nm, and blue has a wavelength between 440 to 480 nm [10]. Color stimuli are used by insects as guides in their activities to find food sources, copulate and adapt to their surroundings ([11]. This process involves an insect's visual sensor in the form of light receptors in compound eyes. There are two types of light receptors that insects use in responding to the visible light spectrum, namely blue light receptors for the shortwave region between 450 to 480 nm (blue color) and green light receptors (green receptors) for the wave region length between 500 to 550 nm (green color) [12].

Figure 3. The mean of fruit flies trapped in each trap color at n weeks after transplanting.

This paper only reports the results of the analysis of variance on the total number of trapped fruit flies that were accumulated from 9 to 14 WAT observation. The results of the analysis of variance showed that there was no interaction between the methyl eugenol dose and the trap colour on the total number of trapped fruit flies with Probability $F_{0.1097}$, $F$ value 2.67. However, the analysis showed that each single factor (methyl eugenol dose, trap colour) had a very significant effect on the total number of trapped fruit flies, with Probability $F_{0.000176}$ and $F$ value 67.38 for methyl eugenol dose; Probability $F_{0.00255}$ and $F$ value 10.23 for trap colour.

The average number of fruit flies trapped at each methyl eugenol dose is presented in Table 1 and, the average for each colour of the trap is presented in Table 2. The data in Table 1 shows that the number of fruit flies trapped at 1.5 ml dose of methyl eugenol is significantly higher than those at the 0.5 ml dose. Meanwhile, the data in Table 2 shows that the number of fruit flies trapped in the yellow trap is not significantly different from the red color, but the two colors of these traps can trap fruit flies which are significantly higher than the blue traps.

The difference in the number of fruit flies caught in the colored trap treatment is caused by the attraction of fruit flies to certain colors. They prefer yellow and red traps over blue traps, because many of the individual fruit flies that are trapped have additional light receptors in addition to the blue and green light receptors that they already have. The emergence of additional light receptors is due to the coevolution process between fruit flies and the surrounding environment which reflects mostly the long-wave spectrum such as yellow and red. In the vicinity of the research location, apart from red chili plants, there are many fruit plants that reflect the yellow and red spectrum, such as papaya, cayenne pepper, mango, orange and rambutan. This is in accordance with the statement of Lebhardt et al., [13] that insects that rely on vision sensors for long periods of time can increase their ability to distinguish
wavelengths. The increase of this ability lies in changes in the amino acid composition of the insect's vision pigments, which allows for yellow and red receptors to appear.

Table 1. Mean of fruit flies trapped at each dose of methyl eugenol (total from six observation times).

| Methyl eugenol doses | Mean of fruit flies |
|----------------------|---------------------|
| 0.5 ml               | 106.25 a            |
| 1.5 ml               | 277.25 b            |

Note: The numbers followed by the same letter are not significantly different according to Duncan test at α 5%.

Table 2. Mean of fruit flies trapped in each trap color (total from six observation times).

| Methyl eugenol doses | Mean of fruit flies |
|----------------------|---------------------|
| red                  | 210.375 b           |
| yellow               | 223.375 b           |
| blue                 | 141.500 a           |

Note: The numbers followed by the same letter are not significantly different according to Duncan test at α 5%.

3.2. The attack rate of fruit fly

The level of fruit fly attack on chili fruit at each methyl eugenol dose is presented in Figure 4, and for each color of the trap is presented in Figure 5. Based on Figures 4 and 5, it can be seen that the level of fruit fly attacks on chilies is influenced more by the dose of methyl eugenol compared to trap color. Figure 4 shows that the rate of fruit fly attack was higher in chili plants with a dose of 0.5 ml methyl eugenol compared to those with a 1.5 ml dose. Meanwhile, Figure 5 shows that there is no difference in the level of fruit fly attack between each color of the trap.

Figure 4. The mean of percentage of chili fruits infested by fruit flies at each dose of methyl eugenol at n weeks after transplanting.
Figure 5. The mean of percentage of chili fruit infested by fruit flies in each trap color at n weeks after transplanting.

By comparing Figure 2 and Figure 4, it can be stated that more fruit flies were trapped at 1 ml dose of methyl eugenol compared to those at 0.5 ml. This causes the attack intensity by fruit flies at 1 ml dose to be lower compared to that of the 0.5 ml dose. The intensity of fruit fly attacks on chilies in this study was relatively low compared to other studies conducted by Dondo et al., [14], Astriyani et al.[6]. The difference in the percentage of fruit fly attacks is caused by several factors including cultivation techniques, use of insecticides, attractants, and adhesive glue. The percentage of fruit fly attacks also depends on environmental conditions and the attacked fruit vulnerability [6]. According to Dondo et al., [14] the time of setting the methyl eugenol trap also influences its effectiveness in controlling fruit flies. Methyl eugenol can suppress the population of fruit flies in chili plants if the methyl eugenol traps are installed early when the chili fruits were young and have never been harvested.

4. Conclusions

The use of synthetic methyl eugenol attractant significantly affected the number of trapped fruit flies. The 1.5 ml dose of methyl eugenol traps more fruit flies because it emits a stronger aroma of methyl eugenol compared to 0.5 ml dose of methyl eugenol. The use of trap colors also had a significant effect on the number of fruit fly catches. Furthermore, the yellow and red traps trapped more fruit flies. Methyl eugenol attractant has a stronger effect when compared to trap color. The use of 1.5 ml dose of methyl eugenol attractant had a lower attack rate when compared to 0.5 ml dose of methyl eugenol attractant.

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