Effectiveness of the combination of attractants and colors in trapping fruit flies \([\textit{Bactrocera} \textit{spp.}]\) on chili plant \([\textit{Capsicum annuum} \textit{L.}]\)

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\textbf{Abstract}. The research was carried out to examine the effect of attractants and the color of traps in trapping fruit flies \([\textit{Bactrocera} \textit{spp.}]\). The research was done by using Randomized Block Design \([\text{RBD}]\) with 2 factors and 3 replications. The first factor was the type of attractants consisted of 3 levels; A0 \([\text{methyl eugenol + water}]\), A1 \([\text{methyl eugenol + guava juice}]\), and A2 \([\text{methyl eugenol + starfruit juice}]\). The second factor was the colors of trap consisted of 4 levels; B0 \([\text{without color [transparent]}]\), B1 \([\text{red}]\), B2 \([\text{yellow}]\), and B3 \([\text{green}]\). The result shows that: trap A1B3 \([\text{methyl eugenol and guava juice as an attractant, green trap}]\) was a type of trap that has the broadest spectrum to attract and trap various species of fruit flies. There was no significant effect of adding color to traps in attracting and trapping male fruit flies. Male fruit flies generally were more attracted and more trapped in traps with methyl eugenol as an attractant than the traps added with fruit juice. Female fruit flies were attracted and trapped only in a trap with attractants containing fruit juice as an attractant.

1. Introduction
\textit{Bactrocera} \textit{spp.} [Diptera: Tephritidae] is one of the main pests of chili which has the potential to cause significant losses to chili production [1], [2] and [3]. The control of fruit flies mostly is still done by using synthetic insecticides [4]. The continuous use of insecticides can harm the environment. Pesticides applications provide potential risks for the environment, farmers and consumers [5]. According to [6] the use of insecticides in agroecosystems can cause pest resistance and resurgence, secondary pest outbreaks, natural enemies killed, flora changes, and poisoning plants if used unwisely.

One of the more environmentally friendly alternative controls of fruit flies is the use of traps with methyl eugenol as an attractant. The use of methyl eugenol can reduce the use of pesticides by 75-95\% [7], but the use of methyl eugenol can only attract male fruit flies. One way to increase the effectiveness of using methyl eugenol is by combining methyl eugenol with fruit juice. The combination of methyl eugenol and star fruit extract is effective in trapping fruit flies [8].

Fruit flies use several visual cues or chemical cues to find a host. Appropriate visual and chemical signals will cause fruit fly pests to be more interested in finding their host [9]. Therefore, research on the effectiveness of the combination of attractant and color in trapping fruit flies \([\textit{Bactrocera} \textit{spp.}]\) in chili plant \([\textit{Capsicum annuum} \textit{L.}]\) is necessary.
2. Materials and methods
The research was carried out at the Research Farm with an area about 0.25 hectares and then the samples were identified in the Plant Pest Laboratory of the Agriculture Faculty, Jambi University from August - November 2018. A factorial randomized block design was used in the research with 2 factors which are type of fruit fly attractants [A] and the color of the traps [B]. Factor A contains of 3 levels which are A0: Methyl eugenol + Water, A1: Methyl eugenol + Guava Juice, and A2: Methyl eugenol + Star fruit juice. Meanwhile Factor B contains of 4 levels which are B0: No color [Transparent], B1: Red, B2: Yellow, and B3: Green.

So, there were 12 treatment combinations namely: A0B0, A1B0, A2B0, A0B1, A1B1, A2B1, A0B2, A1B2, A2B2, A0B3, A1B3, and A2B3. Each treatment combination was repeated 3 times randomly placed in groups. Groups were determined based on the slope of the land and surrounding vegetation.

The fruit fly trap used is a modified Steiner trap type II. Traps with methyl eugenol as bait was made from 1.5 l mineral water plastic bottles and plastic funnels. Traps were then colored according to the inside using a wire and dropped with 1.5 ml of methyl eugenol using a syringe [10]. Next, the bottle was filled with 200 ml of water. Water was replaced with fruit juice in a treatment that uses fruit juice to avoid trapped fruit flies get out from the trap and was added carbofuran insecticide as much as ½ teaspoon per trap [11].

Installation of traps was done when the plant enters the generative phase which is 9 weeks after planting [wap], the trap was placed zig-zagically. A total of 36 bottle traps were installed in the planting area, grouped into 3 groups so that there were 12 traps each group. Trap bottles were installed at a stake with a height of 1 m above ground level [12]. The installation of traps was done once a week for 2 months. Traps were installed at 07.00 WIT [Western Indonesian Time] and left exposed for a week. Methyl eugenol and fruit juice were replaced with new ones at each observation.

Observations were made on the type, number, and sex of fruit fly starting from 9 to 16 waps. All fruit flies found in the traps were put into a specimen bottle containing 70% alcohol, then labeled with an area about 0.25 hectares and then the samples were identified in the Plant Pest Laboratory of the Agriculture Faculty, Jambi University from August - November 2018.

The samples were identified using a microscope for species level using fruit fly’s key determination based on traps, groups, and time, then identified in the laboratory. The trapped fruit flies were counted. The samples were identified using a microscope for species level using fruit fly's key determination and other related literature [13] [14]. The data obtained were analyzed using ANOVA. The differences between treatments were analyzed using Duncan's Multiple Range Test [DMRT] at a 5% level.

3. Results and discussion

3.1. Effect of trap type on the species of trapped fruit flies

| No | Fruit flies     | A0 | A0 | A0 | A0 | A1 | A1 | A1 | A2 | A2 | A2 | A2 |
|----|----------------|----|----|----|----|----|----|----|----|----|----|----|
|    |                | B0 | B1 | B2 | B3 | B0 | B1 | B2 | B3 | B0 | B1 | B2 |
| 1  | B. umbrosa     | +  | +  | +  | +  | +  | +  | +  | +  | +  | +  | +  |
| 2  | B. caramboliae | +  | +  | +  | +  | +  | +  | +  | +  | +  | +  | +  |
| 3  | B. papayae    | +  | +  | +  | +  | +  | +  | +  | +  | +  | +  | +  |
| 4  | B. cucurbitae | -  | -  | -  | -  | +  | +  | +  | +  | +  | +  | +  |
| 5  | B. tau        | +  | -  | -  | -  | -  | -  | -  | -  | -  | -  | -  |
| 6  | B. dorsalis   | +  | +  | +  | +  | +  | +  | +  | +  | +  | +  | +  |
| 7  | B. occipitalis| +  | +  | +  | +  | +  | +  | +  | +  | +  | +  | +  |
| 8  | B. musae      | +  | +  | -  | -  | -  | -  | -  | -  | -  | -  | -  |
| 9  | B. correcta   | -  | -  | -  | -  | +  | -  | -  | -  | -  | -  | -  |

|                | Total trapped | 7  | 6  | 5  | 6  | 7  | 6  | 6  | 8  | 7  | 6  | 6  | 7  |

Note: + = trapped, - = not trapped
Table 1 shows 9 species were trapped. 5 species which are *B. umbrosa*, *B. carabobae*, *B. papaya*, *B. dorsalis*, and *B. occipitalis* were trapped in all treatment. 8 species were interested and trapped in the treatment of A1B3 [ME + guava juice, green trap]. Only 1 species was not trapped in the treatment of A1B3. The other treatment can attract and trap fruit flies less than 8 species. There were 7 fruit flies species attracted and trapped in each of combination treatment of A0B0 [Methyl eugenol + Water, colorless trap], A1B0 [Methyl eugenol + Guava Juice, colorless trap], A2B0m [Methyl eugenol + Star fruit juice, colorless trap], A2 B3 [Methyl eugenol + Star fruit juice, green trap].

6 fruit flies species were attracted and trapped in each of combination treatment of A0B1 [Methyl eugenol + Water, red], A0B3 [Methyl eugenol + Water, green trap], A1B1 [Methyl eugenol + Guava Juice, red trap], A1B2 [Methyl eugenol + Guava Juice, yellow trap], A2B1 [Methyl eugenol + Star fruit juice, Red], and A2B2 [Methyl eugenol + Star fruit juice, yellow trap]. 5 species of fruit flies were attracted and trapped in each of combination treatment of A0B1. The A1B3 treatment showed the broadest spectrum to attract and trap various species of fruit flies. However, all treatment combinations also have a broad spectrum in attracting and trapping various species of fruit flies. This is because various species of fruit flies have a wide range of hosts. After all, fruit flies are polyphagous pests [15] [16].

3.2. Effect of trap type on the number of trapped fruit flies.

Variance analysis showed that the attractant type significantly affected the number of fruit flies trapped. The effect of trap type on the number of trapped fruit flies, in general, is shown in Figure 1.

Traps with methyl eugenol attractants without fruit juice could attract and trapped more fruit flies than with methyl eugenol attractants added with fruit juice [Figure 1a]. Methyl eugenol is one of the synthetic attractants that is widely used to control fruit flies. Methyl eugenol is volatile and releases fragrance [17]. The application of methyl eugenol using yellow traps effectively captures fruit flies [18].

The data also shows that the addition of fruit juice to the trap with methyl eugenol can reduce the effectiveness of methyl eugenol in trapping fruit flies. There was no significant effect of adding color to traps in attracting and trapping male fruit flies [Figure 1b].

![Graph](image-url)
3.3. Effect of trap type on the number of trapped mele fruit flies

Variance analysis showed that the attractant type significantly affected the number of male fruit flies trapped. The effect of trap type on the number of trapped male fruit flies, in general, can be seen in Figure 2.
Traps with methyl eugenol attractant without fruit juice can attract and trap more male fruit flies than traps with methyl eugenol attractants added with fruit juice [Figure 2a]. The data also show that the addition of fruit juice to the trap with methyl eugenol as attractant can reduce the effectiveness of methyl eugenol in trapping male fruit flies. There was no significant effect of adding color to traps in attracting and trapping male fruit flies [Figure 2b].

Methyl eugenol has the chemical element C_{12}H_{24}O_2. This compound is needed by male fruit flies for consumption and is useful in the copulation process [19]. Methyl eugenol which has been consumed will then be transformed in the form of 2-[2-propenyl]-4,5-dimethoxyphenol and E-coniferyl alcohol as a result of pheromone and alomon metabolism.

3.4. Effect of trap type on the number of trapped female fruit flies

Variance analysis and DMRT show that there was a significant effect of attractant types, color and interaction between both factors in attracting and trapping female fruit flies [Table 2].

Table 2. The effect of trap type on the number of trapped female fruit flies in 12 wap.

| Treatments                        | The Number of Trapped Female Fruit Flies |
|-----------------------------------|------------------------------------------|
|                                   | B0 [no color] | B1 [Red] | B2 [Yellow] | B3 [Green] |
| A0 [Methyl eugenol + water]      | 0.00 a P      | 0.00 a P | 0.00 a P    | 0.00 a P    |
| A1 [Methyl eugenol + Guava Juice i] | 1.00 a P     | 0.67 a P | 1.33 b P    | 0.33 a P    |
| A2 [Methyl eugenol + Star fruit juice] | 4.33 b Q    | 0.33 a P | 1.33 b P    | 2.67 b Q    |

Numbers followed by the same lowercase letters in the same column are not significantly different at the 5% level while numbers followed by the same capital letters on the same row are not significantly different at the 5% level.

Table 2 shows that the female fruit flies were more attracted to the treatment of A2B0 [methyl eugenol + starfruit juice on colorless trapping] and A2B3. [Methyl eugenol + starfruit juice on green
color trapping]. This is different from the results of research by Sodiq et al. [20] who reported that the female fruit flies were most attracted to guava juice. Wati [8] reported that the combination of methyl eugenol plus star fruit extract was effective in trapping fruit flies. Fruit flies, in addition to using chemical cues in the form of aromas issued by the fruit and synthetic attractants to find its host, fruit flies also use visual such as form, size, and color of the trap as visual stimuli that provide certain responses of fruit flies [9]. Female fruit flies were not interested in the treatment with attractants of methyl eugenol without fruit juice, indicated by no female fruit flies coming and being trapped.

4. Conclusions
Trap A1B3 [methyl eugenol and guava juice as an attractant, green trap] has the broadest spectrum to attract and trap various species of fruit flies. Color of traps doesn’t affect significantly to attract and trap male fruit flies. Male fruit flies are more attracted and trapped in the trap with methyl eugenol as attractants than the trap added with fruit juice. Female fruit flies are only attracted and trapped in a trap with attractants containing fruit juice as an attractant.

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