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# Evaluation of Trap Size, Trap Entrance Size and Methyl Eugenol Amount for the Catch of *Bactrocera Dorsalis* Hendel

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**Abstract:** The Oriental fruit fly, *Bactrocera dorsalis* (Hendel) (Diptera: Tephritidae), is a damaging pest of fruit and vegetable crops in many tropical and sub-tropical countries. In Indonesia, the fly is a serious pest of pepper that can cause total yield loss. The purposes of the current study were to determine: (1) The effect of trap size and Methyl Eugenol (ME) amount per trap on the number of *B. dorsalis* adults caught per trap and (2) the effect of trap entrance size and ME amount per trap on the number of *B. dorsalis* caught per trap and trap field longevity. For the first trial, treatments were arranged in a randomized complete block design in a factorial with five replications. The trap sizes were 330, 600, and 1500 mL. Methyl eugenol amounts were 0.5, 1.0, and 1.5 mL per trap. The second trial also used a randomized complete block design in factorial with five replications. The trap entrance sizes were 0.5 × 0.5, 1.0 × 0.5, 1.0 × 1.0, 1.5 × 1.5 cm and 2.0 × 2.0 cm. ME amounts used per trap were 0.5, 1.0. and 1.5 mL. The results showed that bigger traps were more effective in catching the fruit fly males. Similarly, traps with a higher amount of ME caught significantly more fruit flies. The biggest trap (1500 mL) with the most ME (1.5 mL) per trap caught significantly more fruit flies per trap than did the other treatments. The results also showed that traps with smaller entrances caught more fruit flies and had longer field longevity in comparison to the other treatments. Traps with the smallest entrance (0.5 × 0.5 cm) with the most ME per trap were more effective in catching the fruit fly and had longer field longevity than the other treatments.

**Keywords:** *Bactrocera Dorsalis*, Pepper, Trap, Methyl Eugenol, Field Longevity

## Introduction

The Oriental fruit fly, *Bactrocera dorsalis* (Hendel) (Diptera: Tephritidae), is a devastating pest and has been reported to in fest about 300 species of plants, including numerous important fruit and vegetable crops. The insect is native to Asia and now its presence has been detected in at least 65 countries (CABI, 2015). Drew and Hancock (1994) reported the presence of the pest in Indonesia, including Sulawesi Island. Currently, the Oriental fruit fly is one of the most damaging pests of pepper that can cause yield loss of up to 100% on unprotected crops (Ampareng, 2021).

The Oriental fruit fly females lay eggs by inserting their ovipositors under the pepper fruit skin and leaving ovipositor marks as dark spots on the affected fruits. The egg stadium lasts for 2-3 days and the larvae feed and develop within the fruits. The last larval instar (the third instar) leaves the fruits and goes down to the soil to pupate (Mau and Matin, 2007). The affected fruits usually prematurely drop off the plants rendering them unmarketable. Before they mate, the newly emerging adults seek protein-source foods, essential for the fly's ovary maturation and egg production (Vargas *et al*., 2015).

To control the Oriental fruit fly, farmers mostly depend on insecticide use. Unfortunately, most of the time, the tactic is not effective in controlling the pest because once the eggs have been laid inside of the fruits the spray cannot reach them. Therefore, insecticide applications can only target adults which are very mobile and can easily avoid the spray. To have some control, the farmers apply insecticides frequently, more than 20 applications per season during the plant generative growth stage. One way of improving the spray efficacy is by combining insecticide and male annihilation lures such as protein hydrolysate (Smith and Nannan, 1988, Hsu *et al*., 2010). However, until now the chemical compound is not available commercially to the farmers in the area.

Another control measure of *B. dorsalis* employed by the local farmers is the use of traps to catch adult males. Various types of traps are available commercially in other countries, including Elkofon and McPhail traps (Eliopoulos, 2007). However, such trap types are not available in the local market for farmers to use, and those would be unaffordable for most smallholder farmers. Farmers design their traps by using used mineral water bottles of different sizes. Two to four openings as trap entrances were made evenly spaced around the bottle at about two-thirds of the height of the bottle from its bottom. There is no standard for the entrance size. The traps were filled with water about 30% of the bottle volume. A cotton wick impregnated with Methyl Eugenol (ME) is used as bait in each trap. The cotton wick was hung inside of the trap using a fine wire. The traps are set up in the field supported by 1.5 m bamboo stakes.

The Oriental fruit fly has different preferences in trap color, size, and height. In a laboratory experiment, Wu *et al*. (2007) reported that the insect preferred green, yellow, and orange colors the most; while Ravikumar and Viraktamath (2007) found that the pest is most allured to green and orange and black traps set up in guava and mango fields, respectively. Sticky trap height from the ground and size also influence the preference of *B. dorsalis* (Said *et al*., 2017; Abdullah *et al*., 2017). In addition, methyl eugenol dispenser types also affect the catches of the Oriental fruit fly males (Shelly, 2010, Suckling *et al*., 2008). However, in Indonesia, no published reports on the relative effectiveness of different trap sizes, trap entrance sizes and ME amounts used per trap. Therefore, the objectives of the current study were to determine: (1) The effect of trap size and ME amount used per trap on the number of *B. dorsalis* adults caught per trap and (2) the effect of trap entrance size and ME amount per trap on the number of *B. dorsalis* adults caught per trap and trap field longevity.

## Materials and Methods

### *Study Site and Trap Design*

Field experiments were conducted at the Experiment Farm, Faculty of Agriculture, Hasanuddin University (5°07'42" S, 119°28'47" E), Makassar, South Sulawesi Province of Indonesia, from August to November 2020 (dry season), and trap catches were evaluated from October to November when the fruit fly populations were high towards the end of the season. The experiment was repeated in the following rainy season (February to June 2021). Trap catches were evaluated from March to April when the fruit fly populations were high towards the end of the season. The study site is about 7 m above sea level with temperatures ranging from 22.5 to 32.5°C (an average of 27.5°C) and rainfalls ranging from 15 to 734 mm per month (an average of 261 mm/month) (BMKG, 2020). Chili plants have been cultivated on the farm for the last six years and the Oriental fruit fly, *B. dorsalis*, was consistently present in the field in each planting season during that period.

Traps were made of plastic water bottles, commonly used by chili growers to control fruit flies in the province. Four openings as trap entrances were made evenly spaced around the bottle at two-thirds of the height of the bottle from its bottom. The traps were filled with water about 30% of the bottle volume. A 2 cm-diameter cotton wick impregnated with Methyl Eugenol (ME) was used as bait in each trap. The cotton wick was hung inside of the trap using a wire (Fig. 1).

### *Effect of Trap Size and ME Amount*

Field trials were conducted to determine the effect of trap size and attractant amount per trap on the number of fruit fly males caught per trap. The treatments were arranged in a randomized complete block design in factorial. Trap size and ME amount used per trap was the first factor and the second factor, respectively. The trap size has three levels: 330 mL (15.4 cm ht, 5.4 cm diam); 600 mL (22.5 cm ht, 6.5 cm diam); and 1500 mL (31.5 cm ht, 8 cm diam). The second factor, ME amount used per trap, has three levels: 0.5 mL per trap; 1. 0 mL per trap (factory recommendation); and 1.5 mL per trap. Each treatment combination had five replications of one trap each. Therefore, there were 45 traps altogether used in this experiment. Each trap was supported using a bamboo stake and the trap was set up 1.5 m above the ground (Hasyim and Kogel, 2006).

The first count for flies caught per trap was conducted seven days after the traps were set up and every seven days thereafter with a total of 8 observations in 2020 and four observations in 2021. After each observation, the ME-impregnated cotton wick in each trap was replaced with a fresh one. The trapped *B. dorsalis* males in each trap were collected in a separate vial containing 70% ethanol and then brought to our lab for identification and count under a dissecting microscope (40-100X).

### *Effects of Trap Entrance Size and ME Amount*

Field trials were conducted to determine the effect of trap entrance size and attractant amount per trap on the number of fruit fly males caught per trap. The size of the traps used was 300 mL. The treatments were arranged in a randomized complete block design in factorial. Trap entrance size and ME amount used per trap were the first factor and the second factor, respectively. The trap entrance sizes were: 0.5 × 0.5, 1.0 × 0.5, 1.0 × 1.0, 1.5 × 1.5 and 2.0 × 2.0 cm. The second factor, ME amount used per trap, had three levels: 0.5, 1.0 mL per trap (factory recommendation); and 1.5 mL per trap.


**Fig. 1:** Trap made of used plastic water bottle

Each treatment combination had five replications of one trap each. Therefore, there were 75 traps altogether used in this experiment. Each trap was supported using bamboo and the trap was set up 1.5 m above the ground (Hasyim and Kogel, 2006).

The first count for flies caught per trap was conducted seven days after the traps were set up and every seven days thereafter with a total of six observations. After each observation, the trapped water was replaced with fresh water and the ME-impregnated cotton wick was kept throughout the experiment to determine the field longevity of the attractant. To monitor the field population of the insect, five traps (1500 mL with entrance size of 0.5 × 0.5 cm and 1.5 mL ME) with a ME-impregnated cotton wick were replaced with fresh wick every week. The trapped flies in each trap were collected in a separate vial containing 70% ethanol and then brought to our lab for identification and count under a dissecting microscope (40-100X).

### *Statistical Analysis*

For the experiment of determining the effect of trap size and ME amount on the number of fruit fly males caught per trap, the data were transformed using log (x + 1) before being analyzed with analysis of variance and then means were separated using Tukey's post hoc test. For the experiment of determining the effect of the trap entrance size and ME amount on the number of fruit fly males caught per trap, data were analyzed with the Kruskal-Wallis non-parametric rank and separation test because data transformation failed to normalize and homogenize the data distributions and the data variances, respectively. The data were analyzed using SPSS 2020 version 27.0.0 (SPSS Inc., Chicago, IL, USA).

## Results

### *Effect of Trap Size*

In 2020, there were significant differences among the trap size treatments in the numbers of *B. dorsalis* males caught per trap, except on the first observation (2 Oct) (Table 1). There was a tendency that bigger traps caught more fruit flies. The highest catches of the fruit fly were found in the largest traps (1,500 mL), which were significantly higher than the other treatments (300 mL and 600 mL) throughout the experiment. The number of the Oriental fruit fly males caught per trap was strongly correlated with the trap size ($y = 0.15x + 49.4$; $r^2 = 0.81$; $P<0.01$) (Fig. 2). The number of *B. dorsalis* males caught per trap increased as the trap size increased. Similarly, in 2021, the highest catches were found in the biggest traps (1,500 mL) and they were significantly different from the other treatments. The smallest traps (300 mL) caught the least number of fruit fly males during the course of the trial (Table 2).

### *Effect of ME Amount*

In 2020, there were significant differences among treatments of ME amount per trap in the numbers of *B. dorsalis* males caught per trap throughout the experiment (Table 3). There was a general trend that the more ME put in a trap the higher catches were. The highest catches of the fruit fly were found in the traps with the most ME (1.5 mL /trap), in comparison to the other treatments (0.5 mL and 1.0 mL per trap) throughout the experiment. The number of the Oriental fruit fly males caught per trap was positively correlated with the ME amount per trap ($y = 85.9x + 35.2$; r2 = 0.30; $P < 0.01$) (Fig. 3). The number of *B. dorsalis* males caught per trap increased with an increase in the amount of ME used per trap. Similarly, in 2021, the highest catches were found in the traps with 1.5 mL /trap and they are significantly different from the other treatments. The traps with the least ME amount (0.5 mL /trap) caught the least number of fruit fly males during the course of the trial and were significantly lower than the catches in the other treatments (Table 4).

### *Effect of Trap Size and ME Amount Combination*

There were significant differences among the combined treatments of trap size and ME amount per trap in the numbers of fruit fly males caught per trap per week (Table 5). For trap sizes of 330 and 600 mL, the numbers of fly males caught per trap were not significantly different amongst the ME amount treatments for the first four observations but there were significant differences for the rest of the trial when the fruit fly populations were high. The catches in the traps with 1.5 mL ME were significantly higher than those in the traps with 0.5 mL ME per trap from the fifth to the eighth observations. However, for the trap size of 1,500 mL, the numbers of the Oriental fruit fly males caught per trap were significantly different among the ME amount treatments throughout the experiments. The highest numbers of fruit flies caught per trap were found in the trap size of 1.500 with 1.5 mL ME per trap, which was significantly different from those in the other treatments. These were followed by the catches in the trap size of 1.500 with 1.0 mL ME per trap and the trap size of 1.500 with 0.5 mL ME per trap. Overall, the results indicated that the bigger the trap and the more ME used per trap, the higher the catches were.

### *Effect of Trap Entrance Size*

On each observation date, there were significant differences among the trap entrance size treatments in the numbers of *B. dorsalis* males caught per trap per week (Fig. 4). The number of the Oriental fruit fly males caught per trap was strongly negatively correlated with the trap entrance size ($y = -7.2x + 36.6$; $r2 = 0.44$; $P<0.01$) (Fig. 5). There was a tendency that the smaller the trap entrance size, the more fruit fly males were caught per trap. For each observation, a trap entrance size of $0.5 \times 0.5$ cm caught significantly more fruit flies than did the other treatments. However, for all treatments, the number of fruit flies caught per trap steadily decreased from the first observation to the last one. The extent of the decrease was affected by the trap entrance size treatments. For entrance sizes of $0.5 \times 0.5$ and $1.0, \times 0.5$ cm were able to capture fruit flies until the last observation (six weeks after the traps were set up in the field). While entrance sizes of $1.5 \times 1.5$ and $2.0 \times 2.0$ cm were able to catch fruit flies only until the fourth observation. Traps with fresh ME (weekly replaced) consistently caught high numbers of fruit flies. The numbers of fruit flies trapped by the smallest entrance size ($0.5 \times 0.5$ cm) were not significantly different from the catches of the fresh traps for the first three observations but significantly lower for the rest of the experiment.

### *Effect of ME Amount*

On each observation date, there were significant differences among ME amount treatments in the numbers of *B. dorsalis* males caught per trap per week (Fig. 6). There was a general trend that the more ME used per trap, the more fruit fly males were caught per trap. For each observation, 1.5 mL ME per trap caught significantly more fruit flies than did the other treatments (0.5 and 1.0 mL per trap). However, for all treatments, the number of fruit flies caught per trap steadily decreased from the first observation to the last one. The extent of the decrease was affected by ME amount treatments. Traps with 1.0 and 1.5 mL ME were able to capture fruit flies until the last observation (six weeks after the traps were set up in the field). While traps with 0.5 mL ME were able to catch fruit flies only until the third observation. Traps with fresh ME (weekly replaced) consistently caught high numbers of fruit flies throughout the experiment. The numbers of fruit flies trapped by the traps with 1.5 mL ME were not significantly different from the catches of the fresh traps for the first two observations but significantly lower for the rest of the experiment.

### *Effect of Trap Entrance Size and ME Amount Combination*

There were significant differences among the combined treatments (trap entrance size and ME amount used per trap) in the numbers of fruit fly males caught per trap per week (Fig. 7). For trap entrance sizes of $0.5 \times 0.5$, $1.0 \times 0.5$, and $1.0 \times 1.0$ cm, the numbers of fly males caught per trap were significantly different amongst the ME amount treatments. For those three trap entrance sizes, the catches in the traps with 1.5 mL ME were significantly higher than those in the traps with 0.5 mL and 1.0 mL. However, for the trap entrance size of $1.5 \times 1.5$ and $2.0 \times 2.0$ cm, the numbers of the Oriental fruit fly males caught per trap were not significantly different among the ME amount treatments. The highest numbers of fruit flies caught per trap were found in the trap entrance size of $0.5 \times 0.5$ cm with 1.5 mL ME per trap, which was significantly different from those in the other treatments. Overall, the results indicated that the smaller the trap entrance size with more ME used per trap, the higher the catches were.

**Table 1:** Influence of trap size on the average number of fruit flies caught per trap, 2020

| | Date | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Trap size (ml) | 2 Oct | 10 Oct | 17 Oct | 24 Oct | 31 Oct | 07 Nov | 14 Nov | 21 Nov |
| 3300 | $40.3^a$ | $51.9^a$ | $52.5^a$ | $60.1^a$ | $110.1^a$ | $96.2^a$ | $183.7^a$ | $157.9^a$ |
| 6000 | $38.5^a$ | $76.0^b$ | $58.7^b$ | $59.9^b$ | $129.2^b$ | $116.1^a$ | $186.3^a$ | $145.3^a$ |
| 1500 | $65.5^a$ | $136.3^c$ | $136.3^c$ | $131.7^c$ | $216.0^c$ | $181.8^b$ | $243.8^b$ | $232.9^b$ |

Values within a column followed by the same letter are not significantly different (Tukey's test, 0.05) 300

**Table 2:** Influence of trap size on the average number of fruit flies caught per trap, 2021

| | Date | | | |
|---|---|---|---|---|
| Trap size (ml) | 15 Mar | 22 Mar | 29 Mar | 6 Apr |
| 3300 | 6.50[a] | 12.4[a] | 17.84[a] | 16.25[a] |
| 6000 | 11.75[b] | 21.2[b] | 28.52[b] | 22.32[b] |
| 1500 | 15.71[b] | 36.90[c] | 42.98[c] | 34.56[c] |

Values within a column followed by the same letter are not significantly different (Tukey's test, 0.05)

**Table 3:** Influence of the amount of methyl eugenol used per trap on the average number of fruit flies caught per trap, 2020

| ME | Date | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| (ml/trap) | 2 Oct | 10 Oct | 17 Oct | 24 Oct | 31 Oct | 07 Nov | 14 Nov | 21 Nov |
| 0,5 | 32.1[a] | 69.3[a] | 49.8[a] | 50.8[a] | 80.7[a] | 81.1[a] | 129.2[a] | 113.3[a] |
| 1,0 | 45.5[a] | 80.9[b] | 87.2[a] | 92.6[a] | 177.9[a] | 144.1[a] | 201.6[a] | 176.7[a] |
| 1,5 | 66.7[b] | 113.9[c] | 110.4[b] | 108.3[b] | 196.7[b] | 168.9[b] | 282.9[b] | 246.1[b] |

Values within a column followed by the same letter are not significantly different (Tukey's test, 0.05)

**Table 4:** Influence of the amount of methyl eugenol used per trap on the average number of fruit flies caught per trap, 2021

| | Date | | | |
|---|---|---|---|---|
| ME (ml/trap) | 15 Mar | 22 Mar | 29 Mar | 6 Apr |
| 0.5 | 7.80[a] | 11.25[a] | 21.80[a] | 24.35[a] |
| 1.0 | 12.25[b] | 23.2[b] | 26.52[a] | 37.21[b] |
| 1.5 | 14.89[b] | 30.90[b] | 38.75[b] | 44.56[b] |

Values within a column followed by the same letter are not significantly different (Tukey's test, 0.05)

**Table 5:** Influence of trap size and the amount of methyl eugenol used per trap on the average number of fruit flies caught per trap, 2020

| Trap size | ME | Date | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| (ml) | (ml/trap) | 2 Oct | 10 Oct | 17 Oct | 24 Oct | 31 Oct | 7 Nov | 14 Nov | 21 Nov |
| 3300 | 0,5 | 30.8[a] | 28.2[a] | 28.4[a] | 36.2[a] | 33.8[a] | 54.2[a] | 100.0[a] | 80.6[a] |
| 3300 | 1 | 42.6[a] | 58.4[ab] | 50.8[ab] | 73.6[ab] | 137.0[b] | 110.6[b] | 184.0[b] | 167.0[b] |
| 3300 | 1,5 | 47.4[a] | 69.0[ab] | 78.2[ab] | 70.4[ab] | 159.4[b] | 123.8[b] | 267.0[c] | 226.0[c] |
| 6000 | 0,5 | 31.6[a] | 55.0[ab] | 36.8[a] | 28.4[a] | 63.4[a] | 68.2[a] | 116.2[a] | 112.4[a] |
| 6000 | 1 | 36.0[a] | 52.0[ab] | 76.2[ab] | 71.2[ab] | 173.0[b] | 150.2[b] | 191.6[b] | 163.8[b] |
| 6000 | 1,5 | 48.0[a] | 121.0[b] | 63.0[ab] | 80.2[ab] | 151.2[b] | 129.8[b] | 251.0[c] | 159.8[b] |
| 1500 | 0,5 | 34.0[a] | 124.8[b] | 84.2[ab] | 87.8[ab] | 144.8[b] | 120.8[b] | 171.4[b] | 146.8[b] |
| 1500 | 1 | 58.0[a] | 132.4[b] | 134.6[b] | 133.0[b] | 223.8[c] | 171.4[b] | 229.2[c] | 199.4[b] |
| 1500 | 1,5 | 104.6[b] | 151.6[c] | 212.0[c] | 174.4[c] | 279.4[c] | 253.2[c] | 330.8[d] | 352.6[d] |

Values within a column followed by the same letter are not significantly different (Tukey's test, 0.05)

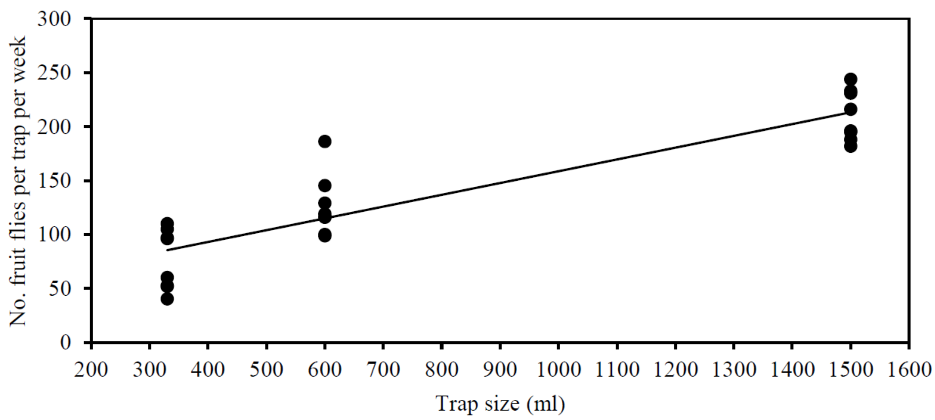


**Fig. 2:** Relationship between the trap size (mL) and the number of fruit flies caught per trap per week

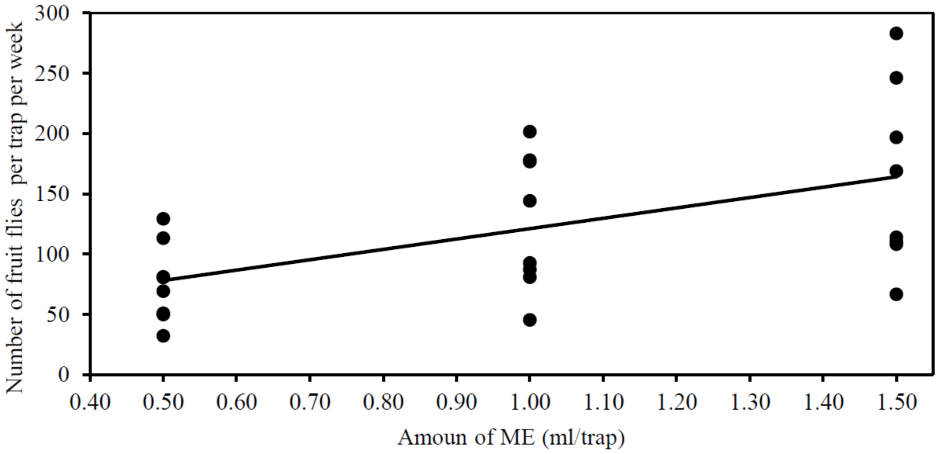


**Fig. 3:** Relationship between the amount of ME: 0.5, 1.0, 1.5 mL per trap and the number of fruit flies caught per trap per week

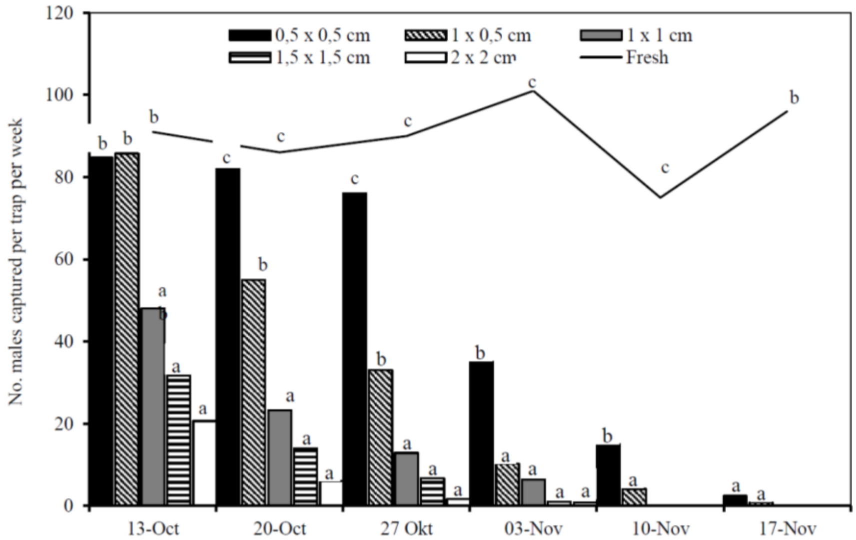


**Fig. 4:** Captures of *B. dorsalis* males for different trap entrance size treatments with weathered ME (bars). Fresh = trap size of 300 mL, entrance size of 0.5 × 0.5 cm, and 1.5 mL liquid ME per trap, replaced every seven days (line). Bars and lines with the same letter on the same date are not significantly different (Kruskal-Wallis nonparametric rank analysis and separation test, $P = 0.05$)

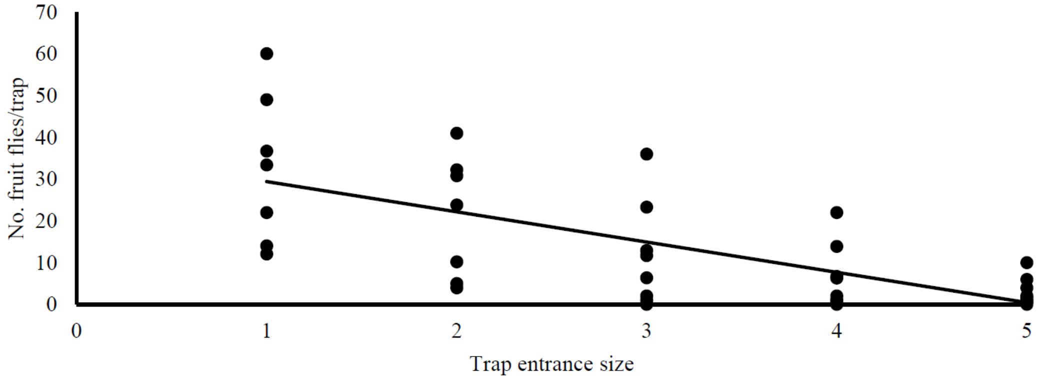


**Fig. 5:** Relationship between the trap entrance size and the number of fruit flies caught per trap per week. 1 = 0.5 × 0.5, 2 = 1.0 × 0.5, 3 = 1.0 × 1.0, 4 = 1.5 × 1.5, 5 = 2.0 × 2.0 cm

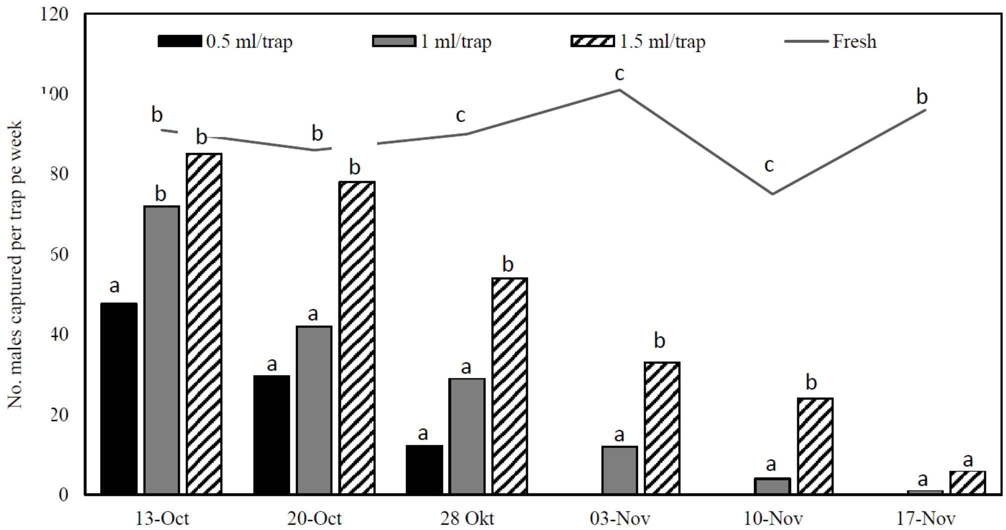


**Fig. 6:** Captures of *B. dorsalis* males for a different amount of weathered ME treatments (bars). Fresh = trap size of 300 mL, entrance size of 0.5 × 0.5 cm, and 1.5 mL liquid ME per trap, replaced every seven days (line). Bars and lines with the same letter on the same date are not significantly different (Kruskal-Wallis non-parametric rank analysis and separation test, $P = 0.05$)

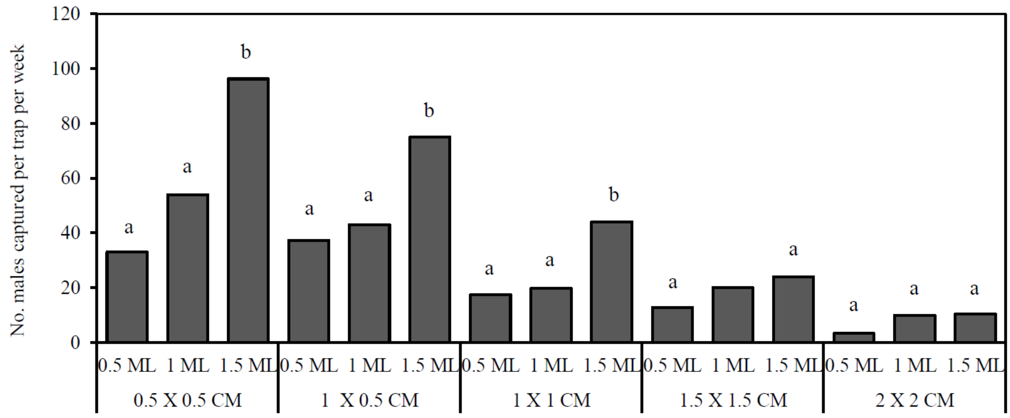


**Fig. 7:** Captures of *B. dorsalis* males for treatment combination of trap entrance size and the amount of ME per trap. Bars with the same letter for the same trap entrance size are not significantly different (Kruskal-Wallis non-parametric rank analysis and separation test, $P = 0.05$)

## Discussion

*Bactrocera dorsalis* was present in the experiment site year-round with fluctuating populations. In the early to middle of the dry season of 2020, the fruit fly was abundant in mango trees existing on the site that were blooming and fruiting. After most of the mangoes were harvested, the insect moved to pepper crops that started blooming and fruiting. The population on pepper continuously built up until the rainy season of 2021 when the population decreased. A series of field trials were conducted to determine the effects of trap size, trap entrance size, and ME amount per trap on the number of *B. dorsalis* males caught per trap per week. The study results showed that trap size, trap entrance size, and the amount of ME per trap used affected the number of fruit fly males caught per trap per week. Bigger traps caught more *B. dorsalis* males. This trend was consistently found in both the dry planting season 2020 and the rainy planting season 2021 when fruit fly populations were high and low, respectively. Similarly, during both planting seasons, more Oriental fruit fly males were caught as more ME amount was used per trap. This result is in agreement with the results of several previous studies showing that *B. dorsalis* males respond to a small amount of ME but their preference increased as the amount of ME used per trap increased (Howarth and Howarth, 2000; Wee *et al*., 2002; Shelly *et al*., 2020).

A combination of trap size and ME amount showed that the most fruit fly catches were found in the biggest trap size (1.500 mL) with the highest amount of

ME per trap (1.5 mL). The average of fruit fly catches in those traps during the course of the study was 232.3 flies per trap per week, which was about 85% and 78% higher than the average catches in the trap 600 mL with 1.5 mL ME (125.5 flies per trap per week) and 300 mL with 1.5 mL ME (130.1 flies per trap per week), respectively. This study indicates that trap effectiveness can be improved by using a bigger trap with more ME amount per trap. However, the study results cannot be used to assess the optimal combination of trap size and ME amount and it requires further investigations.

Our results also indicate that the size of the trap entrance significantly influences the trap catch. Traps with smaller entrance sizes caught more *B. dorsalis* males than did the bigger ones. This is probably due to fewer fruit flies escaping from the traps because of the small entrance size. In addition, because ME is highly volatile (Shelly *et al*., 2020), ME in the traps with smaller entrance sizes weathered more slowly, hence their effectiveness lasted longer. Fruit fly catches in the traps with the smallest entrance (0.5 x 0.5 cm) were not significantly different from the catches in the traps with fresh bait with the same entrance size for the first three weeks.

Traps with more ME caught more flies and their effectiveness lasted longer. The numbers of fruit flies caught in the trap with 1.5 mL ME were not significantly different from those caught in traps with fresh ME for the first two observations. However, the number of fruit flies caught in traps with 1.0 ME was on par with those caught in traps baited with fresh lure only for the first observation. While traps with 0.5 mL ME caught fruit flies with numbers always significantly lower than did the fresh traps. These data are parallel to the finding of Shelly *et al*. (2020) that the longevity of methyl eugenol traps is affected by the amount of lure contained in the traps.

The catches of the biggest trap and the most ME used per trap in this experiment could be improved by using other substances in the trap instead of water. The use of a solid-lure insecticide dispenser improved the effectiveness of fruit fly traps by preventing the catches from escaping (Vargas *et al*., 2010). Propylene glycol was also reported to improve fruit fly trap effectiveness (Uchida *et al*., 2007). If more ME is put in our traps, the number of catches and the field longevity could be increased. The standard amount of ME for fruit fly control and monitoring is 5 mL per trap and could last up to six weeks (IPRFFSP, 2006), which is much higher than the highest amount of ME used in our experiment (1.5 mL per trap). Therefore, further studies should be conducted by incorporating the current study findings and those aspects into a more effective trap system.

## Conclusion

The finding of the current study on the effect of the trap size, trap entrance size, and the amount of ME used per trap on the fruit fly captures and trap longevity, to our knowledge, is novel in the country. The current study results suggested that the trap effectiveness could be improved by using bigger traps with more ME and small trap entrances. To improve the effectiveness of the fruit fly trap, the findings of the current study should be incorporated with the findings of the previous studies, including the use of an appropriate insecticide dispenser in future studies.

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## Authors’ Contributions

**Andi Nasruddin:** Designed the experiments, supervised the whole work, validated the data, prepared the original manuscript, and critically revised and approved the manuscript.

**Iftitah Kartika Amaliah, Julisa**, **Firdaus, Nurul Arfiani, Andi Dirham Nasruddin, Ainul Sri Rejeki, and Jumardi Jumardi:** Conducted the field experiment, Collected the data, analyzed the data, critically reviewed the manuscript, and approved the manuscript.

**Sri Nur Aminah Ngatimin:** Designed the experiments, statistically analyzed the data, critically revised the manuscript, and approved the manuscript.

**Itji Diana Daud:** Designed the experiments, statistically analyzed the data, prepared the original manuscript, critically revised the manuscript, and approved the manuscript.

**Muhammad Junaid:** Designed the experiments, prepared the original manuscript, interpreted the data, critically revised the manuscript, and approved the manuscript.

## Ethics

The authors confirm and declare that the content of this article consists of original and unpublished material and no ethical issues pertaining to the work.

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