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THE EFFECT OF METHYL EUGENOL BLOCK PLUS ON *Bactrocera dorsalis* COMPLEX TOTAL CAPTURED IN CHILI PLANTATION

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Abstract. *Fruit flies (Bactrocera spp.) are an important pest for horticultural crops, especially fruits and vegetables. One of the most effective and eco-friendly methods to control male and female fruit flies is by using traps that use Methyl Eugenol (ME) block plus fruit essence as an attractant. The purposes of this research were to acquire the most effective formulation of ME Block plus fruit essence to catch the most male and female fruit flies on the chili plantation and to determine the increase in total of fruit flies caught. This research started from December 2017 to January 2018 at Cibeureum Village, Sukamantri District, Ciamis Regency, West Java Province. The research was conducted using a randomized block design consisting of eight treatments and three repetitions. The treatments consisted of adding fruit essence to the ME block: 2 ml of ME on cotton; 2 ml of ME block; 2 ml of ME block + 4 ml of mango essence; 2 ml of ME block + 4 ml of orange essence; 2 ml of ME block + 4 ml of guava essence; 2 ml of ME block + 4 ml of star fruit essence; 2 ml of ME block + 4 ml of chili essence; Antilat (Organic pesticide) as a comparison. The results showed that ME block plus fruit essence has increased the total of male fruit flies caught, but it did not attract female fruit flies. The best combinations with the highest average of male fruit flies caught were ME block plus orange essence with 750.67/5 week, followed by ME block plus chili essence with 746.00/5 week.*

Keywords: *Bactrocera spp., chili fruit essense. fruit flies, methyl eugenol.*

Citation

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INTRODUCTION

Fruit flies *Bactrocera* spp. (Diptera: Tephritidae) are one of the important pests for horticultural crops in tropical and subtropical regions. Tephritidae is the largest family of the Diptera order and is one of the most important families because it is very detrimental economically (Siwi et al., 2006). According to Hashim et al. (2014), fruit flies are categorized as polyphagous mites, which have many host plants. Besides chilies, other host plants for fruit flies are jackfruit, star fruit, mango, tomato, melon, papaya, and cucumber.

Fruit flies can cause both quantitative and qualitative damage to chilies. Quantitative damage occurs due to lower harvest, while qualitative damage occurs due to rot

in chilies. According to Hasyim et al. (2014), damages because of fruit fly attacks are about 20-60%, depending on the type of fruit or vegetable, the attack intensity, and the climate condition. Moreover, with a high population, the intensity of the attack can reach up to 100% (Sahetapy et al., 2019). As a result of these losses, the population of fruit flies must be controlled.

An environmentally-friendly control method that can reduce the fruit fly population is to use traps. The common traps used to reduce the fruit fly population are attractants. Attractants are the compounds that can attract insects (Kardinan et al., 2005). The attractant oftenly used in controlling fruit fly attacks is Methyl Eugenol that will be referred to as ME further on. The ME is the compound needed by male fruit flies to be consumed in order to attract female fruit flies (Haq et al., 2018). It can attract male fruit flies from the genus *Bactrocera* spp. in large quantities. According to Prayudi (2013) ME is quite effective in controlling fruit flies on plants with fruits because it can reduce fruit fly attacks on various local fruits by at least 35%.

ME traps can be built using wooden blocks. Stonehouse et al. (2002) conducted an experiment using the Male Annihilation Technique to control fruit flies in Pakistan. However, this experiment used wooden blocks soaked with ME and insecticide instead of plastic traps. The results showed that the wooden traps blocks with ME killed fruit flies four times as conventional cotton traps. In addition, the advantages of using wooden blocks are that they are cheap and do not require refilling or replacement. The results of research by Sidahmed et al. (2014) showed that the use of plywood blocks is more effective because it attracts more male fruit flies, lasts longer, and costs less compared to eucalyptus, foam, and cotton in guava plantations in Khartoum and Gezira states.

The use of convenient and continuous traps can reduce the fruit flies population and thus reduce the attack rate. This proves that the use of ME block is quite effective and efficient in controlling fruit flies. Nevertheless, the use of these traps still has a drawback, it only attracts male fruit flies. An alternative control method to improve the use of these traps is by adding fruit aromas or fruit essences to the fruit fly trap. According to Jang (2002), female fruit flies will be attracted to the smell of the fruit of their host plants. Ullah et al. (2015) stated that the fruit essence treatment improved the performance of the attractant traps in attracting fruit flies (*B. zonatus*, *B. dorsalis*, and *B. cucurbitae*) compared to traps without a fruit essence. A similar result was reported by Faoziyah (2016) who stated that the use of fruit essences in ME showed the highest average number of catches compared to ME treatment alone.

Therefore, the addition of fruit essence is expected to improve the performance of attractant traps to catch female fruit flies. In this experiment, the essences of star fruit, chili, guava, orange, and Kweni - a type of mango - are used. The selection of these fruits based on the fact that these fruits are these types of fruits are the host plants often attacked by fruit flies. The addition of fruit essence to the ME block trap will be called ME block plus. Testing the effect of the ME block plus formulation in the field, especially in a chili cultivation field, is still unknown. Therefore, this experiment needs aimed to determine the increase in the number of fruit flies captured and the most effective fruit essence in catching both male and female fruit flies.

MATERIALS AND METHODS

The experiment was carried out on a chili plantation owned by farmers in Cibeureum Village, Sukamantri District, Ciamis Regency, West Java Province, Indonesia which was at an altitude of ± 900 meters above the sea-leveled (masl). The identification of fruit flies was carried out at the Plant Pest Laboratory, Department of Plant Pests and Diseases, Faculty of Agriculture, Universitas Padjadjaran. The experiment started in December 2017 to January 2018. The method based and modified from previous research by Susanto et al. (2018), using a single factor randomized block design consisting of 8 treatments and 3 replications, to obtain 24 experiments. The treatments tested were: 2 ml ME cotton (control); (B) ME block 2 ml; (C) 2 ml ME block + 4 ml Kweni essence; (D) 2 ml ME block + 4 ml orange essence; (E) 2 ml ME block + 4 ml guava essence; (F) 2 ml ME block + 4 ml star fruit essence; (G) 2 ml ME block + 4 ml chili essence; and (H) Antilat (comparison).

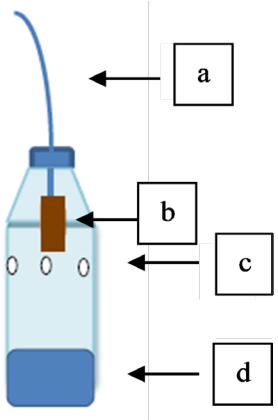

Figure 1. Design of water bottle fruit flies trap. (a) wire hook; (b) ME block; (c) hole; (d) 100 ml of 1 % formalin solution.

Attractant and Essences Preparation

The attractants used in this experiment are produced for the distillation of cloves available in the Plant Pest Laboratory, Department of Plant Pests and Diseases, Faculty of Agriculture, Universitas Padjadjaran, and had the active ingredient compound of ME ($C_{12}H_{24}O_2$). The synthetic essences (mango, orange, guava, star fruit and chili) used were the commercial food aromas which purchased from chemical stores.

Producing and Installation of ME Block with Essences Traps

The traps were made from 600 ml mineral water bottles with dimensions of 6.50 cm × 23.50 cm × 6.50 cm. The wall of the bottle was ± 10 cm long from the top of the bottle with 4 holes (0.7 cm in diameter) placed the middle of the bottle which was parallel to the wood, serve as entrances for the fruit flies, then a small hole was drilled on the bottle cap using a soldering iron to hooked the wire (Figure 1). The wood used in this experiment was a particle board typed made from compacted wood chips and sawdust. The wood was cut to a size of 8 × 2 × 1.5 cm (Figure 2).

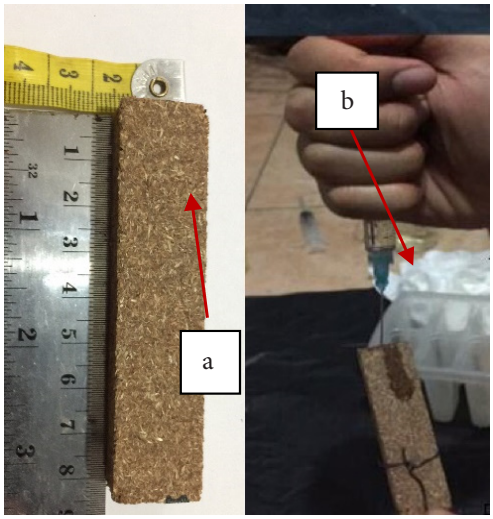

Figure 2. Block size and ME + essence application method. (a) *block* used; (b) ME and Essence Application

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After being cut, the top of the wood was dripped with 2 ml of me and 4 ml of fruit essence each. Before the installation, the trap bottle was filled with 100 ml of water and 1% formalin solution to prevent trapped fruit flies from rotting so that they could be identified. The installation of the trap was carried out on 17 December 2018 by attaching the wire section above the bottle cap to the stems of the chili plants (Figure 3). The traps were installed according to the number of experiments. The distance of the traps between the trees was about 6 meters and they were placed at a height of 1 meter above the ground

Figure 3. Set trap bottle

Observation of The Number of Fruit Flies

The mechanism of the trap was to lure fruit flies into the trap using the ME blocked plus formulation which was placed in the trap bottle. The experiments were carried out on 1 hectare of chili plantation with a spacing of 60 × 50 cm, the age of the chilies was about 50-60 days after planting (DAP), and were already bearing fruit. The first observation was conducted 7 days after the installation. The observation was carried out by counting the number of male and female fruit flies that entered the trap. It was carried out once a week, five times. Based on Susanto et al. (2020), 10% of all fruit flies that were trapped at the experimental site were taken randomly for identification based on their morphological characters in the laboratory using a z61 typed microscope. In addition, observations on biotic data, which was the host availability factor, and abiotic data, such as rainfall and rainy days, were also carried out.

Data Analysis

The observation data were analyzed statistically using Analysis of Variance (ANOVA) through the SPSS 21 program. If the effects of the treatment were significantly different, the Duncan's multiple distance test at the 5% significant level was then carried out. The effects of the biotic and the abiotic factors were analyzed using correlation and regression analysis.

RESULTS AND DISCUSSION

The Effect of ME Block Plus Formulation

The results of experiments in the field for 5 weeks showed that the highest number of fruit flies captured of all treatments occurred in week 1 with a total of 3,709 fruit flies, while the lowest number of fruit flies captured occurred in week 5 with a total catch of 1,351 (Table 1).

Table 1. Fruit flies captured for 5 weeks.

Observation at week -	Total of fruit flies captured	
	Male	Female
1	3709	0
2	2960	0
3	2048	0
4	1569	0
5	1351	0

This happened because, in week 1, the plants have entered the fruit ripening period and, in week 5, they have begun to enter the fourth harvesting period. Ye & Liu (2007) reported that the fruit ripening period and fruit production are very influential factors on fruit flies fluctuations in the field.

The addition of essences to this experiment was aimed to attract female fruit flies, but in fact, the results of the experiments in the field showed that no female fruit flies trapped. This happened presumably because the aroma of chilies is stronger than the synthetic essences. The *B. dorsalis* fruit fly will come and lay eggs on ripe or near-ripe fruits because they emit the aroma of ester extraction and organic acids needed for the formation of fertile eggs as well as larval skin replacement (Novriarceh 2012; Indriyanti 2013). According to Mayasari et al. (2019), the condition of a chili fruit that has undergone the ripening process has a softer skin and releases compounds that can attract the presence of fruit flies. This is one of the factors for not trapping female fruit flies in the treatments given. Furthermore, it is suspected that the aroma of synthetic essences lasts shorter than the aroma produced by the ME compound. Handayani (2015) stated that the ME was able to survive for 36 days.

The results of statistical tests show that the ME block plus formulation is significantly different from the 2 ml ME cotton and 2 ml ME block treatments in attracting male fruit flies. Table 2 shows that the addition of essences to the ME block formulation increases the number of male fruit flies captured compared to the single ME treatment or without the addition of essences.

Table 2. The effect fruit essences application on the number of male fruit flies captured.

Treatment	The capture of male fruit flies	
	Total	Averages ± SD
A: ME cotton 2 ml	221	73.67 a ± 11.68
B: ME block 2 ml	712	237.33 b ± 14.01
C: ME block + Mango Essences	1469	489.67 c ± 123.71
D: ME block + Orange Essences	2252	750.67 d ± 163.41
E: ME block + Guava Essences	1739	579.67 cd ± 124.73
F: ME block + Star fruit Essences	1307	435.67 c ± 42.23
G: ME block + Chili Essences	2238	746.00 d ± 77.66
H: Antilat	1699	566.33 c ± 112.88

Note: Numbers marked with the same letter are not significantly different according to Duncan's Multiple Distance Test at the 0.05 level.

This is indicated by the number of male fruit flies captured in the ME block plus treatment that is around 500-1500 more than the single ME treatment.

According to Zulfitriany et al. (2004), traps that contain more than one attractant can attract more fruit flies than traps that contain only one. This statement indicates that essences have almost the same role as ME, which can attract male fruit flies. In addition, Kardinan (2007) stated that the mixing of two types of chemicals was categorized to be synergistic if it is able to increase the capture potential as well as reduce the concentration of each material used. The research conducted by Shelly (2009) proved that the addition of fruit-flavored essences also plays a role in the competition to attract fruit flies and increases the performance in copulation. Thus, in this experiment, the use of ME block plus essence improved the traps' performance in attracting fruit flies, especially male fruit flies.

The 2 ml ME block treatment had a higher number of male fruit flies than the 2 ml ME cotton treatment. Based on the result of the research conducted by Bagheri et al. (2017), the ME block formulation is more effective at catching fruit flies than cotton-based traps because it can last up to four months (135 days). The result supports the statement of Afzal & Javed (2001), which stated that the use of ME block was almost twice as effective as the use of cotton because it is cheaper, more resistant to bad weather, and does not need to be replaced repeatedly.

The addition of orange essence and chili essence to the ME block formulation was the treatment that has the highest number of male fruit flies captured compared to other treatments. Orange essence has a more fragrant and distinct aroma because oranges are included in essential oil-producing fruits which have three functions, one of the functions is to help the pollination process by attracting several types of insects or animals. Also, it has 38 volatile compounds (Riyadi, 2012). These volatile compounds evaporate easily so they act as an initial trigger for the attraction of fruit flies to the bait served.

Adding chili essence also results in the highest number of male fruit flies captured compared to mango, star fruit, and guava essences. This occurs because the host plant at the experiment location is a chili plant so that it is related to the suitability of the habitat and the availability of food for the fruit flies in the experiment location. It also presumed insects were able to stop near the source of the scent which causes insects to stop for a long time at the source of the scent as their mechanism of finding the source of the second category of aroma. Himawan et al. (2013) stated that insects were able to detect special scents associated with essential elements of their host. The use of ME block plus bottle traps can be categorized to be quite effective in applying fruit flies control because it can increase the number of male fruit flies captured.

Fruit Flies Identification

The identification was conducted by randomly sampling all fruit flies captured. There were 1000 specimen samples taken. The result of the identification of the fruit fly samples captured in the chili planting area of Cibeureum Village, Sukamantri Ciamis District, shows that the area contains *B. dorsalis*, *B. carambolae* and *B. umbrosa* species (Table 3). The captured fruit flies were dominated by the *B. dorsalis* with a male percentage of 84.5%. The dominance of the *B. dorsalis* species is in accordance with the statement of Siwi & Hidayat (2004) that stated the *B. dorsalis* species attack often and cause total damage to chili plants. Sahetapy et al. (2019) reported that the result of the identification

of fruit fly species in the chili cultivation field in two villages was dominated 100% by *B. dorsalis*.

The non-dominant fruit flies species are rarely found and small in numbers. According to Manoi et al. (2016), the rare species can be a species that look for food in a specific habitat and may only explore nearby habitats or even migratory types. This statement is in line with the conditions in the field where there are jackfruit plants around the chili planting site, which is the main host plant for *B. umbrosa*. According to Siwi & Hidayat (2004), *B. umbrosa* is an important pest for kluwih (*Artocarpus altilis*) and jackfruit (*Artocarpus heterophyllus*).

Table 3. The results of identification of fruit flies trapped in the ME block plus formulation.

Sex	Total of Fruit Flies					
	B. dorsalis		*B. carambolae*		*B. umbrosa*	
	Total	%	Total	%	Total	%
Male	854	85.4	137	13.7	9	0.9
Female	-	-	-	-	-	-

The Effect of Chili Cultivation Availability

The availability of fruits or host plants in the field affects the number of fruit flies captured. According to Syahfari & Mujianto (2013), the availability of host plants in the field is one of the biotic factors that affect the fluctuation of fruit flies. The result of the regression analysis shows that the availability of fruits has a significant and positive correlation with the development of fruit flies in the field ($Y = 495{,}300 + 610{,}700x$ $R^2 = 0.952$ $p = 0.004$).

The results of the observations in the field show that the fruit fly population peaked at the first week of observation with a catch of 3,709 fruit flies. In the 1st week of the observation, the chili plants were in a ripe state with a scoring of 5 (abundant number of fruits). Chen et al. (2006) stated that the level of fruit maturity was eminently related to the number of fruit flies captured in the field because ripe fruit emits a high aroma of ester extraction and organic acids, thus attracting fruit flies to come and lay their eggs. Further, Susanto et al. (2017) stated that plants that are approaching harvest time were the most preferred host for fruit flies so that there is an increase in the captured fruit flies.

Figure 4 shows that the lowest population is in the 5th week of observation with 1,351 fruit flies captured with a scoring of 1, which means that the number of fruits in the field is extremely small due to the fourth harvest period. According to Susanto et al. (2017), when the availability of fruit is sufficient, there is an opportunity for fruit flies to secure a place to reproduce, and vice versa. If the availability of fruit decreases, it will reduce the chances of fruit flies reproducing. The statement proves that there is a connection between fruit availability and the level of fruit maturity with the fruit fly population in the field.

The Effect of Rainfall

Rainfall is one of the abiotic factors that can affect the development of fruit flies. High rainfall will cause high soil moisture, which has a negative impact on pupation and the appearance of fruit flies (Ye & Liu, 2007). The analysis showed that there is a positive correlation between rainfall and the number of fruit flies captured in the field, but it does not have a significant effect. This is indicated by the regression equation of Y= 929,296 + 17,520x;

$R^2 = 0.318$; $p = 0.322$. The presence of a positive correlation means that any increase in rainfall in the field will always be followed by an increase in the population of fruit flies.

The result of the observations in weeks 1-5 (Figure 5) shows that the increase in rainfall occurred in week 1 with around 133.6 mm of rain followed by a high number of fruit flies that reached 3,709. In weeks 2 and 3, there was a decrease in rainfall to 56 mm followed by a decrease in the number of fruit flies by 2,960 and 2,048. However, in weeks 4 and 5, there was an increase in rainfall to 77 mm, but this was not followed by an increase in the number of fruit flies captured. This occurs because the volume of rainfall in this experiment was the optimum rainfall amount for the development of fruit flies, which is around 50-200 mm. According to Ye & Liu (2007), the fruit fly population will decrease when the amount of monthly rainfall is lower than 50 mm and increase when the rainfall ranges from 100 mm to 200 mm and will decrease again when the amount of monthly rainfall is higher than 250 mm which was supported by other factors such as temperature and a special host with respect of the population fluctuation.

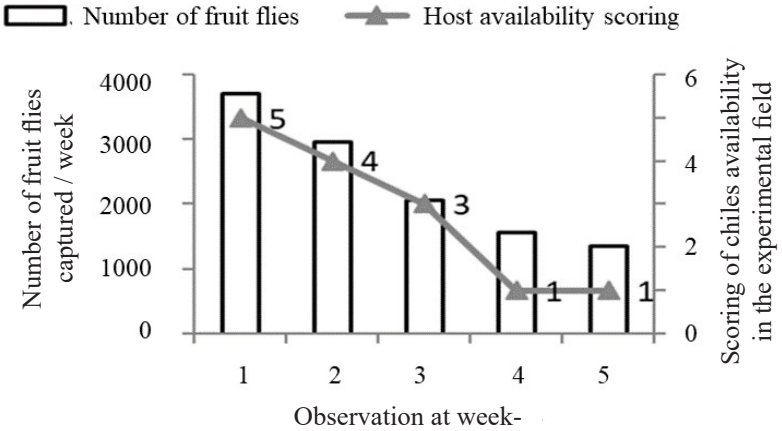

Figure 4. The effect of chili cultivation availability on the number of fruit flies captured

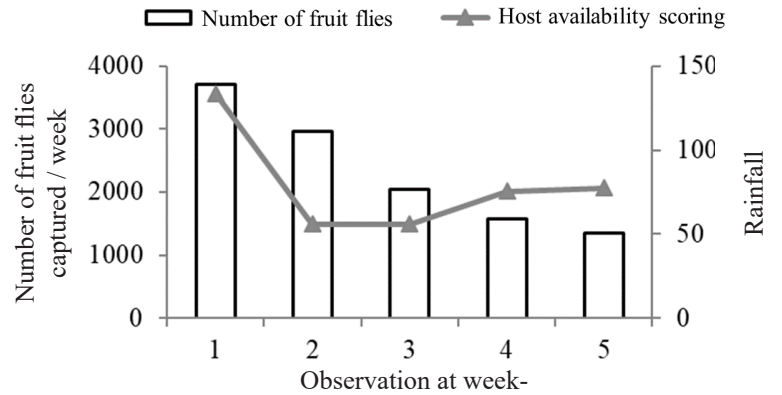

Figure 5. The effect of rainfall on the number of fruit flies captured

The Effect of Number of Rainy Days

The result of the regression analysis shows the negative correlation between the number of rainy days and the number of fruit flies captured in the field and it does not have a significant effect. This is proven in the regression equation of Y= 9228,000 – 1113,00x; R^2 = 0.886; p = 0,17. The presence of a negative correlation means that any increase in the number of rainy days in the field will be followed by a decrease in the number of fruit flies captured and vice versa. This is supported by Boopathi et al. (2013) who stated that climatic factors such as rainfall and rainy days had no effect on the population of fruit flies in the chili cultivation field. Besides, Susanto et al (2018) reported that the number of rainy days had no effect on the number of fruit flies captured in a mango cultivation field.

The observation in week 1 has the lowest number of rainy days with the highest number of fruit flies captured, and during the observation in weeks 4 and 5 the number of rainy days increased followed by a decrease in the number of fruit flies captured (Figure 6). Hasyim et al. (2008) explained that the development and the activity of fruit flies were influenced by the number of rainy days. The percentage of successful formation of the pupa into adult imago in fruit flies can decrease if the number of rainy days and the amount of rainfall are too high. These can reduce the mobility of fruit flies in the field for foraging and laying eggs, and also inhibit the formation of pupa so that the fruit fly population in the field becomes small (Susanto, 2010).

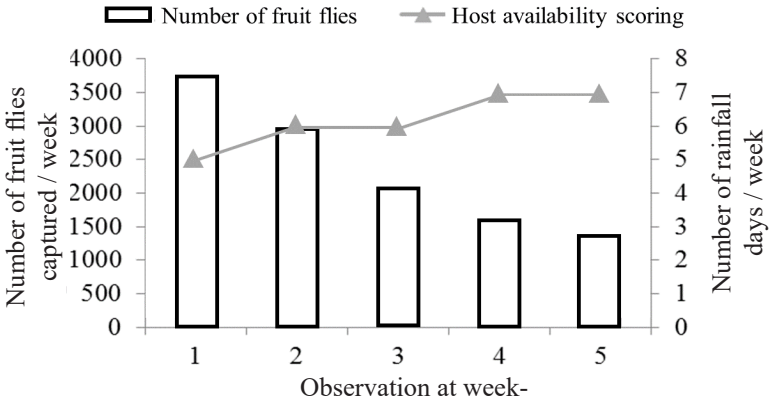

Figure 6. The effect of rainfall on the number of fruit flies captured

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