The Diversity of Fruit Fly (Diptera: Tephritidae) on Combination of Attractant and Different Trap Height in Cucumber Field (Cucumis sativus L.)

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Abstract: The main pest in the Cucurbitaceae family is the fruit fly. The common effort to control fruit flies is using a trap with methyl eugenol (ME) and cue lure (CUE) as an insect attractant. The trap height installation is also affecting the fruit fly population. The fruit fly population in the field has an important effect on the damage intensity in the commodity. This research objective was to study the distribution and diversity of fruit fly on the cucumber field with trap height installation and attractant combination. The used research method was Factorial Group Randomized Design (RAKF). The first factor was attractant combination of Metil Eugenol (ME) and Cue Lure (CUE) consisted of 6 treatment levels were K1: 5 mL ME, K2: 5 mL ME + 1 mL CUE, K3: 5 mL ME + 3 mL CUE, K4: 5 mL ME + 5 mL CUE, K5: 5 mL ME + 7 mL CUE and K6: 5 mL CUE. While the second factor was the high tramp installation consisted of 3 treatment levels were T1: 50 cm, T2: 100 cm, and T3: 150 cm. The treatment consisted of 3 replication on three different cucumber fields. The result showed discovered fruit fly species were eight species, B. dorsalis (Hendel), B. carambolae Drew & Hancock, B. occimitilis (Bezzi), Z. caudata (Fabricius), B. umbrosa (Fabricius), B. neocognata Drew & Hancock, Z. cucurbitae (Fabricius) and B. albistrigata (de mejiere). The dominant fruit fly in each treatment in fruit fly fields was B. dorsalis (Hendel). The best treatment in trapping fruit fly was K1 (5 mL ME) with trap height installation T1 (50 cm). The diversity and species richness of fruit fly in the cucumber field was considered low and uneven.

1. Introduction

Cucumber (Cucumis sativus L.) is an annual vegetable from the pumpkin family or Cucurbitaceae widely consumed fresh and has good nutritional value as a source of minerals and vitamins [1]. Cucumber production in Indonesia fluctuated each year, from 2014 to 2018 respectively was 477,976 tons, 447,677 tons, 430,201 tons, 429,917 tons, and 433,923 tons [2]. One of the obstacles to increasing production is the presence of pests and diseases [3]. The main pests of the Cucurbitaceae family are fruit flies [4]. Fruit flies are common on various types of cultivated plants, especially fruits. This group of insects becomes important
pests on fruits and vegetables [5]. It is reported that there are 4000 fruit flies species in the world and 35% of them are important pests of fruit, including commercial fruits with high economic value [6]. The fruit fly species Bactrocera cucurbitae is a fruit fly whose main hosts are from the Cucurbitaceae family includes watermelon and cucumber [7]. The study results of [8] showed that the percentage of fruit fly attacks on cucumber plants was 8%.

The distribution of fruit flies is very wide in Indonesia. There are 89 species of fruit flies classified as local species (indigenous) in western Indonesia. There only eight species are important pests, Bactrocera albistrigata (Meijere), Bactrocera dorsalis (Hendel), Bactrocera carambolae Drew and Hancock, Bactrocera papayae Drew and Hancock, Bactrocera umbrosa (Fabricius), Bactrocera caudata (Fabricius), Bactrocera tasu (Walker), Bactrocera cucurbitae (Conquillet), and Dacus (Callantra) longicornis (Wiedemann) [9]. The distribution and diversity of fruit fly species in an area influenced by climatic factors and food availability [10]. The fruit fly attack intensity increases on fruits and vegetables in a cool climate, with high humidity and less wind [11]. A suitable climate will increase the ability of fruit flies to attack the cultivated plants [12]. This is closely related to the nature of fruit flies, namely ectotherms. Ectotherms are animals whose body temperature depends on the temperature of their surroundings. Fruit fly attacks in the dry season ranged from 12-20% and in the rainy season reach 100% [13].

The most widely used and successful fruit fly control effort is control using attractant traps [14]. Types of attractants that common to catch fruit fly insects are methyl eugenol and cue lure. Certain aromas of compounds such as methyl eugenol and cue lure can attract male Tephritidae fruit flies [15]. Fruit flies Bactrocera dorsalis, B. muse, and B. umbrosus species are highly attracted to Methyl Eugenol (ME) while male fruit flies Bactrocera cucurbitace and B. trivialis are attracted to Cue Lure (CUE) [16]. The combination of the two types of attractants will be more effective in controlling fruit fly pests.

In addition to the type, the height of the trap also affects the insect pest population which in turn will affect the damage to the fruit. The height of the trap affects the attraction of the trapped fruit fly [17]. The results of the study [18] showed that the trap height of 100 cm gave the highest number of trapped fruit flies and the least reduction in production although the intensity of the attack was the same as the 50 cm trap height treatment.

Research of fruit flies on cucumber plants using a combination of 2 types of attractants, methyl eugenol and cue lure at different trap heights was carried out to determine the diversity of fruit flies. The result of this research can be used for insect collection purposes or for controlling fruit flies in cucumber plants.

2. Material and Methods

This research was conducted in December 2020 – April 2021 in Balunijuk Village, Merawang District. Identification of fruit fly specimens was carried out at the Laboratory of Agrotechnology, Faculty of Agriculture, Fisheries and Biology, University of Bangka Belitung. The tools used in the study were plastic scissors, knives, stationery, cameras, microscopes, ropes, brushes, injections, pinning blocks, ovens, insect needles, traps, thermometers, hygrometers, and lux meters. The materials used were methyl eugenol, cue lure, insecticide (deltamethrin 25 g/L), 70% alcohol. The research method used is the experimental method. The technique for determining the location of the study was carried out using the purposive sampling method with the criteria of land area 200-300 m², plant age 35-45 days, and plants already bearing fruit. The research design used was a factorial randomized block design. The first factor is a combination of attractant Methyl Eugenol (ME) and Cue Lure (CUE) which consists of 6 treatment levels, namely K1 : 5 mL ME, K2: 5 mL ME + 1 mL CUE, K3: 5 mL ME + 3 mL CUE, K4 : 5 mL ME + 5 mL CUE, K5: 5 mL ME + 7 mL CUE and K6 : 5 mL CUE. The second factor was the height of the attractant trap which consisted of 3 treatment levels, namely T1: 50 cm, T2: 100 cm, and T3: 150 cm. The treatment consisted of 3 replications on three different cucumber plants.
3. Result and Discussion

Fruit flies collected from three cucumber fields locations using trap with attractants combination and different heights installation were identified and found 732 specimens of fruit flies and 1,106 specimens of Ankylopteryx c.f. anomala (Brauer). The total number of specimens obtained was 1,838 specimens. Treatment K1 (5 mL ME) traps 581 specimens, K2 (5 mL ME + 1 ml CUE) traps 316 specimens, K3 (5 mL ME + 3 mL CUE) traps 361 specimens, K4 (5 mL ME + 5 mL CUE) traps 281 specimens, K5 (5 mL ME + 7 mL CUE) trapping 262 specimens and K6 (5 mL CUE) trapping 37 specimens (Table 1). The 732 identified fruit fly species consisted of 8 species, namely B. dorsalis (Hendel), B. carambolae Drew & Hancock, B. occipitalis (Bezzi), Z. caudata (Fabricius), B. umbrosa (Fabricius), and B. neocognata Drew & Hancock, Z. cucurbitae (Fabricius) and B. albistrigata (de meijere). Other insects that also collected in the trap were 1,106 specimens of Ankylopteryx c.f. anomala (Brauer). Ankylopteryx c.f. anomala (Brauer) might be attracted to ME because ME content is found in flowers of various types of plants [19]. This showed by the large percentage of Ankylopteryx c.f. anomala (Brauer) was 60% of the total specimens found and mostly in treatment K1 (5 mL ME) 282 specimens (Table 1).

Table 1. Number of trapped fruit flies on each Attractant combination treatment in cucumber field

| No | Fruit Fly Species                  | Number | %  | Attractant Combination Treatment |
|----|-----------------------------------|--------|----|---------------------------------|
| 1  | B. dorsalis (Hendel)              | 330    | 18 | K1                              |
| 2  | B. carambolae Drew & Hancock      | 30     | 2  | K1                              |
| 3  | B. occipitalis (Bezzi)            | 44     | 2  | K1                              |
| 4  | B. umbrosa (Fabricius)            | 59     | 3  | K1                              |
| 5  | B. neocognata Drew & Hancock      | 185    | 10 | K1                              |
| 6  | Z. caudata (Fabricius)            | 16     | 1  | K1                              |
| 7  | Z. cucurbitae (Fabricius)         | 64     | 3  | K1                              |
| 8  | B. albistrigata (de meijere)      | 4      | 1  | K1                              |
| 9  | Ankylopteryx c.f. anomala (Brauer)| 1,106  | 60 | K1                              |

Total Individuals: 1.838

Notes: Genus B: Bactrocera; Z: Zeugodacus, Attractant combination K1: (5 mL ME); K2: (5 mL ME + 1 ml CUE); K3: (5 mL ME + 3 mL CUE); K4: (5 mL ME + 5 mL CUE); K5 (5 mL ME + 7 mL CUE) K6 (5 mL CUE) ME: Metyl eugenol; CUE: Cue Lure

Specimens trapped in the trap installed at 50 cm (T1) height were 783 specimens, 100 cm (T2) height was 605 specimens, and 150 cm (T3) height traps 450 specimens. The fruit fly species trapped at a height of 50 cm, 100 cm and 150 cm were B. dorsalis (Hendel), B. carambolae Drew & Hancock, B. occipitalis (Bezzi), Z. caudata (Fabricius), B. umbrosa (Fabricius), and B. neocognata Drew & Hancock, Z. cucurbitae (Fabricius) and B. albistrigata (de meijere) (Table 2).

Table 2. Number of individual trapped at a traps installled with different height in cucumber fields

| No | Species                          | Number | %  | Trap Height Installation |
|----|----------------------------------|--------|----|--------------------------|
| 1  | B. dorsalis (Hendel)             | 330    | 18 | T1 | 197 | 94  | 39  |
| 2  | B. carambolae Drew & Hancock     | 30     | 2  | T1 | 12  | 16  | 2   |
| 3  | B. occipitalis (Bezzi)           | 44     | 2  | T1 | 17  | 18  | 9   |
| 4  | B. umbrosa (Fabricius)           | 59     | 3  | T1 | 23  | 20  | 16  |
| 5  | B. neocognata Drew & Hancock     | 169    | 10 | T1 | 109 | 46  | 30  |
| 6  | Z. caudata (Fabricius)           | 16     | 1  | T1 | 9   | 4   | 3   |
| 7  | Z. cucurbitae (Fabricius)        | 64     | 3  | T1 | 45  | 12  | 7   |
| 8  | B. albistrigata (de meijere)     | 4      | 1  | T1 | 2   | 1   | 1   |
| 9  | Ankylopteryx c.f. anomala (Brauer)| 1,106  | 60 | T1 | 369 | 394 | 343 |

Individual Total: 1.838

Notes: Genus B: Bactrocera; Z: Zeugodacus, Trap Height: T1: 50 cm; T2: 100 cm; T3: 150 cm
The results of analysis of variance showed that the combination of attractants had a significant effect on all variables and trap height had a significant effect on the abundance of fruit fly and pest fruit fly abundance variables except for the abundance of Ankylopteryx c.f. anomala (Brauer). Meanwhile, the interaction was not significant between the combination of attractants and the height of the trap installation for all variables (Table 3).

Table 3. Analysis of variance of attractant combination and different trap height installation

| Variables               | Attractant Combination | Trap Height | Interaction | KK**       |
|------------------------|------------------------|-------------|-------------|------------|
|                        | Pr > F                 | Pr > F      | Pr > F      |            |
| Fruit Fly abundance    | 0.0001**               | 0.0004**    | 0.2546**    | 86.6792    |
| Pest fruit fly abundance| 0.0001**               | 0.0072**    | 0.1644**    | 111.9067   |
| Ankylopteryx c.f anomala (Brauer) Abundance | 0.0001** | 0.6315** | 0.7041** | 42.9965 |

Notes : KK : Coefision of variance, *: Significantly different by 95% trust level,**: Significantly different by 99% trust level, tn : Not significant , KK** : result of data transformation with Log (x+1) are not different with the original data

The results of the Duncan Multiple Range Test (DMRT) tests showed that the combination of attractant K1 (5 mL ME) was the best combination of attractants that trapped more individuals and was significantly different compared to other attractant combinations (Table 4). The best treatment of attractants combination that traps the most individuals was treatment K1 (5 mL ME) with a total number of trapped specimens was 581 specimens. While the combination of attractants that traps the least was K6 (5 mL CUE) with 37 trapped specimens (Table 4). The difference of trapped fruit flies was influence by the type of attractant used. This is following [20] states that methyl eugenol is a volatile substance or evaporates and releases a fragrant aroma so that this substance is a food lure or required by male fruit flies for consumption. Insects use several chemical cues and visual cues to find habitats and select host plants [21], fruit flies are no exception [22]. The correspondence between visual and chemical cues determines the attraction of fruit flies to their hosts. Adult fruit flies use visual and olfactory stimuli for their ability to search for hosts [23]. Methyl eugenol (ME) is the attractant that strongly attracts male fruit flies because the nature of this attractant is similar to the distinctive fragrance released by female fruit flies in its mating period to attract male fruit flies [24], [23], a luring agent containing a single component (male lures) called parapheromone is only effective at attracting male fruit flies. This parapheromone has the same properties as the methyl eugenol compound which only attracts male insects. While CUE is not a natural product but is the result of rapid hydrolysis in many plant parts including species from Rosaceae (rose-rose family), Asteraceae (kenikir tribe), and Lamiaceae (mint tribe), CUE can be found in orchids [25]. Based on the identification results, the fruit fly species attracted to the Methyl Eugenol (ME) attractant trap were B. dorsalis (Hendel), B. carambolae Drew & Hancock, B. occipitalis (Bezzi), and B. umbrosa (Fabricius). B. neocognata Drew & Hancock, Z. cucurbitae (Fabricius), and B. albistrigata (de meijere) were attracted to Cue Lure (CUE) attractants (Table 5). Vargas et al. (2010), CUE is a more effective attractant to attract Z. cucurbitae. Many of the male tephritid species are highly attracted to certain compounds that occur naturally in plants (ME) or are synthetic analogs of plant-stored substances (CUE). Based on the results of the study found B. neocognata species in ME attractant traps. This was probably due to the mixed of ME and CUE so that B. neocognata entered the ME trap (K1).
Table 4. Duncan’s Multiple Range Test (DMRT) test Result of Attractant Combination towards fruit fly, fruit fly pest and *Ankylopteryx c.f. anomala* (Brauer) abundance

| Factor | Fruit Fly abundance | Fruit fly pest abundance | Ankylopteryx c.f. anomala (Brauer) abundance |
|--------|---------------------|--------------------------|---------------------------------------------|
| K1     | 33.222a             | 31,444a                  | 31.333a                                     |
| K2     | 15.667b             | 11,333b                  | 24.667ab                                    |
| K3     | 10.556b             | 8,000b                   | 24.444ab                                    |
| K4     | 10.444b             | 5,889b                   | 21.667b                                     |
| K5     | 7.444b              | 3,667b                   | 20.667b                                     |
| K6     | 4.000b              | 0.444b                   | 0.111c                                      |

Notes: Number that followed by the same letter in the same column show not significant at DMRT test with $\alpha = 0.05$

Fruit flies trapped at 50 cm, 100 cm, and 150 cm height in the DMRT test results performed in the T1 treatment (50 cm height) on the variables of fruit fly abundance and pest fruit fly abundance giving more trapped fruit flies compared to 100 cm height and 150 cm. Meanwhile, all trap height treatments gave the best results for the abundance variables of *Ankylopteryx c.f. anomala* (Brauer) and not significantly different from the other trap heights. The higher the trap installation, the less number of fruit flies obtained (Table 5). The best trap height treatment which traps the most specimens was T1 (50 cm) with 783 specimens trapped, followed by T2 (100 cm) with 605 specimens and T3 (150 cm) with 450 (Table 6). It shows that the higher the trap installation, the smaller the number of specimens obtained. It presumes that more fruit flies are fly around the ground because there are many sources of food needed by male fruit flies. In addition, the fruit flies adults on the ground or those that fall with the fruit from the stem will be closer to the traps installed at 50 cm height. This is consistent with [26], male fruit flies will mostly be near the ground because there are many food sources. [27] added that the height of the trap also affects the insect pest population. This is because the stems are moderately low and the branches tend to bend down when the fruit is ripe. Generally, cucumber plants grow up to 50-250 cm with twigs that tend to bend down when the fruit is ripe. This affects the foraging activity of fruit flies. Fruit flies will fly close to their food source. So that there are fewer fruit flies in traps installed at above 100 cm height. The longest distance between the trap and the canopy, the fewer the number of trapped flies [18].

Table 5. Duncan’s Multiple Range Test (DMRT) test Result of high trap installation towards fruit fly, pest fruit fly and *Ankylopteryx c.f. anomala* (Brauer) abundance

| Factor | Fruit Fly abundance | Fruit fly pest abundance | Ankylopteryx c.f. anomala (Brauer) abundance |
|--------|---------------------|--------------------------|---------------------------------------------|
| T1     | 23.000a             | 16,944a                  | 21.889a                                     |
| T2     | 11.722b             | 9,167b                   | 20.500a                                     |
| T3     | 5.944b              | 4,278b                   | 19.056a                                     |

Notes: Number that followed by the same letter in the same column show not significant at DMRT test with $\alpha = 0.05$

Table 6 shows that the diversity index of all treatments was low. It was caused by *B. dorsalis* (Hendel) dominates the field. [28], a community is said to have a high species diversity index value if the community is composed of many species with the same or similar species abundance, besides if the diversity is low, the community is dominated by one species. The dominance of the fruit fly *B. dorsalis* (Hendel) also caused the species richness index considered as low was ($< 3$). The high and low species richness was influence by the large number of species found. [29], species richness describes the species in a community. The species evenness index was also low. The lower evenness of the species, the uneven distribution of the species. The higher the evenness value of species indicates that the number of individuals of each species is more even or uniform [30]. High host diversity strongly affects species diversity, individual abundance, and
distribution of fruit flies in an area, while this study was conducted on cucumber plantations whose homogeneous habitat generally consisting of hosts with limited species, causing the limitations of fruit fly species found in the area. [31] confirmed, the plants cultivate deliberately in high numbers affecting fruit fly species abundance that become pests of these plants.

**Table 6.** Diversity index, richness index and eveness index of fruit flies in combination of attractant and different trap height installation.

| No | Treatment | Diversity Index (H') | Richness Index (Dmg) | Eveness Index (E) |
|----|-----------|----------------------|----------------------|------------------|
| 1  | KIT1      | 1.19*R               | 0.62*R               | 0.66*S           |
| 2  | KIT2      | 1.33*R               | 0.66*R               | 0.74*T           |
| 3  | KIT3      | 0.91*R               | 0.45*R               | 0.56*S           |
| 4  | K2T1      | 1.11*R               | 0.53*R               | 0.53*S           |
| 5  | K2T2      | 0.91*R               | 0.43*R               | 0.47*S           |
| 6  | K2T3      | 0.98*R               | 0.45*R               | 0.50*S           |
| 7  | K3T1      | 1.44*R               | 0.66*R               | 0.66*S           |
| 8  | K3T2      | 1.27*R               | 0.56*R               | 0.61*S           |
| 9  | K3T3      | 1.01*R               | 0.49*R               | 0.57*S           |
| 10 | K4T1      | 1.43*R               | 0.73*R               | 0.79*T           |
| 11 | K4T2      | 0.66*R               | 0.27*R               | 0.33*S           |
| 12 | K4T3      | 0.52*R               | 0.22*R               | 0.32*S           |
| 13 | K5T1      | 1.25*R               | 0.60*R               | 0.64*S           |
| 14 | K5T2      | 0.60*R               | 0.29*R               | 0.44*S           |
| 15 | K5T3      | 0.64*R               | 0.28*R               | 0.36*S           |
| 16 | K6T1      | 0.38*R               | 0.18*R               | 0.35*S           |
| 17 | K6T2      | 0.60*R               | 0.31*R               | 0.55*S           |
| 18 | K6T3      | 0.50*R               | 0.32*R               | 0.72*T           |

Notes: -R : The lowest value, Category low; +R : The highest value, category Low; +S : The highest value, Category medium; +T : The highest value, Category high

4. Conclusion

There were 8 species of fruit fly, namely B. dorsalis (Hendel), B. carambolae Drew & Hancock, B. occipitalis (Bezzi), Z. caudata (Fabricius), B. umbrosa (Fabricius), and B. neocognata Drew & Hancock, Z. cucurbitae (Fabricius) and B. albistrigata (de meijere). The dominant fruit fly in each treatment in cucumber plantations was B. dorsalis (Hendel). The best treatment combination for trapping fruit flies was K1 (5 mL ME) with a trap height of T1 (50 cm). The use of an attractant with a composition of 5 mL ME with a trap height of 50 cm recommend to control fruit flies in cucumber plantations because it can trap more fruit flies.

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