The fluctuation of fruit fly attack (Bactrocera spp.) in a polycultural system of chili and watermelon crops

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Abstract. The fruit fly (Bactrocera spp.) is a serious threat of developing chili and watermelons in Indonesia. Chili growers rely mainly on synthetic insecticide use to control the pest. Excessive use of the insecticides could cause resistance in the pest, environmental issues, and health issues to the consumers. Thus, alternative control methods should be developed, such as a polyculture cropping system. The study was conducted in Rompegading Village, Cenrana District, Maros Regency, from August to October 2018. The purpose of the study was to evaluate a polycultural cropping system, using 2 plant species: chili plant and watermelon as the main and secondary crops. Five schemes of cropping model were tested in this study, namely: (a) chili without mulch, (b) chili with plastic mulch, (c) chili and watermelon, (d) watermelon only, and (e) chili with farmers’ cultivation practice. The percentage of fruit fly attack on the chili and watermelon fruit were calculated. The results showed that the chili with plastic mulch treatment had 90.1%, pepper and watermelon treatment had 93.03%, and farmers’ practices treatment had 83.3% of the fruits damaged by the fruit fly. While the percentage of watermelon damaged by fruit flies was the highest in the treatment of chili and watermelon (50.00%).

1. Introduction

Globalization in trade of fresh fruits and vegetables makes the country must pay attention to plant health from attack of fruit flies. There have been many cases of refusal to export fresh fruit and vegetable commodities from an importing country due to symptoms of fruit flies attacks [1]. Red chili, Capsicum annuum L. is one of the most strategic horticultural commodities in Indonesia. Red chili consumption data by the Indonesian people is 2.93 kg/capita/year. This amount of consumption will increase 10-20% when entering religious holidays or party events [2]. Chili production in South Sulawesi Province in 2017 amounted to 78,058 tons and a decline production in 2018 amounted to 63,513 tons [3]. Efforts to increase chili production can be done in various ways. The practice of chili cultivation is always faced with various attacks by plant pest organisms.

Fruit flies are pests that are most often the complaints of farmers. These pests can cause serious crop losses for chili farmers in Indonesia. Fruit fly pests can also damage other plants such as melons, which can cause losses up to 100% [4]. Fruit flies include pests which caused huge losses to agriculture in Indonesia, especially farmers of fruit and vegetables. The extent of its attacks in Indonesia reached 4,790 ha with losses reaching 21.99 billion rupiahs [5]. Melon fruit Bactrocera curcurbitae (Diptera; Tephritidae) is one of the main causes of tropical fruit which suffers considerable damage especially in the Cucurbitaceae family with varied yield losses of 30% -100% [6, 7]. All this
time, control of pests and diseases is still based on the use of synthetic pesticides. But it is realized that besides the results are unsatisfactory and the price is expensive, the use of synthetic pesticides continuously can lead to pest resistance, damage the environment and is harmful to consumers. Therefore control of plant pest organisms is expected to be environmentally so that balance occurs in nature, including the polyculture planting system.

Polycultural system that combines various types of plants that are planted together in the same place. This is in line with the opinion Tilman et al.; Balvanera et al.; Cadotte et al.; Cardinale et al.; and Denise et al. [8-12] which suggested that increasing plant diversity in deliberately managed ecosystems can improve various ecosystem performance simultaneously. This aims to reduce pest populations in crops. According to Falcao et al.; Khaeruddin [13, 14], little abundance at a time when species diversity is high then a species cannot become dominant as well as when diversity is low, a species can become dominant. Based on this, it is necessary to study the fluctuation of fruit fly attacks on chili and watermelon intercropping

2. Methodology
The study was conducted in Rompegading Village, Cenrana District, Maros Regency, from August to October 2018. There are two types of plants combined, namely chili plants as main plant and watermelon. Chili and watermelons are planted together in a trial plot. Before being planted, chilies are seeded for thirty days and watermelons ten days in the hope of growing plants when they are transplanting uniformly.

The treatment is as follows: P1 = chili plants without plastic mulch; P2 = Watermelon plants; P3 = chili plant + watermelon; P4 = chili plant + plastic mulch; and P5 = Farmer treatment (control) using plastic mulch and pesticides. Each treatment was repeated three times so that there were 15 experimental units. Each trial plot is made in the form of a bed as is the case in the cultivation of chili as usual, the size of beds made width 1.1 x 5 m. Each treatment is made of four beds with a distance between 0.5 m beds. The distance between treatments on a 5 m experimental field, while for observations on farmland taken from the nearest location and planting together with experimental land. Chili is planted in beds using a spacing of 0.5 mx 0.6 m with a plant population of 20 trees/beds so that each treatment of the population of chili plants is 80 trees. Watermelon plants are planted at each end of the beds with a distance of 0.5 mx 5 m so that the population of watermelon plants is 16 trees/treatment. Plant maintenance does not use synthetic pesticides.

Sampling of 2 chili plants and 2 watermelons per bed. The following is a pattern of planting monoculture chili and polyculture chili and how to take plant samples can be seen in figure 1 and 2.

![Figure 1](image-url). Cropping patterns of monoculture chili and sampling methods
Observation of fruit fly attacks begins when chili begins to form fruit. Observations were carried out every seven days after the appearance of the first fruit, then observed eight times by observing all the plants in each replication (8 chili plants 8 watermelons). Healthy chili fruit, which is attacked by fruit flies calculated every time of observation. Percentage of fruits attacked by fruit flies is determined using the following equation:

\[
\text{Percentage of fruit attacked} = \frac{\text{number of fruits attacked per plant}}{\text{total number of fruits per plant}} \times 100\%
\]

Data about the percentage of fruits attacked per plant were analyzed by Randomized Group Design using the Microsoft Excel program.

3. Results and discussion

The average percentage of chili fruit attacked by fruit flies can be seen in table 1.

| Plant Age (DAP) | Percentage of chili fruits attacked /plant | Chili with farmers cultivation practice |
|-----------------|------------------------------------------|----------------------------------------|
|                 | Chili without mulch | Chili with plastic mulch | Chili and watermelon |                             |
| 30              | 0.00 a               | 13.08 b                      | 12.64 b               | 6.73 b                      |
| 37              | 0.00 a               | 9.79 b                       | 9.41 b                | 0.00 a                      |
| 44              | 0.00 a               | 9.05 b                       | 12.88 b               | 21.01 c                     |
| 51              | 0.00 a               | 17.10 b                      | 30.38 c               | 23.75 b                     |
| 58              | 16.40 a              | 32.53 b                      | 47.42 c               | 26.29 b                     |
| 65              | 56.31                | 52.58                        | 30.71                 | 36.96                       |
| 72              | 68.53                | 51.68                        | 44.48                 | 68.36                       |
| 79              | 51.76 a              | 54.01 a                      | 49.22 a               | 76.53 b                     |
| 86              | 64.18                | 90.10                        | 93.03                 | 83.33                       |
| 93              | 67.46 a              | 84.77 b                      | 80.34 b               | 54.56 b                     |

Note: The average number followed by the same letter on the same line is not significantly different from the LSD test with a level of 0.05
In table 1, it can be seen that the percentage of chili fruit attacked by fruit flies at the 1st observation on 30 days after planting (DAP) was highest on chili and watermelon treatment which was 13.08% and the lowest on chili treatment without mulch which was 0%. In the second observation (37 DAP), the highest percentage of attack was on the chili and watermelon and plastic mulch chili treatments which were 9.41% and 9.79%. The lowest was on the chili without mulch and the chili of farmer’s treatment (0%) At the third observation (44 DAP), the highest percentage of attack was on chili of farmers treatment (21.01%) and the lowest was on chili without mulch which is 0%. At the 4th observation (51 DAP), the highest percentage of attack was on chili and watermelon treatment, which was 30.38% and the lowest was on chili treatment without mulch was 0%. At the fifth observation (58 DAP) the highest percentage of attack was on chili and watermelon (47.42%) and the lowest was on chili without mulch (16.40%).

At the 6th observation (65 DAP) the highest percentage of attack was on chili without mulch (56.31%) and the lowest was on chili and watermelon (30.71%). At the 7th observation (72 DAP) the highest percentage of attack was on chili without mulch (68.53%) and chili treatment by farmers (68.36%). And the lowest was on chili and watermelon (44.48%). At the 8th observation (79 DAP) the highest percentage of attack was on chili treatment of farmers (76.53%) and the lowest was on watermelon chili (49.92%). At the 9th observation (86 DAP) the highest percentage of attack was on watermelon chili (93.03%) and the lowest was on chili treatment without mulch (64.18%). On the 10th observation (93 DAP) the highest percentage of attack was on plastic mulch chili (84.77%) and the lowest was on chili treatment by farmers (54.56%).

It can be seen on table 1 that the percentage of fruit fly attacks on chili fruit varies from the age of plants 30 to 93 days after planting. The highest attack was 90.10% on chili with plastic mulch, 93.03% for chili and watermelon, and 83.33% for chili by farmer’s treatment while the chili without mulch is 64.18%. This happens because chili without mulch has high evaporation so that the soil does not store enough water for the plant so that the cure is dwarfed. It is supported by the statement of Lumbanrja [15] that soil water content increased significantly by 2.09% g/g with the use of black silver plastic mulch. So that the attack of fruit flies is also reduced because the media laying the fruit fly eggs are less chili.

Fluctuations in fruit fly attacks on chili and watermelon plants increased from the age of plants 30 to 86 DAP, and there was a decrease in percentage of fruit fly attacks at 83 DAP. This happens because of abiotic (environmental) influence around the crop. In 2018 from August to November there was a significant increase in rainfall. Rainfall in August 1 mm, September 8 mm, October 116 mm, and November 184 mm [16]. So that affects the development of fruit flies. The observation process is carried out in the beginning of August until the beginning of October, where rainfall in August and September is very low compared to rainfall in October and November. The lack of environmental factors that can suppress the growth and development of fruit flies will cause a percentage of fruit fly attacks to increase from observations 1th (30 DAP) to observations 9th (86 DAP). At observation of 10th (93 DAP), there was a decrease in the percentage of attacks. This is affected because at the 10th observation, there was an increase in rainfall which was significant from September to October. This statement is supported by the results study of Ye and Liu's [17] that too high rainfall will cause high soil moisture so that it will have a negative impact on the appearance and appearance of fruit flies.

Environmental factors such as rainfall, there are other factors such as wind speed affecting the percentage of fruit fly attacks in the crop. The percentage of fruit flies attack both in each treatment were plastic mulch chili, chili and watermelon, farmer's chili treatment, chili without mulch, and high watermelon. Data from the Meteorology, Climatology and Geophysics Agency Class 1 Maros [16], there is an increase in wind speed from 3 knots in July to 4 knots in August to October. The difference is not so significant as rainfall data. Wind helps the process of migrating fruit flies from one plant to another. This statement is supported by Akshay and Shakunthala [18] that wind influences insect metabolism and small insects are affected by wind, insects can be carried away as far as possible by wind movements.
Another abiotic factor is temperature. Data from the Meteorology, Climatology and Geophysics Agency Class 1 Maros [16], temperatures in August to November are 27.2 °C, 27.9 °C, 28.1 °C, and 27.8 °C respectively, which are optimal temperatures for development of fruit flies in plants. According to results study from Ye and Liu [19] that fruit flies can live and develop at temperatures of 10-30°C, while optimal temperature for the development of fruit flies is 20-28°C. So that the development of fruit flies in the crop increases with the age of plants. Likewise the case with other climate factors such as humidity. The higher the temperature, the lower the humidity and the lower temperature, the higher humidity around the planting area. Low humidity will affect the amount of evaporation that occurs in the planting area so that very humid air causes a lack of evaporation. The average percentage of watermelon attacked by fruit flies can be seen in table 2.

### Table 2. Percentage of watermelon fruits attacked by fruit flies

| Plant age (DAP) | Number of fruits attacked/plant | Chili and watermelon | Watermelon only |
|-----------------|--------------------------------|----------------------|-----------------|
| 30              | 0.00                           | 0.00                 |                 |
| 37              | 3.03                           | 0.00                 |                 |
| 44              | 18.41                          | 1.00                 |                 |
| 51              | 38.89                          | 2.78                 |                 |
| 58              | 39.65                          | 2.78                 |                 |
| 65              | 50.00                          | 2.78                 |                 |

Note: The average number followed by the same letter on the same line is not significantly different from the LSD test with a level of 0.05.

At the 1st observation (30 DAP), all treatments for a percentage of watermelon attacked by fruit flies 0%. The second observation (37 DAP), chili and watermelon 3.03% and watermelon only 0%. The third observation (44 DAP) the highest percentage of attack was on chili and watermelon (18.41%), the lowest was on watermelon only (1%). The 4th observation (51 DAP) the highest percentage of attack was on chili and watermelon (38.8%) and the lowest was on watermelon only (2.78%).

At the 5th observation (58 DAP), the highest percentage of attack was on chili and watermelon (39.65%) and the lowest was on watermelon only (2.78%). At the 6th observation (65 DAP), the highest percentage of attack was on the treatment of chili and watermelon (50%) and the lowest was on watermelon only (2.78%).

In table 2, fruit flies attack at age of plants 30 DAP, treatment of chili and watermelon and treatment of monoculture watermelons is zero. This happens because it is difficult to see the beginning of symptoms of attack from fruit flies on watermelons. Because fruit fly ovipositor puncture marks, only in the form of spot stains. This statement was supported by Hasyim et al [20] that adult female fruit flies damage plants by inserting their eggs by sticking the ovipositor to healthy fruit tissue only as deep as 2-4 mm.

The high intensity of attacks on polyculture treatment compared to monoculture is thought to be due to the presence of chili plants intercropped with watermelons which are also the same host plants. If food is available with suitable quality and sufficient quantity, then the insect population will rise quickly. Conversely, if the food situation is lacking, the insect population will also decrease. According to the statement from Jumar [21], that food is a source of nutrition used by insects to live and develop.
4. Conclusion

The highest percentage of fruit fly attack on chili fruit was on chili with plastic mulch (90.10%), chili and a watermelon (93.03%), and in chili by farmers treatment (83.33%) which did not significantly influence between the three and significantly affected the treatment of chili without mulch is 64.18%. While the percentage of flies attack on watermelon is highest on chili and watermelon, which is 50.00% and on watermelon which is 2.78% at the age of plant 65 DAP.

References

[1] Suputa, Anik K and Cahyanianti 2006 Guidelines for Identification of Fruit Flies (Yogyakarta: Universitas Gadjah Mada)
[2] Leli N and Noviati 2015 Chili Outlook Center for Agricultural Data and Information Systems Secretariat General of the Ministry of Agriculture ISSN: 1907-1507
[3] Agriculture Department of South Sulawesi 2019 Development of chili production in 2009 – 2018 (Makassar)
[4] Dhillon M K, Singh R, Naresh J S and Sharma H C 2005 The Melon Fruit Fly Bactrocera cucurbitae: A Review of Biologi and Management J.Insect.Sci. 5 1-16
[5] Balitro 2008 Fruit Fly Traps (Malang: Balitro)
[6] Nath P and Bhusan S 2006 Evaluation of poison bait traps for trapping adult fruit fly Ann. Plant Prot. Sci. 14 297–299
[7] Avadhesh K R, Subrata S and Debi S M 2012 Role of abiotic factors on seasonal abundance and infestation of fruit fly bactrocera cucurbitae on bitter gound Journal Of Plant Protection Research (India: Universitas Hindu Banaras) 52
[8] Tilman D, Wedin D and Knops J M H 1996 Productivity and sustainability influenced by biodiversity in grassland ecosystems Nature 379 718–720.
[9] Balvanera P, Pfisterer A B, Buchmann N, He J S, Nakashizuka T, Raffaelli D and Schmid B 2006 Quantifying the evidence for biodiversity effects on ecosystem functioning and services Ecology Lett. 9 1146–1156
[10] Cadotte M W, Cardinale B J and Oakley T H 2008 Evolutionary history and the effect of biodiversity on plant productivity Proceedings of the National Academy of Sciences of the United States of America 105 (America: United States of America) p 17012–17017
[11] Cardinale B J, Duffy J E, Gonzalez A, Hooper D U, Perrings and Venail C 2012 Biodiversity loss and its impact on humanity Nature 486 59–67
[12] Denise M, Finney and Jason P K 2017 Functional diversity in cover crop polyculture increases multifunctionality of an agricultural system J. of App. Eco. 54 509–517
[13] Falcao R, Castellani M A, Ribeiro A, Perez-Maluf R, Moreira A A, Nagamoto N S and Nascimento A S 2012 Faunal analysis of the species Anastrepha in the fruit growing complex Gavião River, Bahia, Brazil Bull Insectol. 65 37-42
[14] Khaeruddin 2015 Identification of fruit flies (Diptera: Tephritidae) in several districts in the province of West Sulawesi Thesis (Bogor: Institut Pertanian Bogor)
[15] Lumbanraja P and Malau S 2018 Pengaruh pemakaian mulsa plastik hitam perak dan pupuk kandang terhadap perbaikan kadar air tanah, pertumbuhan dan produksi cabai merah (Capsicum annum) pada Ultisol Simalingkar J Ilmiah Pendidikan Tinggi (JURIDIKTI) 6 97-105
[16] Meteorology Climatology and Geophysics Agency Class 1 Maros 2019 Climate Data (Maros: BMKG)
[17] Ye H and Liu J 2007 Population dynamics of oriental fruit fly Bactrocera dorsalis (Diptera: Tephritidae) in Xishuangbanna,Yunnan Province, China Front. Agric. China 1 76-80
[18] Akshay K R and Shakunthala S 2016 Arthropod Diversity and Conservation in the Tropics and Sub-tropics (India: University of Agriculture Sciences Gandhi Krishi Vignana Kendra)

[19] Ye H and Liu J 2005 Population Dynamics of the oriental fruit fly, Bactrocera dorsalis (Diptera: Tephritidae) in the Kunming Area, South Western China Insect Sci. J. 15 387-392

[20] Hasyim A, Setiawati W and Liferdi L 2014 Pest Control Technology Fruit Flies in Chili Plants (Lembang: Vegetable Research Institute)

[21] Jumar 2000 Agriculture Entomology (Jakarta: PT Rineka Cipta)