Kelimpahan Lalat Buah (*Bactrocera spp.*) pada macam Klon Pohon Jeruk dI Kabupaten Sleman

The Abundance Of Fruit Flies (*Bactrocera* spp.) on Citrus Tree Clones in Sleman Regency

Salwa Ramadina Putri Utari[1*], Muamar Kadafi[2], Fahmi Dwilaksono[3,4], Ayu Purnamasari[5], Alfassabiq Khairi[6]

[1]Undergraduate Student, Department of Sustainable Agriculture, Faculty of Agricultural Science and Technology, Universitas Teknologi Sumbawa, Indonesia
[2]Department of Sustainable Agriculture, Faculty of Agricultural Science and Technology, Universitas Teknologi Sumbawa, Indonesia
[3]Department of Sustainable Agriculture, Faculty of Agricultural Science and Technology, Universitas Teknologi Sumbawa, Indonesia
[4]Doctoral Student, Department of Environmental Science and Technology, University of Maryland, College Park, United States
[5]Doctoral Student, Department of Plant Protection, Faculty of Agriculture Science, Erciyes Üniversitesi, Türkiye
[6]Department of Sustainable Agriculture, Faculty of Agricultural Science and Technology, Universitas Teknologi Sumbawa, Indonesia

[*] Coresponden Author: awasalwarmd02@gmail.com

Received: 03 Februari 2026; Accepted 01 Mei 2026; Published 01 Juni 2026

ABSTRACT

Fruit flies (*Bactrocera spp.*) are among the most serious pests in citrus production due to their high infestation potential and detrimental effects on fruit quality. This study examined fruit fly abundance based on sex and citrus tree clones and evaluated the impact of trap placement position on fruit fly populations in Sleman Regency, Indonesia. The experiment was conducted in August 2025 at Pusat Inovasi Agroteknologi, Universitas Gadjah Mada, employing a Completely Randomized Block Design with four trap placement treatments: medium inside, high inside, medium outside, and high outside. Medium and high trap heights were set at 1 m and 2 m above ground level, respectively, with traps positioned either inside or outside the tree canopy. Observations were performed at two-day intervals over 15 observation periods on three citrus species: Siamese orange (*Citrus nobilis* Lour.), kaffir lime (*Citrus hystrix*), and grapefruit (*Citrus maxima* (Burm.) Merr.). The results showed that fruit fly abundance was consistently higher in traps installed outside the tree canopy than in those placed inside across all citrus species and observation periods. No significant differences were detected between medium and high trap heights within the same placement location. Female fruit flies exhibited greater population variability than males, indicating higher sensitivity to environmental factors. Furthermore, correlation analysis revealed strong positive relationships among citrus clones, suggesting similar levels of susceptibility to fruit fly infestation. In conclusion, the findings highlight that trap placement location plays a more decisive role than trap height in influencing fruit fly abundance on citrus trees.
Keywords: Citrus trees, fruit fly attacks, pest management, plant pests, yellow sticky trap

ABSTRAK

Lalat buah (*Bactrocera* spp.) merupakan salah satu hama paling serius dalam produksi jeruk karena memiliki potensi infestasi yang tinggi serta berdampak merugikan terhadap kualitas buah. Penelitian ini bertujuan untuk mengkaji kelimpahan lalat buah berdasarkan jenis kelamin dan klon tanaman jeruk serta mengevaluasi pengaruh posisi pemasangan perangkap terhadap populasi lalat buah di Kabupaten Sleman, Indonesia. Percobaan telah dilaksanakan pada bulan Agustus 2025 di Pusat Inovasi Agroteknologi, Universitas Gadjah Mada, dengan menggunakan Rancangan Acak Kelompok Lengkap yang terdiri atas empat perlakuan posisi perangkap, yaitu dalam sedang, dalam tinggi, luar sedang, dan luar tinggi. Perangkap dipasang pada ketinggian sedang (1 m) dan tinggi (2 m) dari permukaan tanah, baik di dalam maupun di luar kanopi tanaman. Pengamatan dilakukan setiap dua hari dengan total 15 kali pengamatan pada tiga jenis jeruk, yaitu jeruk siam (*Citrus nobilis* Lour.), jeruk purut (*Citrus hystrix*), dan jeruk bali (*Citrus maxima* (Burm.) Merr.). Hasil penelitian menunjukkan bahwa kelimpahan lalat buah secara konsisten lebih tinggi pada perangkap yang dipasang di luar kanopi dibandingkan dengan yang dipasang di dalam kanopi pada semua jenis jeruk dan periode pengamatan. Tidak terdapat perbedaan yang nyata antara ketinggian perangkap sedang dan tinggi dalam lokasi pemasangan yang sama. Lalat buah betina menunjukkan variasi populasi yang lebih tinggi dibandingkan lalat buah jantan, yang mengindikasikan sensitivitas yang lebih besar terhadap faktor lingkungan. Selain itu, analisis korelasi menunjukkan adanya hubungan positif yang kuat antar klon jeruk, yang mengindikasikan tingkat kerentanan yang relatif serupa terhadap serangan lalat buah. Kesimpulannya, hasil penelitian ini menegaskan bahwa posisi pemasangan perangkap lebih berpengaruh dibandingkan ketinggian perangkap dalam menentukan kelimpahan lalat buah pada tanaman jeruk.

Kata kunci: Hama tanaman, pengendalian hama, perangkap lengket kuning, pohon jeruk, serangan lalat buah

Introcduction

Citrus is one of the horticultural crops with high economic value and promising development prospects in Indonesia. In addition to its relatively stable consumption level, the domestic market potential for citrus continues to grow. The projected demand for citrus fruits during the 2019–2020 period increased by 1.32% per capita per year, with Indonesian citrus production reaching 2,593,384 tons (Wicaksono et al., 2024). However, this increase in demand has not been fully matched by optimal productivity at the farm level.

One of the major factors contributing to low citrus productivity is pest and disease infestation, which can result in yield losses ranging from 50% to 90% (Rahmawati et al., 2024). Among the various pests attacking citrus plants, fruit flies are considered the primary pests that significantly reduce both fruit quality and production. In Indonesia, at least four species of fruit flies are known to infest citrus crops, namely *Bactrocera carambolae*, *Bactrocera papayae*, *Bactrocera dorsalis*, and *Bactrocera cucurbitae* (Meidi et al., 2022).

Fruit flies (*Bactrocera spp.*) belonging to the genus *Bactrocera* are known for their excellent flight capability, with dispersal distances reaching up to 2 km in search of food and host plants (Rahmawati et al., 2024). Fruit fly infestations can cause crop damage ranging from 40% to 80%, depending on location, season, and host availability (Rahmawati et al., 2024). The primary damage is caused by oviposition activity, in which female fruit flies puncture the fruit to lay eggs, allowing larvae to develop within the fruit tissue and resulting in decay and quality deterioration (Theron et al., 2023).

Globally, fruit flies (Diptera: Tephritidae) are among the most destructive phytophagous insect pests of fruits and vegetables, causing substantial losses in horticultural crops worldwide (Adhikari et al., 2022). Species within the genus *Bactrocera* have been reported to infest more than 173 species of fruits and vegetables (Jaleel et al., 2018), with some studies suggesting infestation of nearly 400 host plant species, including apples, guavas, mangoes, papayas, melons, and passion fruits (Rahmawati et al., 2024). Their polyphagous nature, high fecundity, and rapid dispersal ability make fruit flies particularly difficult to manage.

A recent survey in South China reported that the fourth generation of *Bactrocera dorsalis* caused the most severe damage in citrus orchards, influenced by host plant availability and winter temperature conditions (Li et al., 2024). This problem highlights that fruit fly population dynamics are strongly influenced by environmental factors and host plant availability, emphasizing the need for ecologically based pest management strategies. This study aimed to analyze the abundance of fruit flies on several citrus tree clones in Sleman Regency. Specifically, this research sought to (1) examine differences in fruit fly abundance based on sex (male and female) on citrus trees, (2) evaluate the effects of trap placement position on fruit fly populations, including placement location (inside and outside the canopy) and trap height.

Materials and Methods

Study site and plant material

This research was conducted in August 2025 at Pusat Inovasi Agroteknologi Universitas Gadjah Mada (PIAT UGM), located in Kalitirto Village, Berbah District, Sleman Regency, Yogyakarta Special Region, Indonesia. The planting site was characterized by a microclimate with an average air temperature of 28.50 ± 3.20°C, relative humidity of 78.50 ± 2.35%, sunlight intensity of 37,623.08 ± 1,812.93 lx, and wind speed of 2.34 ± 0.56 m s^{-1}.

Experimental design and treatments

This research was conducted using a Completely Randomized Block Design consisting of four treatments based on the placement of yellow sticky fruit fly traps on citrus trees: medium inside (T1), high inside (T2), medium outside (T3), and high outside (T4). Trap heights were adjusted to 1 m for the medium position and 2 m for the high position above ground level, with traps installed either within or outside the tree canopy. Each treatment was replicated five times, resulting in 20 experimental units. The experimental treatments were applied to three citrus species, namely Siamese orange (*Citrus nobilis* Lour.), kaffir lime (*Citrus hystrix*), and grapefruit (*Citrus maxima* (Burm.) Merr.).

Observation parameters

The observed parameters included the number of fruit flies based on sex (male and female) and citrus species (Siamese orange, kaffir lime, and grapefruit). Observations were conducted at two-day intervals for a total of 15 observation periods.

Statistical analysis

Observational data were analyzed using analysis of variance (ANOVA) at significance level 5%. When significant differences were detected, mean comparisons were performed using Duncan’s Multiple Range Test (DMRT) at the 5% level. Statistical analyses were conducted using SPSS software, while correlogram analyses were performed using Minitab.

Results and Discussion

Figure 1 presents a correlogram of male fruit fly infestation across three citrus tree clones, namely grapefruit, kaffir lime, and Siamese orange. The correlation analysis revealed strong positive relationships among the levels of male fruit fly attacks on all citrus clones, with correlation coefficients ranging from 0.89 to 0.92. The strongest correlation was observed between grapefruit and kaffir lime (r = 0.92), indicating highly similar infestation patterns of male fruit flies on these two citrus clones. Meanwhile, the correlations between Siamese orange and grapefruit and between kaffir lime and Siamese orange were both 0.89, also reflecting strong positive associations.

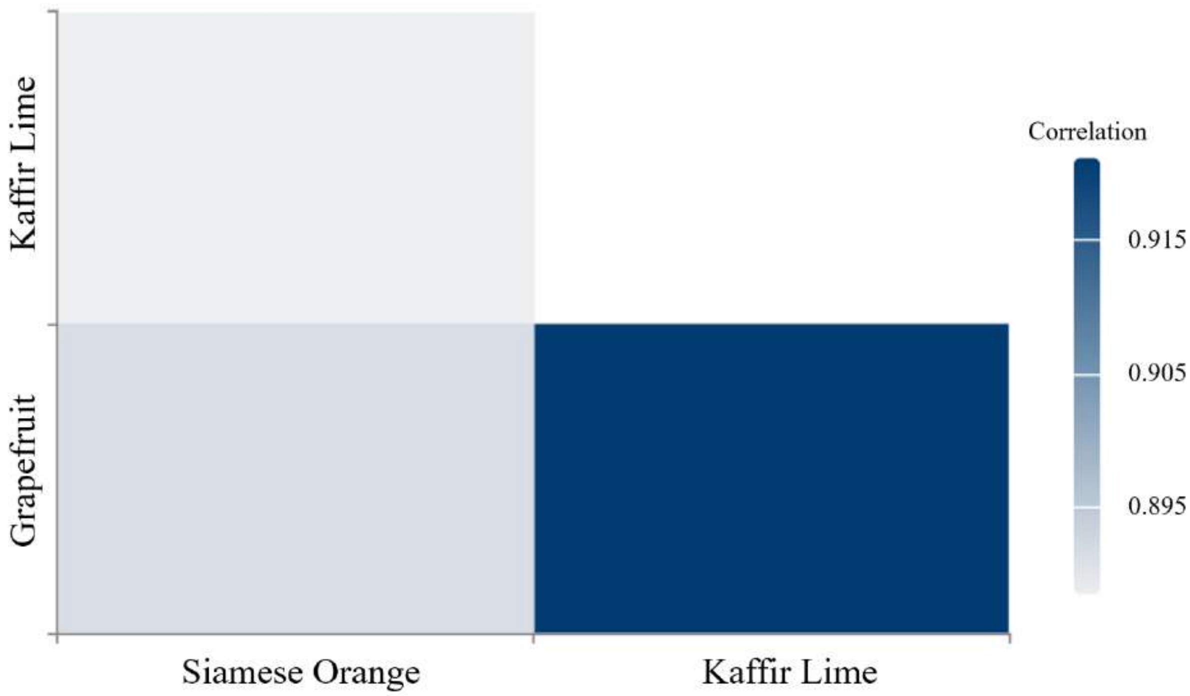

Figure 1. Correlogram of male fruit fly infestation on several citrus tree clones

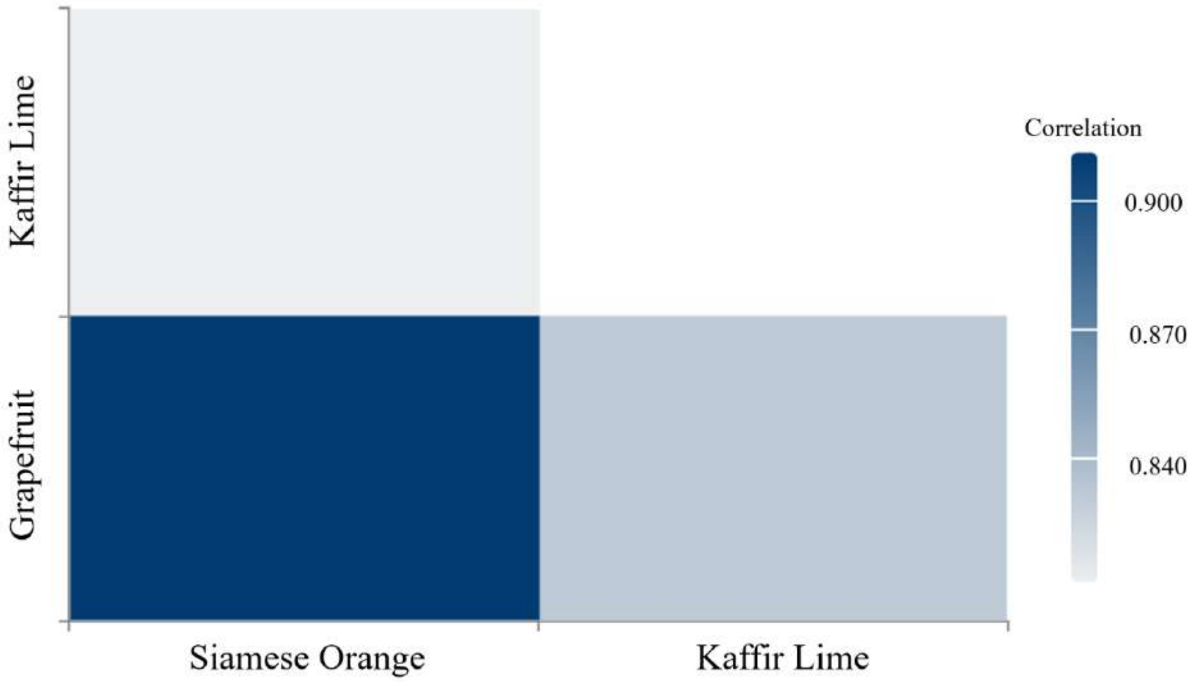

Figure 2. Correlogram of female fruit fly infestation on several citrus tree clones

The high positive correlations among citrus clones suggest that male fruit fly infestation levels tend to increase or decrease simultaneously across the three citrus types. This indicates that male fruit flies likely respond to similar host-related factors, such as volatile compound emissions, fruit morphological traits, or the presence of specific attractant compounds, which are relatively comparable among the clones. The highest correlation between grapefruit and kaffir lime (r = 0.92) implies a greater similarity in their attractiveness to male fruit flies compared with Siamese orange. However, the consistently strong correlations involving Siamese orange (r = 0.89) indicate that differences in susceptibility among the clones are relatively minor.

Figure 2 illustrates a correlogram of female fruit fly infestation among three citrus tree clones, namely grapefruit, Siamese orange, and kaffir lime. The correlation analysis revealed moderate to strong positive relationships in female fruit fly attack levels across the citrus clones, with correlation coefficients ranging from 0.81 to 0.91. The highest correlation was observed between Siamese orange and grapefruit (r = 0.91), indicating a strong similarity in female fruit fly infestation patterns between these two citrus clones. In contrast, the correlations between grapefruit and kaffir lime (r = 0.83) and between kaffir lime and Siamese orange (r = 0.81) were slightly lower, although they still reflect positive associations.

Table 1. Male fruit fly population on Siamese orange with different treatments

Observation Days	Treatments			
	Medium Inside	High Inside	Medium Outside	High Outside
1	12.20 ± 0.40 b	12.00 ± 0.00 b	13.60 ± 0.49 a	13.80 ± 0.40 a
2	12.00 ± 0.00 b	12.40 ± 0.49 b	14.00 ± 0.63 a	13.80 ± 0.40 a
3	12.20 ± 0.40 b	12.40 ± 0.49 b	14.20 ± 0.40 a	14.20 ± 0.40 a
4	12.00 ± 0.00 b	12.20 ± 0.40 b	13.80 ± 0.40 a	14.00 ± 0.00 a
5	12.00 ± 0.00 b	12.60 ± 0.49 b	14.20 ± 0.75 a	14.00 ± 0.00 a
6	12.00 ± 0.00 b	12.00 ± 0.00 b	14.20 ± 0.75 a	14.20 ± 0.40 a
7	12.20 ± 0.40 b	12.20 ± 0.40 b	14.20 ± 0.75 a	14.20 ± 0.40 a
8	12.40 ± 0.49 b	12.40 ± 0.49 b	14.40 ± 0.49 a	14.40 ± 0.49 a
9	12.40 ± 0.49 b	12.20 ± 0.40 b	14.20 ± 0.75 a	14.20 ± 0.40 a
10	12.40 ± 0.49 b	12.60 ± 0.49 b	14.20 ± 0.40 a	14.20 ± 0.40 a
11	12.40 ± 0.49 b	12.40 ± 0.49 b	14.40 ± 0.49 a	14.60 ± 0.49 a
12	12.40 ± 0.49 b	12.60 ± 0.49 b	14.60 ± 0.49 a	14.80 ± 0.40 a
13	12.40 ± 0.49 b	12.40 ± 0.49 b	14.40 ± 0.49 a	14.60 ± 0.49 a
14	12.60 ± 0.49 b	12.60 ± 0.49 b	14.60 ± 0.49 a	14.60 ± 0.49 a
15	12.60 ± 0.49 b	12.80 ± 0.40 b	14.80 ± 0.40 a	14.80 ± 0.40 a

Remarks: The numbers followed by the same letter in the same column do not have significant differences based on DMRT test 5%; mean ± standard deviation (n = 5)

The observed correlations suggest that female fruit fly infestation levels are generally aligned among citrus clones, but with a greater degree of variability compared to male fruit fly infestations. The strong correlation between Siamese orange and grapefruit (r = 0.91) implies that these two clones share similar traits influencing female host selection, such as oviposition preference, fruit texture, nutrient content, or the presence of oviposition-stimulating compounds. The comparatively lower correlations involving kaffir lime indicate that this clone may exhibit distinct characteristics affecting female fruit fly behavior, potentially related to differences in fruit peel thickness, secondary metabolites, or deterrent compounds that influence oviposition decisions. This suggests that female fruit flies may be more selective and responsive to subtle host-specific cues than males.

Table 1 presents the population dynamics of male fruit flies on Siamese orange under four different treatments over 15 observation days. Across all observation days, male fruit fly populations recorded under medium inside and high inside treatments were consistently lower, ranging from 12.00 to 12.80, indicating no significant differences between these two treatments. In contrast, both medium outside and high outside treatments resulted in significantly higher male fruit fly populations, with values ranging from 13.60 to 14.80, indicating significant differences compared to the inside treatments. Temporal observation revealed a gradual increase in male fruit fly populations across all treatments from day 1 to day 15. However, the magnitude of increase was more pronounced under the outside treatments, particularly during the later observation days (days 11–15), where population values reached their highest levels.

The higher populations recorded under outside treatments may be attributed to greater accessibility of attractants, higher exposure to environmental cues, or increased movement of male fruit flies in open areas. The lack of significant differences between medium and high intensities within each placement location indicates that increasing treatment intensity beyond a certain threshold may not provide additional control benefits.

Table 2. Female fruit fly population on Siamese orange with different treatments

Observation Days	Treatments			
	Medium Inside	High Inside	Medium Outside	High Outside
1	17.20 ± 0.40 b	17.20 ± 0.40 b	18.40 ± 0.49 a	18.00 ± 0.00 a
2	17.20 ± 0.40 b	17.20 ± 0.40 b	18.20 ± 0.40 a	18.40 ± 0.49 a
3	17.20 ± 0.40 c	17.40 ± 0.49 bc	19.00 ± 0.63 a	18.40 ± 0.49 ab
4	17.20 ± 0.40 b	17.20 ± 0.40 b	18.40 ± 0.49 a	18.40 ± 0.49 a
5	17.60 ± 0.49 ab	17.40 ± 0.49 b	18.60 ± 0.80 a	18.60 ± 0.49 a
6	17.40 ± 0.49 a	17.40 ± 0.49 a	18.20 ± 0.40 a	18.40 ± 0.49 a
7	17.20 ± 0.40 c	17.40 ± 0.49 bc	18.20 ± 0.40 ab	18.60 ± 0.49 a
8	17.40 ± 0.49 c	17.60 ± 0.49 bc	18.20 ± 0.40 ab	18.80 ± 0.75 a
9	17.60 ± 0.49 b	17.60 ± 0.49 b	18.20 ± 0.40 a	18.60 ± 0.49 a
10	17.40 ± 0.49 b	17.60 ± 0.49 ab	18.20 ± 0.40 ab	18.60 ± 0.49 a
11	17.40 ± 0.49 b	17.40 ± 0.49 b	18.40 ± 0.49 a	18.60 ± 0.49 a
12	17.40 ± 0.49 b	17.60 ± 0.49 b	18.60 ± 0.49 a	18.60 ± 0.49 a
13	17.60 ± 0.49 a	17.60 ± 0.49 a	18.60 ± 0.80 a	18.60 ± 0.49 a
14	17.80 ± 0.75 a	17.60 ± 0.49 a	19.00 ± 0.63 a	19.00 ± 0.63 a
15	17.80 ± 0.75 b	18.00 ± 0.63 b	19.00 ± 0.63 ab	19.40 ± 0.49 a

Remarks: The numbers followed by the same letter in the same column do not have significant differences based on DMRT test 5%; mean ± standard deviation (n = 5)

Table 2 shows the population dynamics of female fruit flies on Siamese orange under four different treatments, namely medium inside, high inside, medium outside, and high outside, observed over a 15-day period. Across all observation days, female fruit fly populations were consistently higher under outside treatments compared to inside treatments. Population values under medium inside and high inside treatments ranged from 17.20 to 18.00, whereas populations under medium outside and high outside treatments ranged from 18.20 to 19.40. On most observation days, outside treatments were significantly higher populations than inside treatments. The highest population was recorded on day 15 under the high outside treatment (19.40), followed closely by medium outside (19.00). In contrast, inside treatments showed lower and more stable population levels throughout the observation period.

The results demonstrate that trap placement location significantly influenced female fruit fly population levels on Siamese orange, with outside treatments consistently resulting in higher populations compared to inside treatments. This pattern suggests that female fruit flies are more active or more strongly attracted in external environments. Unlike the male population (Table 1), female fruit flies exhibited greater variability in population levels.

Table 3. Male fruit fly population on kaffir lime with different treatments

Observation Days	Treatments			
	Medium Inside	High Inside	Medium Outside	High Outside
1	7.00 ± 0.00 b	7.20 ± 0.40 b	8.00 ± 0.00 a	8.20 ± 0.40 a
2	7.00 ± 0.00 b	7.00 ± 0.00 b	8.20 ± 0.40 a	8.20 ± 0.40 a
3	7.20 ± 0.40 b	7.20 ± 0.40 b	8.20 ± 0.40 a	8.20 ± 0.40 a
4	7.20 ± 0.40 b	7.20 ± 0.40 b	8.00 ± 0.00 a	8.20 ± 0.40 a
5	7.40 ± 0.49 b	7.40 ± 0.49 b	8.20 ± 0.40 a	8.40 ± 0.49 a
6	7.40 ± 0.49 b	7.40 ± 0.49 b	8.20 ± 0.40 ab	8.60 ± 0.49 a
7	7.40 ± 0.49 b	7.60 ± 0.49 b	8.60 ± 0.49 a	8.60 ± 0.49 a
8	7.40 ± 0.49 b	7.60 ± 0.49 b	8.40 ± 0.49 a	8.40 ± 0.49 a
9	7.20 ± 0.40 b	7.40 ± 0.49 b	8.40 ± 0.49 a	8.60 ± 0.49 a
10	7.60 ± 0.49 b	7.80 ± 0.40 ab	8.60 ± 0.49 a	8.60 ± 0.49 a
11	7.80 ± 0.75 a	7.80 ± 0.75 a	8.60 ± 0.49 a	8.60 ± 0.49 a
12	7.40 ± 0.49 b	7.80 ± 0.40 ab	8.60 ± 0.49 a	8.60 ± 0.49 a
13	7.60 ± 0.49 a	7.60 ± 0.49 a	8.60 ± 0.49 a	8.80 ± 0.75 a
14	7.60 ± 0.80 b	7.60 ± 0.49 b	8.80 ± 0.75 ab	9.00 ± 0.63 a
15	7.80 ± 0.40 b	8.00 ± 0.63 b	8.40 ± 0.49 ab	9.20 ± 0.75 a

Remarks: The numbers followed by the same letter in the same column do not have significant differences based on DMRT test 5%; mean ± standard deviation (n = 5)

Table 3 presents the population dynamics of male fruit flies on kaffir lime under four different treatments, namely medium inside, high inside, medium outside, and high outside, observed over a 15-day period. Across all observation days, male fruit fly populations under inside treatments (medium inside and high inside) were consistently lower, ranging from 7.00 to 8.00, and indicating no significant differences between these two treatments. In contrast, outside treatments (medium outside and high outside) resulted in significantly higher male fruit fly populations, with values ranging from 8.00 to 9.20, and were predominantly reflecting significant differences compared to inside treatments. A gradual increase in male fruit fly populations was observed over time across all treatments, with the highest population recorded on day 15 under the high outside treatment (9.20).

The results show that trap placement location (inside versus outside) had a significant influence on male fruit fly populations on kaffir lime. The consistently lower populations observed in inside treatments suggest that internal trap placement was more effective in reducing male fruit fly abundance, possibly due to reduced fly movement or lower exposure to environmental attractants. The higher male fruit fly populations recorded under outside treatments may be associated with greater dispersal activity and increased responsiveness of male fruit flies to visual cues and attractants in open environments. Similar to the findings on Siamese orange, the absence of consistent significant differences between medium and high trap heights suggests that increasing trap height alone does not substantially enhance trapping efficiency.

Table 4. Female fruit fly population on kaffir lime with different treatments

Observation Days	Treatments			
	Medium Inside	High Inside	Medium Outside	High Outside
1	12.20 ± 0.40 b	12.20 ± 0.40 b	13.00 ± 0.00 a	13.20 ± 0.40 a
2	12.20 ± 0.40 b	12.20 ± 0.40 b	13.20 ± 0.40 a	13.20 ± 0.40 a
3	12.20 ± 0.40 a	12.20 ± 0.40 a	13.40 ± 0.80 a	13.20 ± 0.40 a
4	12.20 ± 0.40 b	12.00 ± 0.00 b	13.20 ± 0.40 a	13.20 ± 0.40 a
5	12.20 ± 0.40 b	12.40 ± 0.49 b	13.40 ± 0.49 a	13.40 ± 0.49 a
6	12.20 ± 0.40 a	12.40 ± 0.49 a	12.40 ± 0.49 a	12.60 ± 0.49 a
7	12.40 ± 0.49 b	12.40 ± 0.49 b	13.40 ± 0.49 a	13.40 ± 0.49 a
8	12.40 ± 0.49 a	12.40 ± 0.49 a	13.60 ± 0.49 a	13.60 ± 0.80 a
9	12.60 ± 0.49 a	12.80 ± 0.75 a	13.60 ± 0.49 a	13.60 ± 0.49 a
10	12.60 ± 0.49 b	12.40 ± 0.49 b	14.00 ± 0.63 a	14.00 ± 0.00 a
11	12.80 ± 0.40 b	12.80 ± 0.40 b	14.00 ± 0.63 a	14.20 ± 0.40 a
12	12.80 ± 0.40 b	12.80 ± 0.40 b	14.20 ± 0.40 a	14.20 ± 0.40 a
13	12.80 ± 0.40 b	12.80 ± 0.40 b	14.20 ± 0.40 a	14.20 ± 0.40 a
14	12.80 ± 0.40 b	13.20 ± 0.40 b	14.40 ± 0.49 a	14.60 ± 0.49 a
15	13.00 ± 0.63 b	13.20 ± 0.40 b	14.40 ± 0.49 a	14.60 ± 0.49 a

Remarks: The numbers followed by the same letter in the same column do not have significant differences based on DMRT test 5%; mean ± standard deviation (n = 5)

Table 4 presents the population dynamics of female fruit flies on kaffir lime under four different treatments, namely medium inside, high inside, medium outside, and high outside, observed over a 15-day period. Across all observation days, female fruit fly populations recorded under inside treatments (medium inside and high inside) were consistently lower, ranging from 12.00 to 13.20. These treatments were generally indicating no significant differences between the two inside trap positions. In contrast, outside treatments (medium outside and high outside) resulted in significantly higher female fruit fly populations, with values ranging from 12.40 to 14.60. The highest population was observed on day 15 under the high outside treatment (14.60), followed closely by the medium outside treatment (14.40). Differences between medium and high trap heights within the same placement location were generally not significant.

The results illustrate that trap placement location had a pronounced effect on female fruit fly populations on kaffir lime, whereas differences in trap height had a relatively minor influence. The consistently lower populations observed under inside treatments suggest that placing traps within is more effective for suppressing female fruit fly abundance. The higher female fruit fly populations under outside treatments may be attributed to greater exposure to environmental cues and host-related signals, which play an important role in female fruit fly behavior. Compared with male fruit flies, female populations on kaffir lime exhibited greater sensitivity to treatment location, as reflected by the clear separation of significance groups between inside and outside treatments.

Table 5. Male fruit fly population on grapefruit with different treatments

Observation Days	Treatments			
	Medium Inside	High Inside	Medium Outside	High Outside
1	5.20 ± 0.40 b	5.00 ± 0.00 b	7.00 ± 0.00 a	7.20 ± 0.40 a
2	5.20 ± 0.40 b	5.20 ± 0.40 b	7.20 ± 0.40 a	7.20 ± 0.40 a
3	5.20 ± 0.40 b	5.20 ± 0.40 b	7.20 ± 0.40 a	7.20 ± 0.40 a
4	5.20 ± 0.40 b	5.20 ± 0.40 b	7.20 ± 0.40 a	7.20 ± 0.40 a
5	5.20 ± 0.40 b	5.40 ± 0.49 b	7.20 ± 0.40 a	7.20 ± 0.40 a
6	5.40 ± 0.49 b	5.40 ± 0.49 b	7.20 ± 0.40 a	7.20 ± 0.40 a
7	5.20 ± 0.40 b	5.20 ± 0.40 b	7.40 ± 0.49 a	7.40 ± 0.49 a
8	5.40 ± 0.49 b	5.40 ± 0.49 b	7.40 ± 0.49 a	7.40 ± 0.49 a
9	5.40 ± 0.49 b	5.60 ± 0.49 b	7.40 ± 0.49 a	7.40 ± 0.49 a
10	5.80 ± 0.75 b	5.80 ± 0.40 b	7.40 ± 0.49 a	7.80 ± 0.40 a
11	5.80 ± 0.40 b	5.80 ± 0.40 b	8.00 ± 0.63 a	8.20 ± 0.40 a
12	5.60 ± 0.80 b	5.60 ± 0.49 b	8.00 ± 0.89 a	7.80 ± 0.40 a
13	5.80 ± 0.40 b	6.00 ± 0.63 b	7.60 ± 0.49 a	8.00 ± 0.63 a
14	5.80 ± 0.40 b	5.80 ± 0.40 b	8.00 ± 0.63 a	8.00 ± 0.63 a
15	5.80 ± 0.40 b	5.80 ± 0.40 b	8.00 ± 0.89 a	8.20 ± 0.40 a

Remarks: The numbers followed by the same letter in the same column do not have significant differences based on DMRT test 5%; mean ± standard deviation (n = 5)

Table 5 presents the population dynamics of male fruit flies on grapefruit under four different treatments, namely medium inside, high inside, medium outside, and high outside, observed over a 15-day period. Across all observation days, male fruit fly populations under inside treatments (medium inside and high inside) were consistently lower, ranging from 5.00 to 6.00, and indicating no significant differences between these two treatments. In contrast, outside treatments (medium outside and high outside) resulted in significantly higher male fruit fly populations, with values ranging from 7.00 to 8.20. The highest population was recorded on day 15 under the high outside treatment (8.20), followed by the medium outside treatment (8.00).

The results describe that trap placement location had a significant effect on male fruit fly populations on grapefruit, whereas differences in trap height had a limited impact. The consistently lower populations observed under inside treatments indicate that placing traps within was more effective in reducing male fruit fly abundance. The higher populations recorded under outside treatments may be associated with greater flight activity and responsiveness of male fruit flies to visual and olfactory cues in open environments.

Table 6. Female fruit fly population on grapefruit with different treatments

Observation Days	Treatments			
	Medium Inside	High Inside	Medium Outside	High Outside
1	9.00 ± 0.00 b	9.00 ± 0.00 b	11.00 ± 0.00 a	11.20 ± 0.40 a
2	9.20 ± 0.40 b	9.20 ± 0.40 b	11.00 ± 0.00 a	11.20 ± 0.40 a
3	9.20 ± 0.40 b	9.20 ± 0.40 b	11.20 ± 0.40 a	11.20 ± 0.40 a
4	9.20 ± 0.40 b	9.20 ± 0.40 b	11.20 ± 0.40 a	11.20 ± 0.40 a
5	9.20 ± 0.40 b	9.20 ± 0.40 b	11.20 ± 0.40 a	11.20 ± 0.40 a
6	9.40 ± 0.49 b	9.40 ± 0.49 b	11.40 ± 0.49 a	11.40 ± 0.49 a
7	9.40 ± 0.49 b	9.40 ± 0.49 b	11.20 ± 0.75 a	11.40 ± 0.49 a
8	9.40 ± 0.49 b	9.40 ± 0.49 b	11.40 ± 0.49 a	11.60 ± 0.49 a
9	9.40 ± 0.49 b	9.20 ± 0.40 b	11.20 ± 0.75 a	11.60 ± 0.49 a
10	9.20 ± 0.40 b	9.20 ± 0.40 b	11.40 ± 0.80 a	11.60 ± 0.49 a
11	9.40 ± 0.49 b	9.40 ± 0.49 b	11.40 ± 0.49 a	11.60 ± 0.49 a
12	9.60 ± 0.49 b	9.60 ± 0.49 b	11.80 ± 0.75 a	11.80 ± 0.40 a
13	9.60 ± 0.49 b	9.60 ± 0.49 b	11.60 ± 0.49 a	11.60 ± 0.49 a
14	10.00 ± 0.63 b	10.00 ± 0.63 b	11.80 ± 0.40 a	12.00 ± 0.63 a
15	10.20 ± 1.17 c	10.60 ± 1.02 bc	12.00 ± 0.63 ab	12.40 ± 0.49 a

Remarks: The numbers followed by the same letter in the same column do not have significant differences based on DMRT test 5%; mean ± standard deviation (n = 5)

Table 6 presents the population dynamics of female fruit flies on grapefruit under different trap placement treatments throughout 15 observation days. Traps positioned outside the tree canopy, both at medium and high heights, consistently recorded significantly higher numbers of female fruit flies compared to traps placed inside the canopy. Among the outside placements, the high outside treatment generally captured the highest female fruit fly populations, particularly toward the later observation days, reaching a maximum mean value of 12.40 individuals on day 15. However, no statistically significant differences were observed between medium outside and high outside treatments on most observation days, suggesting that trap height had a limited effect when traps were placed outside the canopy.

In contrast, both medium inside and high inside treatments consistently recorded lower female fruit fly populations throughout the observation period, with mean values ranging from 9.00 to 10.60 individuals. The lack of significant differences between medium and high trap heights within the inside placement further indicates that trap height did not substantially influence female fruit fly abundance when traps were positioned inside the canopy.

The present study demonstrates that the abundance of fruit flies on citrus trees is strongly influenced by trap placement location, citrus species, and fruit fly sex. Across all citrus clones and observation periods, traps positioned outside the tree canopy consistently captured higher numbers of fruit flies than those placed inside, regardless of trap height. This result suggests that trap placement location plays a more decisive role than vertical positioning, likely due to greater exposure to flight pathways and olfactory cues in open canopy environments.

The consistently higher captures in outside traps observed in Tables 1–6 align with the findings of Soraya et al. (2019), who reported that yellow traps placed at approximately 100 cm above ground level were particularly effective in attracting *Bactrocera dorsalis*, especially males. Although the present study found no significant differences between medium (1 m) and high (2 m) trap heights, the effectiveness of outside placement supports the notion that visual and chemical cues disperse more efficiently in less obstructed spaces, enhancing trap attractiveness.

Sex-based differences in fruit fly abundance were evident in this study, with female populations generally exhibiting greater variability compared to males. This pattern may be linked to behavioral and physiological differences between sexes. Female fruit flies are actively involved in host selection and oviposition, processes that are highly sensitive to environmental conditions and host availability. Adhikari et al. (2022) reported that female fruit flies oviposit eggs beneath the peel of young citrus fruits, where larvae subsequently feed on pulp and juice, making the larval stage the most destructive. This reproductive behavior likely contributes to the greater fluctuations observed in female populations across treatments and observation periods.

Furthermore, morphological differences may also explain the observed sex-related variability. Basnet et al. (2025) reported that female *Bactrocera minax* individuals are consistently larger and heavier than males, which may influence flight capacity, dispersal ability, and responsiveness to traps. Such traits could enhance the likelihood of females encountering traps placed outside the canopy, where movement and host-seeking activities are more intense.

Correlation analysis among citrus clones (Figure 2) revealed strong positive relationships in fruit fly abundance, indicating comparable susceptibility patterns across Siamese orange, kaffir lime, and grapefruit. This result is consistent with the broad host range reported for *Bactrocera* species. Izzaty et al. (2023) documented that *Bactrocera dorsalis* infests multiple fruit hosts, including citrus, mango, guava, chili, and salak, while *Bactrocera carambolae* and *Bactrocera tau* also attack diverse plant species. The wide host adaptability of these species explains the similar infestation trends observed across different citrus clones in the present study.

The high abundance and widespread distribution of *Bactrocera* species observed in Sleman Regency reflect broader regional and global patterns. Previous studies have reported the extensive distribution of *Bactrocera dorsalis*, *Bactrocera carambolae*, and *Bactrocera tau* across Asia, Africa, and parts of Europe (San Jose et al., 2018; Leblanc et al., 2019; Hudiwaku et al., 2021; Mutamiswa et al., 2021; Saputra & Afriyansyah, 2021; Izzaty et al., 2023). Such wide geographic distribution underscores the ecological adaptability of these pests and their capacity to persist in various agroecosystems.

The implications of these findings are particularly significant for citrus pest management and export-oriented production systems. High fruit fly diversity and abundance pose serious risks to commercial fruit quality and market access. As reported by Hudiwaku et al. (2022), fruit exports from Indonesia are frequently subjected to additional quarantine requirements or rejected due to fruit fly infestation. Therefore, optimizing trap placement—particularly prioritizing outside canopy positions—can serve as a practical and cost-effective strategy for monitoring and potentially suppressing fruit fly populations in citrus orchards.

Citrus plants as host crops play an important role in determining the abundance and activity patterns of fruit flies. According to Ardiyanti et al. (2019), fruit crops naturally function as the primary attractants for adult fruit flies, where host plants act as sexual attractants for males and as food attractants for females. The presence of volatile compounds such as methyl eugenol, which naturally occurs in several fruits including citrus, mango, and banana, further enhances the attractiveness of host plants to fruit flies. This finding is consistent with the results of the present study, which demonstrated higher populations of both male and female fruit flies in traps placed outside the tree canopy (Figures 1 and 2), where volatile cues from host plants are more easily detected.

The relatively similar abundance of fruit flies among different citrus species, as indicated by the strong positive correlations among citrus clones, suggests that the three citrus species examined have comparable levels of attractiveness and susceptibility to fruit fly infestation. This observation supports the results of Heriza (2017), who stated that greater plant species diversity within an area is associated with higher insect community diversity. The semi-natural management of the citrus orchard at the study site likely provided a stable ecological environment that supported sustained fruit fly populations.

The higher abundance and greater variability of female fruit flies, particularly in traps placed outside the canopy, are closely associated with oviposition behavior. Female fruit flies actively search for suitable host fruits for egg-laying, especially immature fruits with relatively soft peel characteristics. Astriyani et al. (2016) reported that fruit fly infestation is characterized by oviposition punctures on the fruit surface, leading to tissue damage, premature fruit drop, and reduced fruit quality and yield. This behavior explains the greater variability observed in female fruit fly populations compared to males, as reflected in Tables 2, 4, and 6.

In contrast, not all fruit species are equally susceptible to fruit fly infestation. Pujiastuti et al. (2020) reported that several fruits, including avocado, noni, pineapple, and salak, were not attacked by fruit flies, which was attributed to their hard fruit skin. Dias et al. (2018) further explained that hard fruit skin acts as a physical barrier that prevents adult fruit flies from inserting their ovipositors and laying eggs. These data provide an ecological context for the present study, as citrus fruits, which generally have softer peels than those fruits, are more vulnerable to fruit fly infestation.

Conclusion

In summary, the findings of this study indicate that fruit fly (*Bactrocera spp.*) abundance on citrus trees in Sleman Regency is primarily affected by trap placement location, citrus species, and fruit fly sex. For all citrus clones evaluated—Siamese orange, kaffir lime, and grapefruit—traps positioned outside the tree canopy consistently recorded higher fruit fly captures than those placed inside, emphasizing that trap placement location has a greater influence on trapping efficiency than trap height. Although male and female fruit flies exhibited comparable population trends with gradual increases over time, female fruit flies displayed higher variability and greater responsiveness to treatment differences, likely associated with behavioral mechanisms related to host selection and oviposition. Moreover, correlation analysis revealed strong positive associations among citrus clones, indicating similar levels of susceptibility to fruit fly infestation across the evaluated species.

Acknowledgement

The authors gratefully acknowledge PIAT UGM for providing the facilities and infrastructure that supported this research. We also thank all staff and technicians at PIAT UGM for their assistance during the implementation of the study.

References

Adhikari, D., Thapa, R.B., Joshi, S.L., Du, J.J., & Tiwari, S. (2022). Biology and Management of Chinese Citrus Fly, *Bactrocera minax* (Enderlein) (Diptera: Tephritidae). *Journal of Agriculture and Forestry University*, 5(1): 1-13.

Ardiyanti, R.M., Maryana, N. & Pudjianto. (2019). Keanekaragaman Lalat Buah (Diptera: Tephritidae) dan Parasitoidnya di Taman Buah Mekarsari, Cileungsi, Bogor. *Jurnal Entomologi Indonesia*, 16(2): 65-74.

Astriyani, N.K.N.K., Supartha, I.W., & Sudiarta, I.P. (2016). Kelimpahan Populasi dan Persentase Serangan Lalat Buah yang Menyerang Tanaman Buah-Buahan di Bali. *Journal of Agricultural Science and Biotechnology*, 5(1): 19-27.

Basnet, B., Thapa, A., Aryal, P., Shrestha, S., & Adhikari, D. (2025). Morphometrics and Management of Chinese Citrus Fly, *Bactrocera minax* (Enderlein) (Diptera: Tephritidae) in Kathmandu, Nepal. *Nepalese Journal of Agricultural Sciences*, 28(1): 85-92.

Dias, N.P., Nava, D.E., Garcia, M.S., Silva, F.F., & Valgas RA. (2018). Oviposition of Fruit Flies (Diptera: Tephritidae) and Its Relation with the Pericarp of Citrus Fruits. *Brazilian Journal of Biology*, 78(3): 443-448.

Heriza, S. (2017). Dinamika Populasi Lalat Buah (Diptera: Tephritidae) pada Tanaman Buah-Buahan di Kabupaten Dharmasraya. *Agrin*, 21(1): 59-70.

Hudiwaku, S., Himawan, T., & Rizali, A. (2021). Diversity and Species Composition of Fruit Flies (Diptera: Tephritidae) in Lombok Island, Indonesia. *Biodiversitas Journal of Biological Diversity*, 22(10): 4608-4616.

Hudiwaku, S., Himawan, T., & Rizali, A. (2022). Keanekaragaman, Komposisi Spesies, dan Kunci Identifikasi Lalat Buah (Diptera: Tephritidae: Dacinae) di Pulau Lombok. *Jurnal Entomologi Indonesia*, 19(2): 111-126.

Izzaty, H., Zamroni, Y., & Suana, I.W. (2023). Keanekaragaman Lalat Buah *Bactrocera spp.* di Pasar di Pulau Lombok. *Jurnal Bios Logos*, 13(3): 158-168.

Jaleel, W., Yin, J., Wang, D., He, Y., Lu, L., & Shi, H. (2018). Using Two-Sex Life Tables to Determine Fitness Parameters of Four *Bactrocera* Species (Diptera: Tephritidae) Reared on a Semi-Artificial Diet. *Bulletin of Entomological Research*, 108(6): 707-714.

Leblanc, L., Hossain, M.A., Doorenweerd, C., Khan, S.A., Momen, M., San Jose, M., & Rubinoff, D. (2019). Six Years of Fruit Fly Surveys in Bangladesh: A New Species, 33 New Country Records and Discovery of the Highly Invasive *Bactrocera carambolae* (Diptera, Tephritidae). *ZooKeys*, 876: 87-109.

Li, X.Z., Wang, G.L., Wang, C.L., Li, W.J., Lu, T., Ge, Y.G., Xu, C.K., Zhong, X., Wang, J.G., & Yang, H.Y. (2024). Long-Term Monitoring of *Bactrocera* and *Zeugodacus spp.* (Diptera: Tephritidae) in China and Evaluation of Different Control Methods for *Bactrocera dorsalis* (Hendel). *Crop Protection*, 182: 106708.

Meidi, E., Pakpahan, Y.M., Nadia, N., Yuana, Y., Dani, D.R., Nurfadila, Y., Nasution, M.P., Umayah, A., Gunawan, B., & Arsi, A. (2023). Kelimpahan Populasi Spesies Lalat Buah (Diptera : Tephritidae) pada Pertanaman Jeruk di Ogan Ilir, Sumatera Selatan. In: Herlinda, S. et al. (Eds.), Prosiding Seminar Nasional Lahan Suboptimal ke-10 Tahun 2022, Palembang 27 Oktober 2022. pp. 607-613. Palembang: Penerbit & Percetakan Universitas Sriwijaya (UNSRI).

Mutamiswa, R., Nyamukondiwa, C., Chikowore, G., & Chidawanyika, F. (2021). Overview of Oriental Fruit Fly, *Bactrocera dorsalis* (Hendel) (Diptera: Tephritidae) in Africa: Invasion, Bio-Ecology and Sustainable Management. *Crop Protection*, 141: 105492.

Pujiastuti, Y., Irsan, C., Herlinda, S., Kartini, L., & Yulistin, E. (2020). Keanekaragaman dan Pola Keberadaan Lalat Buah (Diptera: Tephritidae) di Provinsi Sumatera Selatan. *Jurnal Entomologi Indonesia*, 17(3): 125-135.

Rahmawati, Y.F., Leksono, A.S., Gama, Z.P., & Rizali, A. (2024). Diversity of *Bactrocera spp.* in Different Habitat Types in Citrus Orchards at Malang Regency. *Al-Hayat: Journal of Biology and Applied Biology*, 7(2): 107-118.

San Jose, M., Doorenweerd, C., Leblanc, L., Bar,r N., Geib, S., & Rubinoff, D. (2018). Tracking the Origins of Fly Invasions: Using Mitochondrial Haplotype Diversity to Identify Potential Source Populations in Two Genetically Intertwined Fruit Fly Species (*Bactrocera carambolae* and *Bactrocera dorsalis* [Diptera: Tephritidae]). *Journal of Economic Entomology*, 111(6): 2914-2926.

Saputra, H.M., & Afriyansyah, B. (2021). Distribution and Identification of Fruit Flies (Diptera : Tephritidae) Attracted on Methyl Eugenol and Cue Lure in Central Bangka Regency, Bangka Belitung. *Jurnal Hama dan Penyakit Tumbuhan Tropika*, 21(1): 72-81.

Soraya, M., Marheni, & Hasanuddin. (2019). Efektifitas Penggunaan Berbagai Perangkap dengan Ketinggian Perangkap yang Berbeda terhadap Lalat Buah (Diptera:Tephritidae) pada Tanaman Jeruk. *Jurnal Agroekoteknologi*, 7(2): 448-454.

Theron, C.D., Kotzé, Z., Manrakhan, A., & Weldon, C.W. (2023). Oviposition by the Oriental Fruit Fly, *Bactrocera dorsalis* (Hendel) (Diptera: Tephritidae), on Five Citrus Types in a Laboratory. *Austral Entomology*, 62(4): 503-516.

Wicaksono, R.C., Endarto, O., Istianto, M., Budiarto, K., Tarigan, R., Triasih, U., & Wuryantini, S. (2024). Penerapan Prosedur Operasional Standar Budi Daya Tanaman Jeruk Ramah Lingkungan untuk Menekan Infestasi Kutu Perisai Merah *Aonidiella aurantii* (Maskell) (Hemiptera: Diaspididae). *Jurnal Entomologi Indonesia*, 21(2): 93-104.