Turkish Journal of Agriculture - Food Science and Technology, 13(2): 312-320, 2025
DOI: https://doi.org/10.24925/turjaf.v13i2.312-320.7128

Turkish Journal of Agriculture - Food Science and Technology

Available online, ISSN: 2148-127X | www.agrifoodscience.com | Turkish Science and Technology Publishing (TURSTEP)

Bio-efficacy of Different Traps and Baits Under Field Condition to Control Fruit Flies (Diptera: Tephritidae) in Watermelon (*Citrullus lanatus* (Thnub.) Matsum & Nakai)

Nawaraj Pandey[1,a,*], Nabin Bhusal[2,b], Priya Karna[1,c]

[1]*Faculty of Agriculture, Agriculture and Forestry University, Rampur Chitwan, Nepal, Postal code: 44209*
[2]*Department of Genetics and Plant Breeding, Faculty of Agriculture, Agriculture and Forestry University, Rampur Chitwan, Nepal*
[*]*Corresponding author*

A R T I C L E I N F O

Research Article

Received : 13.09.2024
Accepted : 03.11.2024

Keywords:
Baits
Bactrocera nigrifacia
Fruit fly
Sticky traps
Watermelon

A B S T R A C T

Tephritid fruit flies (Diptera: Tephritidae) are the major damaging pest for the Watermelon (*Citrullus lanatus* (Thumb.) Matsum. & Nakai). The quality as well as quantity of watermelon is greatly affected by fruit fly. This study was conducted to test the efficacy of different traps and baits for fruit fly control. The experiment was designed in a randomized complete block design containing eight treatments and three replications. Each treatment, 0.2 ml of cue lure as an attractant and 0.1 ml of malathion was used as a toxicant except control. Treatments were installed when the flowering was started. Data collection and treatment replacement were done simultaneously in every 6-day interval. The findings revealed that the diverse fruit fly species (up to 7) were trapped in all treatments however, the *Zeugodacus cucurbitae* (Coquillett, 1889) followed by *Zeugodacus tau* (Walker, 1849) were dominating over the other species in all treatments. Yellow sticky trapped the highest number of fruit flies (15.01±0.38), followed by brewery wastage (13.65±0.37). The male-female ratio of the trapped fly was (>1) in all treatments. Furthermore, the lowest fruit fly damaged percentage (0.87±0.16) with the highest obtainable yield (32.57±1.31) and benefit-cost ratio (1.63±0.06) was observed in the yellow sticky trap. From this experiment, the yellow sticky trap captured more fruit flies caused the least amount of fruit fly damage, and yielded the highest possible yield than the other treatments.

[a] *nrpandey2020@gmail.com* *https://orcid.org/0009-0007-3289-9590*
[c] *bhusal.nabin@gmail.com* *https://orcid.org/0000-0003-2330-0391*
[b] *priyakarna.2017@gmail.com* *https://orcid.org/0000-0002-5727-4913*

Introduction

Insect pests are a major threat to watermelon production globally (Okrikata et al., 2021) . A variety of pest's attack watermelon at different stages throughout its growing period however, the seedling, mid-vegetative, and mid-fruiting stages are more critical than others (Okrikata & Ogunwolu, 2019). The mining insect, leaf miner (*Liriomyza Spp*) (Hamza et al., 2023), piercing and sucking insects melon thrips (*Thrips palmi* Karny) (Whitfield et al., 2005) and leaf feeding pumpkin beetles like red (*Aulacophora africana* Weise) and blue (*Asbecesta nigripennis* Weise, *A. transverse* Allard.), sap-sucking aphids (*Aphis gossypii* L) & white fly (*Bemisia tabaci* Genn.) attack mainly in vegetative stages. Similarly, melon fly (*Zeugodacus cucurbitae* Coq.) and fruit borer (*Helicoverpa armigera* Hub.) attack in the flowering and fruiting stages (Okrikata & Ogunwolu, 2019). Whereas, two-spotted red spider mites, being devastating leaf-feeding pests, occur throughout the growing period(Schmidt-Jeffris et al., 2021).

The fruit flies in the Dacine sub-family of the Tephritidae family are a widespread pest of cucurbits (Dhillon et al., 2005; Nair et al., 2021; Sapkota et al., 2010) causing up to 90% fruit damage (Ryckewaert et al., 2010), They are the primary contributor to the decline of both quantity and quality (Sulaeha et al., 2020), resulting in 63.2% production damage in watermelons (Masika et al., 2022). *Zeugodacus*, *Rhagoletis*, *Dacus*, *Certitis*, *Bactrocera*, and *Anastrepha* are the six major economically significant genera (Li & Zhang, 2019). Sex pheromone (Tan et al., 2014) and cue-lure (C-L) [4-(para-acetoxyphenyl)-2-butanone] are used in current fruit fly programs for detection, monitoring, and control (Vargas et al., 2010). Similarly, female fruit flies show good responses in food containing ammonia derivatives and get more attracted to protein-rich food (Piñero et al., 2020). However, rainfall limits the effectiveness of bait in the open field condition (Delpoux & Deguine, 2015). This encourages the placement of baits in bottles. Furthermore, fruit flies are attracted to those color traps that mimic their natural host indicating their inherent tendency toward those visual stimuli (Singh & Singh, 2018). The direct application of chemical insecticides to control fruit flies is practical but ineffective and unsafe. And microbial pesticides are not widely available in Nepal (Adhikari et al., 2020). To overcome the relevant problems in open field conditions, this study evaluates the effectiveness of different traps and baits, which contain lure and malathion to control fruit flies in watermelon.

Materials and Methods

Experimental Site

The study area was located at Bharatpur-15, Chitwan near the Agriculture and Forestry University Figure 1. Geographically, it is situated at 27°39'09''N latitude and 84°21'57'' E longitude with an elevation of 186m above the mean sea level. The experiment was carried on during the spring season from February to May 2023. The soil property was sandy loam having ph-6.8, which is suitable for watermelon production (Shrefler et al., 2015). The average relative humidity and temperature of the site was 64.14%. and 16.75 ºC. The average maximum and minimum temperatures were 22.5 °C and 12.5 ºC respectively. Additionally, the average maximum and minimum relative humidity were 82.22% and 48.26% respectively.

Experimental Detail and Treatment Setup

Randomized Completely Block Design (RCBD) with eight treatments and three replications were performed. A total of 24 plots, each 5.4m×2.4 m (12.96 m^2), were prepared for experimentation. The treatment gap was maintained at 5m with ref. (Akhtaruzzaman et al., 2000) and a 6m distance was kept between the two replications. In each plot, 18 plants were planted with a spacing of 60*60 cm^2 as in Figure 1. The extra early, vigorous variety of watermelon "Saraswati" (F$_1$ hybrid) product no. IA087 (https://shorturl.at/mqrwG), which was highly popular among the producer and consumers, was cultivated. The seeds were collected from Bharatpur, Chitwan. A plastic tray (of 72-hole type) with peat moss as growing media, was used for growing seedlings. The seedling stage having 3 fully and one half developed leaf, was transplanted on the main field. Table 1 shows the treatment description. The commercial cucurbits grower used cue lure as the fly attractant near the experimental site, and to minimize the biases in the fruit fly attraction to the commercial and experimental field @0.1 ml/ treatment cue lure (Eco-man Biotech Co. Ltd. China) was used as an attractant media in every treatment. Furthermore, @0.2ml malathion 50%EC (Plant Remedies Pvt. Ltd, India)/ treatment was added as a toxicant except control plot.

T_8 was kept as control, 60 grams of black jaggery was mixed with 120 ml of distilled water to prepare 60 ml jaggery bait. Similarly, 60 ml of molasses was used for preparing molasses bait. Watermelon flesh including juice was collected in the beaker and 60 ml of it was used as bait for the next treatment.

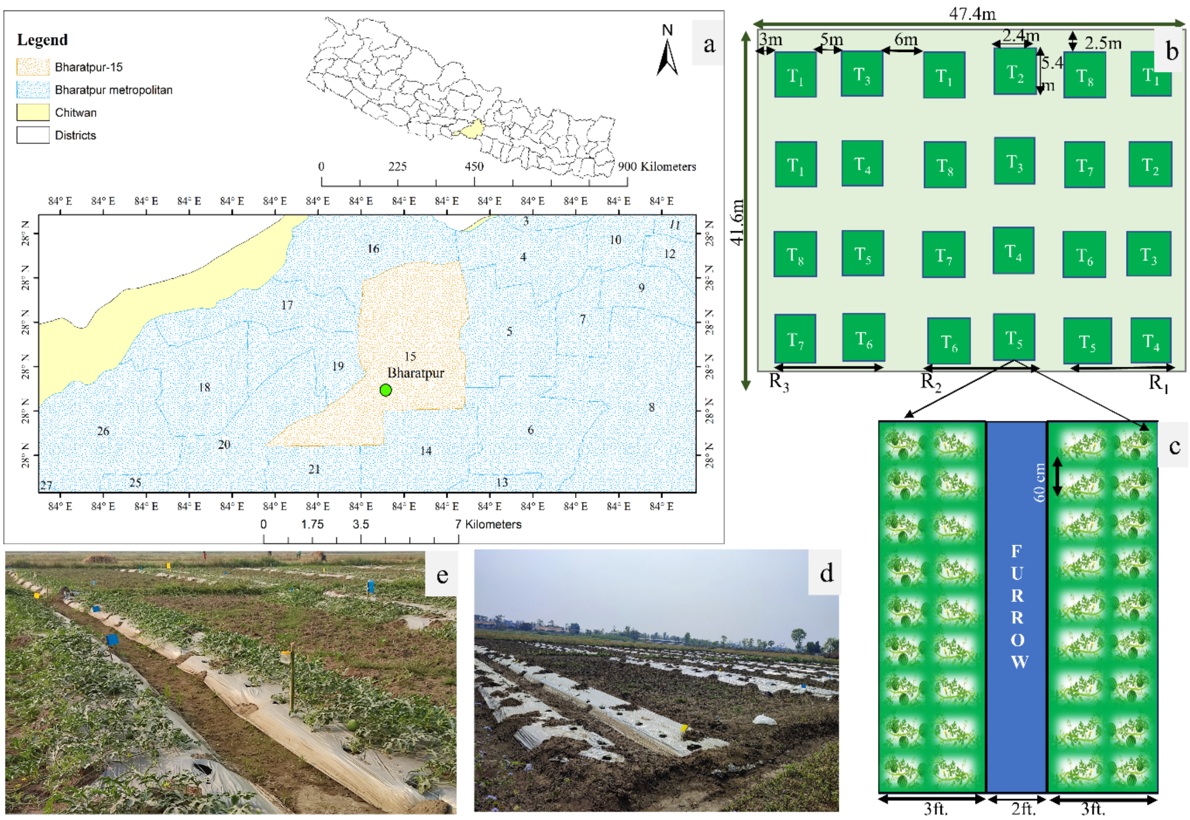


Figure 1. Experimental layout in detail (a. Study area map using Arc. GIS. version 10.8; b. Experimental layout; c. Plot detail; d. Field layout; e. Treatments installment on the field)

Table 1. Detailed explanation of various treatments used in the experiment

Treatments	Attractant[1]	Toxicant[2]	Quantity	Baits and traps media	Source
T_1	0.2	0.1	60ml	Black Jaggery solution	Local retailer, Mangalpur
T_2	0.2	0.1	1 piece	Yellow Sticky Trap	Sharma Agrovet, Chanauli
T_3	0.2	0.1	60ml	Watermelon flesh solution	Local retailer, Mangalpur
T_4	0.2	0.1	1 piece	Blue sticky trap	Sharma Agrovet, Chanauli
T_5	0.2	0.1	60ml	Sugarcane Molasses	Local retailer, Mangalpur
T_6	0.2	0.1	60gm	Brewery solution	Gorkha Brewery Pvt. Ltd
T_7	0.2	0.1	20ml	Citronella oil	Barali Pvt. Ltd. Mangalpur
T_8	0.2	-------	60ml	Tap Water	Local tap water

[1](Lure on ml); [2](Malathion ml 50%EC)

a b

Figure 2. Bait and trap installed on field; (a.) Black jaggery bait with malathion and cue lure on a separate cotton wick with separately hanging and b. Yellow sticky trap with cue lure and malathion kept on a cotton wick separately

A_4 size (21×29.7 cm^2) of yellow sticky trap (YST) and blue sticky trap (BST) were used as trapping media for the rest two of the treatments. All the treatments were installed above 45cm height from the ground, which is a good strategy for monitoring as well as control of *B. dorsalis* (Said et al., 2017).

For the bait installment, plastic bottles (7.5 cm diameter & 12.5 cm height) having 3 holes of 7mm diameter each were used according to (Gupta & Regmi, 2022). Inside the bottle, food bait was added to the base, whereas 0.2 ml of malathion and 0.1 ml of cue lure were dropped in each cotton wick separately and hung with the two wires as shown in Figure 2(a). Similarly, in YST and BST, 0.2 ml of malathion and 0.1 ml of cue lure were dropped in each cotton wick and attached separately as shown in Figure 2(b) All the treatments were installed in the early morning of 7th April, when 25% of the total plants were reached at the flowering stage. Data collection and treatment replacement were performed every 6-day intervals.

Data Collection

Data collection was done on Apr 13th, Apr 19th, Apr 25th, and May 1st respectively, when the plants at flowering, fruit softening, fruit hardening, and fruit maturation stages.

The trapped fruit flies and their sex were counted. Additionally, they were taxonomically identified according to (Adhikari & Joshi, 2018; Australia, 2018; Leblanc et al., 2021; Li & Zhang, 2019) and (Dhillon et al., 2005; Singh et al., 2019) which were visually presented in S1 & S2 respectively. Furthermore, the male-female ratio was calculated according to given formula;

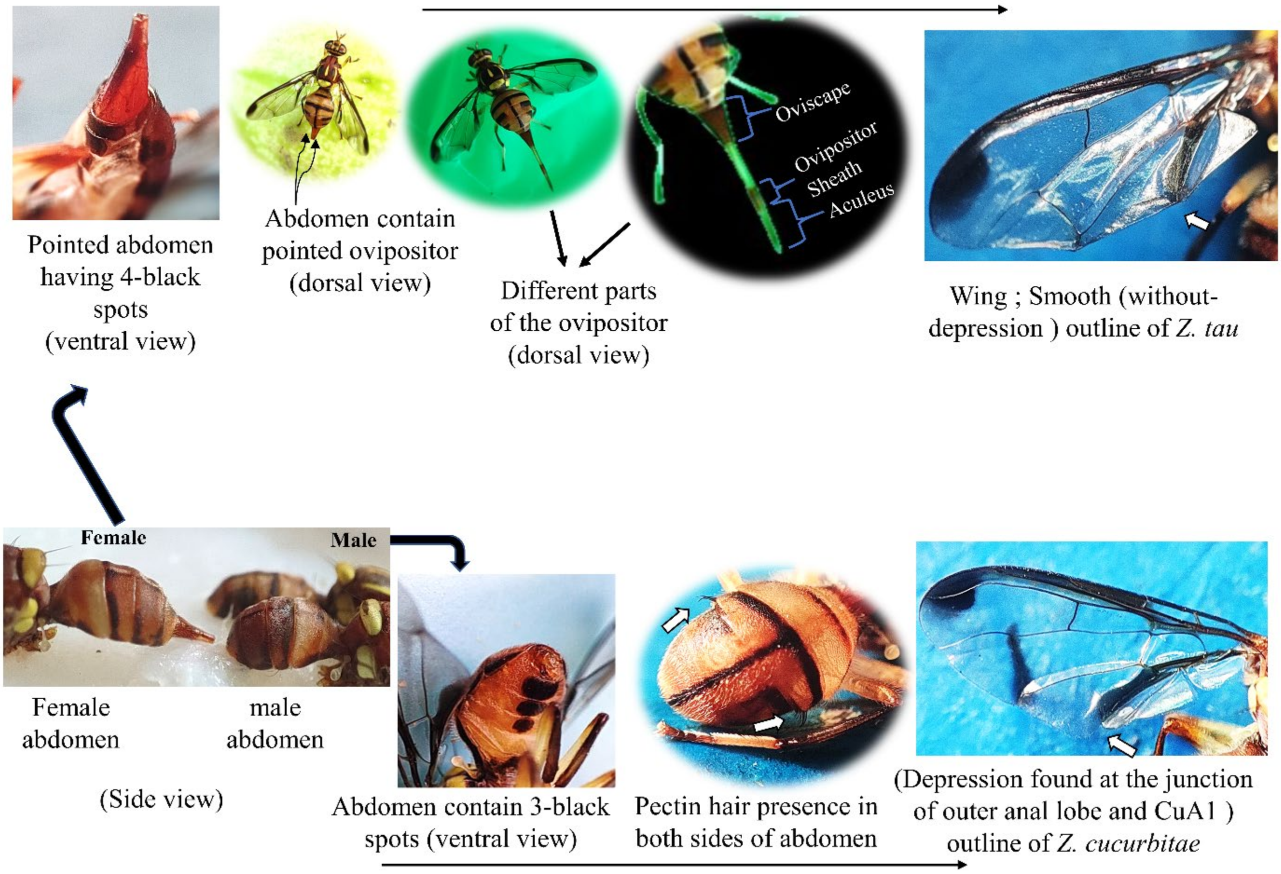
$$\text{Male-female ratio} = \frac{\text{Total number of trapped male}}{\text{Total number of trapped female}} \quad (1)$$

For the economic analysis, five plants were selected as sample plants. which were then used for calculation of total yield (Mtha^{-1}), BCR and percentage infected (damaged) fruits. Infested fruits (IDF) were calculated by the sum of total infected fruits is divided by total number of fruits (Healthy and infected fruits/plant).

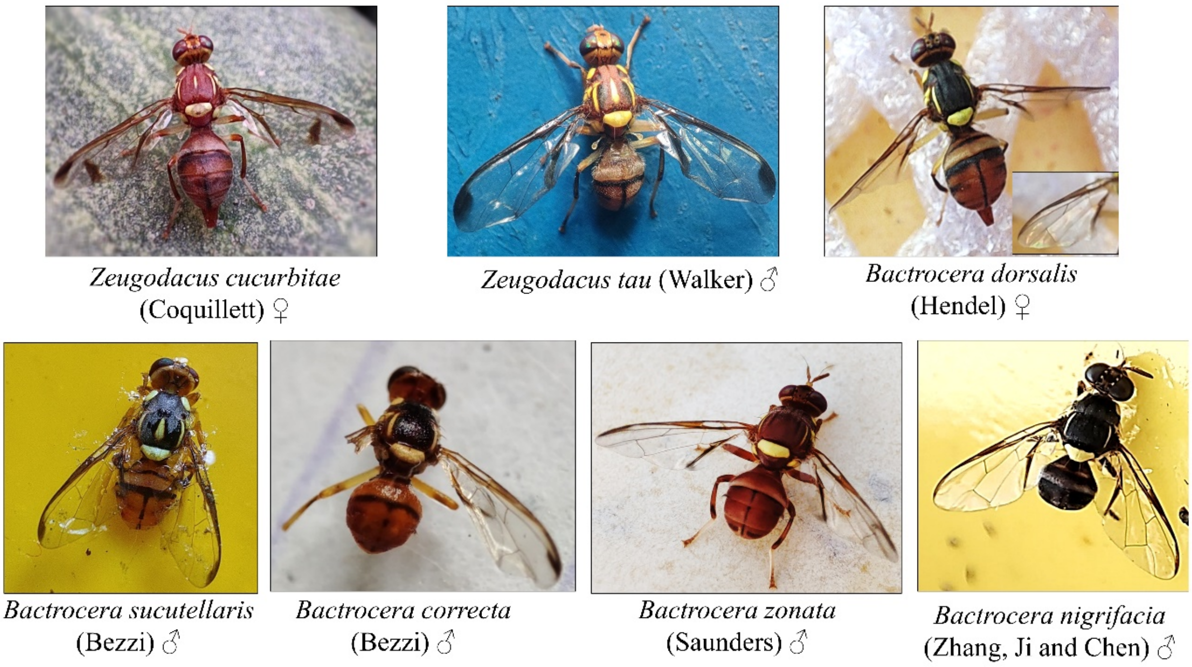
$$\text{IDF (\%)} = \frac{\text{Total no.of infected fruits}}{\text{Total no.of fruits in this plant}} \times 100 \quad (2)$$

Discounting interest is not necessary to calculate for the economic analysis being watermelon as seasonal crops. Hence, only variable cost is included here to calculate

$$\text{benefit cost ratio, BCR} = \frac{\text{Gross return}}{\text{Total variable cost}} \quad (3)$$



S1. Different parts of the trapped male and female fruit flies on watermelon at Chitwan, April-June 2023



S2. Different species of trapped fruit flies in watermelon during the experimental period at Chitwan, April-June 2023

Data entry and Statistical analysis

The data was tabulated and compiled in MS Excel 2019. Most of the counted data were skewed and for minimization of variation, square root $\sqrt{(x + 0.5)}$ transformation was performed (Gomez & Gomez, 1984; Wolda & Marek, 1994). R studio version 4.1.1 was used for data wrangling, inferential analysis and graphical representation. Normal distribution was tested by the gvlma package, and multiple mean comparison of data were performed through agricolae (R Core Team, 2022). Both Fishers and Kruskal-Wallis test were performed by using ggbetweenstats function of ggstatsplot package (Patil, 2021). Furthermore, Fishers test was used for the data which fits for the normality test and Kruskal-Wallis test for non-normal data (Ostertagová et al., 2014). Post Hoc Tukey's test at a 0.05 level of significance was used for multiple mean comparisons (Díaz-Fleischer et al., 2009).

Results and Discussions

Effect Of Treatments on Trapped Fruit Flies

Figure 3 displays the significant differences of treatments on the trapped fruit fly populations at (p<0.001). The highest trapped number (mean per stage) was found in yellow sticky trap (15.01±0.38), followed by brewery wastage (13.65±0.37) which was statistically similar with blue sticky trap (13.26±0.31), black jaggery (13.25±0.39), sugarcane molasses (13.2±0.32), watermelon flesh (12.96±0.21).

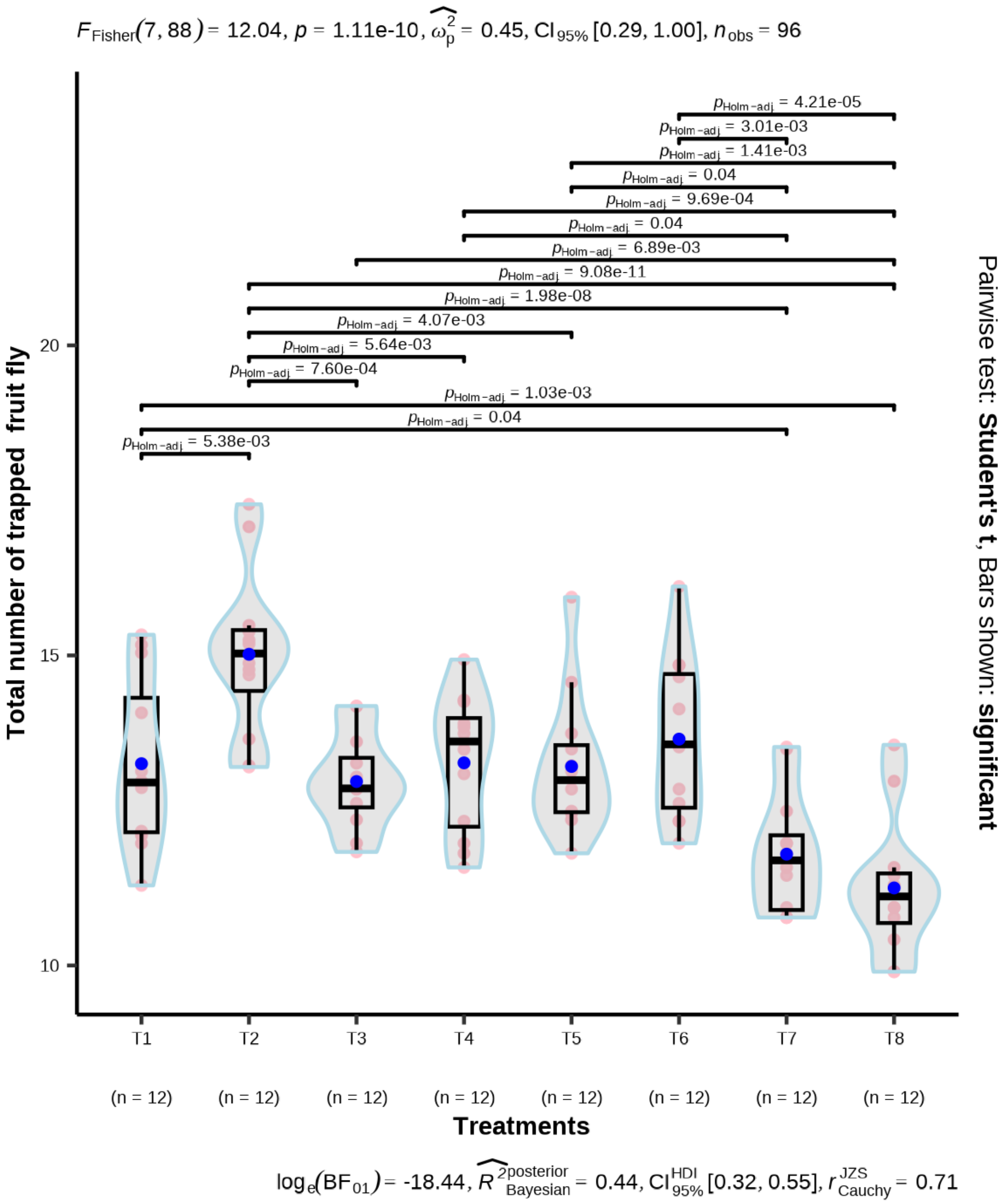


Figure 3. Status of mean trapped fruit fly (per stage) in different treatments installed in watermelon at Chitwan, April-June 2023. Inside the box violin plot, blue dot represents the average mean value, Similarly, n represent the total number of sample (3 replications×4 weeks =12) number was observed in tap water (11.25±0.31)

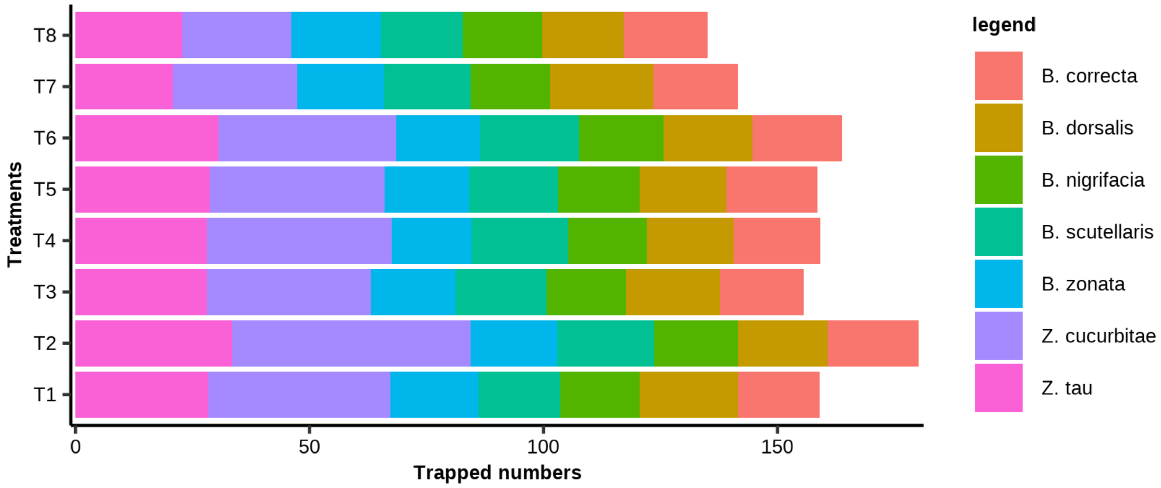


Figure 4. Trapped fruit fly species scenario in different treatments in watermelon at Chitwan, April-June 2023

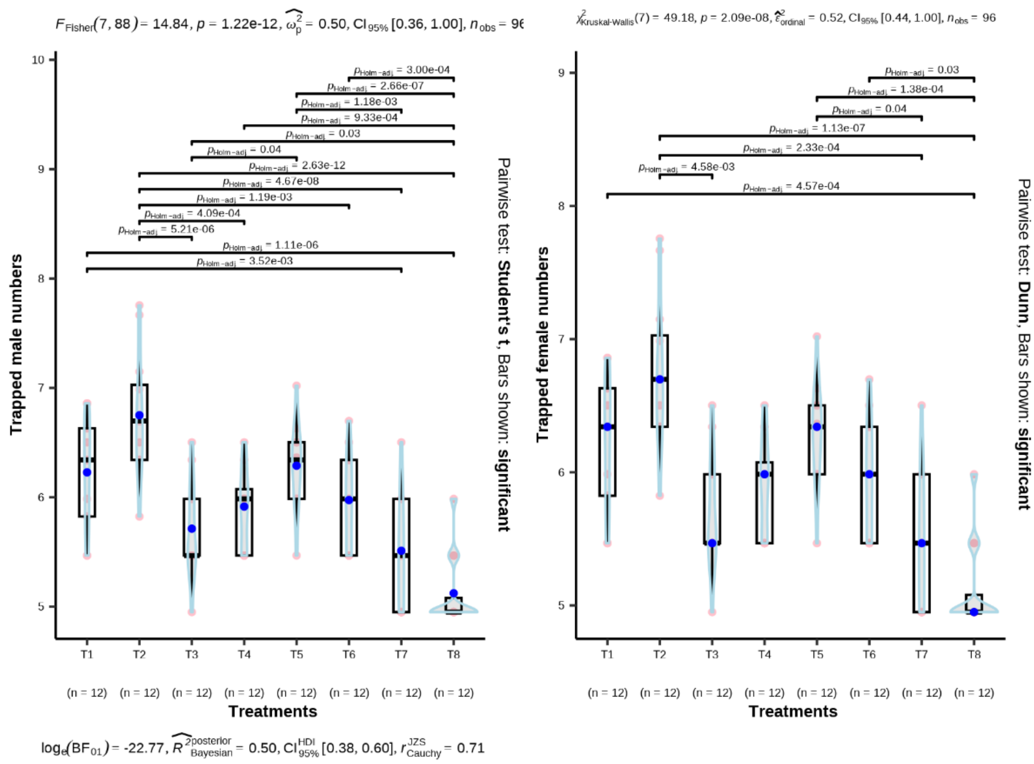


Figure 5. Status of mean male (right) and female (left) trapped fruit fly (per stage) in different treatments installed in watermelon at Chitwan, April-June 2023. Inside the box violin plot, blue dot represents the average mean value, Similarly, n represent the total number of sample (3 replications×4 weeks =12)

Furthermore, the least trapped which was statistically at par with citronella oil (11.79±0.28). Both trapped male and female numbers in each treatment were significantly different (p<0.001). Figure 5. More adult fruit flies were trapped in sticky yellow traps than in other trap colors (Said et al., 2017). Protein bait prepared from brewery wastage is also effective and economical for fruit fly trapping and their control program (Gopaul & Price, 2001). Among eight treatments, the highest number of trapped males (8.26±0.25) and females (6.75±0.16) were observed in the yellow sticky trap. Whereas, the lowest numbers (6.12±0.27) & (5.12±0.09) were found in the control. The male female ratio was >1 in all treatments however they were not significantly different with each other's Figure 6.

Effect of Different Treatments on Trapped Fruit Fly Species

A total of seven species of fruit flies were captured during the whole experimental period, which is visually displayed via a Stack bar plot Figure 4. Among them, *Zeugodacus cucurbitae* (Coquillett, 1889) followed by *Zeugodacus tau* (Walker, 1849) dominating over other species, and *Bactrocera nigrifacia* (Zhang, Ji and Chen, 2011) was found in the least number. The proportion of *Bactrocera zonata* (Saunders, 1842), *Bactrocera sucutellaris* (Bezzi, 1913), *Bactrocera dorsalis* (Hendel, 1912), *Bactrocera correcta* (Bezzi, 1916), *B. zonata* was similar. According to (Umeh & Garcia, 2008), brewery-containing bait can be used for the fruit fly detection program since it can easily attract and prefers *Ceratistis spp*., *Z. cucurbitae* (Coquillett) followed by *Z. tau* (Walker). *Z. cucurbitae* (Coquillett) followed by *B. dorsalis* (Hendel) and *B. tau* (Walker) were the dominating species in Budgam and Srinagar (Ganie et al., 2013).

Economic Analysis of Different Treatments

The highest obtainable yield was found in yellow stick trap and citronella oil (32.57±1.31 $Mtha^{-1}$) whereas the lowest was in control (18.14±4.74 $Mtha^{-1}$). All treatments except the control treatment were found profitable for long-term watermelon farming. Despite of high initial investment, damage due to fruit fly was low in citronella oil considering its repellency nature and hence results in BCR:1.63±0.06. Similarly, the initial installment cost of the yellow sticky trap was also high however it provided a high return (BCR:1.65±0.06). This finding is in line with (Lu et al., 2012), which suggested that the yellow sticky trap can also use for the white fly control in tomato, inside the greenhouse. Further, instead of low initial investment, the damaged percentage due to fruit fly was high (11.1±4.02) in black jaggery bait Table 2.

Table 2. Economic analysis of various treatments for the fruit fly control in watermelon at Chitwan, April-June 2023

Treatments	Obtainable Yield ($Mtha^{-1}$)	Installment cost \$ ha^{-1}	Total cost \$ ha^{-1}	Total revenue \$ ha^{-1}	Benefit Cost Ratio
Black jaggery	28.77±01	168.47	3,134.6	4,597.42	1.46±0
Yellow sticky trap	32.57±1.31	186.41	3,152.33	5,203.9	1.65±0.06
Watermelon flesh	28.01±1.31	166.14	3,132.28	4,476.13	1.42±0.06
Blue sticky trap	31.81±1.31	186.41	3,152.33	5,082.61	1.61±0.06
Sugarcane molasses	31.05±3.94	182.51	3,148.47	4,961.31	1.57±0.2
Brewery waste	31.81±1.31	194.2	3,160.04	5,082.61	1.6±0.06
Citronella oil	32.57±1.31	209.79	3,175.45	5,203.9	1.63±0.06
Tap water	18.14±4.74	153.19	3,119.49	2,899.27	0.92±0.24

Note: Installment cost = Treatment Installment cost, total cost = Installment cost+ other cost, farm sell price of the watermelon was 0.16\$$kg^{-1}$

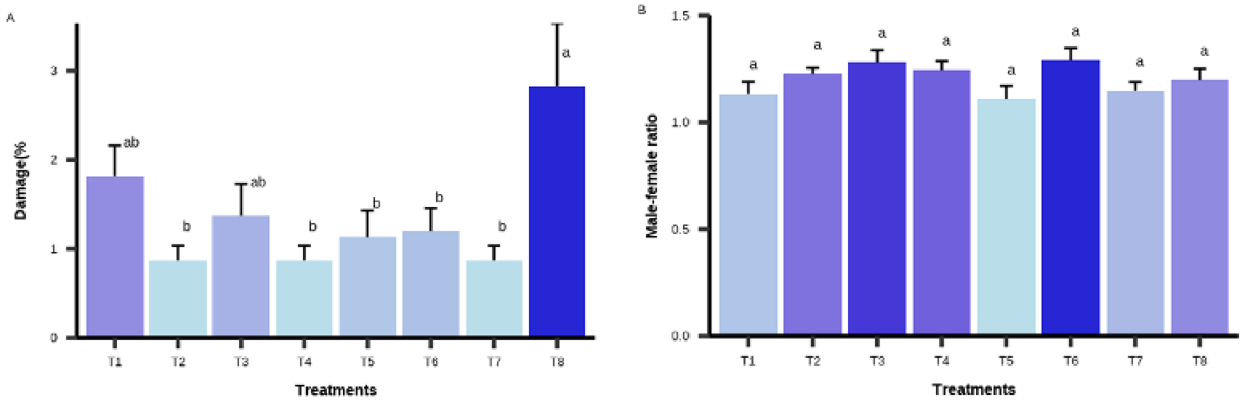


Figure 6. Male female ratio and fruit damage/ infestation percentage in various treatments in watermelon at Chitwan, April-June 2023

Conclusion

These findings reflect the result of the experiment carried out on the Saraswati F_1 hybrid variety of watermelon grown in the summer season of the subtropical region (Chitwan). Yellow sticky trap attracts the highest number of male and female fruit flies. The experiment documented seven different species of *Zeugodacus* and *Bactrocera* genera. *Z. cucurbitae* (Coquillett, 1899), followed by *Z. tau* (Walker, 1849), were dominant over the other five species i.e., *B. dorsalis* (Hendel, 1912), *B. scutellaris* (Bezzi, 1913), *B. correcta* (Bezzi, 1916), *B. zonata* (Saunders, 1842), and *Bactrocera nigrifacia* (Zhang, Ji, and Chen, 2011). In overall yellow sticky trap with cue lure and malathion would be efficient solution for fruit fly control.

Declarations

Authors' Contribution

Nawaraj Pandey: conceptualization, data curation, data visualization & analysis, and writing-original draft,

Priya Karna: data visualization & analysis, methodology preparation and language editing

Nabin Bhusal: Supervision, reviewing & editing and approved the final manuscript

Funding Source

This research was not funding by any authority

Availability of Data and Materials

Data will be made available upon reasonable request

Conflict of Interest

The author declares no conflicting interest.

Acknowledgments

Not needed

References

Adhikari, D., & Joshi, S. L. (2018). Occurrences and field identities of fruit flies in sweet orange (*Citrus sinensis*) orchards in Sindhuli, Nepal. *Journal of Natural History Museum*, *30*, 47–54. https://doi.org/10.3126/jnhm.v30i0.27511

D. Adhikari, S.L. Joshi, R.B. Thapa, V. Pandit, D.R. Sharma, Fruit fly management in Nepal: A case from plant clinic, *Journal of Biological Control 34* (2020) 8–14. https://doi.org/10.18311/jbc/2020/22833.

Akhtaruzzaman, M., Alam, M. Z., & Sardar, M. M. A. (2000). Efficacy of Different Bait Sprays for Suppressing Fruit Fly on Cucumber. *Bulletin of the Institute of Tropical Agriculture, Kyushu University*, *23*, 15–26. https://doi.org/10.11189/bita.23.15

Plant Health Australia, The Australian handbook for the identification of fruit flies version 3. 1. *Plant Health Australia. Canberra, ACT*., 2018.https://www.planthealthaustralia.com.au/wp-content/uploads/2018/10/The-Australian-Handbook-for-the-Identification-of-Fruit-Flies-v3.1.pdf.

Delpoux, C., & Deguine, J.-P. (2015). Implementing a Spinosad-Based Local Bait Station to Control *Bactrocera cucurbitae* (Diptera: Tephritidae) in High Rainfall Areas of Reunion Island. *Journal of Insect Science*, *15*(1), 11. https://doi.org/10.1093/jisesa/ieu177

Dhillon, M. K., Singh, R., Naresh, J. S., & Sharma, H. C. (2005). The melon fruit fly, Bactrocera cucurbitae: A review of its biology and management. *Journal of Insect Science*, *5*(1). https://doi.org/10.1093/jis/5.1.40

F. Díaz-Fleischer, J. Arredondo, S. Flores, P. Montoya, M. Aluja, there is no Magic Fruit Fly Trap: Multiple Biological Factors Influence the Response of Adult *Anastrepha ludens* and *Anastrepha obliqua* (Diptera: Tephritidae) Individuals to Multi Lure Traps Baited with Bio-lure or n-lure, *Journal of Economic Entomology 102* (2009) 86–94. https://doi.org/10.1603/029.102.0113.

Ganie, S. A., Khan, Z. H., Ahangar, R. A., Bhat, H. A., & Hussain, B. (2013). Population Dynamics, Distribution, and Species Diversity of Fruit Flies on Cucurbits in Kashmir Valley, India. *Journal of Insect Science*, *13*, 65. https://doi.org/10.1673/031.013.6501

Gomez, K. A., & Gomez, A. A. (1984). *Statistical Procedures for Agricultural Research* (Second). *John Wiley & Sons*. https://pdf.usaid.gov/pdf_docs/PNAAR208.pdf

Gopaul, S., & Price, N. S. (2001). Local Production of Protein Bait for Use in Fruit Fly Monitoring and Control. *Food and agricultural research council*, 117. https://citeseerx.ist.psu.edu/document?repid=rep1&type=pdf&doi=f0ca8c057af2337f57f9576f31d9779061769482#page=144

Gupta, A., & Regmi, R. (2022). Efficacy of Different Homemade and Commercial Baits in Monitoring of Fruit Flies at Maranthana, Pyuthan, Nepal. *Malaysian Journal of Sustainable Agriculture*, 101–109. https://doi.org/10.26480/mjsa.02.2022.101.109

Hamza, M. A., Ishtiaq, M., Mehmood, M. A., Majid, M. A., Gohar, M., Radicetti, E., Mancinelli, R., Iqbal, N., & Civolani, S. (2023). Management of Vegetable Leaf Miner, *Liriomyza Spp*., (Diptera: Agromyzidae) in Vegetable Crops. *Horticulturae*, *9*(2), Article 2. https://doi.org/10.3390/horticulturae9020255

Leblanc, L., Hossain, M. A., Momen, M., & Seheli, K. (2021). New Country Records, Annotated Checklist and Key to the Dacine Fruit Flies (Diptera: Tephritidae: Dacinae: Dacini) of Bangladesh. *Insecta Mundi*, *2021*(880), 1–56. https://doi.org/10.5281/zenodo.5352282

Z. Li, Mr.Y. Zhang, Morphological Identification of Economically Important Fruit Flies, (2019).https://assets.ippc.int/static/media/files/publication/en/2020/01/20191217_ZhihongLi_Morphological_Identification_of_Economically_Important_Fruit_Flies_isYIE8L.pdf.

Lu, Y., Bei, Y., & Zhang, J. (2012). Are Yellow Sticky Traps an Effective Method for Control of Sweet Potato Whitefly, *Bemisia tabaci* , in the Greenhouse or Field? *Journal of Insect Science*, *12*(113), 1–12. https://doi.org/10.1673/031.012.11301

F.B. Masika, T. Alicai, H. Shimelis, G. Ddamulira, S.Y. Athman, P. Ipulet, M. Andama, A.K. Tugume, Pumpkin and Watermelon Production Constraints and Management Practices In Uganda, *CABI Agric Biosci 3* (2022) 39. https://doi.org/10.1186/s43170-022-00101-x..

Nair, N., Chatterjee, M., Das, K., Sehgal, M., & Malik, M. (2021). Fruit Fly Species Complex Infesting Cucurbits in India and Their Management. *International Journal of Agriculture, Environment and Sustainability*, *3*(2), Article 2. https://www.medicaljournalshouse.com/index.php/Int-J-Agriculture-Environment/article/view/760

Okrikata, E., & Ogunwolu, E. O. (2019). Determination of the Critical Period of Cyper-diforceÂ® Treatment Against Arthropod Fauna and Productivity of Watermelon. *Iraqi Journal of Science*, 1904–1919. https://doi.org/10.24996/ijs.2019.60.9.3

Okrikata, E., Ogunwolu, E. O., & Odiaka, N. I. (2021). Modelling the Impact of Key Pests of Watermelon on its Performance Using Linear Regression Models. *Walailak Journal of Science and Technology (WJST)*, *18*(7), Article 7. https://doi.org/10.48048/wjst.2021.9052

Ostertagová, E., Ostertag, O., & Kováč, J. (2014). Methodology and Application of the Kruskal-Wallis Test. *Applied Mechanics and Materials*, *611*, 115–120. https://doi.org/10.4028/www.scientific.net/AMM.611.115

Patil, I. (2021). Visualizations with statistical details: The'ggstatsplot'approach. *Journal of Open Source Software*, *6*(61), 3167. https://doi.org/10.21105/joss.03167

Piñero, J. C., Souder, S. K., & Vargas, R. I. (2020). Synergistic and Additive Interactions Among Components of Food-based Baits Underlie Female Fruit Fly Attraction. *Entomologia Experimentalis et Applicata*, *168*(4), 339–348. https://doi.org/10.1111/eea.12890

R Core Team. (2022). *R*: A Language and Environment for Statistical Computing*, R foundation for statistical computing, Vienna, Austria*. https://www.R-Project.org/

P. Ryckewaert, J.-P. Deguine, T. Brévault, J.-F. Vayssières, Fruit flies (Diptera: Tephritidae) on Vegetable Crops in Reunion Island (Indian Ocean): State of Knowledge, Control+ Methods and Prospects for Management, Fruits *65* (2010) 113–130. https://doi.org/10.1051/fruits/20010006.

Said, A. E., Fatahuddin, Asman, & Nasruddin, A. (2017). Effect of Sticky Trap Color and Height on the Capture of Adult Oriental Fruit Fly, *Bactrocera dorsalis* (Hendel) (Diptera: Tephritidae) on Chili Pepper. *American Journal of Agricultural and Biological Sciences*, *12*(1), 13–17. https://doi.org/10.3844/ajabssp.2017.13.17

R. Sapkota, K.C. Dahal, R.B. Thapa, Damage Assessment and Management of Cucurbit Fruit Flies in Spring-Summer Squash, *Journal of Entomology and Nematology 2* (2010) 7–12. https://academicjournals.org/journal/JEN/article-full-text-pdf/702B71610088.

Schmidt-Jeffris, R. A., Coffey, J. L., Miller, G., & Farfan, M. A. (2021). Residual Activity of Acaricides for Controlling Spider Mites in Watermelon and Their Impacts on Resident Predatory Mites. *Journal of Economic Entomology*, *114*(2), 818–827. https://doi.org/10.1093/jee/toaa320

Shrefler, J., Brandenberger, L., Rebek, E., Damicone, J., & Taylor, M. (2015). Watermelon Production. *Oklahoma Cooperative Extension, Oklahoma State University, Oklahoma, United States of America, Fact Sheets, HLA-6236*.https://pods.okstate.edu/fact-sheets/HLA-6236pod2015.pdf

Singh, S., & Singh, A. K. (2018). Skewed Distribution of Melon Fruit Flies, *Bactrocera cucurbitae* (Coquillett) Owing to Color Preference. *Indian Journal of Scientific Research*, *8*(2), 1–4. https://shorturl.at/bpqO9

Singh, S., Yadav, N., & Singh, A. (2019). *Sexually Dimorphic Morphological Traits in Melon Fruit Fly, Bactrocera cucurbitae (Diptera: Tephritidae)*. *5*, 1–6. https://doi.org/10.5281/zenodo.2553615

Sulaeha, S., Bahtiar, A. H., & Melina, M. (2020). Identification Fruit Fly Species Associated with Watermelon Plants (Citrullus lanatus (Thunb.) Matsum. & Nakai) in South of Sulawesi, Indonesia. *IOP Conference Series: Earth and Environmental Science*, *486*(1), 012161. https://doi.org/10.1088/1755-1315/486/1/012161

Tan, K. H., Nishida, R., Jang, E. B., & Shelly, T. E. (2014). Pheromones, Male Lures, and Trapping of Tephritid Fruit Flies. In T. Shelly, N. Epsky, E. B. Jang, J. Reyes-Flores, & R. Vargas (Eds.), Trapping and the Detection, Control, and Regulation of Tephritid Fruit Flies: Lures, Area-Wide Programs, and Trade Implications (pp. 15–74). *Springer Netherlands*. https://doi.org/10.1007/978-94-017-9193-9_2

Umeh, V. C., & Garcia, L. E. (2008). Monitoring and Managing *Ceratitis spp*. Complex of Sweet Orange Varieties Using Locally Made Protein Bait of Brewery Waste. *Fruits*, *63*(4), 209–217. https://doi.org/10.1051/fruits:2008014

Vargas, R. I., Shelly, T. E., Leblanc, L., & Piñero, J. C. (2010). Chapter Twenty-Three—Recent Advances in Methyl Eugenol and Cue-Lure Technologies for Fruit Fly Detection, Monitoring, and Control in Hawaii. In G. Litwack (Ed.), *Vitamins & Hormones* (Vol. 83, pp. 575–595). Academic Press. https://doi.org/10.1016/S0083-6729(10)83023-7

Whitfield, A. E., Ullman, D. E., & German, T. L. (2005). Tospovirus-Thrips Interactions. *Annual Review of Phytopathology*, *43*(1), 459–489. https://doi.org/10.1146/annurev.phyto.43.040204.140017

Wolda, H., & Marek, J. (1994). Measuring Variation in Abundance, the Problem with Zeros. *Eur. J. Entomol.*, *91*(2), 145–161. https://www.eje.cz/pdfs/eje/1994/02/01.pdf