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EVALUATING THE EFFICIENCY OF FOOD-BASED MASS TRAPPING AGAINST THE OLIVE FRUIT FLY (BACTROCERA OLEAE) IN PALESTINE

Haroon Alataweneh[1*], Rasha Najajra[2], Wesam Atawneh[3], Yousef Salah[5], Abd-Jalil Hamdan[3], Hatem sharabati4, Mohammad Alqurneh[5]

[1]Palestine Technical University - khadoorie, Faculty of Agricultural Engineering, Horticulture and Agricultural Extension Dept., Palestine.
[2]Agricultural Development Association – PARC- Ramallah, Palestine.
[3]Hebron University, Plant Production and Protection Dept., Hebron, Palestine.
[4]HAS University of Applied Sciences, Horticulture and Business Management Dept., Netherlands.
[5]Ministry of Agriculture, Plant Protection Dept., Ramallah, Palestine.

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Corresponding Author: Haroon Alataweneh
(haroon.atawneh@ptuk.edu.ps)

ABSTRACT

The olive fruit fly, Bactrocera oleae (Rossi), is the primary pest threatening olive production in Palestine and the Mediterranean basin. While the current method of controlling the pest is through the application of chemicals, the latter's impact on the quality and health aspects, as well as environmental issues, triggers the need for the development and application of eco-friendly alternatives. This study evaluates the performance of food-based traps for monitoring and population suppression (Bio-traps) compared to standard yellow sticky traps across four Palestinian governorates (Salfit, Ramallah, Bethlehem, and Hebron) from June to December 2024. A considerably greater number of adult flies were taken by bio-, rather than by yellow sticky traps (mean 5.7 ± 0.47 per trap and 2.5 ± 0.39 per trap, respectively; p<0.0001). There was a marked male dominance in the sex ratio in both types of traps. A geographical analysis indicated that there was high heterogeneity of pest densities with lower-altitude habitat like Salfit having the highest capture rates. These findings confirm that the bio trap is a mass-trapping design that will minimize the use of chemical pesticides in Palestine and maintain a healthy ecosystem free from pesticide residues.

KEYWORDS: Bactrocera oleae, mass-trapping, Bio-trap, yeast volatiles, IPM.

1. INTRODUCTION

The major approach in controlling pests is through the use of chemical pesticides. Annually, worldwide, about 2 million tons of pesticides are used (Sharma et al. 2019). The use of pesticides is widespread in current agricultural systems due to its cost-effectiveness and efficiency in improving the quality and quantity of products through the protection of crops against various types of pests. This has contributed to meeting the global food demands of the ever-increasing population. However, the regular use of pesticides has negative impacts on non-target species, human health, foods, groundwater, surface water, soil, and the environment in general (Hussain & Tahir 2022; Shekhar et al. 2024). In the agricultural industry, the improper use of insecticides has significant socio-economic and environmental hazards (Dungani et al. 2018). This has economic costs to farmers. It also interferes with the normal control of pests in nature through the destruction of indigenous predators. This has led to the development of resistance in many pest species. The olive fruit fly is one of the major pest species that has become resistant to pesticides (Skouras et al. 2007).

The olive fruit fly, B. oleae (Rossi) (Diptera: Tephritidae), is one of the major pests of olive trees (Olea europaea L.) in the Mediterranean region and Palestine (Hamdan 2016). The harm brought about by the olive fruit fly can be severe, with losses potentially reaching up to 70% without control measures being implemented (Hamdan & Alqurneh 2017). The economic damage is incurred through reduced yield due to aborted fruits, reduced fruit weight due to larval feeding, as well as reduced quality of olives due to the fly infestation that makes them unfit for consumption as table olives (Malheiro et al. 2015). Currently, in Palestine, growers use broad-spectrum insecticides belonging to the organophosphates class applied either as baits and cover crops. This has resulted in excessive pesticide residues being found in both olives and olive oil in Palestine, posing considerable economic losses to growers (Manousis & Moore 1987; Tabic et al. 2011). In olive fruit fly-infested countries in the Mediterranean region, major efforts have been made, especially in the last two decades, to find new approaches to control the olive fruit fly, aiming to eliminate the use of toxic insecticides. These approaches include mass trapping, biological control, and the Sterile Insect Technique (SIT) (Balampekou et al. 2024).

Mass trapping has now become one of the common methodologies for pest management; it has proved to be effective against Lepidoptera and Diptera-which includes flies (El-Sayed et al. 2006; Ortis et al. 2025). These strategies work based on attracting pest insects to traps from which they can be removed from the general pest population. This can be achieved by retaining insects within the trap (mass trapping) or using toxic substances (lure-and-kill) (Tephritidae et al. 2025; Yasin et al. 2014). While mass trapping is often advocated as a environmentally friendly method of controlling pests as opposed to using pesticides, its effectiveness is largely dependent on factors such as the size of the area treated, landscape, and immigration of adult pests from other neighboring orchards that have not been treated. The basic purpose behind applying the mass trapping approach is to ensure that there is a substantial reduction in the population of the pest within the agricultural ecosystem in order to reduce crop damage. (Nestel et al. 2004; Yasin et al. 2014).

Olive (O. europaea L.) is considered one of the most important fruit species in Palestine. Olive cultivation covers about 940 million square meters of land area and is of great economic significance in Palestine for the production of foodstuffs, soap, and handicrafts (MOA & PCBS, 2021). The olive sector is responsible for about 15% of the total agricultural revenues in Palestine; it provides about 3-4 million job days per year for about 100,000 families (Ministry of Agriculture, 2014). Despite its economic and social importance in Palestine, olive farming faces a number of challenges such as land fragmentation, high pesticide usage rates, as well as infestation by olive fruit flies. Of these pests, the olive fruit fly (B. oleae) remains the most harmful to olive trees, as it contributes to significant fruit damage as well as a decrease in olive product quality (Hamdan & Alqurneh, 2017). Based on the above challenges faced by olive cultivation in Palestine, the main objective of this study is to assess the effectiveness of a food-based bio-trap in comparison with chromatic traps for the capture of olive fruit fly adults in different parts of Palestine.

2. MATERIAL AND METHODS

2.1. Targeted area

This research was conducted in four governorates (Salfit, Ramallah, Bethlehem, and Hebron; Table. 1) in the West Bank, Palestine. The experiment was conducted from 1st June to 1st December 2024. There were five olive farm sites selected, including the site in Beit Kahel in Hebron, the site in Berzit in Ramallah, the site in Salfit in Salfit, and two sites in Bethlehem named Al-khader and Beit Jala farms. These targeted olive farms were selected after their owners had accepted the voluntary conduct of the experiment. Baladi olive cultivar was grown in four sites except the Beit Khahel, which is grown with Baladi and Nabali Mahasan cultivars. The trees are older than 100 years. In each olive farm, three dunums were targeted. One dunum was targeted by the Bio trap, the second was targeted by the sticky yellow trap, and the third maintained as an untreated control.

Table 1: Geographical coordinates and altitudes of selected locations in West Bank

Site	Governorate	Latitude	longitude	Altitude
Beit Kahil	Hebron	31°34'46.68"N	35° 2'56.37"E	665m
Beit Jala	Bethlehem	31°42'32.01"N	35°10'59.43"E	815m
Al-khader	Bethlehem	31°41'45.44"N	35°10'30.79"E	831m
Berzeit	Ramallah	31°58'31.79"N	35°11'25.83"E	702m
Salfit	Salfit	32° 5'29.45"N	35°11'3.12"E	520m

2.2. Fly traps preparation

The bio trap NO MED FLY was made from a yellow plastic bottle containing approximately 2 liters, containing a food-attractant lure composed of 34 g inactive yeast (88%) and 12% sodium borate. The bottle was filled with water up to the designated line according to the manufacturer's instructions (Fig.1). The second trap type, the yellow sticky trap (15 × 20 cm) was coated with adhesive material to capture adult insects (Fig.1). Both trap types were supplied by Shariati Company, Hebron, Palestine.

Figure 1. Types of traps used in the experiment. The trap on the right is a bio-trap (NO MED FLY) baited with a food-based attractant consisting of inactive yeast (34 g; 88%) mixed with 12% sodium borate. The trap on the left is a standard sticky yellow trap.

2.3. Experiment design

For the first method of treatment, the ten bio-traps were placed randomly in a one dunam area (0.1 ha). The height of the traps was 1.5 meters on the eastern side of the tree trunk. The traps were filled with water, and as the experiment progressed, we added water to the traps to compensate for evaporation, ranging between 200-300 ml of water. The traps remained in the same position till the end of the experiment.

In addition to this first treatment, ten yellow sticky traps were randomly distributed in another plot of one dunam (0.1 ha), in a similar to the pattern of the bio-trap placement. They were positioned at a height of 1.5 m on the eastern side of the trees. Unlike the bio traps, however, the yellow sticky traps were replaced with new ones at each inspection visit throughout the experimental period. The traps were labeled using the first letters of the city, site, trap type, and trap number for proper identification. The traps were checked every two weeks, the numbers of female and male olive fruit flies were recorded and counted, and captured insects were removed using a specially designed homemade long-handled spoon.

2.4. Fruit infestation rate

In September 2024, a total of 100 olive fruits were randomly collected from each three of the treated trees from each treatment (bio trap, sticky yellow trap, and control). The collected fruits were examined using the dissecting microscopic to detect infection holes caused by B. oleae larvae. The infestation rate of the olive fruit fly was calculated based on the following equation:

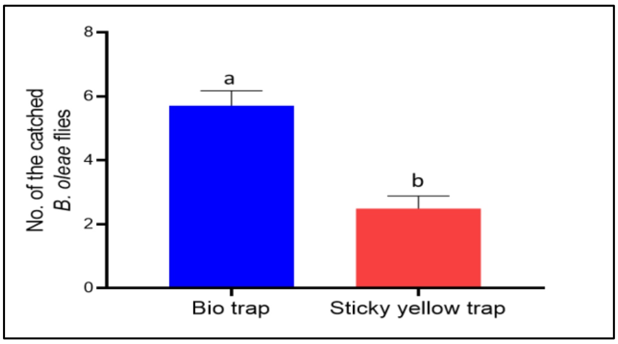
$$\text{Infestation rate [\%]} = \frac{\text{Number of infected fruits}}{\text{Total number of the examined fruits}} \times 100$$

2.5. Statistical analysis

GraphPad Prism 8.0.1 version (GraphPad Software, La Jolla, CA, USA) was used to carry out the statistical analyses. The statistical significance was established when the $p \leq 0.05$. The Kolmogorov-Smirnov test was used to test the normality of the data. An unpaired, two tailed, Student's t -test was used to determine the differences between traps, while the non-parametric Kruskal -Wallis rank-sum test was used to determine the differences in trapping flies across sites to which Dunn's multiple-comparison procedure was applied. Geographical coordinates and altitudes of selected locations were obtained from Google Earth Pro 7.3. (October 5, 2024).

3. RESULTS

The study was conducted during the 2024 olive production season. Results obtained indicate that the bio-trap was able to capture a significantly higher number of fruit flies compared to the yellow sticky trap (unpaired Student's t-test, $t = 5.270$, $df = 1497$, $p < 0.0001$; Fig. 2). The mean ± standard error captures were 5.7 ± 0.47 flies per trap for bio-trap and 2.5 ± 0.39 flies per trap for yellow sticky trap (Fig. 2), which reflected a two-fold improvement in capture efficiency for bio-trap.



Figur 2. Comparison of olive fruit fly captures at the trap level.

Bio trap captured flies two times more than sticky yellow traps. Column rep. mean ± SE, n= entire dataset, Bio trap 760 reads, Sticky yellow trap= 739 reads. The difference between two traps were highly significant (unpiared Student's T. test, p value <0.0001).

Also, the proportion of males trapped was higher than the proportion of females in both traps. Bio-traps trapped about four times as many males as females (unpaired Student's t-test, t = 6.984, df = 758, p < 0.0001). Additionally, yellow sticky traps trapped about twice as many males as females (unpaired Student's t-test, t = 3.452, df = 737, p = 0.0006; See in Table 2).

Table 2. Mean (± SE) captures of B. oleae by sex and trap type

Trap Type	Males (Mean ± SE)	Females (Mean ± SE)	Total Captures (Mean)
Bio-trap	8.9 ± 0.9^{a}	2.6 ± 0.2^{b}	**5.7**
Sticky Yellow	3.8 ± 0.7^{a}	1.1 ± 0.2^{b}	**2.5**

Different letters within the same row indicate significant differences between male and female captures for each trap type (unpaired Student's t-test, p < 0.05; n = 380 observations).

In respect to geographical distribution, the median trap catch of the captured B. oleae individuals in bio-traps varied significantly among the different sites. The Beit Kahil-Hebron site had the highest median trap catch of 11 individuals per trap, followed by the Salfit site with a median trap catch of 9.5 individuals per trap, and these two values were significantly higher than the median trap catch at the Beit Jala, Al-Khader, and Birzeit sites, which were 4, 2, and 4 individuals per trap, respectively.

By contrast, the number of captures in yellow sticky traps differed among sites, with four sites having a significantly greater number of captures than Birzeit, although the number of captures was generally low at all sites. The Kruskal-Wallis rank sum test, together with the Dunn's multiple comparison test, showed highly significant geographic variability among sites (p < 0.0001, Fig. 3).

On the other hand, there were no significant differences found regarding the infestation of olive fruit by the bio-trap, yellow sticky trap, and control (Kruskal-Wallis test, p = 0.813). The median value of infestation was 39% (range: 2-90) for the bio-trap treatment, 39% (range: 12-60) for the yellow sticky trap treatment, and 38% (range: 15-60) for the control (n = 15 replicates).

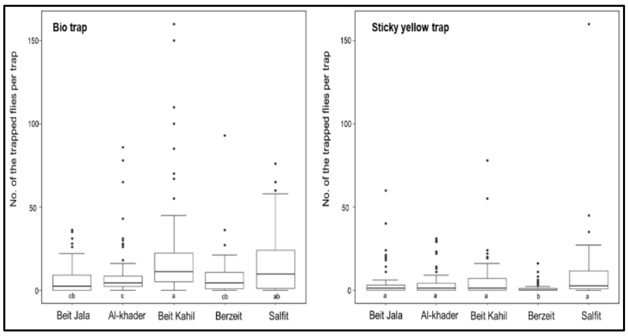


Figure 3. Number of captured flies per trap at the regional distribution. The column represents the mean (± SE) number of olive fruit flies captured per trap in different locations. One-way ANOVA test followed by Tukey's multiple comparisons test, p value <0.0001, n = 40 - 100 observations.

4. DISCUSSION

The findings show that bio-traps proved more effective in capturing the olive fruit fly compared to the yellow sticky traps, thus validating the attraction efficiency of food traps towards the flies. These results can be explained by the composition of the bait used in the biological traps, which consists of inactive yeast and sodium borates (Bego et al. 2021; Vitanović et al. 2020). The two ingredients are known for their attractiveness towards insects, especially Diptera, attributed to the production of odor volatiles during the fermentation process (Psoma et al. 2023). On the other hand, the attraction in the sticky traps is solely dependent on the yellow color. Which may be less effective under certain environmental conditions. The effectiveness of the bio-trap over the entire experimental duration without the need for replacement might have been a factor in its superior performance, ensuring continuous attraction. The implication of these results is that there is potential use of bio-traps not only as a monitoring device but also in IPM strategies, especially when the use of chemical pesticides is preferred to be avoided or reduced.

Moreover, the data suggest that the proportion of male olive fruit flies captured using bio-traps and yellow sticky traps was significantly higher than that of female olive fruit flies. This is not surprising, given that it is consistent with the results of previous studies on the population dynamics and efficiency of olive fruit fly capture (Haniotakis, 1998; Phytopathologia Mediterranea). There are a number of reasons that might explain the observed difference between the capture of male and female olive fruit flies. First, it is not uncommon for the behavioral responses of male insects, which are driven by visual and chemical cues from food-based or color attractants, to be more pronounced, thereby making them more susceptible to trap capture than female insects (Mazomenos & Haniotakis, 1985). Second, it is expected that the increased activities of male olive fruit flies in mate location and canopy patrol would make them more vulnerable to trap capture than female olive fruit flies, which might spend more time locating oviposition sites or staying within the olive fruits (Mazomenos & Haniotakis, 1985). Third, it has been noted that female flies could become less responsive to food-based attractants when oviposition activity starts because their behavioural priorities began to shift towards fruit localisation and not protein-acquiring (Villamil et al. 2013).

The dominance of males in trap catches has important implications in pest control measures. While a reduction in the number of males in a population might help in limiting mating, a high number of males in trap catches would not be sufficient to limit fruit infestations. In fact, a lack of significant differences in fruit infestations among treatments in this study shows that even with high adult captures, mainly males, females were able to oviposit in sufficient numbers to cause significant fruit damage. The effectiveness of mass trapping in reducing infestations, therefore, would have to be considered in a wider area-wide control measure. In this aspect, mass trapping would have to be considered in a complementary manner with other control measures aimed at females, such as attract-and-kill techniques, protein bait sprays, or biological control agents, to make significant inroads in reducing infestations (Yokoyama 2014).

There were large differences between the number of adult B. oleae trapped among the different locations. Salfit and Beit Kahil had significantly higher entrapment levels compared to the other locations. This can be related to differences among locations related to altitude. Salfit and Beit Kahil are at comparatively low altitudes compared to the other locations (Table 1), which may contribute to increased olive fruit fly activity and density (Sentas et al. 2025). Another reason for entrapment differences may be related to cultivars. In Beit Kahil, mainly Baladi and Nabali Mushan olive tree cultivars are found. The Nabali Mushan cultivar has larger olives and a softer pericarp compared to other cultivars. This may make it vulnerable to or attractive for B. oleae, which may be related to the high number of adult entrapments found at this location (Hamdan 2016).

In summary, the current study proves the efficiency of food-based bio-traps in monitoring and control the adult populations of the olive fruit fly in the field conditions existing in Palestine. On the other hand, the restricted effect of food-based bio-traps on the infestation of fruits on a small geographical scale highlights the need for area-wide implementation of these traps along with other control methods.

5. CONCLUSION

Food bio-traps showed a higher effectiveness over the yellow sticky traps in capturing adult B. oleae in the Palestinian field conditions, thus validating their effectiveness as a monitoring and control tool. However, the absence of significant declines in fruit infestation indicates the limited effectiveness of small-scale mass trapping techniques in the fragmented olive ecosystem under high immigration pressure. These results imply that bio-traps cannot be used as an effective method for olive fruit fly control when used alone, but rather can be used in an IPM approach that focuses on the elimination of female olive fruit fly. This research provides field-based evidence that can aid in the management of olive fruit fly using food traps in Palestine.

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