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Bionomics of Olive Fruit Fly, *Bactrocera oleae* (Rossi) [Diptera: Tephritidae] Infesting Ten Olive Cultivars in the Southern Highlands of West-Bank, Palestine

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Abstract

Olive fruit fly, *Bactrocera oleae* (Rossi) is the most dangerous pest that affected olive trees (*Olea europaea* L.) in the Mediterranean basin including Palestine. This study was conducted in Al-Arroub Agricultural Experimental Station in Palestine during 2012-2013, to monitor the seasonal flight activity and population dynamics of the *B. oleae* using ten olive cultivars in the southern highlands of West-Bank. Throughout this research, it was clear that *B. oleae* had two annual peaks of flight activity, and those peaks were respectively recorded on August and October in 2012 season but on April and September in 2013 season. This research also confirmed that, significant differences in % of olive fruit fly infestation were recorded between the olive cultivars, and thus, olive cultivars with larger fruits were higher in susceptibility to *B. oleae* infestation rather than that with smaller fruits. In addition, present study proved that the phenomena of biennial yield alteration of olive is inversely related with fruit infestation, and the high fruit production in 2012 was accompanied with lower rate of infestation in comparison to high rate of infestation that recorded accompanied to the low fruit production yield in 2013.

Keywords: *Bactrocera oleae*; Monitoring Flight Activity; Olive Cultivars; Population Dynamics.

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1. Introduction

Olive tree is one of the most important fruit trees in Palestine. Up to 2011, the number of olive trees in Palestine reached 1,097,400 cultivated in an area of 60,000 hectares that constitute about 85% of the total area planted to fruit trees in Palestine [1].

The olive fruit fly, *Bactrocera oleae* (Rossi) (Diptera: Tephritidae), is a serious pest affecting olive groves (*Olea europaea*, Linneus) in the Mediterranean basin. It was primarily known from the Mediterranean area of southern Europe; and is also found in North Africa; the Middle East, and along the east coast of South Africa [2].

In Arab countries including Palestine, olive fruit flies have become a serious pest. In almost countries of the Mediterranean region, the olive fruit fly has 4-5 generations yearly depending on local conditions [3, 4].The first generation appears as early as June, which coincides with pit hardening; the second generation appears in August; and, the additional generations of flies are produced during the late summer and fall months into December depending on fruit availability [4, 5]. And if *B. oleae* was not controlled, it may cause crop losses up to 80% in the oil producing areas and 100% in areas growing table olive varieties [6].

Several studies were published about the biology, ecology, and management of the olive fruit fly; however, few address responses to visual cues. One of these studies, conducted author [7] showed that among sticky-coated rectangles of different colours, the yellow ones were the most attractive and efficient in monitoring *B. oleae*.

The present study aimed to monitor the flight activity of olive fruit fly using yellow sticky coated rectangular traps and to record its population dynamics on 10 olive cultivars planted in the olive grove of Al-Arroub agricultural experimental station in the southern highlands of West-Bank, Palestine.

2. Materials and Methods

Present study was conducted in an olive grove about 50 years old in Al-Arroub agricultural experimental station. This olive groove includes four terraced blocks, planted with 10 olive cultivars including: Balady; Carmelat; Grosya-Deponia; Manzanilo; Nabaly –Balady; Nabaly-Mohasen; Nasohi-Gaba; Sevelano; Tell; and Telmesane;

The main objectives of this research were: to monitor the seasonal flight activity of the B. oleae and, to record the rate of fruit infestation by B. oleae on the 10 different olive cultivars in the southern highlands of Palestine.

Hence, its well known in Palestine that olive production have a biennial production cycle composed of one golden production year (Massi Year) followed by low production year (Shaltoni Year), therefore, present study conducted throughout two successive growing seasons, 2012 & 2013.

2.1. Recording the seasonal flight activity of olive fruit fly in the southern highlands of Palestine during 2012 +2013 seasons

To monitor the flight activity of olive fruit fly, an experiment was carried out in the olive grove from 1st July 2012 - 30th October 2013. Four traps were used, each constituted yellow colored sticky rectangular poster-broads 15*25 cm dimension (Fig. 1). One side of the board was painted with adhesive (sticky) paste, which is Rinifoot® (Polisobutene 80%). Traps were hanged on randomly selected trees (one in each block in the olive grove) at a height of 1 to 2 m. The sticky board were weekly monitored, exchanged, and took back to the laboratory where, the captured olive fruit flies were counted and sexed under binocular microscope.

Figure 1: Yellow colored sticky trap

2.2. Recording the population dynamics of olive fruit fly infesting 10 olive cultivars in during 2012 + 2013 seasons

To record the population dynamics of olive fruit fly infesting olive trees in the southern highlands of West-Bank, three olive trees from each cultivar in the olive grove of the Al-arroub agricultural experimental station were observed.

Rate of fruit fly infestation was recorded every 10-15 days throughout the two successive seasons from 19th July to 30th September 2012 and, from 20th August to 10th October 2013. At each check (date of monitoring) a total of one hundred fruits were randomly collected from the three trees that were randomly selected from each cultivar, and were taken back to the laboratory for detection of fruit infestation.

3. Results

3.1. Seasonal flight activity of olive fruit flies in the southern highlands of West-Bank, Palestine during 2012 + 2013 seasons

The results in (Fig 2) show the flight activity of B. oleae in the southern highlands of Palestine throughout two successive seasons (2012 + 2013). Results obtained during 2012 showed that flight activity of *B. oleae* in Al-

arroub agricultural experimental station, started in early July, and, continued its activity throughout the season till the late of November. However, during 2013, the flight activity started earlier at the beginning of March, and continued its activity throughout the season up to late October.

Results also show that, two peaks of flight activity of *B. oleae* were annually recorded in the olive grove throughout the two successive years (2012 & 2013). In 2012 season, the 1st peak of flies captured (1.67 flies/trap) was recorded in August, and the 2nd peak (6.33 flies/trap) in October, however, in 2013 season, 1st peak of flies captured (10 flies/trap) was recorded early in April and 2nd peak (14.67 flies/trap) in September.

Furthermore, results show that, duration period of flight activity was for 5 months (July – November) in 2012 season but extended up to 8 months (April – November) in 2013 season.

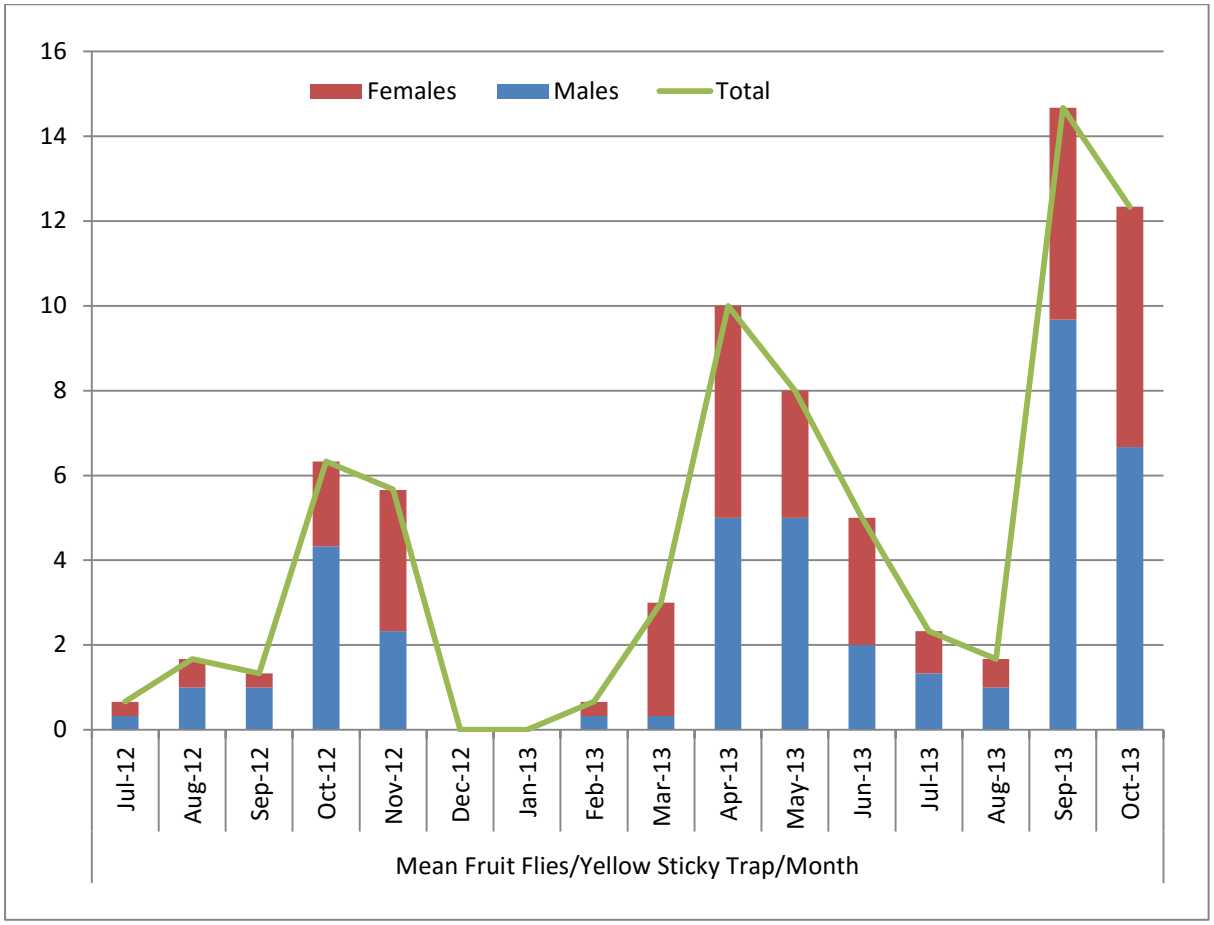

Figure 2: Seasonal flight activity of olive fruit flies in Al-Arroub Agricultural Experimental Station during 201 + 2013 seasons

3.2. Population dynamics of olive fruit fly infestation on 10 olive cultivars

Results presented in Table (1) show the percentage of olive fruit fly infestation recorded on 10 olive cultivars throughout 2012 & 2013 seasons. Throughout all observations during the two successive years of study, significant differences in % of olive fruit fly infestation were recorded between the olive cultivars.

Table 1: Mean* % of olive fruits infested by *B. oleae* during 2012 & 2013 seasons

Olive Cultivars	19-07-12	05-08-12	16-08-12	02-09-12	19-09-12	30-09-12	20-08-13	09-09-13	10-10-13
Balady	0c	36.67b	36.67b	16.67c	33.33b	5.25c	34.44b	100a	79.84ab
Carmelatan	58.57a	66.67b	81.94a	65.61b	68.33a	83.33a	31.19b	96.67a	100a
Grosya-Deponia	66.22a	100a	93.33a	100a	100a	100a	85.71a	100a	100a
Manzanilo	1.59c	20.63	24.52b	31.11bc	44.44b	43.49b	15.22b	50c	49.37b
Nabaly-Balady	55.27a	25bc	26.51b	41.67b	33.97b	35.42b	17.32b	78.89ab	74.44ab
Nabaly-Mohasen	57.3a	54.72b	61.11a	41.11b	100a	100a	64.44a	82.23a	92.06a
Nasohi-Gaba	0c	0c	2.22c	0c	0c	3.3c	0b	70.56b	79.52a
Sevilano	19.24b	97.78a	14.82bc	33.33bc	72.22a	75.56a	11.11b	100a	100a
Tell	26.84b	10c	16.67bc	6.67c	0c	7.71c	5.56b	67.9bc	23.06c
Telmisani	0c	6.67c	0c	0c	28.33b	37.5b	0b	94.44a	83.98a
P value	0.001	0.001	0.003	0.018	0.001	0.001	0.001	0.001	0.001

**: Means within the same column with different letters differ significantly at P value ≤0.05 (Using Fisher's pairwise comparisons)*

In 2012 season, start of *B. oleae* infestation recorded on 19th July was significantly high on: Grosya-Deponia (66.22%), Carmelatan (58.57%), Nabaly-Mohasen (57.3%), and Nabaly-Balady (55.27%); medium on: Tell (26.4%) and Sevilano (19.2%); and no infestation were recorded on Balady, Nasohi-Gaba and Tell cultivars.

However, in 2013 season, start of *B. oleae* infestation recorded on 20th August was significantly high on: Grosya-Deponia (85.71%), Nabaly-Mohasen (64.44%); medium on: Balady (34.44%), Carmelatan (31.19%), Nabaly-Balady (17.32%); Manzanilo (15.22%) and Sevilano (11.11%), Tell (5.56%), and no infestation were recorded on Nasohi-Gaba and Telmisani cultivars.

Furthermore, results recorded at the end of each growing season, just before harvesting show that, in 2012, according to % infestation recorded on 30th September on olive cultivars, olive cultivars can be categorized in three levels of B. oleae infestation: high susceptible cultivars included Grosya-Deponia (100%), Nabaly-Mohasen (100%), Carmelatan (83.33%) and Sevilano (75.5%); Medium susceptible cultivars included Manzanilo (44.44%), Telmisani (37.5%) and Nabaly-Balady (35.42%); and low susceptible cultivars included Tell (7.71%), Balady (5.25) and Nasohi-Gaba (3.3%)

However, in 2013 season, % of *B. oleae* infestation recorded on 10th October was higher in almost olive cultivars compared with 2012 season, and changes occurred in level of susceptibility to fruit fly infestation of some cultivars and categorization according to % infestation was as follow: high susceptible cultivars included Grosya-Deponia (100%), Carmelatan (100%) Sevilano (100%); Nabaly-Mohasen (92.06%) and Telmisani (83.98%), Nasohi-Gaba (79.52%); Medium susceptible cultivars included and Balady (79.84%), Nabaly-Balady (74.44%) and Manzanilo (49.37%); and low susceptible cultivars included Tell (23.06%).

In addition, further statistical analysis of the data collected using Two Sample T-Test (Table 2) show that, no significant difference was recorded between the average rate of infestation at the beginning of either 2012 (27.5%) or 2013 seasons (26.5%) . Meanwhile, significant differences were recorded between the rate *B. oleae* infestations on olive grove recorded on 10th October 2013 vs 30th September 2012 at P value of 0.0027. Thus, average rate of olive fruit fly infestation recorded on 10th October 2013 (78.2%), just before harvesting of 2013 season was significantly higher than that recorded on 30th September 2012 (48.8%), just before harvesting in 2012 season.

Table 2: Average % (Mean ± SE*) of olive fruits infested by *B. oleae* in Al-Arroub Agricultural Experimental Station Throughout 2012 & 2013 Growing Seasons

Start of Infestation			**Just Before Harvesting**		
Date of Record	N	Mean ± SE	Date of Record	N	Mean ± SE
19-07-12	29	27.5 ± 5.9	30-09-12	27	48.8 ± 7.9
20-08-13	30	26.5 ± 6.0	10-10-13	30	78.2 ± 4.8
T value		-0.11	T value		3.18
P value		0.91	P value		0.0027

**: Means within the same column with different letters differ significantly at P value ≤0.05 (using two sample T-Test)*

4. Discussion

4.1. Seasonal flight activity of B. oleae in the southern highlands of Palestine

Results of the present study showed that throughout two years of study (2012 and 2013), the seasonal flight activity of *B. oleae* started in early July, and continued its activity throughout the season till the mid of November during 2012. However, during 2013, the flight activity started early in April and continued its activity up to late November.

Present results also demonstrated that, two peaks of *B. oleae* flight activity were annually observed throughout the two years (2012 & 2013), and those peaks were respectively recorded on August and October in 2012 season but on April and September in 2013 season. In addition, throughout the two years, the population of *B. oleae* was very high in the second peak of flight activity which coincides the repining period of olive fruits and before the harvesting.

Those results are similar to that concluded by author [8] found that, the start of the fly's activity in the central highlands of Palestine, began in early July and continued until the end of November. Moreover, author [9] reported three peaks of olive fruit flies activity in the central highlands of Jordan. He reported that, the first peak appeared in late July, the second peak appeared in early October and the third appeared near the end of October. However, in Syria and Lebanon, the olive fruit fly had 4-5 generations yearly depending on local

conditions [3, 5].

In addition, this research confirmed that throughout the two seasons, the sticky yellow traps were efficient in capturing *B. oleae* similar to that concluded by author [10] whom reported that yellow sticky traps were found to attract the fly more than orange, red, green, black, and white color traps. In addition, [11] reported that the yellow and orange spheres trapped the greatest number of males of *B. oleae*.

4.2. Population dynamics of B. oleae on ten olive cultivars in Palestine

Results of present study show that, throughout all observations during the two successive years of study, significant differences in % of olive fruit fly infestation were recorded between the olive cultivars.

Furthermore, results recorded at the end of 2012 growing season, just before harvesting show that, olive cultivars were grouped in three levels in their susceptibility to olive fruit fly infestation as follow: high susceptible cultivars included Grosya-Deponia (100%), Nabaly-Mohasen (100%), Carmelatan (83.33%) and Sevilano (75.5%); Medium susceptible cultivars included Manzanilo (44.44%), Telmisani (37.5%) and Nabaly-Balady (35.42%); and low susceptible cultivars included Tell (7.71%), Balady (5.25) and Nasohi-Gaba (3.3%)

However, in 2013 season, changes occurred in level of susceptibility to fruit fly infestation of some cultivars and categorization according to % infestation was as follow: high susceptible cultivars included Grosya-Deponia (100%), Carmelatan (100%) Sevilano (100%); Nabaly-Mohasen (92.06%) and Telmisani (83.98%), Nasohi-Gaba (79.52%); Medium susceptible cultivars included and Balady (79.84%), Nabaly-Balady (74.44%) and Manzanilo (49.37%); and low susceptible cultivars included Tell (23.06%). Similar results were reported by Alqurneh (2013) who found that, the rate of fruit infestation in the central highlands of Palestine was 79% in Balady and 73% on Nabaly.

Such variation in olive cultivars susceptibility to fruit fly infestation was discussed by several authors [12, 13], whom considered the size of fruit as one of the most important factors in the choice of olives by *B. oleae* female. They reported that, the infestation level on cultivars which characterized by a large drupe size resulted usually higher than that one recorded on cultivars bearing small olives. And, in general larger sizes and olives with higher water content were more susceptible for infestation than olives with lower water content

In addition, [14] considered other factors that possibly play a role include fruit size; weight; color; fruit pericarps hardness; surface covering; phonological stage of the crop; and chemical factors.

Results of present study that listed Grosya-Deponia; Carmelatan; Sevilano; Nabaly-Mohasen; Telmisani and Nasohi-Gaba cultivar as high susceptible ones to olive fruit fly can fit with the above mentioned factors including fruit size; weight; color; fruit pericarps hardness, hence all these cultivars are characterized by large fruit, yellowish green color and soft fruit pericarps, meanwhile, Tell and Balady cultivars which were classified as low in susceptibility to fruit fly infestation are characterized by smaller fruits; greenish in color and harder pericarps

Furthermore, present study proved that the phenomena of biennial yield alteration of olive is inversely related with fruit infestation, and the high fruit production in 2012 was accompanied with lower rate of infestation in comparison to high rate of infestation that recorded accompanied to the low fruit production yield in 2013. This result was similar to that concluded by several authors whom concluded that, if the production is high, the rate of fruit infestation is low and vice versa [3, 8, 9, 15, 16].

5. Conclusions

Throughout this research, following conclusions were recorded:

1. *B. oleae* had two annual peaks of flight activity, and those peaks were respectively recorded on August and October in 2012 season but on April and September in 2013 season.
2. Significant differences in % of olive fruit fly infestation were recorded between the olive cultivars,
3. Olive cultivars with larger fruits were higher in susceptibility to *B. oleae* infestation rather than that with smaller fruits.
4. The phenomena of biennial yield alteration of olive is inversely related with fruit infestation, and the high fruit production in 2012 was accompanied with lower rate of infestation in comparison to high rate of infestation that recorded accompanied to the low fruit production yield in 2013.

6. Recommendations

Based up on the findings of the study, following recommendations are given:

1. Monitoring of flight activity of *B. oleae* should be conducted from the beginning of April till end of the season.
2. Balady; Nabaly-Balady; Manzanilo and Tell cultivars are the lowest in susceptibility to olive fruit fly infestation, therefore, its recommended to be used for establishing new olive groves in Palestine.

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