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Susceptibility of olive cultivars to olive fly (*Bactrocera oleae*) and parameters that play a role in olive fly (*Bactrocera oleae*) cultivar selection

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Abstract
Olive, which is an important product of the Mediterranean basin, is a source of healing and an economically strategic product. The sustainability and protection of this product is extremely important. There are many harmful species seen in olives. The main pest of the olive fly; *B. olea*. The olive fly (*Bactrocera oleae*) causes damage both directly and indirectly.
The purpose of this review is to obtain more successful results in the control by determining the susceptibility of olive varieties to olive fly (*Bactrocera oleae*) and the parameters that play a role in the selection of olive fly (*Bactrocera oleae*).
In this review, seasonal flight activity and population dynamics of olive fly (*Bactrocera oleae*), susceptibility of olive cultivars to olive fly (*Bactrocera oleae*), effects of pomological characteristics on olive fly (*Bactrocera oleae*) olive variety selection, olive fly (*Bactrocera oleae*) on the fruit and the physicochemical changes that occur as a result of the damage caused by the olive fly (*Bactrocera oleae*) on the fruit are mentioned.

Keywords: Olive fly (*Bactrocera oleae*), olive, resistance, susceptibility, oil content

1. Introduction
Olive, one of the most important commercial products of the Mediterranean basin, has become very popular in recent years. It is among the species that contribute the most to CO_2 emissions, especially due to climate change. However, the importance of olive plantations is increasing due to the natural antioxidant and healing effects of olives and olive oil.

Today, it is known that there are about 2000 olive varieties all over the world. Olive, whose history dates back thousands of years, is a commercial species that is produced economically in the world. Sustainability of this species is extremely important. During the production of olive products, which have a very important place in the Turkish economy, many diseases and pests cause product and tree losses. The olive fly (*Bactrocera oleae*), which is among the existing olive pests, is the most important pest of olives. The olive fly (*Bactrocera oleae*) (Rossi) (*Diptera: Tephritidae*) is a serious pest affecting olive plantation (*Olea europaea, Linneus*) in the Mediterranean basin. Although the first emergence of the olive fly (*Bactrocera oleae*) is in the Mediterranean basin, it can be seen along the east coast of North Africa, the Middle East and South Africa. The olive fly (*Bactrocera oleae*) has the potential to reduce at least 15% of the worldwide olive production with its direct damage (Bueno and Jones, 2002) [1]. Although the economic loss caused by the olive fly (*Bactrocera oleae*) varies from year to year, it is approximately $800 million/year (Luchetti, 2002; Genc, 2013) [2]. If the olive fly (*Bactrocera oleae*) is not taken under control, it causes product losses up to 80% in varieties produced for oil production and up to 100% in varieties grown for table use. The olive fly (*Bactrocera oleae*) is a monophagous pest in both orchard and marginal areas (Genc and Nation, 2008; Tzanakakis, 2006) [7, 5]. Most of the olive fly (*Bactrocera oleae*) population spends the winter as pupae a few cm deep in the soil (Moreno, 2005; Álvarez and Moraga, 2007) [6, 10]. Olive fly (*Bactrocera oleae*) females lay their eggs inside olive fruits (Genc and Nation, 2008) [7].

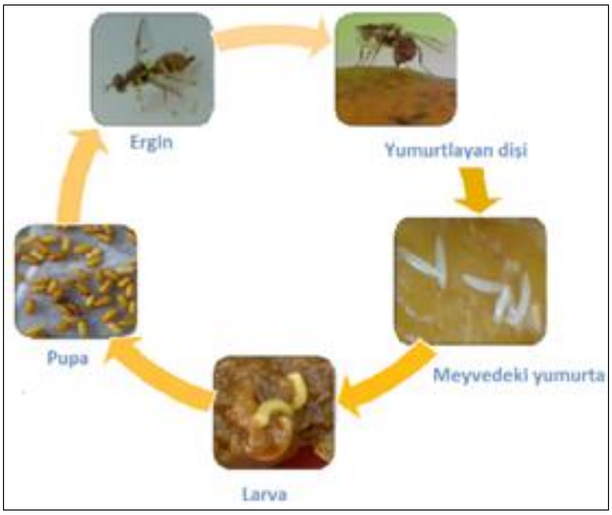

Fig 1: Olive Fly (*Bactrocera oleae*) Life Cycle

The olive fly (*Bactrocera oleae*) causes damage both directly and indirectly. Olive fly (*Bactrocera oleae*); It can cause fruit drop, fruit damage and a decrease in olive oil quality with an increase in free acidity and peroxide number (Iannotta, 2003) [9]. In addition, microorganisms (*Camarosporium dalmaticum*) can develop in the area where the olive fly (*Bactrocera oleae*) lays eggs on fruits and in feeding tunnels (Iannotta *et al*., 1999) [12].

Olive fly (*Bactrocera oleae*) gives 4-5 offspring per year depending on climatic conditions (Avidov and Harpaz, 1969; Vossen, Varela and Devarenne, 2006) [16, 14]. Olive fly (*Bactrocera oleae*); at temperatures below 30 °C, they reach sexual maturity and reproduce, while temperatures above 30 °C and low humidity prevent the olive fly (*Bactrocera oleae*) from laying eggs and cause reproductive diapause (Álvarez and Moraga, 2007) [10].

The first generation of the olive fly (*Bactrocera oleae*) emerges in June, which coincides with pit hardening. The second generation can be seen in August and the other generations, depending on the presence of fruit, from late summer and autumn to December (Vossen *et al*., 2006; Varela and Vossen, 2000) [14]. The olive fly (*Bactrocera oleae*) has become uncontrollable worldwide as resistance to insecticides has developed against adult individuals of the chemical, which has been used in high amounts since the early 1960s (Kakani *et al*., 2008, 2010; Stasinakis, 2001) [70, 17]. In addition, the chemical used had serious adverse effects on non-target fauna in olive plantation (Pascual *et al*., 2010; Ruano *et al*., 2001) [18, 19]. Cultural measures used against olive fly (*B. oleae*); other methods such as mass trapping, kaolin (physical barrier) and copper applications have not been very successful (Daane and Johnson, 2010; Haniotakis, 2005) [21, 20]. It is necessary to develop new olive varieties resistant to both biological control and olive fly (*B. oleae*) and to develop alternatives to synthetic chemicals in the fight against olive fly (*Bactrocera oleae*) (Escobar *et al*., 2013; Moraga, Aranda and Álvarez, 2010) [22, 24]. Genetic resistance of the olive germ plasmid is an important tool for controlling the olive fly (*B. oleae*). Olive varieties resistant to the olive fly (*Bactrocera oleae*) are used to obtain quality products in both organic and conventional systems and also contribute to the reduction of insecticide applications (Rizzo *et al*., 2012) [27].

Susceptibility of olive cultivars to olive fly (*Bactrocera oleae*) changes depending on olive fruit's pomological properties (fruit size, color, peel hardness, etc.) (Gümusay *et al*., 1990; Kombargi *et al*., 1998; Neuenschwander *et al*., 2009; Rizzo *et al*., 2012) [44, 26, 28, 27], and physicochemical properties (from olive leaves and fruit mineral element contents (Bononi and Tateo, 2017; Garantonakis *et al*., 2016; Malheiro *et al*., 2015, 2016) [31, 32, 29, 30]. In this study, the susceptibility of olive varieties to olive fly (*Bactrocera oleae*), pomological characteristics and physicochemical characteristics of olive fly, which are effective in olive variety selection, physicochemical changes resulting from damage of olive fly to fruit were investigated.

1.1 Seasonal Flight Activity and Population Dynamics of Olive Fly (*Bactrocera oleae*)

Monitoring of flight activity and adult population density of olive fly (*Bactrocera oleae*) is done with McPhail and yellow sticky traps. In the studies carried out; yellow sticky traps were found to be more effective at attracting olive fly (*Bactrocera oleae*) than orange and red ones (Neuenschwander and Michelakis, 1978) [33]. In another study by Katsoyannos and Kouloussis (2001) [34], similar results were obtained; yellow and orange sticky traps; It has been reported that the olive fly (*Bactrocera oleae*) male is more attracted to the green, black and white colored sticky traps. McFadden (1975), in his study, emphasized that among the rectangular sticky traps of different colors, the yellow ones were the most effective and attractive for the monitoring of the olive fly (*Bactrocera oleae*).

The flight activity of *Bactrocera oleae* continues from mid-July to late August, a period when olive fly (*Bactrocera oleae*) adults prefer more suitable areas with high temperature and low relative humidity (Tzanakakis, 2006) [5]. In order to determine seasonal flight activities and population dynamics of olive fly (*Bactrocera oleae*) in 2012-2013 using 10 olive cultivars in the southern highlands of the West Bank, flight activity of olive fly (*B. oleae*) was determined by July. It was observed that it started at the beginning of the year and continued its activity throughout the season until the end of November. However, in 2013, it was determined that the flight activity started in early March and continued throughout the season until the end of October. In addition, it was determined that the olive fly (*B. oleae*) peaked twice a year for two consecutive years (2012 and 2013). Peak 1 (1.67 flies/trap) of flies caught in the 2012 season was recorded in August, and peak 2 (6.33 flies/trap) in October, however, peak 1 (10 flies/trap) of the flies caught in the 2013 season was recorded in early April and 2. The peak (14.67 flies/traps) was observed in September. flight activity; It was determined that it was 5 months (July – November) in the 2012 season, and it extended up to 8 months (April – November) in the 2013 season (Hamdan, 2016) [50].

Similar results were obtained in another study by Alqurneh (2013) [36]; It was determined that olive fly (*Bactrocera oleae*) activities started in early July and continued until the end of November. Al-Zaghal (1985) [37], in his study; reported that the olive fly (*Bactrocera oleae*) peaked in three periods. He observed that the first peak occurred at the end of July, the second peak in early October, and the third peak in late October. In a study conducted with 20 olive cultivars for 3 years in Spain (Cordoba), it was found that the flight activity of the wintering adults of the olive fly (*Bactrocera oleae*) generally starts from early May to early June and continues from late September to mid-October. has been reported. However, it was determined that the flight activities of the wintering adults stopped for a while between 10 July and 30 August, and the most olive fly (*Bactrocera oleae*) damage occurred in the middle and end of October. In addition, the flight activity of the autumn generation of the olive fly (*Bactrocera oleae*); It was determined that it started in early November and ended in early December. In addition, with the study; It has been observed that the number of olive fly (*Bactrocera oleae*) caught with traps in all the years of application was higher in irrigated gardens than in rain-fed gardens (Moraga *et al*., 2018) [25].

1.2 Susceptibility of Olive Varieties to Olive Fly (*Bactrocera oleae*)

It has been determined by many studies that olive varieties have different susceptibility to olive fly (*Bactrocera oleae*) (Scarpati *et al*., 1996; Daane and Johnson 2010) [39, 21]. Olive cultivars grown in the same geographical conditions may have different susceptibility levels to the olive fly (*Bactrocera oleae*) (Daane and Johnson 2010) [21]. Other studies on this subject have shown that the egg laying preference and larval performance of the olive fly (*Bactrocera oleae*) differ between olive varieties (Gonçalves *et al*., 2012; Burrack and Zalom, 2008; Al-Salti *et al*., 2011; Iannotta *et al*., 1999; Iannotta *et al*., 2007; Gümusay *et al*., 1990) [41, 42, 54, 12, 43, 44].

In a study conducted in 2012-2013 using ten olive varieties in the southern highlands of the West Bank, susceptibility rates of cultivars in 2012; Grosya-Deponia (66.22%), Carmelatan (58.57%), Nabaly-Mohasen (57.3%), and Nabaly-Balady (55.27%); Tell (26.4%) and Sevilano (19.2%); No olive fly (*Bactrocera oleae*) damage was observed in Balady, Nasohi-Gaba and Tell cultivars. Sensitivity rates seen in 2013 are; Grosya-Deponia (85.71%), Nabaly-Mohasen (64.44%); Balady (34.44%), Carmelatan (31.19%), Nabaly-Balady (17.32%); Nasohi-Gaba, Telmisani and Manzanilo (15.22%) and Sevilano (11.11%) were Tell (5.56%). When the data obtained as a result of the 2-year study is evaluated; the susceptibility of olive cultivars to olive fly (*Bactrocera oleae*) was categorized in 3 levels. Highly susceptible varieties; Grosya-Deponia (100%), Nabaly Mohasen (100%), Carmelatan (83.33%) and Sevilano (75.5%); Moderately susceptible varieties; Manzanilo (44.44%), Telmisani (37.5%), and Nabaly-Balady (35.42%); and low-susceptibility varieties; Tell (7.71%), Balady (5.25) and Nasohi-Gaba (3.3%).

With this study; olive cultivars least susceptible to olive fly (*Bactrocera oleae*) damage; Balady; Nabaly-Balady; It was determined as Manzanilo and Tell and it was recommended to be used in the establishment of new olive groves in Palestine (Hamdan. A., 2016) [50]. Similar results were obtained in another study reported by Alqurneh (2013) [36]. In another study using 14 different olive cultivars to determine resistant and susceptible cultivars to the olive fly (*Bactrocera oleae*) in Çanakkale, it was determined that Arbequin was the cultivar less sensitive to the olive fly (*Bactrocera oleae*), Gemlik-2M 2 It was observed that /3 showed a significant sensitivity. Also, olive fly (*Bactrocera oleae*) females to lay their eggs; It has been observed that Lucques and Rabbit heart varieties are more preferred (Genç, 2016) [56]. In another study conducted in Italy on the susceptibility of different olive cultivars to the olive fly (*Bactrocera oleae*), 24 different olive cultivars grown under the same agricultural and pedoclimatic conditions were used. The results showed that, despite the number of bruises, some olive cultivars less damage than others due to their genetic resistance. The data obtained as a result of the study; the most resistant cultivars to olive fly (*Bactrocera oleae*) were 'Dritta di Moscufo' and 'Gentile di Chieti' with 0.25% damage rate, followed by 'Nostrole di Rigali (0.50%) and 'Nocellara Etnea' (0.75%) respectively) showed that the varieties followed. On the other hand, cultivars most susceptible to olive fly (*Bactrocera oleae*) were 'Carolea' and 'Cucco' (10%). Also in the study; the cultivar with the lowest shoot was 'Gentile di Chieti (5.6%), followed by 'Dritta di Moscufo', 'Picholine' and 'Nocellara messinese'; the highest hit count was determined in 'Nostrale di Rigali' (19.30%) and 'Nocellara etnea' (18%) varieties. As a result of the examinations made with 24 different olive varieties, it was seen that the most affected olive variety was 'Carolea' followed by 'Nocellara de Belice' respectively. It was observed that 'Dritta di Moscufo' and 'Gentile di Chieti' were less sensitive than the other cultivars examined. The cultivars 'Carolea and Cucco' were the most affected, and therefore the most susceptible, both in terms of damage rate and hits (Ionatto, 1999) [12].

In another study on olive fly (*Bactrocera oleae*) susceptible cultivars, we determined the molecular response of two olive cultivars with different susceptibility levels to the olive fly (*Bactrocera oleae*) 'Ortice' (olive fly sensitive) and 'Ruveia' (tolerant). A transcriptomic approach was used to analyze As a result of the study, while there was no damage to the olive fly (*Bactrocera oleae*), it was seen that there was no transcriptomic difference between the two cultivars. The difference between the tolerant and susceptible genotype was observed only in the presence of larvae. In addition, the data from the study show that the more sensitive olive cultivars show a weak reaction against the olive fly (*Bactrocera oleae*), while the resistant olive cultivars are less preferred for the olive fly (*Bactrocera oleae*) due to a more active and compound molecular response. Beta-glucosidases in olives and oleuropein, a phenolic compound, have been found to be an important element in olive defense against olive fly (*B.oleae*) (Pugliano, 2000) [47].

In a study conducted in İzmir between 1984-1988 to determine the susceptibility of 5 different olive cultivars (Çakır, Çilli, Memecik, Domat and Ayvalık) to olive fly (*Bactrocera oleae*). The Çilli cultivar is the most susceptible cultivar; The sensitivities of Memecik, Çakır and Domat cultivars were found to be moderate. In the light of the findings obtained as a result of the study, it is recommended to use Çilli trees as traps in the fight against olive fly (*Bactrocera oleae*) (Gümusay *et al*., 1990) [44]. In a study conducted in 2005; it was determined that the olive fruit was damaged more by the olive fly (*Bactrocera oleae*) during the first ripening period. In the same research, cultivars least susceptible to olive fly (*B. oleae*) attack; it has been reported that "Tonda nera dolce and Bardhi Tirana" and cultivars with high sensitivity are: "Carolea, Carboncelladi, Pianacce, Gentile di Chieti, Giarraffa, Nocellara del Belice, Nociara and Picholine" (Iannotta, 2007) [43]. 20 of olive varieties (Arbequina, Cornicabra, Empeltre, Frantoio, Hojiblanca, Lechín de Sevilla, Nevadillo Blanco de Jaén, Pico Limón, Arbequina, Cornicabra, Frantoio, Hojiblanca, Lechín de Sevilla, Picual and In a study conducted with Picudo (oil olive varieties) and Ascolana Tenera, Barnea, Callosina, Dulzal de Carmona, Gordal Sevillana, Kalamon, Manzanilla de Sevilla, Mollar de Cieza, Öcal and Uovo de Piccione (table olive varieties); "Nevadillo Blanco de Jaén" was found to be the most susceptible variety to the olive fly (*Bactrocera oleae*), with an average damage rate ranging from 6.7% to 52.2% in rain fed conditions and 10.3% to 69.2% in irrigated conditions. "Arbequina" was the least susceptible variety, with an average damage rate ranging from 0.6 to 12.7% and under irrigated conditions between 2.3% and 18%. Among the table olive varieties, “Callosina” and “Kalamon” varieties were determined to be the most resistant, while “Gordal Sevillana”, “Ascolana Tenera”, “Barnea” and “Öcal” varieties were the most sensitive varieties. In the same study, it was also observed that olive fly (*B. oleae*) damage occurred later in olive groves that were not irrigated except for rain, compared to olive groves with extra irrigation (Moraga *et al*., 2018) [25].

Table 1: Some Varieties Susceptible and Resistant to Olive Fly (*Bactrocera oleae*)

Olive Fly (*Bactrocera oleae*) Susceptible and Resistant Varieties		
Resistant	**Medium Sensitive**	**Sensitive**
Tell	*Carmelatan*	*Çilli*
Balady	*Nabaly-Mohasen*	*Grosya-Deponia*
Nasohi-Gaba	*Nabaly-Balady*	*Gemlik*
Manzanilo	*Nostrole di Rigali*	*Lucques*
Arbequine	*Memecik*	*Tavşan Yüreği*
Dritta di Moscufo	*Çakır*	*Carolea*
Callosina	*Domat*	*Cucco*
Nocellera Etnea		*Nocellera de Belice*
Ruveia		*Ortice*
Tonda nera dolce		*Carboncelladi*
Bardhi Tirana		*Pianacce*
Kalamon		*Gentile di Chieti*
		Giarraffa
		Nociara
		Picholine
		Nevadillo Blanco de Jaen
		Gordal Sevillana
		Ascolana Tenera
		Barnea
		Öcal

1.3 The effect of pomological characteristics on olive variety selection of olive fly (*Bactrocera oleae*)

It has been proven by studies that the pomological characteristics of the fruit are effective in the selection of olive variety of the olive fly (*Bactrocera oleae*). There are differences in susceptibility of olive varieties to olive fly (*Bactrocera oleae*) damage (Jimenez, 1988) [49]. It has been determined that fruit size is one of the most important factors in olive fly (*B. oleae*) female olive variety selection (Rice, 2000). The damage rate in cultivars characterized by a large fruit size was generally higher than that recorded in cultivars with small olive fruit. In general, it has been determined that the olive cultivars with larger and higher water content are more susceptible to the olive fly (*Bactrocera oleae*) than the cultivars with the lower water content. Studies on susceptibility of olive cultivars to olive fly (*Bactrocera oleae*); fruit size as well as fruit color; flesh firmness; phenological stage; and chemical factors are also effective (Innotta, 2007) [43].

In a study conducted with ten olive cultivars in the southern highlands of the West Bank in 2012-2013, the olive fly was found among the olive cultivars. (*Bactrocera oleae*), significant differences were noted in the percentage of damage, and therefore, olive varieties with larger fruits were more susceptible to olive fly (*B. oleae*) than varieties with smaller fruits (Hamdan, 2016) [50].

In addition, olive fly (*Bactrocera oleae*) damage is inversely proportional to olive fly (*Bactrocera oleae*) damage, that is, olive fly (*Bactrocera oleae*) damage is high in years when fruit yield is low, and olive fly (*Bactrocera oleae*) damage is low in years when fruit yield is high. was found to be. There are also researchers who argue the opposite of this situation (Avidov and Harpaz, 1969; Alqurneh., 2013; Zaghal, 1985, Yaman, 1963; Momane and Antere, 2008) [16, 36, 37, 52, 53]. In another study conducted in Izmir between 1984-1988; In order to determine the causes of susceptibility of olive varieties (Çakır, Çilli, Memecik, Domat and Ayvalık) to olive fly (*Bactrocera oleae*), oil and water content of the fruits of olive varieties, fruit pulp firmness (measured by penetrometer), the color (fruit color: L (black and white), B (yellow and blue) and A (green and red) fruit samples were measured monthly by colorimeter), size and weight of the fruits were examined.

In the results of study; although there is no close relationship between fruit sensitivities, it has been determined that Çilli is more and earlier damage than others due to its water content and weight, flesh firmness and spherical form. In contrast, Ayvalık is less damaged by the olive fly (*Bactrocera oleae*) due to its higher oil content as well as lower water content and lower fruit weight. These data obtained are similar to the findings obtained from the studies by Donia *et al*., (1971) [55] and Beniloch (1943). On the other hand; It has been determined that fruit shape is more important than fruit weight in olive variety preference of olive fly (*Bactrocera oleae*). The difference between large-fruited varieties, Domat and Çilli, can be explained by their fruit shapes, namely that Çilli is spherical and Domat is cylindrical. With the studies conducted by Procopy *et al*., it was concluded that fruit shapes are an important criterion for the olive fly (*Bactrocera oleae*); spherical shaped fruits (99-100%) were more preferred by olive fly (*Bactrocera oleae*) than rectangular shaped fruits (20-21%). In addition, there are studies showing that the color of the fruit is also important in the selection of the egg laying zone among the olive varieties of the olive fly (*Bactrocera oleae*) in the same plantation (Gonçalves *et al*., 2012; Burrack and Zalom, 2008; Al-Salti *et al*. 2011) [41, 42, 54]. Domat and Çilli varieties can maintain their green color until the end of the season, therefore they are more damaged by the olive fly (*Bactrocera oleae*) (Gümusay *et al*., 1990) [44]. The results obtained are similar to the studies conducted by the researcher Neuenschwander in 1985 [57]; it was determined that black olives is less damage than green olives.

Studies on this subject, olive fly (*Bactrocera oleae*) females; showed that he preferred the larger fruited varieties more than the small fruited ones. However, there are also studies that argue the opposite. Some researchers working on this subject have determined that the size of the olive fruit is not a fundamental factor determining the egg laying preferences of females (Gonçalves *et al*., 2012) [41]. In a study conducted by Genç (2016) [56], it was determined that olive varieties showed different levels of susceptibility to the attack of the olive fly (*Bactrocera oleae*). In the study, olive fly (*Bactrocera oleae*) females to lay their eggs; it was observed that females preferred Lucques and Tavşan yüreği varieties more. At the same time, it has been determined that the olive fly (*Bactrocera oleae*) prefers some parts of the olive fruit more for laying eggs. Olive fly (*Bactrocera oleae*) damage was not associated with fruit weight. Evaluations showed that pupal yield and fruit weight were related. The best pupa performance was observed in Eğriburun, which is a local variety weighing about 6.69 g (Genç, 2016) [56]. Other studies on this subject have shown that the egg laying preference and larval performance of the olive fly (*Bactrocera oleae*) differ between olive varieties (Gonçalves *et al*., 2012; Burrack and Zalom, 2008; Al-Salti *et al*., 2011; Iannotta *et al*., 1999; Iannotta *et al*., 2007; Gümusay *et al*., 1990) [41, 42, 54, 12, 43-44].

In a study conducted with eight olive varieties (Abani, Aellah, Blanquette de Guelma, Chemlal, Ferkani, Limli, Rougette de Mitidja and Souidi) in Algeria; the effects of olive fly (*Bactrocera oleae*) damage on pomological parameters were investigated. As a result of the study, it was determined that the cultivars included in the experiment showed different degrees of susceptibility to olive fly (*Bactrocera oleae*), and fruit size (weight) / seed weight were significantly related to olive fly (*Bactrocera oleae*) damage.

As a result of the study, it was observed that pomological parameters, namely the weight of olive fruits, had a significant effect on their susceptibility to olive fly (*B. oleae*). The cultivar Rougette de Mitidja with large fruits showed the highest attack rate (65.33%), while the cultivar Souidi, Chemlal (21.33%) with the smallest fruit similarly showed the lowest (21%) attack rate. Although the other two cultivars, Abani and Blanquettede Guelma, had similar maturity index (5.74 and 5.55, respectively), the attack percentages of the olive fly (*Bactrocera oleae*) were different (34.67% and 59%, respectively). In addition, it was determined in the study that varieties with lower maturity index and larger fruit were preferred more in terms of olive fly (*Bactrocera oleae*). Similar results were also supported by other studies (Neuenschwander *et al*., 1985; Wang *et al*., 2009; Rizzo *et al*., 2012) [33, 59, 27]. In another study by Innotta *et al*., (2007) [43]; found that in addition to fruit size, characteristics such as weight, color, flesh firmness, and phenological stage of the fruit were also effective in susceptibility to olive fly (*Bactrocera oleae*). Grosya-Deponia; Carmelatan; Sevilano; Nabaly-Mohasen; Telmisani and Nasohi-Gaba varieties; it shows high sensitivity to olive fly (*Bactrocera oleae*) due to its large, yellowish green and soft fruits; Tell and Balady cultivars with small fruit, greenish color and harder fruit flesh had low susceptibility to olive fly (*Bactrocera oleae*). In a study by Edriss *et al*., (2008) [58], it was observed that the olive fly (*Bactrocera oleae*) started eggs laying when the average weight of the fruit was more than 0.8 g, reaching an average weight of 1.7 g. In another study, it was determined that olive flies (*Bactrocera oleae*) prefer fruits with a diameter of 7.5 mm compared to small fruits (Al Salti *et al*., 2011) [54]. Similar results were obtained in a study by Antonelli and Chesi (1985) [60] and Mesbah and Megda (1996) [61]. It was confirmed that the attack rate of olive fly (*Bactrocera oleae*) increased as the weight, diameter and length of the fruit increased. In another study by Sharaf (1980) [65], the highest percentage of damage (65.33%) was seen in Rougette de Mitidja cultivar. However, Gonçalves *et al*. (2012) [41] reported that fruit size is not a fundamental factor determining egg laying preference. The ripening process of olive fruits is another factor that can affect the susceptibility of cultivars due to its influence on fruit characteristics and color. Gümusay *et al*., (1990) [44] and Rizzo *et al*. (2012) [27] reported that late ripening of olives would be more conducive to the attack of the olive fly (*Bactrocera oleae*) due to the persistence of the green color.

In another study by Neuenschwander *et al*., (1985) [33], Gümusay *et al*., (1990) [44] and Malheiro *et al*., (2015b) [63]; indicated that a slower ripening process had an attractive effect for the olive fly (*Bactrocera oleae*). It is possible that the olive fly (*Bactrocera oleae*) prefers fruits with low epicarp hardness to lay its eggs. Sharaf (1980) [62] confirmed that small fruit size and high firmness reduce the attack rate. In the same sense, Gümusay *et al*., (1990) [44] stated that fruits with soft pericarp are susceptible to olive fly (*Bactrocera oleae*) attack. In the study, which investigated the factors affecting the susceptibility of some cultivars such as fruit size and oil yield of olive oil and table olive varieties to olive fly (*B. oleae*), it was observed that as the fruit size and oil yield of the olive increased, the percentage of damage to the fruit increased. Therefore, Arbequina cultivar, which is the smallest cultivar among the oil olive cultivars, was determined to be the least susceptible cultivar in all years of the study in both irrigated and rain-irrigated conditions. Similar results were obtained in different studies (Moraga *et al*., 2018) [25]. In a study conducted for three consecutive years with the "Arbequina" variety, one of the few important commercial olive varieties in California; this cultivar was reported to be the least susceptible cultivar, but despite this, several small-fruited olive cultivars (e.g. and “Lechín de Sevilla”) were also reported to *B. oleae* than larger fruited cultivars (i.e. “Picudo” and “Pico Limón”). was found to be more sensitive (Burrack & Zalom, 2008) [42].

Table 2: Pomological parameters effective in cultivar selection of olive fly (*Bactrocera oleae*)

Pomological parameters effective in olive fly cultivar selection		
Fruit Size	Big	Small
Fruit Firmness (Pericarp Firmness)	Soft	Hard
Fruit Shape	Cylindrical	Round
Fruit Color (Maturation Index)	Green	Black
Fruit Water Content	Low	High
Fruit Oil Content	Low	High

It has been determined that the olive fly especially prefers fruity varieties with large fruit, hard fruit flesh, round fruit shape, green fruit color, high water content and low oil content (Table 2).

1.4. Physicochemical Changes in Fruits as a Result of Damage by Olive Fly (*Bactrocera oleae*)

Olive oil (*Olea europeae L*.) is a premium vegetable oil due to its health and nutritional benefits and distinctive taste (Kırıtsakis, 1998). It is known that the properties and quality of olive oil can be affected by the variety, degree of maturity, industrial processes used to extract the oil, cultural practices, as well as environmental conditions (availability of mineral matter, temperature, light, water) (Tovar *et al*., 2001; Kırıtsakis, 1998) [71]. Oil quality is also strongly related to the physiological conditions of the fruit from which it is obtained. Olive varieties show varying levels of tolerance to the olive fly (*Bactrocera oleae*) (Daane and Johnson, 2010; Iannotta and Scalercio, 2012) [21, 72]. When different olive varieties are compared; the olive fly (*Bactrocera oleae*) damage percentage ranges from less than 10% to 31% (Iannotta and Scalercio, 2012). In cases where chemical methods are not used in the control against olive fly (*Bactrocera oleae*), olive oil obtained from olives collected from olive plantation with a damage percentage of 10% or less is considered to be of high quality (Gucci *et al*., 2012) [73]. The use of olive varieties with high tolerance to the olive fly (*Bactrocera oleae*) is an important factor in reducing economic losses and the use of chemical pesticides. Olive fly (*Bactrocera oleae*) negatively affects the quality of olive oil and impairs its physicochemical properties. It has been reported that oil obtained from olives infected with olive fly (*Bactrocera oleae*) and containing developed larvae or pupae and/or exit holes have higher acidity and peroxide values and lower total polyphenol content (Delrio *et al*., 1995; Parlatti *et al*., 1990a; b; 1992; Zunin *et al*., 1992; 1993).

Recent studies have reported that olive fly (*B.oleae*) infestation causes significant changes in mineral elements (such as P, K, Fe and Mg) in fruits (Garantonakis *et al*., 2016) [32].

Studies have shown that the different tolerances of olive varieties against the olive fly (*Bactrocera oleae*) vary depending on the waxy layer of the olive fruits, phenolic compounds (oleuropein, cyanidin). High oil content during the first period of fruit ripening contributes to increased fly attractiveness (Sharaf, 1980; Al-Salti *et al*., 2011) [65, 54]. It has been reported that olive fly (*Bactrocera oleae*) females prefer varieties with high oil content for laying eggs (Gonçalves *et al*. 2012) [41].

Studies have shown that there is a negative correlation between the carbohydrate content in the fruit and the attack of the olive fly (*Bactrocera oleae*), in contrast to the lipids. The cultivars Chemlal and Souidi (59% and 56%, respectively), which were the richest in carbohydrates, were attacked by olive fly (*Bactrocera oleae*) 21% less. Protein levels of olive fruits are extremely important for larval development. It was determined that there is a positive relationship between the protein content of the olive fruit and the attack of the olive fly (*Bactrocera oleae*). In a study, it was seen that the cultivars Aellah, Limli and Rougette (5.25%, 5.24% and 5.21%, respectively) with high protein content were more preferred by the olive fly (*Bactrocera oleae*) than other cultivars (Medjouh *et al*., 2018) [6].

Another result obtained as a result of the study is; it is the decrease in the nitrogen content of the fruits damaged by the olive fly (*Bactrocera oleae*). The ash content of the olive pomace obtained from the varieties used in the experiments is; it ranged from 3.34% (Rougette de Mitidja) to 5.48% (Blanquettede Guelma). It was determined that Rougette de Mitidja, which has the lowest ash content, did not suffer any damage from the olive fly (*Bactrocera oleae*) attack. In another study (Garantonakis *et al*., (2016) [32], it was determined that there was a positive correlation between the K and Fe content of olive varieties and the damage rate of olive fly (*B. oleae*). In another study conducted in Portugal to determine the effects of olive fly (*Bactrocera oleae*) damage on the oil quality of three important commercially produced olive cultivars (Cobrançosa, Madural and Verdeal Transmontana), the olive fly mainly due to the effect of hydrolytic enzymes and the lipolytic activity of microorganisms. (*Bactrocera oleae*) damage has been observed to increase the acidity, peroxide value and oxidation of olives and accordingly reduce the quality of olive oil (Stella and Pıcchi, 1991) [65]. In the Verdeal Transmontana cultivar; A twofold difference was found between the acidity value of the oil obtained from 100% infested olives by the olive fly (*Bactrocera oleae*) and the acidity value of the oil obtained from healthy fruits (0% infestation).

Also, olive fly (*Bactrocera oleae*) damage effect varies according to olive varieties. Total tocopherol contents of olive oil decreased in cases where olive fly (*Bactrocera oleae*) damage was maximum. In the study, it was determined that the oil obtained from the Verdeal Transmontana olive cultivar had the lowest tocopherol content compared to the oil obtained from the Cobrançosa and Madural cultivars. In the study (Pereira *et al*., 2004) [66], it was determined that olive fly (*B. oleae*) damage reduced the olive oil quality of the varieties; it was determined that the rate of damage varies according to the varieties. However, in general, low total tocopherol content of cultivars damaged by olive fly (*Bactrocera oleae*) was observed. In the same study; it was determined that the reason why the oil quality obtained from Verdeal Transmontana variety was lower than the oil obtained from Cobrançosa and Madural varieties was due to the low total tocopherol content. In general, regardless of the damage rate of the olive fly (*Bactrocera oleae*), the oils were determined as virgin olive oil because the acidity value did not exceed '0.53%'.

In the study, the peroxide value of oils increased in oils obtained from fruits damaged by olive fly (*Bactrocera oleae*) due to fruit lipoxygenase activity. In addition, while there was no relationship between peroxide value and olive fly (*Bactrocera oleae*) damage in Madural olive cultivars, in Cobrançosa and Verdeal Transmontana olive cultivars, peroxide value increased in proportion to olive fly (*Bactrocera oleae*) damage. Considering the stability values of olive oils, high stable values were found in Cobrançosa and Verdeal Transmontana olive varieties. The stability values of Madural olive cultivar were 60% less. The reason for this can be explained by the fact that the Madural olive variety matures earlier than the other varieties and the antioxidant activity and polyphenols decrease during ripening (Gutierrez *et al*., 2009) [67].

In addition, it was determined that there was a correlation between olive fly (*Bactrocera oleae*) infestation and tocopherol contents of olive oil. It has been observed that the tocopherol level of olive oils also affects the stability of olive oil. In studies with all olive varieties, tocopherol contents decreased as olive fly (*Bactrocera oleae*) damage increased.

In the study, when the fatty acid compositions of the olive varieties were examined, it was determined that the Verdeal Transmontana olive variety had the highest oleic acid (C18: 1c) content, while the Madural olive variety had the highest linoleic acid content. However, no correlation was found between variations in fatty acid levels and olive fly (*Bactrocera oleae*) damage rate. The data obtained as a result of the study showed that the olive fly (*Bactrocera oleae*) caused the most damage to the Verdeal Transmontana olive variety, and revealed that the olive oil obtained from this variety was of lower quality. On the other hand, the Cobrançosa olive variety was partially damaged by the olive fly (*Bactrocera oleae*), due to the high stability and high tocopherol content of the oils obtained from this variety.

In another study conducted in 2005; It was determined that the olive fruit was damaged more by the olive fly (*Bactrocera oleae*) during the first ripening period. In the same research; cultivars least susceptible to olive fly (*B. oleae*) attack; It has been reported that "Tonda nera dolce and Bardhi Tirana", and cultivars with high sensitivity are: "Carolea, Carboncelladi, Pianacce, Gentile di Chieti, Giarraffa, Nocellara del Belice, Nociara and Picholine". In previous studies on this subject; the reason why Bardhi Tirana variety is less damaged by olive fly (*Bactrocera oleae*) is the high amount of oleuropein in its fruits; they explained that in Tonda nera dolce, the amount of cyanidin is high in the fruits.

Table 3: Physicochemical characteristics that are effective in cultivar selection of olive fly (*Bactrocera oleae*)

Physicochemical characteristics that are effective in cultivar selection of olive fly (*Bactrocera oleae*)
High Oleuropein content
High Cyanidin content
Low carbohydrate content
High Protein content

When the physicochemical properties of olive varieties were examined, it was seen that fruits with high oleuropein, protein, cyanidin content and low carbohydrate content were more preferred by the olive fly (*Bactrocera oleae*) (Table 3).

Table 4: Physicochemical properties resulting from damage by olive fly *(Bactrocera oleae*)

Physicochemical properties resulting from damage by olive fly (*Bactrocera oleae*)
Increase in acidity value
Increase in peroxide value
Reduction in polyphenol content
Reduction in nitrogen content
Increase in oxidation value
Reduction in tocopherol content
Increase in ash ratio of olive pomace

2. Conclusıon

In the light of the researches, the susceptibility of olive varieties to olive fly, pomological characteristics and physicochemical characteristics of olive fly, which are effective in olive variety selection, physicochemical changes resulting from damage of olive fly *(Bactrocera oleae)* to fruit were investigated. When the studies on the susceptibility of olive varieties to olive fly *(Bactrocera oleae)* were examined, it was determined that the damage rate caused by the olive fly varies depending on the pomological characteristics and physicochemical characteristics of the olive varieties. In this respect, when olive varieties are examined; It has been determined that olive fly *(Bactrocera oleae)* especially prefers fruit varieties with large fruit, hard fruit flesh, round fruit shape, green fruit color, high water content and low oil content.

When the physicochemical properties of olive varieties were examined, it was seen that fruits with high oleuropein, protein, cyanidin content and low carbohydrate content were more preferred by the olive fly (*Bactrocera oleae*). It has been determined that there are some changes in physicochemical properties as a result of the damage caused by the olive fly on the olive fruit. As a result of olive fly damage; While an increase was observed in acidity peroxide and oxidation values in olive oil, it was determined that there was a decrease in polyphenol, nitrogen and tocopherol values. In addition, it was observed that there was an increase in the ash content of the olive pomace. With this review, the olive varieties preferred by the olive fly *(Bactrocera oleae)* were determined, and it is thought that the use of these varieties as trap plants while establishing olive orchards will provide an effective success in the fight against pests.This research will shed light on more detailed studies in the future in terms of ensuring the sustainability of olive cultivation and in the control of the olive fly *(Bactrocera oleae)*, which is the most important pest of olives.

3. References

1. Bueno AM, Ve Jones O. Alternative nethods for controlling the olive fly, *Bactrocera oleae*, involving semiochemicals. Use of pheremone and other semiochemicals in integrated production, IOBC wprs Bulletin. 2002;25(9):147-156.
2. Luchetti F. Importance and future of olive oil in the world market – an introduction to olive oil, Eur. J. Lipid Sci. Technol. 2002;104:559-563.
3. Genç H. Journal of Biological & Enviromental Science, cilt. (Hakemli Dergi) 2013;7:25-32.
4. Genç H, Zobar D, Nation JL. Maintaining *Bactrocera oleae* (Gmelin) (Dipt: Tephritidae) Colony on Its Natural Host in the Laboratory; c2008.
5. Tzanakakis ME. Insects and Mites Feeding on Olive: Distribution, Importance, Habits, Seasonal Development, and Dormancy. Applied Entomology Library Ed, Brill, Leiden, Boston. 2006, 182.
6. Moreno A. Entomología Agraria: Los Parásitos Animales de las Plantas Cultivadas. La Diputación Provincial, İspanya. 2005, 301s.
7. Genc H, Nation JL. Survival and development of *Bactrocera oleae* Gmelin (Diptera: Tephritidae) immature stages at four temperatures in the laboratory, African Journal of Biotechnology. 2008;7(14):2495-2500.
8. Ben-Yosef Ve Ark. Symbiotic bacteria enable olive fly larvae to overcome host defenses. MG-RAST digital repository; c2015. http://metagenomics.anl.gov.tr.
9. Iannotta N. Ladifesafitosanitaria. In Olea, trattato di olivi coltura; Fiorino, P., Ed.; Edagricole: Bologna; c2003. p. 393-410.
10. Álvarez S, Moraga Q. The olive fruit fly. Oleae. 2007;26:60-61.
11. Pavlidi N, Gioti A, Wybouw N, Dermauw W, Ben-Yosef M, Yuval B, *et al*., Transcripto micresponses of the olive fruit fly *Bactrocera oleae* and its symbiont Candidatus Erwinia dacicola to olive feeding. Scientific Reports. 2017;7:42633.
12. Iannotta N, Perri L, Tocci C, Zaffina F. The behavior of different olive cultivars following attacks by *Bactrocera oleae* (Gmel.), Acta Hortic. 1999;474:545-548.
13. Iannotta N, Perri E, Siriani R, Tocci C. Influence of Colletotrichum gloeosporioides (Penzig) and *Cladosporium dalmatica* (Thum) attacks on olive oil quality. Acta Horticulturae. 1999;474:573-776.
14. Vossen P Varela, Devarenne A. Olive Fruit Fly. University of California Cooperative Extension.133 Aviation Blvd, Suite 109. Santa Rosa; c2006.
15. Varela L, Vossen P. Olive Fruit Fly. University of California Cooperative Extension; c2000.
16. Avidov Z, Harpaz J. Plant Peat of Israel. Israel Univ. Press, Jerusalem; c1969. 549pp.
17. Stasinakis P, Katsares V, Mavragani-Tsipidou P. Organaphosphate resistance and allelic frequencies of estareses in the olive fruit fly *Bactrocera oleae* (Diptera: Tephritidae). Jourbal of Agricultural and Urban Entomology. 2001;18;157-168.
18. Pascual S, Cobos G, Seris E, Gonzales-Nunes M. Effects of processed kaolin on pests and non-target arthropods in a spanish olive grove. Journal of Pest Science. 2010;83:121-133. https://doi.org/10.1007/s10340-009-0278-5.
19. Ruano F, Lozano C, Tinaut A, Perla A, Pascual F, Garcia O, *et al*., Impact of pesticides on benefial arthropod fauna in olive orchards. IOBC/WPRS Bulletin. 2001;24:113-120.
20. Haniotakis G. Olive pest control: Present status and prospects. IOBC/WPRS Bulltetin. 2005;28:1-9.
21. Daane KM, Johnson MW. Olive Fruit fly: Managing an ancient pest in modern times. Annual Review of Entomology. 2010;55:155-169.
22. Escobar F, Leon R, Gomez L, Testi JA, Orgaz F, Trapero A. Evolution of sustainability of the olive production systems; c2013.

23. Arcas N, Lopez A, Caballero FN, Andria J, Fermandez RDM, Escobar RR. Zenoli (Eds.), Present and Fure of the Mediterranean olive sector (pp. 11-42). Zaragoza, Spin: CIHEAM/IOC.
24. Moraga QE, Aranda CM, Alveres SC. Control de plagas. In J. A. Gomez (Ed.), Sostenibilidad de la production de olivar en Andalucia. Cordoba, Spain: Instituto de Agricultura Sostenible; c2010. p. 277-330
25. Moraga QE, Álvarez SC, González CS, Mármol CG, Fernández AA. Field evaluation of the susceptibility of mill and table olive varieties to egg- laying of olive fly. Journal of Applied Entomology; c2018.
26. Kombargi WS, Michelakis SE, Petrakis CA. Efffect of olive surface waxes on oviposition by *Bactrocera oleae* (Diptera: Tephritidae). Journal of Economic Entomology. 1998;91:993-998. https://doi.org/10.1093/jee/91.4.993.
27. Rizzo R, Virgilio C, Alberto L. Relation of fruit color, elongation, hardness, and volüme to the infestation of olive cultivars by the olive fruit fly, *Bactrocera oleae*. Entomologia Experimentalis et Appplicata. 2012;145:15-22.
28. Neuenschwander P, Michelakis S, Holloway P, Berchtol W. Factors affecting the susceptibility of fruits of different olive varieties to attck by Dacus oleae (Gmel.) (Dip., Tephritidae). Journal of Applied Entomology. 2009;100:174-188.
29. Malheiro R, Casal S, Cunha SC, Baptista P, Pereira JA. Olive volatiles from portuguese cultivars cobrançosa, madural and verdeal transmontana: Role in oviposition preference of *Bactrocera oleae* (Rossi) (Diptera: Tephritidae); c2015.
30. Malheiro R, Casal S, Cunha SC, Baptista P, Pereira JA. Identification of leaf volatiles from olive (Olea europaea) and their possible role in the ovipositional preferences of olive fly, *Bactrocera oleae* (Rossi) (Diptera: Tephritidae); c2016.
31. Bononi M, Tateo F. Preliminary data on volatile composition of olive fruits of CV. "SIMONA" and possible relationship to resistance to fly oviposition. Italian Journal of Food Science. 2017;29:582-590.
32. Garantonakis N, Varikou K, Markakis E, Birouraki A, Sergentani C, Psarras G, *et al*., Interaction between *Bactrocera oleae* (Diptera: Tephritidae) infestation and fruit mineral element content in Olea europaea (Lamiales: Oleaceae) cultivars of global interest. Applied Entomology and Zoology. 2016;51:257-265.
33. Neuenschwander P, Michelakis S. Infestation of Dacus oleae (Gmel.) (Dipetra, Tephretidae) at harvest time and its influence on yield and quality of olive oil in Grete. Apple. Entomol. 1978;86:420-33.
34. Katsoyannos B, Kouloussis N. Captures of the olive fruit fly *Bactrocera oleae* on spheres of different colors. Entomologia Experimentalis et Applicata. 2001;100:165-172.
35. Tzanakakis ME. Insects and mites feeding on olive: Distribution, importance, habits, seasonal development and dormancy. Boston, MA: Brill; c2006.
36. Alqurneh M. Field Studies on Biology, Ecology and Management of Olive Fruit Fly, *Bactrocera oleae* (Rossi) [Diptera: Tephritidae], in the central highlands of West-Bank, Palestine. M. Sc. Thesis, Plant Protection, Hebron University, Palestine; c2013. p. 93
37. Al-Zaghal K. Some Ecological Aspects of the Olive fruit fly (Dacus oleae Gmelin, Dipetra, Tephritidae) in Jordan. M. Sc. Thesis, Plant Protection, Faculty of Agriculture. University of Jordan; c1985.
38. Enrique M, Candido A, Salvador G, German M, Alfonso F, Meelad Y. Field evaluation of the susceptibility of mill and table olive varieties to egg- laying of olive fly. Journal of Applied Entomology; c2018.
39. Scarpati ML, LoScalzo R, Vita G, Gambacorta A. Chemiotropic behavior of female olive fly (*Bactrocera oleae* Gmel) on Oleae uropaea L. Journal of Chemical Ecology. 1996;22:1027-1036.
40. Daane KM, Johnson MW. Olivefruitfly: Managing an ancient pest in modern times. Annual Review of Entomology. 2010;55:151-160.
41. Gonçalves MF, Malheiro R, Casal S, Torres L, Pereira JA. Influence of fruit traits on oviposition preference of the olive fly, *Bactrocera oleae* (Rossi) (Diptera: Tephritidae), on three Portuguese olive varieties (Cobrançosa, Madural and Verdeal Transmontana), Scientia Horticulturae. 2012;145:127-135.
42. Burrack HJ, Zalom FG. Olive fruit fly (Diptera: Tephritidae) ovipositional preference and larval performans in several commercially important olive varieties in California, J of Econ. Entomol. 2008;101(3):750-758.
43. Iannotta N, Noce ME, Ripa V, Scalercio S, Vizzarri V. Assessment of susceptibility of olive cultivars to the *Bactrocera oleae* (Gmelin, 1790) and Camarosporium dalmaticum (Thum.) Zachos & Tzav-Klon attacks in Calabria (Southern Italy), J Environ. Sci. Health, Part B. 2007;42:789-793.
44. Gümusay B, Ozilbey U, Ertem G, Oktar A. Studies on the susceptibility of some important table and oil olive cultivars of Aegean Region to olive fly (Dacus oleae Gmel.) in Turkey, Acta Hortic. 1990;286:359-361.
45. Genc H. Screening of organophosphate resistance in the acetycholinesterase gene of field collected olive fruit fly, *Bactrocera oleae* Rossi (Diptera: Tephritidae), Romanian Biotechnological Letters. 2016;21:11209-11216.
46. Iannotta N, Perri E, Siriani R, Tocci C. Influence of Colletotrichum gloeosporioides (Penzig) and *Cladosporium dalmatica* (Thum) attacks on olive oil quality. Acta Horticulturae. 1999;474:573-776.
47. Pugliano G. La risorsa genetica dell'olivo in Campania. Napoli (IT): Regione Campania; c2000. p. 158.
48. Iannotta N, Noce ME, Ripa V, Scalercio S, Vizzarri V. Assessment of susceptibility of olive cultivars to the *Bactrocera oleae* (Gmelin, 1790) and Camarosporium dalmaticum (Thum.) Zachos & Tzav-Klon attacks in Calabria (Southern Italy), J Environ. Sci. Health, Part B. 2007;42:789-793.
49. Jimenez A. Influencia de la variedad de olivo en el comportamiento ovipositor de Dacus oleae Gmel. Boletin de Sanidad Vegetal. Plagas. 1988;14:95-98.
50. Hamdan A. Bionomics of Olive Fruit Fly, *Bactrocera oleae* (Rossi) [Diptera: Tephritidae] Infesting Ten Olive Cultivars in the Southern Highlands of West-Bank, Palestine. International Journal of Sciences: Basic and Applied Research; c2016.
51. Alqurne M. Field Studies on Biology, Ecology and Management of Olive Fruit Fly, *Bactrocera oleae* (Rossi) [Diptera: Tephritidae], in the central highlands of West-Bank, Palestine. M. Sc. Thesis, Plant Protection, Hebron University, Palestine; c2013. p. 93
52. Abo-Yaman I. Population fluctuation of Dacus oleae

Gmelin, and seasonal conditions. Prospects of Iraq Biology. 1963;3:22-34.

53. AL-Momane A, AL-Antere T. Garden and Home Pests, and Plant Diseases and Agricultural Insects. Plant Protection collage, Faculty of Agriculture, University of Jordan; c2008.
54. Al-Salti MN, Edriss O, Al-Ali M. Susceptibility of two olive varieties aldeibli and alkhudairi to olive fruit fly *Bactrocera oleae* (Gmelin.) (Diptera: Tephritidae), J of Agri. Sci. Tech; c2011. p. 987-996,
55. Donia AR, El Sawaf SK, Abou Ghadir MF, Sawaf SKE, Ghadir M, Abou F. Number of generations and seasonal abundance of the olive fruit fly, Dacus oleae (Gmel.) and the susceptibility of different olive varieties to infestation (Diptera: Trypetidae). Bulletin de la Societe Entomologique d'Egypte. 1971;55:201-209.
56. Genç H. Infestations of Olive Fruit Fly, *Bactrocera oleae* (Rossi) (Diptera: Tephritidae), in Different Olive Cultivars in Çanakkale, Turkey. World Academy of Science, Engineering and Technology International Journal of Agricultural and Biosystems Engineering. 2016;10(7).
57. Neuenschwander P, Michelakis S, Holloway P, Berchtold W. Factors affecting the susceptibility of fruits of different olive varieties to attack by Dacus oleae (Gmel.) (Diptera: Tephritidae) Z. Ang. Entomol. 1985;100:174-188.
58. Edriss O, Nammor D, Al Ali M. The dynamic of development of olive fruit fly population *Bactrocera oleae* Gemlin (Diptera: Tiphritideae) in home province. Journal of Al-Baath University. 2008;30;395-313.
59. Wang XG, Johnson MW, Daane KM, Yokoyama VY. Larger olive fruit size reduces the efficiency of Psyttalia concolor, as a parasitoid of the olive fruit fly. Biological Control. 2009;49:45.
60. Antonelli R, Chesi F. Relation between some physical variables and the probability of olive fruit fly infestation on drupe of the var. Frantoio. Frustula Entomologica. 1985;8:601-611.
61. Mesbah HA, Megda B. The insect pests of olive trees in SiwaOasis with special reference to Dacus oleae, Saissetia oleae and certain beneficial insects. Egyptian German Society of Zoology. 1996;21:167-185.
62. Sharaf NS. Life history of olive fruit fly, Dacus oleae Gmel. (Diptera: Tephritideae) and its damage to olive fruits in Tripolitania. Journal of Applied Entomology. 1980;89:390-400.
63. Malheiro R, Casal SR, Cunha SC, Baptista P, Pereira JA. Olive volatiles from Portuguese cultivars Cobrançosa, Madural and Verdeal Transmontana: Role in Oviposition preference of *Bactrocera oleae* (Rossi) (Diptera: Tephritidae). PLoS One. 2015b;10:e0125070.
64. Medjouh L, Costa A, Tamendjari Bekdouche F, Bouarroudj KPP, Oliveria B. Susceptibility of eight Algerian olive cultivars to *Bactrocera oleae* infestation – a pomological and nutritional quality perspective, Springer; c2018.
65. Stella C, Picchi M. Dacus oleae – induced alterations in olive fruit and oil: initial findings. Adv. Hort. Sci. 1991;5:87.
66. Pereira JA, Alves MR, Casal S, Oliveria MBPP. Effect Of Olive Fruit Fly İnfestation On The Quality on the Olive Oil From Cultivars Cobrancosa, Madural And Verdeal Transmontana. Ital. J Food Sci. 2004;3:16.
67. Gutierrez AP, Cossu QA. Effects of climate warming on olive and olive fly *Bactrocera oleae* (Gmelin) in California and Italy. Climatic Change. 2009;95:195-217. https://doi.org/10.1007/s10584-008-9528-4.
68. Hamdan JA. Bionomics of Olive Fruit Fly, *Bactrocera oleae* (Rossi) [Diptera: Tephritidae] Infesting Ten Olive Cultivars in the Southern Highlands of West-Bank, Palestine. International Journal of Sciences: Basic and Applied Research (IJSBAR). 2016;27(3):194-203.
69. Rice R. Bionomics of the olive fruit fly, Bactrocera (Dacus) oleae. University of California. Plant Protection Quarterly; c2000. p. 1-5.
70. Kakani EG, Mathiopoulos KD. Organophosphosphate resistance-related mutations in the acetylcholinesterase gene of Tephritidae. Journal of applied entomology. 2008 Dec;132(9-10):762-71.
71. Tovar MJ, Motilva MJ, Romero MP. Changes in the phenolic composition of virgin olive oil from young trees (Olea europaea L. cv. Arbequina) grown under linear irrigation strategies. Journal of Agricultural and Food Chemistry. 2001 Nov 19;49(11):5502-8.
72. Scalercio S, Brandmayr P, Iannotta N, Petacchi R, Boccaccio L. Correlations between landscape attributes and ecological traits of Lepidoptera communities in olive groves. European Journal of Entomology. 2012 Apr 5;109(2):207.
73. Gucci R, Caruso G, Bertolla C, Urbani S, Taticchi A, Esposto S, *et al*. Changes of soil properties and tree performance induced by soil management in a high-density olive orchard. European Journal of Agronomy. 2012 Aug 1;41:18-27.