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Assessment of fruit fly *Ceratitis capitata* (Diptera: Tephritidae) infestation levels on three different fruit varieties in Alexandria Governorate, Egypt

Seham, M. El-Mahdy; Mahenaz, A. A. Gab Alla and Afia, Y. E.
Plant Protection Research Institute, Agricultural Research Center, Dokki, Giza, Egypt.

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Abstract

The Mediterranean fruit fly *Ceratitis capitata* (Wiedemann) (Diptera: Tephritidae) is the most important insect pest of fruits**.** Indicated that adult females lay their eggs under the skin of the fruit and hatch into larvae that feed on the fruit flesh. Infested fruits rapidly rot and become inedible or fall on the ground, which causes serious damage in production. This study aimed to evaluate the infestation levels of three different fruit varieties mango, pomegranate, and navel orange by *C. capitata* insect at Alexandria Governorate during seasons 2021 and 2022. The levels of infestation with the Mediterranean fruit fly (MFF), *C. capitata* on three different fruit varieties, mango, pomegranate, and navel orange were studied at Borg El-Arab, Alexandria Governorate during two successive seasons (2021 and 2022). Results obtained indicated that the levels of infestation by *C. capitata* were significant in both seasons in the three different varieties, where the variance of ratio was (97.9-97.6%), for mango, (97.3 - 98.1%) for pomegranate with no differences between the mango and pomegranate where recorded (96.4 – 94.5%) for navel orange for two successive seasons, respectively. The relation between the average numbers of dropping fruits, infested dropping, and percentages of infestation for the three different fruit varieties, mango, pomegranate, and navel orange for two successive seasons 2021 and 2022 were (81.3-87.1%) for mango, (81.6-73.5%) for pomegranate and (92.8-85.4%) for navel orange. Statistical analysis showed that the simple correlation of % infestation dropping fruits of mango and max. and min. temperatures were highly significant whereas (r = 0.1931 & 0.4955) for max. & min. the temperature in the first season of 2021, respectively. Relative humidity was negatively significant, (r = - 0.1919). While in pomegranate was no significant with max., the mini. temperatures were (r = 0.7411, 0.5493) while being negative and significant with relative humidity were (- 0.6297). In navel orange max. the temperature was significant (r= 0.0690), mini. the temperature was highly significant (r = 0.1567). While relative humidity was negative and insignificant (r = - 0.5662) for the first season, 2021. The second season, 2022, follows the same trend. Regarding the percentages of infestation during two successive years, navel orange recorded the highest infestation percentage (92.6% - 85%), then (81.7% - 87.1%) for mango and (80.6%-71.8%) for pomegranate.

Introduction

Fruit trees mango *(Mangifera indica* L.*)*, pomegranate *(Punica granatum L.)*, and Navel orange as cultivars of the species *Citrus sinensis* are the most favorite fruits having an outstanding flavor with a range of varieties (FAO, 2013). These fruits have good nutritional value, have great variations in quality, and have good income production. In Egypt, the cultivated areas of these fruit varieties increased from one year to another, especially in the newly reclaimed

lands. These fruits are attacked by many agricultural pests, mites, and diseases. Tephritid fruit flies are one of the most serious insect pests of most cultivated fruit and vegetable crops; producers face high losses without some control program to manage fruit fly % infestations (Verghese *et al*., 2002). The Mediterranean fruit fly *Ceratitis capitata* (Wiedemann) (MFF) (Diptera: Tephritidae) is the most important insect pest of fruits, especially mango, pomegranate, guava, and citrus (Lux *et al*., 2003; Vayssières *et al*., 2008; Ekesi *et al*., 2009 and Pashakolaei, 2021).

The infestation of fruit fly considered a major general factor in guava production trees (Hasseb, 2007). Mediterranean fruit fly, *C. capitata.*, is one of the serious pests on fruit trees in Turkey (Demirel, 2020). *C. capitata* attacks more than 260 different fruits, fruit trees, and vegetables (Weems, 1981) indicating that *C. capitata* infestation is considered the most serious damage in fruit production and marketing. The quality and quantity of fruit yield were highly dependent on the management sound of fruit flies.

This work aims to evaluate the infestation levels of three different fruit varieties mango, pomegranate, and navel orange by *C. capitata* insect at Alexandria Governorate during seasons 2021 and 2022.

Materials and methods

1. Fruit infestation with Mediterranean fruit fly *Ceratitis capitata* on three different fruit varieties at Borg El-Arab, Alexandria Governorate:

Fruit infestation with *C. capitata* on three different fruit varieties was carried out on a private farm at Borg El-Arab, Alexandria Governorate for two successive seasons (2021 and 2022). The fruit varieties were Mango (Awyesy), Pomegranate (Sukari), and citrus (Navel orange). These trees were cultivated in the same orchard (20 feddan). The fruit trees of the successive varieties were about age 15-20 years old.

2. Fruit samples:

The fruit infestation by *C. capitata* in each of the successive fruit varieties was determined as follows: Five fruit trees that represented each fruit variety were selected. Fallen fruits for each successive fruit variety were collected weekly in plastic bags and then transferred to The Plant Protection Research Institute at Giza Governorate. Then it was incubated in a plastic tray with dimensions 15cm Radius X 25cm highest for about 5 days. Successive Fruits were produced pupae were considered infested and furnished with sterilized sand for pupation. Formed pupae were collected, counted, and reserved in a clear plastic jar until emergence. The collected flies were identified as the (MFF) *C. capitata*. Also, the percentages of infestation in each successive fruit variety by *C. capitata* were determined according to the equation proposed by Facylate (1971):

Degree of infestation = (n / N) X 100

Where: n = Number of infested fruits.

N = Total number of collected fruits.

3. Statistical analysis:

To determine the relationship between the infestation percentage % of the infested fruits by *C. capitata* and total number of fallen fruits and the current climatic factors, maximum and minimum temperatures and daily mean relative humidity at Borg El-Arab zone, Alexandria Governorate were obtained from the Central Laboratory for Agriculture Meteorology (A. R. C.). The daily records of each successive weather factor were calculated as means of weeks during the sampling dates. Weather factors were recorded over 15 weeks for each fruit variety. The results obtained of the total numbers of *C. capitata* and the infestation percentages % were statistically analyzed by using analysis of variance (ANOVA) in the SAS program, **SAS Institute (1988).**

Results and discussion

1. Levels of infestation of three fruit varieties with *Ceratitis capitata* during two seasons: 1

The results in Table (1) indicate the levels of infestation of different fruit varieties with *C. capitata* during the two successive seasons of 2021 and 2022. The

mean numbers of fallen fruits/trees were recorded (71.6 - 93.5 fruits) for mango, (36.4 - 39.3 fruits) for pomegranate, and (95.2 - 107.1 fruits) for navel orange during two successive seasons, respectively. Generally, the average fallen fruits were higher in the second season of 2022 than in the first season of 2021 for the three fruit varieties. The mean numbers of infested fallen fruits were (58.2, 29.7, and 88.3) for mango, pomegranate, and navel orange during the first season, respectively. While, recorded (81.4, 28.9, and 91.5) for the second season, respectively. The percentages of infestation were (81.3 and 87.1%), (81.6 and 73.5%) and (92.8 and 85.4%) for mango, pomegranate, and navel orange during the two successive seasons, respectively. The infestation levels varied differently according to different varieties. The percentages of infestation were higher in the first season (81.6%) than in the second (73.5%) for pomegranate and (92.8%) than in the second season (85.4%) for navel orange. While mango percentage infestation was higher in the second season (87.1%) than that in the first season (81.3%).

The percentage levels of infestation with *C. capitata* were significant in both seasons in the three different varieties, where the variance of ratio was (97.9 – 97.6%), for mango, (97.3 - 98.1%) for pomegranate with no differences between the mango and pomegranate where recorded (96.4 – 94.5%) for navel orange for two successive seasons, respectively.

Table (1): Average number of fallen fruits and percentage of infestation of fruit fly *Ceratitis capitata* on three different fruit varieties at Borg El-Arab, Alexandria Governorate during the 2021 and 2022 seasons.

Crops	Average No. of fallen fruits	Average No. of infested fallen fruits	%Infest. fallen fruits	Average No. of pupae	Average No. of emerged flies	% levels infestation
First season 2021						
Mango	71.6	58.2	81.3	69.6	68.2	97.9[a]
Pomegranate	36.4	29.7	81.6	25.7	25.0	97.3[a]
Navel orange	95.2	88.3	92.8	98.3	95.0	96.4[b]
"F"						189.71
LSD						1.990
Second season 2022						
Mango	93.5	81.4	87.1	72.7	71.0	97.6[a]
Pomegranate	39.3	28.9	73.5	31.8	31.2	98.1[a]
Navel orange	107.1	91.5	85.4	92.4	90.9	94.5[b]
"F"						194.04
LSD						2.034

Data obtained show that the % infestation of fallen fruits is very important in case of re-infestation of the three different fruits mango, pomegranate, and navel orange. Therefore should be collected, these fallen fruits to prevent fruit re-infestation. The obtained results are in Table (1) show the percentage % of the infested fallen fruits on mango trees increased from 27th August 2021 to 29th October 2022 (81.3 and 87.1%), respectively. While in pomegranate variety reached (81.6 and 73.5%) on 20th August 2021 and 7th August 2022, respectively. Also, in navel orange variety reached (92.8 and 85.4%) on 17th September 2021 and 15th September 2022 respectively. Statistical analysis between the percentages of infested fruits of the three different fruit varieties and average numbers of fallen fruits, the variance ratio was (F=189.71) and LSD (1.990) for the first season, 2021, and (F=194.04) and LSD (2.034) for the second season, 2022, respectively.

2. Effect of weather factors:

2.1. Mango variety:

The data obtained about the average numbers of flies of *C. capitata* infested fallen fruits of mango with corresponding means of main weather factors at Borg El-Arab, Alexandria Governorate during the 2021 season are illustrated in Figures (1 and 2). These results revealed that infestation of *C. capitata* was found to occur on mango fruits throughout during end of July infestation was represented with few numbers (80 flies/tree) where the means of weather factors during this period recorded (33°C and 24 °C for maximum and minimum temperature) and (64% relative humidity). Then, infestation increased rapidly in August and recorded (216 flies/tree) and (33 °C and 26 °C for maximum and minimum temperature) and (66% RH.). Afterward, the infestation insect fluctuated and recorded two peaks the first in mid-September (180 flies/tree) where weather factors were recorded (29 °C and 24 °C for maximum and minimum temperature) and 50% RH.), and the second peak at the beginning of October (194 flies/tree) during 2021 with corresponding means of weather factors (30 °C and 23°C for maximum and minimum temperature) and (61% RH.). In the second season 2022, the infestation increased and fluctuated from the end of July to mid-October and recorded two peaks at the beginning of September (98 flies/tree) where weather factors (31°C and 24°C for maximum and minimum temperature) and (61% RH.) and the second mid-September (90 flies/tree) with (29 °C and 24 °C for maximum and minimum temperature) and (58% RH.).

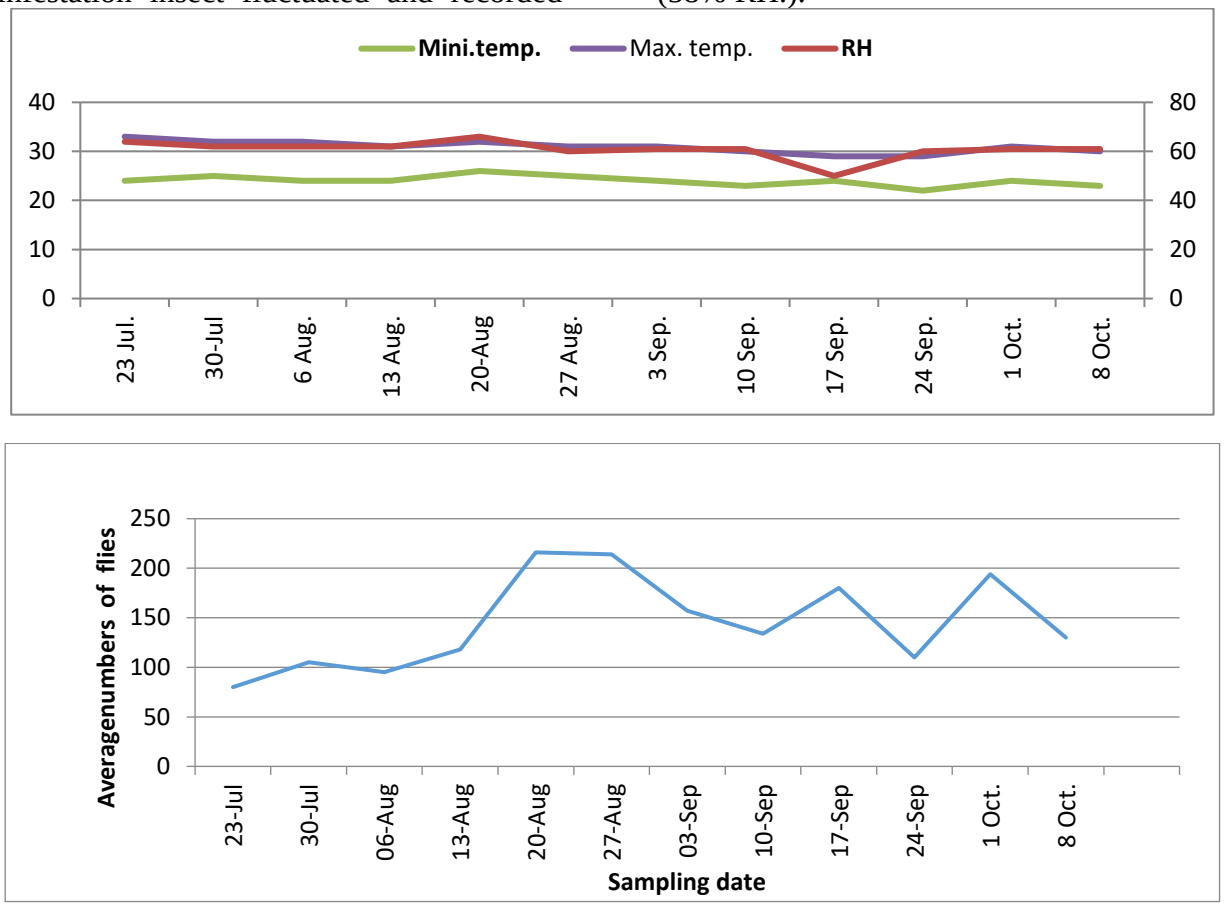


Figure (1): Average numbers of flies of *Ceratitis capitata* infested fallen fruits of mango with the main weather factors at Borg El-Arab, Alexandria Governorate during the 2021 season.

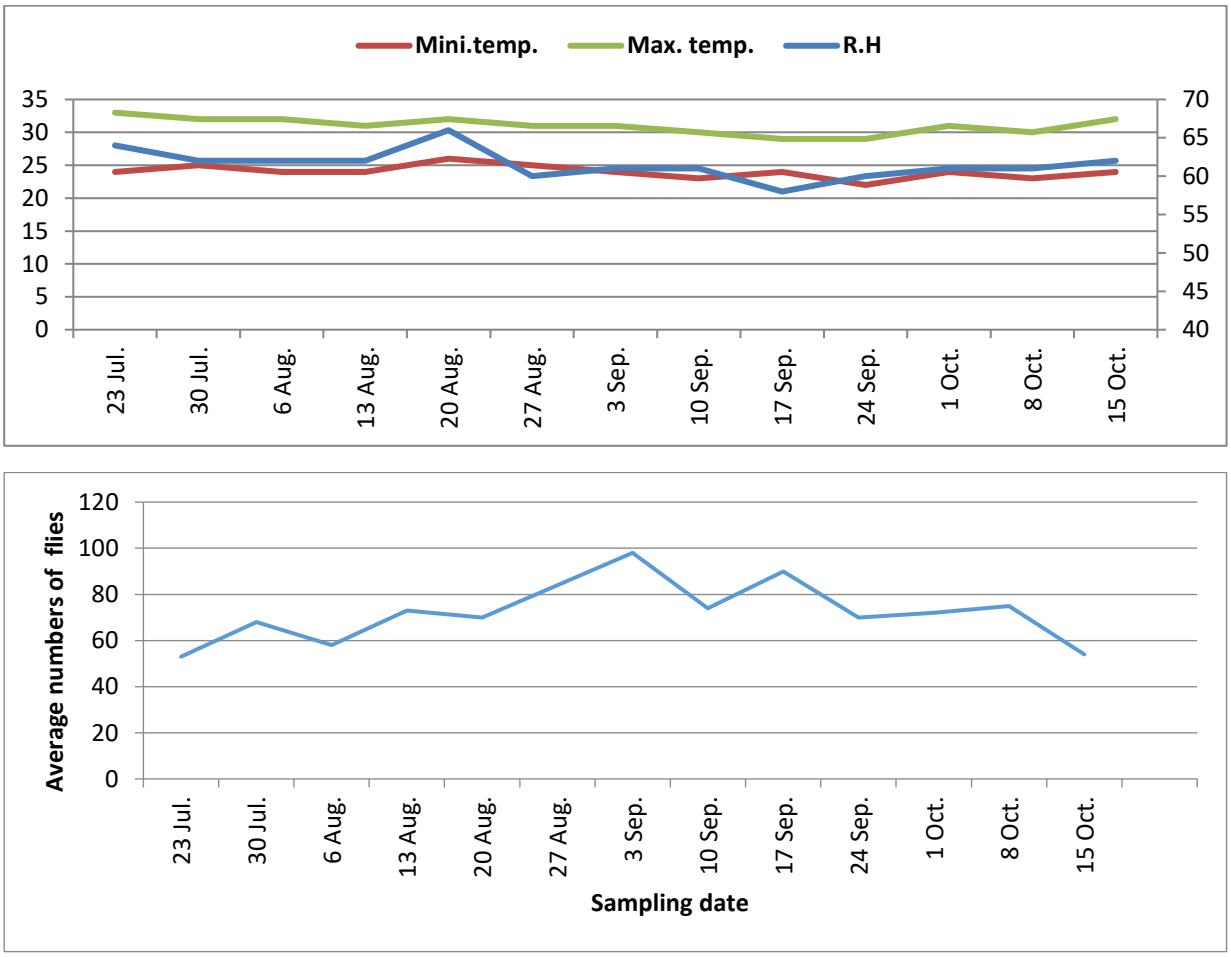


Figure (2): Average numbers of flies of *Ceratitis capitata* infested fallen fruits of mango with the main weather factors at Borg El-Arab, Alexandria Governorate during the 2022 season.

2.2. Pomegranate variety:

Data obtained about the average numbers of flies of *C. capitata* infested fallen fruits of pomegranate with corresponding means of main weather factors at Borg El-Arab, Alexandria Governorate during the 2021 season are illustrated in Figures (3 and 4). These results revealed that infestation of *C. capitata* was found to occur on pomegranate fruits throughout during beginning of August the infestation was represented with few numbers (86 flies/tree) where the means of weather factors during this period recorded (32°C and 24°C for maximum and minimum temperature) and (62% relative humidity). Then, on average the infestation increased rapidly at the end of August and recorded (178 flies/tree) and (32°C and 26°C for maximum and minimum temperatures) and (66% RH.). Afterward, the average infestation decreased gradually and recorded the lowest number (40 flies/tree) in mid-September where weather factors recorded in that period (29°C and 24°C for maximum and minimum temperature and 50% RH.). In the second season 2022, the average infestation increased gradually from mid-August and recorded a maximum (Of 98 flies/tree) where weather factors (32°C and 24°C for maximum and minimum temperature) and (59% RH.) and recorded a high number (155 flies/tree) at the beginning of September where weather factors were (31°C and 25°C for maximum and minimum temperature and 60 % RH.).

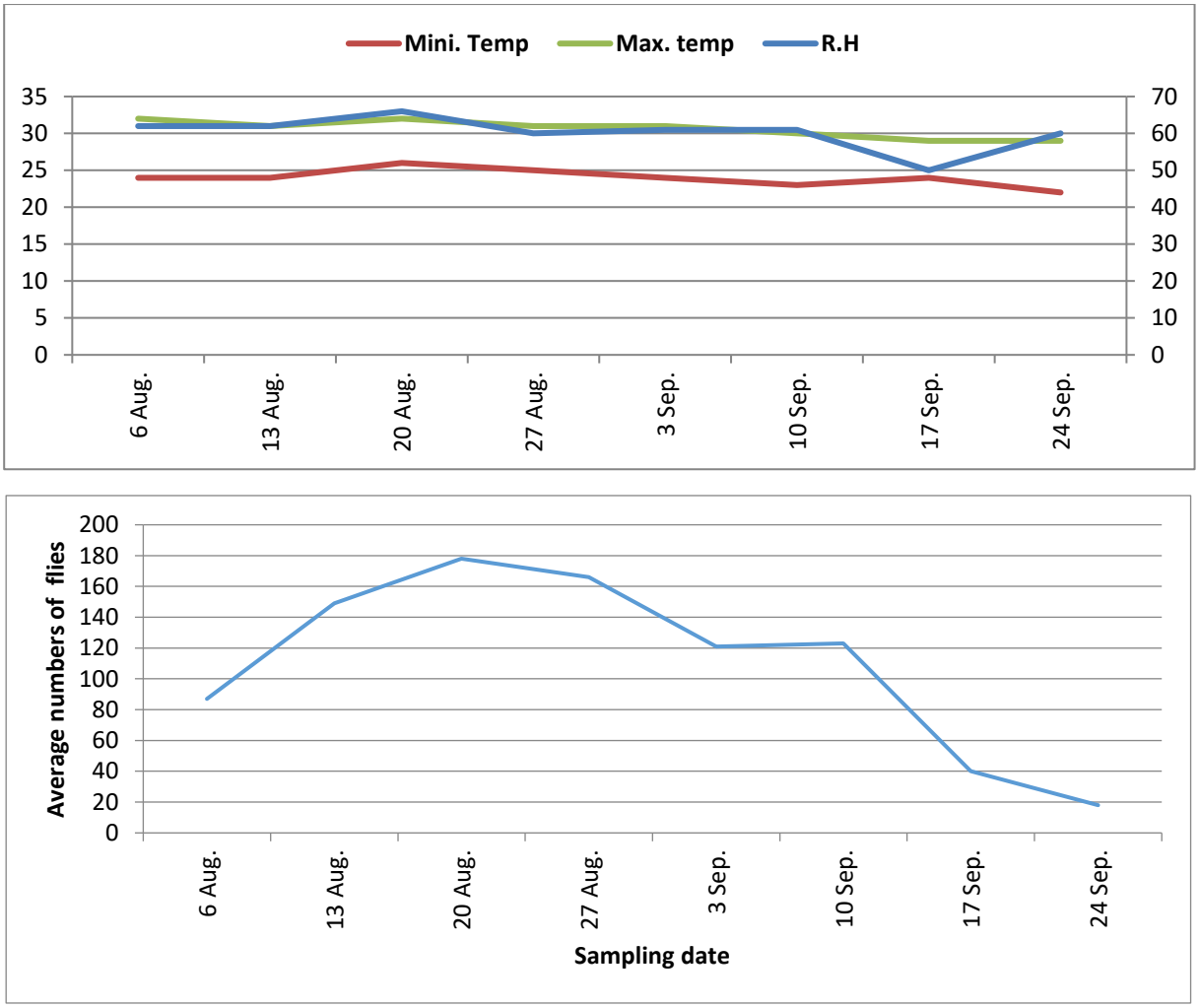
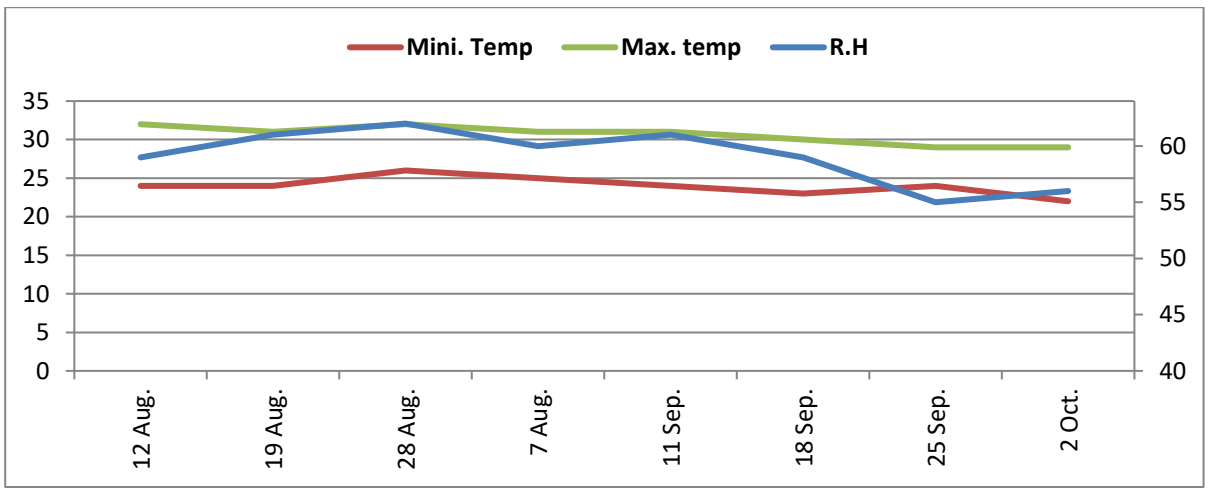


Figure (3): Average numbers of flies of *Ceratitis capitata* infested fallen fruits of pomegranate with the main weather factors at Borg El-Arab, Alexandria Governorate during the 2021 season.



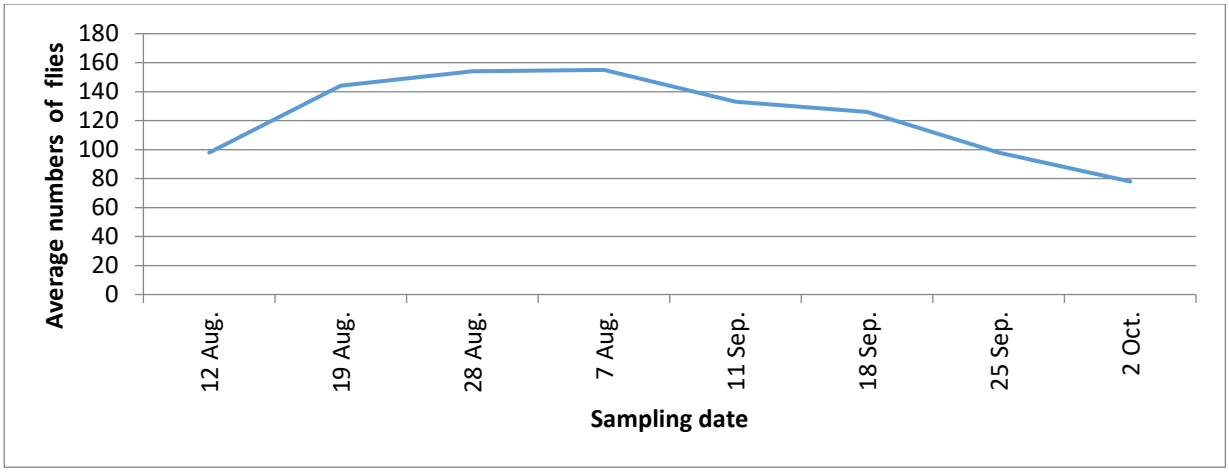
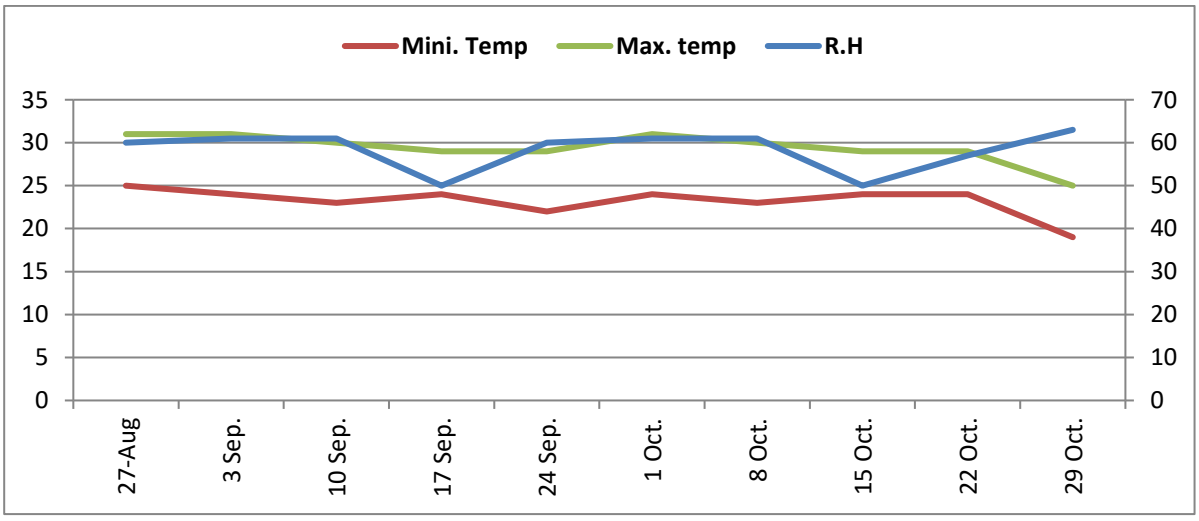


Figure (4): Average numbers of flies of *Ceratitis capitata* infested fallen fruits of pomegranate with the main weather factors at Borg El-Arab, Alexandria Governorate during the 2022 season.

2.3. Navel orange variety:

The results obtained about the average numbers of flies of *C. capitata* infested fallen fruits of navel orange with corresponding means of main weather factors at Borg El-Arab, Alexandria Governorate during the 2021 season are illustrated in Figures (5 and 6). These results revealed that infestation of *C. capitata* was found to occur on navel orange fruits throughout during end of August and the infestation was represented with few numbers (37 flies/tree) where the means of weather factors during this period recorded (31°C and 25°C for maximum and minimum temperature) and (60% relative humidity). Then, the number of flies infestation increased gradually, and the high peak infestation of *C. capitata* was (176 flies/tree) in mid-September and (29°C and 24°C for maximum and minimum temperatures) and (50% RH). Afterward, the infestation decreased gradually and recorded the lowest number (46 flies/tree) in end-October where weather factors were recorded at that period (25°C and 19°C for maximum and minimum temperatures) and (63% RH.). The second season 2022 average infestation increased gradually from end-August and recorded (41 flies/tree) where weather factors (33°C and 25°C for maximum and minimum temperatures) and (59% RH.) and recorded the highest number (171 flies/tree) in mid-September where weather factors were (34°C and 22°C for maximum and minimum temperatures) and (58 % RH.).



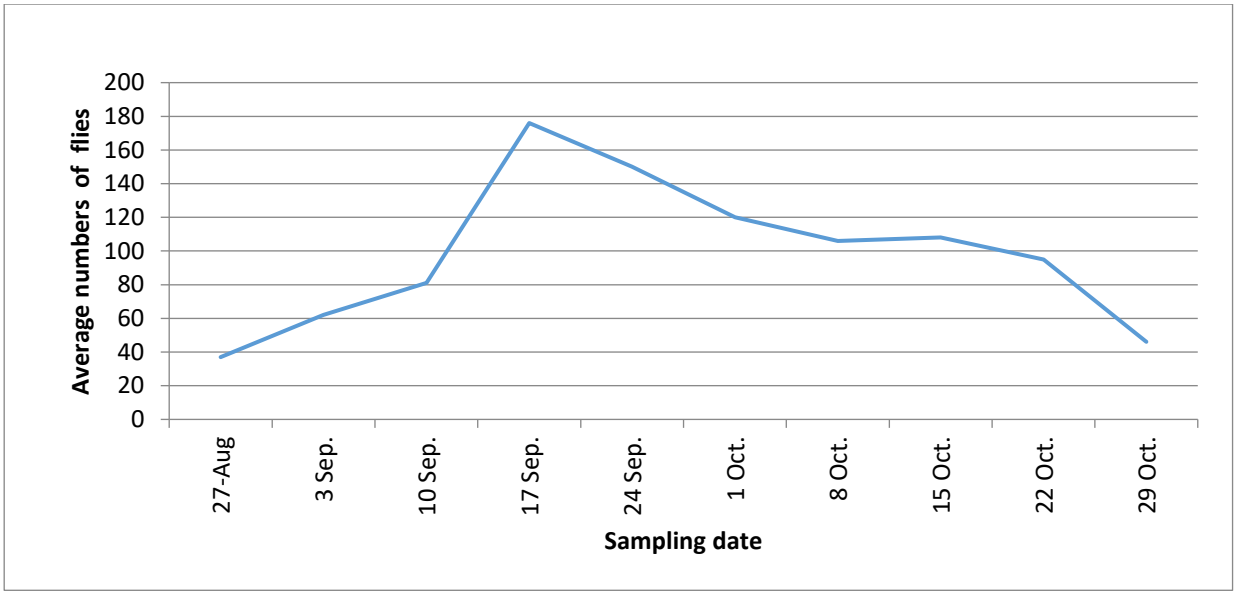


Figure (5): Average numbers of flies of *Ceratitis capitata* infested fallen fruits of navel orange with the main weather factors at Borg El-Arab, Alexandria Governorate during the 2021 season.

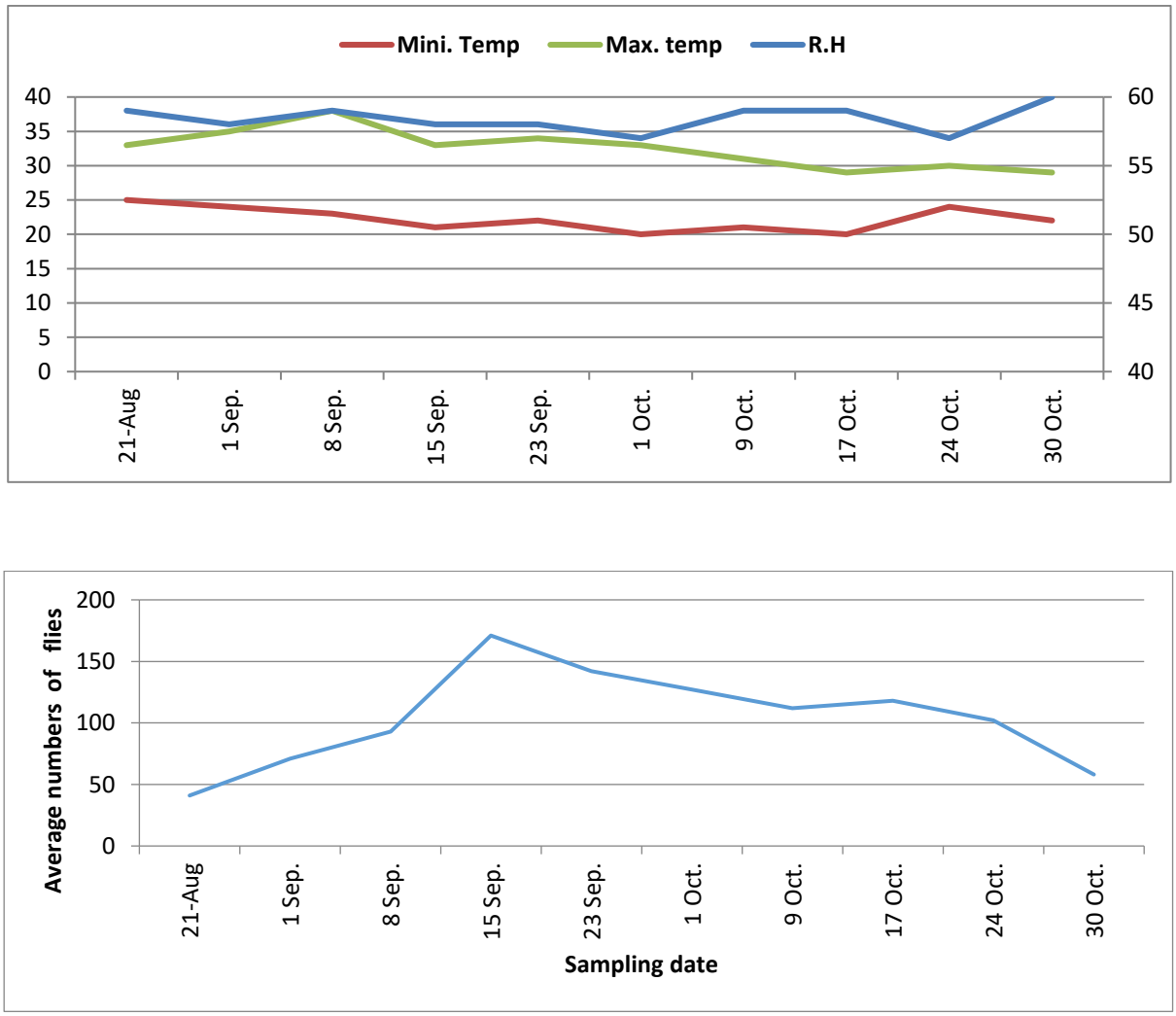


Figure (6): Average numbers of flies of *Ceratitis capitata* infested fallen fruits of navel orange with the main weather factors at Borg El-Arab, Alexandria Governorate during the 2022 season.

3. Average number of droppings, infested and percentages of different fruit varieties:

Results obtained about the relation between the average numbers of dropping fruits, infested dropping, and percentages of infestation for the three different fruit varieties, mango, pomegranate, and navel orange were illustrated in Figures (7 and 8) for two successive seasons 2021 and 2022. Results showed that the percentages of infestation during two successive seasons, the navel orange recorded the highest infestation percentage (92.8% - 85.4%), then (81.3% - 87.1%) for mango and (80.6%-73.5%) for pomegranate. The percentage of infestation was higher in the first season than in the second season.

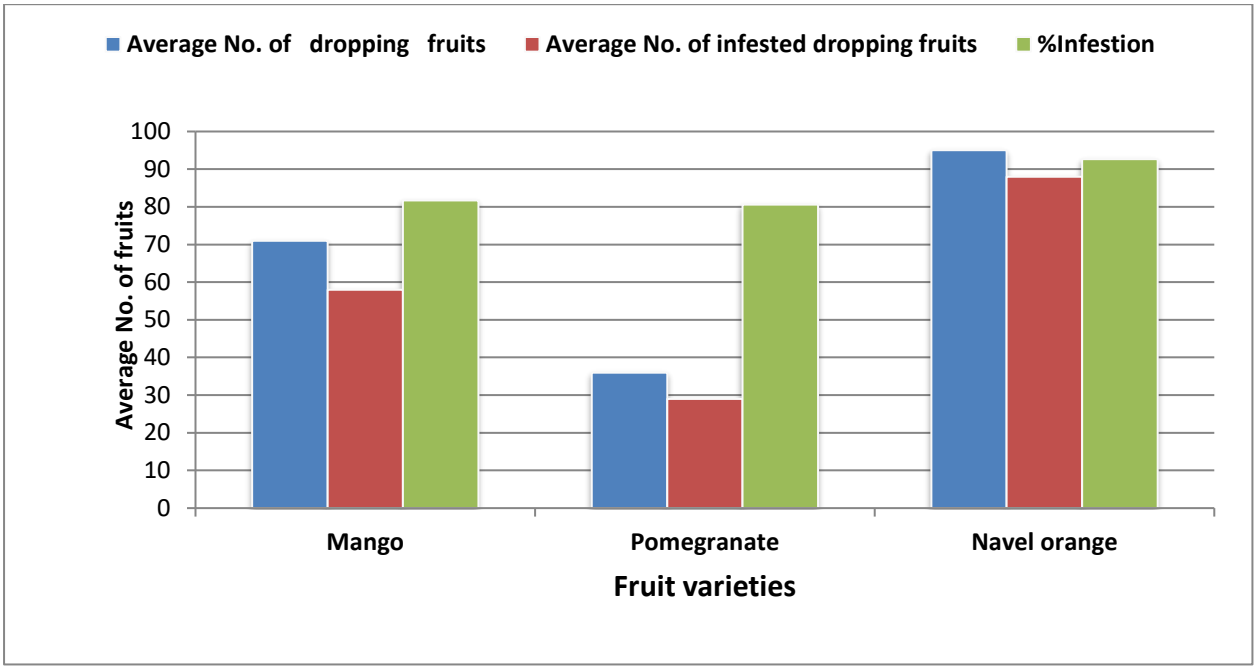


Figure (7): Average numbers of dropping, infested, and percentages of different fruit varieties corresponding with the fruit fly, *Ceratitis capitata* at Alexandria Governorate during 2021.

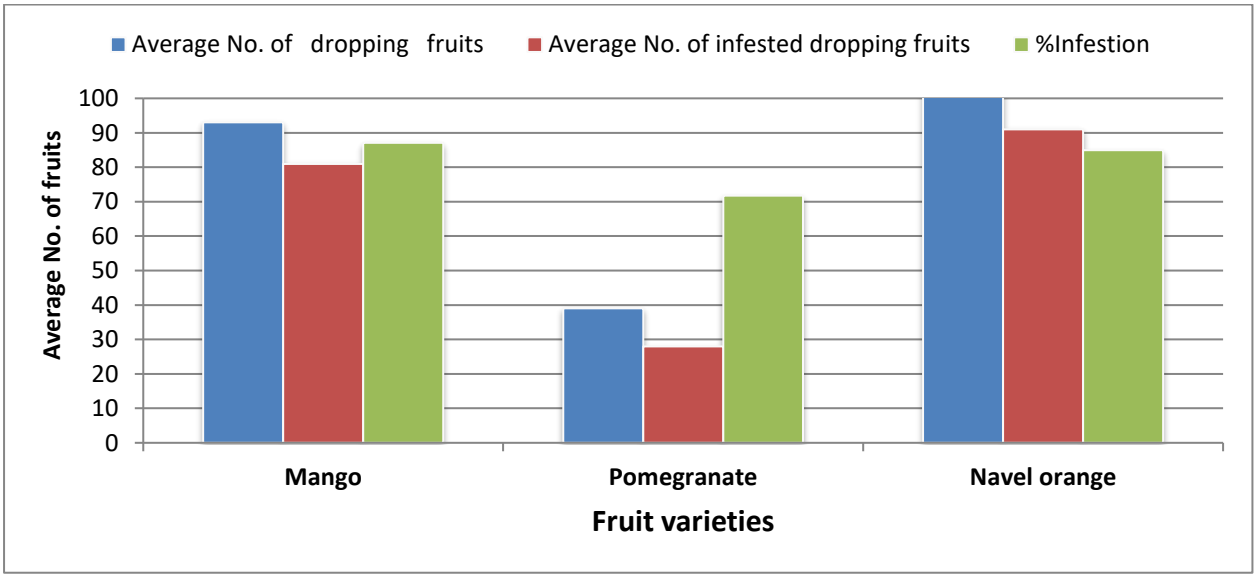


Figure (8): Average numbers of dropping, infested, and percentages of different fruit varieties corresponding with the fruit fly, *Ceratitis capitata* at Alexandria Governorate during 2022.

Data in Table (2) showed that the simple correlation between %infestation of fallen fruits of mango and max., min. temperatures were positive high significant (r = 0.1931 and 0.4955) for max. and mini. temperatures during the first season of 2021, respectively. For relative humidity was negative significant, (r = - 0.1919). While in pomegranate was no significant with max. and mini. temperatures were (r = 0.7411, 0.5493), while was negative and insignificant with relative humidity were (-0.6297). In navel orange max. temperature was significant (r = 0.0690), mini. the temperature was highly significant (r= 0.1567). Relative humidity was negative and insignificant (r= - 0.5662) for the first season, 2021. The second season, 2022, follows the same trend.

Table (2): Results of statistical analysis for simple correlation to show the effects of three weather factors on the percentage infestation of fruits with the fruit fly, *Ceratitis capitata* during the 2021 and 2022 seasons.

Crops	`Source of Variance	Simple correlation "r"	P.	Simple regression "b"	P.
	First season 2021				
Mango	**Max. Temp**	0.1931	0.0005	1.36988	0.0002
	Min. Temp.	0.4955	0.0017	0.82798	0.0094
	RH. %	-0.1919	0.3541	0.27244	0.2837
Pomegranate	**Max. Temp**	0.7411	0.2861	0.24166	0.2964
	Min. Temp.	0.5493	0.3574	0.17274	0.4674
	RH. %	-0.6297	0.4674	-0.41681	0.0005
Navel orange	**Max. Temp**	0.0690	0.0167	0.07630	0.0093
	Min. Temp.	0.1567	0.0054	0.17087	0.0286
	R.H. %	-0.5662	0.2817	0.38780	0.0066
Second season 2022					
Mango	**Max. Temp**	0.5865	0.0083	0.12226	0.0005
	Min. Temp.	0.0190	0.0034	0.91090	0.0149
	RH. %	-0.5377	0.6304	0.62539	0.5721
Pomegranate	**Max. Temp**	0.6001	0.2004	1.07803	0.4666
	Min. Temp.	0.7509	0.1078	0.08696	0.9521
	RH. %	-0.8450	0.2330	-0.30427	0.0057
Navel orange	**Max. Temp**	0.0322	0.0395	0.69968	0.0166
	Min. Temp.	0.6720	0.0052	1.17366	0.0614
	RH. %	-0.4750	0.2507	-0.22472	0.0198

The obtained results agreed with those obtained by Eskafi and Kolbem (1990) in Guatemala. Tsitsipis (1992) in the Netherlands indicated that the host fruit had an important role in the development of fruit flies. Also, Bodenheimer (1951) indicated that the percentage of the infestation (%) on apricot was a hundred percent in May and the early maturing plum was only infested (3%) in July, whereas the percentage was 30% of the later varieties. Also, Saafan *et al.* (2005a and b) in Egypt indicated that *C. capitata* had very low numbers compared to *B. zonata* in apricot in Fayoum Governorate during seasons 2002-2004. Also, Amin (2008) in Egypt referred to that the infestation rate of fruit flies was recorded in July and the highest percentage of infestation % was recorded in August month.

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