Academic Journal of Entomology 16 (2): 70-83, 2023
ISSN 1995-8994

DOI: 10.5829/idosi.aje.2023.70.83

Ecological and Toxicological Studies on Date Palm Scale *Fiorinia phoenicis* Balachowsky (Hemiptera-Diaspididae) Infesting Three Date Palm Cultivars with Reference to Anatomical and Chemical Analysis of Palm Cultivars Leaflets At Giza Governorate, Egypt

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Abstract: One of the most significant fruits in the Middle East is the date palm. Dates are vulnerable to infestation by a variety of pests, including, Fiorinia date scale, *Fiorinia phoenicis* Balachowsky (Hemiptera-Diaspididae), which infests the palm fronds and sucks the sap and the infestation extends to the date fruits in the case of severe infestation and leads to making the fruits unacceptable for consumption. This experiment aimed to study the population density of date palm scale *F. phoenicis* on three different date palm cultivars, they represent the three main groups of date palm cultivars in Egypt to determine the proper time to be controlled and evaluation of some pesticides and their alternatives. Furthermore, the levels of several chemical substances (including total phenols, proline, total indoles, amino acids, total protein, peroxidase, polyphenol oxidase, chlorophyll a and chlorophyll b) in the leaves of both infested and healthy tested date palm cultivars were quantified. The difference in the anatomical structure of the leaflet was also studied in the three tested palm cultivars. The results showed that the population density of the *F. phoenicis* recorded three peaks of the three insect stages for each year of the two studied years 2021/2022 and 2022/2023. The three peaks resulted in three overlapping generations during each year of the two studied years as follows: early summer, late summer and fall generations. The results also showed that there was no significant difference between the insect population in the two years of the study, while there were significant differences between the insects population on the tested date palm cultivars, where the Siwi cultivar recorded the highest number, followed by the Bartamoda cultivar and then the lowest number of insects was the Samani cultivar. Obtained pest dynamics over the three date palm cultivars showed as three intervals of activity per year regardless palm cultivar. Effect of maximum, minimum temperature and % RH was evaluated over each interval (as partial regression) as well as plant ages (as third degree of polynomial) were determined. Both models were significant with superiority to plant age model. The results of the control experiment on the most affected date palm cultivar, Siwi showed that average reduction rate for the three checks after 2 , 4 and 6 weeks, in case of the mixture of (New oil 95% EC + Kimithrene 25% SC) showed the highest efficiency in reducing the insects population with an average of 88.58%, followed by Palmito gold 25% EC with an average of 81.43%, then Admiral with an average of 80.89%, while the effect of the moderate reduction of the insect population of the pesticides Kemithrene 25% SC, New oil 95% EC and Prev-AM 6% (W/V) with averages of 76.74, 75.02 and 73.78% respectively, it had the least effect on reducing the number of Fresh oil 95% EC with an average of 65.23%. *F. phoenicis'* responses to the tested treatments at various life stages revealed that the nymphal stage was the most vulnerable, followed by adults and gravid females. Obtained data indicated that the infested date palm tree leaves contained high significant quantity of proline, total phenols, peroxidase and polyphenol oxidase in leaves, whereas total indoles, amino acids, total protein, chlorophyll a and chlorophyll b contents

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were low compared to healthy date palm. The results of palm leaf dissection showed a difference between the thickness of the cuticle, epidermis and hypodermis layers between the three tested cultivars, where the thickness of the three layers was the largest in the Samani cultivar which had the lowest insect population, followed by the thickness of the layers in the Bartamoda cultivar which had a moderate insect population, while the thickness of the three layers was the lowest in the Siwi cultivar Which had the most insect population.

Key words: *Fiorinia phoenicis* · Date palm pests · Population density · Date palm cultivars · Control · Leaflet components and date palm leave anatomy

INTRODUCTION

The oldest and most significant fruit tree is the date palm *(Phoenix dactylifera*). It is primarily found and grown in North Africa and the Middle East [1-5]. In many places, date palms are used for shelter, wood products and even as a source of carbohydrates. Egypt is the world's top producer of dates, producing about 1.7 million tons of dates annually from 15 million fruitful palm trees. These amounts is considered 20 % of global production [6].

Date palms are exposed to many insect pests and one of the most important of these pests is scale insects [7-11]. It has been known that the diaspidid species *Parlatoria blanchardii* (Targ.) attacks the date palm, *P. dactylifera* L. leaflet, in Egypt [12]. *Fiorinia phoenicis* Balachowsky, a diaspidid species has replaced *P. blanchardii* in many Egyptian governorates, as the main diaspidid species that attacks date palm [13].

Fiorina palm scale insect is an important economic pest that was recorded for the first time on date palms in Egypt by Ghabbour and Mohammad [14]. Numerous nations, including Iraq, Saudi Arabia, Oman, Iran and Spain [19] have *F. phoenicis* recorded [15-19]. In Egypt, some researches have been done on the bionomics of *F. phoenicis* on date palm in the governorates of Giza and Qalubyia [20, 21]. Fiorinia date scale primarily infests the fronds of the date palm and occasionally the date fruits. The crawlers move to the date fruits bunches forming thick crusts in cases of serious infestation, which makes the date fruits unsuitable for human usage. The date palm's growth was severely hampered by the severe infestation, especially the offshoots where the pinnae turned yellow and the fronds became dry [22]. Field observation revealed that the pinnae of older date palm fronds (lower fronds) were heavily infested with *F. phoenicis* than the fresh ones (new higher fronds).

But more studies are required to assess the extent to which the insect population has been affected by the different groups of different palm cultivars in it, as well as the extent to which the population has been affected by climatic changes in temperature and humidity in the last two years. In addition, an evaluation of some pesticides in its control. Also, a study to see if there were differences in the chemical and anatomical composition of the date palm cultivars leaflet, healthy and infested with scale insects *F. phoenicis*, which may explain the reason for the increased sensitivity of one cultivar to the infestation compared to other cultivars.

The current work aimed to study the population density of date scale insect, *F. phoenicis* on three different date palm cultivars, number and duration of annual field generations and its control by different insecticides and alternative insecticides at Giza Governorate. In addition to studying the extent to which its population is affected by the most important weather elements prevailing in the region. Also evaluate the differences in the chemical and anatomical composition of the three tested date palm cultivars leaflet, healthy and infested with *F. phoenicis* scale insects.

MATERIALS AND METHODS

Sampling Procedures: *F. phoenicis* population density was investigated on the three main groups of date cultivars in Egypt, where the fresh palm group was represented by the Samani cultivar, the Semi-dry palm group was represented by the Siwi cultivar, while the Bartamoda cultivar represented the dry palm group. At date palms that are grown in the orchard of the Giza Governorate Research Station of the Agricultural Research Center, Egypt over the course of two seasons, 2021-2022 and 2022-2023. Over a period of 24 months, beginning on April 1, 2021 and ending on April 1, 2023. Throughout the course of this investigation, the date palm orchard was treated as usual and was free of insecticide sprays. For each of the three tested cultivars, three date palm trees of comparable age, height and vigor were chosen at random. For two years, samples were taken every two weeks. Each cultivar was represented by three replicates, each replicate being a palm tree. Twenty leaflets were taken from each palm tree

Table 1: Active ingredient and applied rate of tested insecticides

Trade name	Common name	Pesticide group	Recommended rate
New oil 95 % EC	Miscible oil	Mineral oil	1.5L/100L Water
Fresh oil 95 % EC	Mayonnaise oil	Mineral oil	2.5L/100L Water
Kemithrene 25% SC	Kemithrene	Pyrithroid	1Cm/L Water
Admiral	Insect growth Regulator I.G.R	Pyriproxyfen	75Cm/100L Water
Prev-AM 6% (W/V)	Orange oil	contact bio-pesticide	400Cm/100L Water
Palmito gold 25% EC	Miscible oil	Plant oil	1 L/100L Water

(60 leaflets/ cultivar), each measuring about 30 centimeters in length, were selected at random from palm trees in all directions. The samples that had been collected and kept in pored polyethylene bags were brought to the laboratory so that they could be inspected with a stereomicroscope. The alive individuals in each sample were counted and categorized as pre-adult (nymphs), adult and adult + egg (gravid). Graphically illustrated were the mean of pre-adult, adult and gravid half-monthly means for 60 leaflets. The number of the insect population was counted in each cultivar and recorded.

Meteorological Factors: Means of maximum and minimum daily temperature degrees as well as the mean percentage of daily relative humidity were collected for the Giza area from the Egypt-Weather Underground at https://www.wunderground.com/global/EG.html. These weather parameters are thought to have an impact on the investigated insects. For each period of fifteen days prior to the sample date, the collected data was summarized. The calculated and presented weather factor means over each determined generation. Obtained pest dynamics over the three data palm cultivars showed as three intervals of activity per year regardless palm cultivar. Effect of maximum, minimum temperature and % RH was evaluated over each interval (as partial regression) as well as plant ages (as third degree of polynomial) were determined.

Chemical Control Experiment under Field Conditions: An experiment was carried out to evaluate pesticides and its alternatives to control the date palm scale insect *F. phoenicis* on the most affected date palm cultivar, Siwi through the results of the population density recorded during the two years of the study. The samples were taken using the same method used in the population density experiment. Samples of infested leaves/treatment were taken immediately before spraying as index of pre-treatment count and after 2, 4 and 6 weeks after the spray. Seven treatments, including six treatments with pesticides and a treatment with a mixture of mineral oil and chemical pesticide Table (1), in addition to controls treatment were tested. The tested compounds were applied for 6 weeks, from 3 January to 14 of February 2023 for 6 weeks, using a 25-liter knapsack sprayer. The reduction percentage of *F. phoenicis* nymphs, adult females and gravid females were estimated according to Henderson and Tilton equation [23].

Chemical Components of Infested and Healthy Date Palm Tested Cultivars Leaflets: Leaflets infested with Fiorinia scale insect and healthy leaflets of the tested date palm cultivars with the same size, age and height from the ground and/taken from palms of the same age were collected. The samples were transferred to component of analyzes and studies in the Soils, Water and Environment Unit of the Soils, Water and Environment Research Institute, for the analysis of the chemical components: Total phenols, proline, indoles, amino acid and protein were determined by Ainsworth and Gillespie [24]; Abrahám *et al.* [25]; Selim *et al.* [26]; McGrath [27] and Sarkar *et al.* [28] respectively. Determination of plant pigments: chlorophyll a and chlorophyll b were extracted and evaluated according to Von Wettstein [29]. Estimation of Peroxidase and polyphenol oxidase activity were determined according to Ghazi [30] and Coseteng and Lee [31] respectively.

Anatomical Differences of Leaflet Layers of the Three Tested Date Palm Cultivars: Leaflets of date palm tested cultivars of dry date (Bartamoda) and semi-dry dates (Siwi) and fresh date (Samani) growing in Giza Governorate, on which the experiment was conducted to investigate the anatomical differences. Three palm trees were selected for each cultivar, homogeneous in length and the strength of growth and age as much as possible. Leaflets sample were collected from the fifth row of fronds from the bottom and three leaves from each variety were taken and fixed them in a F.A.A solution for 48 hours, then the cut parts were passed with increasing concentrations of ethyl alcohol, then the samples were buried with Then the samples were buried with paraffin wax at a temperature of 58 °C, after that the samples were cut by a Rotary Microtone with a thickness of a micrometer, loaded on slides and dyed with Safranin dye, then placed in Fast Green dye, then loaded with the addition of drops of DPX and covered according to the method of Al-Attar *et al.* [32]. Then the slides were studied and micrometric measurements (micro meter µm) were taken using the ocular measuring lens (ocular micrometer) in an optical microscope of the Olympus type equipped with a camera connected to the computer in the Central Laboratories of the Faculty of Agriculture, Cairo University.

Statistical Analysis: Obtained data was analyzed using Proc Reg in SAS Anonymous [33]. Weather factors (i.e. max, min temperatures and % RH were considered as linear ones over each inspection period). Data was fitted to the polynomial model, where plant age (as weeks) was presented as third degree of polynomial (i.e. Age, Age2 and Age3). The multiple polynomial equation becomes Y= a ± b1 Tmax ± b2 Tmin ± b3 RH ± b4 Age ± b5 Age2 ± b6 Age3.The effect of each wether factor and plant age was studied individually by applying partial regression coefficient (b) as a measure of significance. Explained variance (E.V.%) and variance ratios (F values) were used as measure of significance in combination of all studied factors in the three intervals.

RESULTS AND DISCUSSION

Population Density of *F. Phoenicis* on Three Date Palm Cultivars from 2021 to 2023: Data demonstrated in Figures (1and 2) indicated the half-monthly variance in the mean population density of the *F. phoenicis* nymphs, adults and gravid females on the leaves of three date palm cultivars in Egypt, Samani, Siwi and Bartamoda which belong to the three main groups of fresh, semi-dry and dry cultivars, respectively at Giza Governorate over two successive years (from the first of April 2021 until the first of April 2023). The nymph, adult and gravid female populations' fluctuation trends were quite comparable. In light of this, it is preferable to discuss population densities based on the total average number of nymphs, adults and gravid females counted at subsequent sampling dates.

Population density of *F. phoenicis* on three date palm cultivars in the 1st year, 2021/2022: The initial mean count of nymph, adult and gravid female populations in April (Fig.1) ranged 11.33-38.11, 25.33-41.11 and 12.56-19.67 insects/leaflet on date palm cultivars, Samani, Siwi and Bartamoda, respectively. This insect's count gradually increased in May to record the 1st peak on the first of June with mean population of 90.56, 137 and 59.78 insects/leaflet on date palm cultivars, Samani, Siwi and Bartamoda, respectively under field conditions of 33.67, 20.53 °C and 45.82 %R.H for maximum, minimum and relative humidity, respectively. In the rest of the month of June and July, the insect populations decreased to 6.11, 10.11 and 0.90 insects/leaflet on date palm cultivars, Samani, Siwi and Bartamoda, respectively in the middle of July. In August, the population gradually increased again with relatively high population. With a mean population of 51.89, 109.33 and 25.44 insects / leaflet on date palm cultivars, Samani, Siwi and Bartamoda, respectively at 36.00, 26.11 °C and 58.87 %R.H for maximum, minimum and relative humidity, respectively, the insect population rose and reached the second peak in early September. The mean number of insects decreased in the rest of September, then gradually increased again in October, to record the third peak of insect activity at the beginning of November, with an average population of 68.11, 104.00 and 155.38 insects/leaflet on date palm cultivars, Samani, Siwi and Bartamoda, respectively at 28.22, 20.30 °C and 57.47 %R.H, respectively. Insect populations quickly started to drop in December. In January and February, there was a further decline in the insect population which fell to 23.22-14.64, 29.89-20.33 and 48.49 - 39.96 insects/leaflet, respectively. In the month of March, the Insect populations continued to decrease as well and then a slight increase in the populations began at the beginning of April.

Population Density of *F. phoenicis* on Three Date Palm Cultivars in the 2nd year, 2022/2023: The mean count of nymph, adult and gravid female populations (Fig. 2) was relatively low in the middle of April. The population started to grow in early May and reached its first peak in early June, with a mean population of 73.03, 71.78 and 86.61 insects/leaflet on date palm cultivars, Samani, Siwi and Bartamoda, respectively at 33.33, 18.30°C and 40.07 %R.H for maximum, minimum and relative humidity, respectively. There was a decrease in the insects population starting from mid-June and continued throughout July, followed by a gradual increase in August and then a significant increase in the first of September to record its second peak for this year, on date palm cultivars, Samani, Siwi and Bartamoda with an average of 88.40, 211.74 and 185.04 insects/leaflet, respectively at 34.81, 25.52 °C and 57.58 %R.H.In mid-September, the number of insects began to decrease and continued to decrease gradually until the beginning of October also, then the gradual increase in the population

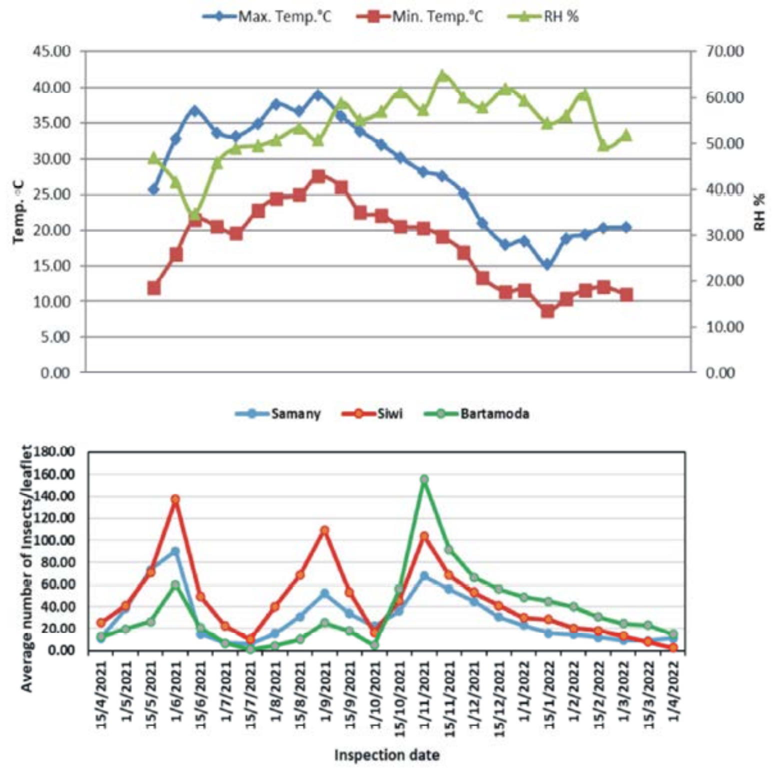

Fig. 1: Population densities of *F. phoenicis* on leaflets of the three date palm fronds cultivars in response to daily mean weather factors at Giza Governorate in the 1st year (2021/2022).

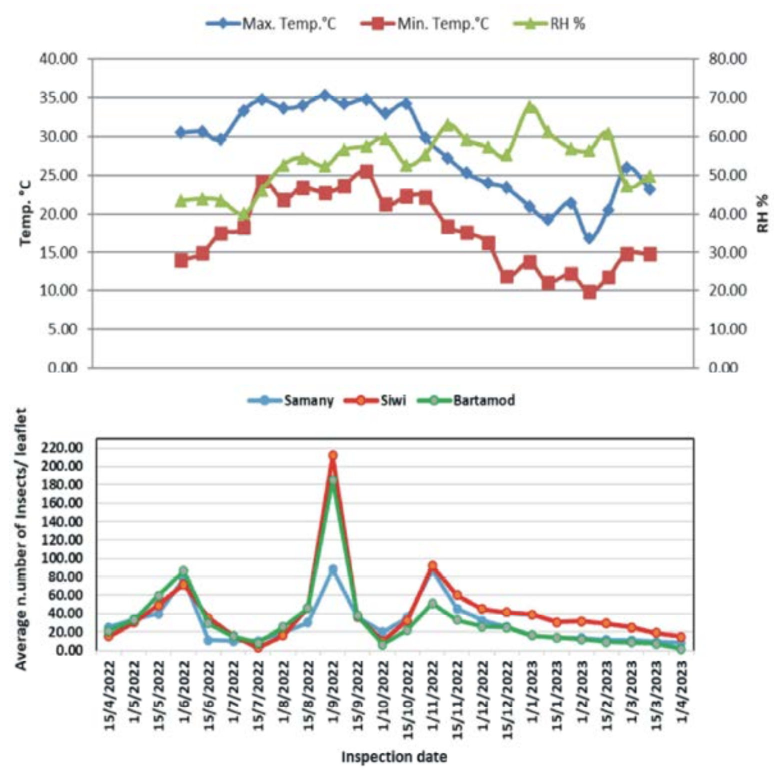

Fig. 2: Population densities of *F. phoenicis* on leaflets of the three date palm fronds cultivars in response to daily mean weather factors at Giza Governorate in the 1st year (2022/2023).

Table 2: Number and durations of annual field generations of *F. phoenicis* on three date palm cultivars at Giza Governorate during two years of study (2021/2022) and (2022/2023).

Years	Generations	Generation duration			Duration (month)
		From	To	Peak	
2021/2022	First generation	Mid. Apri.	Mid. Jul.	First Jun.	3
	second generation	Mid. Jul.	First Oct.	First Sep.	2.5
	Third generation	First Oct.	First Apr.	First Nov.	6
2022/2023	First generation	Mid. Apri.	Mid. Jul.	First Jun.	3
	second generation	Mid. Jul.	First Oct.	First Sep.	2.5
	Third generation	First Oct.	First Apr.	First Nov.	6

began in mid-October and continued until the third peak was recorded in early November with mean of 87.44, 91.89 and 51.44 insects/leaflet on date palm cultivars, Samani, Siwi and Bartamoda, respectively at 27.26, 18.44°C and 63.04 %R.H. Following this peak, the total mean count of nymph adult and gravid adult populations gradually started to drop in December and January. In February and March, the mean number of insects per leaflet varied between 13.33 - 11.11, 31.67 -24.89 and 12.00- 8.56 on date palm cultivars, Samani, Siwi and Bartamoda, respectively. Then the decline continued throughout the month of March until the beginning of April.

The aforementioned studies showed that the fiorinia date scale, *F. phoenicis*, has three overlapping generations under field settings in Giza Governorate. The first generation's peak (early summer) was in early June, the second generation's peak (late summer) was in early September and the third generation's peak (fall) was in early November. The collected data also showed that, as a result of the cold weather, the insect population on date palm fronds dropped over the course of the winter.

Number and Durations of *F. phoenicis* Annual Generations under Field Conditions: *F. phoenicis* has three overlapping generations per year of study, according to the data in Table (2) these generations took place in the following order: (spring/summer), summer and (fall/winter) generations.

The First Generation: The first generation (spring/summer generation) began in the middle of April until mid-July, with duration of three months during the two years under study.

The Second Generation: In both years, the second generation (summer generation) began in the middle of July and ran until the first week of October. The generation lasted for 2.5 months and peaked in the first week of September in both years. This generation was the shortest one due to the high temperature which accelerate the growth of the pest.

The Third Generation: During the two tested years, the third generation (fall/winter generation) took place from the first week of October to the first of April. Early in November of each year, this generation reached its peak. In both years, the generation period lasted for 6 months. (fall/winter generation) was the longest one as a result of low temperature and the pest hibernated as adult females.

These results are consistent with the results obtained from Bahariya Oasis, Egypt El Zoghby [22] in which it was mentioned that, *Fiorinia phoenicis* had three annual field generations on date palms, which peaked in June/July, September and November over the course of two years, according to the data recorded during (2012/2013 and 2013/2014). Elwan, *et al.* [20] investigated *F. phoenicis* fiorinia date scale seasonal activity for two years (March 2008 to mid-February 2010) on date palm at Giza Governorate. The results collected showed that under field circumstances, *F. phoenicis* has three overlapping generations. Early June marked the top for the first generation (early summer generation), while August and September marked the peak for the second generation (late summer generation) and October and November marked the peak for the third generation (autumn generation). In two consecutive years (2013-2014), Youssef *et al.* [34] in Sharkyia Governorate determined the seasonal activity of the fiorinia date scale, *F.phoenicis* on the date palm cultivar Barhy. The acquired results demonstrated that there are three seasonal activity periods each year for both the nymphal and adult stages. In both years, the nymphal activity peaked in the middle of June, the middle of September and the middle of November. For the first and second generations, adult females activity peaked in early June and early September; however, for the third generation, it peaked in mid-November and early October. On the other hand, in the Qalubyia Governorate, Radwan, [21] investigated the seasonal activity of the Fiorinia date scale on date palms during two consecutive years (2009-2011). The acquired results demonstrated that there are two seasonal activity periods for both the nymphal and adult phases each year. The first phase of nymphal activity, which peaked in early

Table 3: Factorial analysis for the significance of different studied factors

Factors	Level	Mean
Cultivars	Samani	30.014 b
	Siwi	43.353 a
	Bartamoda	34.225 b
F value	5.55	
P value	0.005	
LSD	8.1092	
Years	2021/2022	37.032 a
	2022/2023	34.696 a
F value	11.38	
P value	<.0001	
LSD	6.621	

December in both years with mean numbers of 749 and 838 nymphs/10 leaflets, respectively, occurred in the autumn season. Early July (1124 nymphs/10 leaflets) in the first year and early June (1172 nymphs/10 leaflets) in the second year marked the apex of the second period of nymphal activity that took place during the summer season. Early February saw the apex of the first adult activity phase (2385 and 2921 adults/10 leaflets), which was observed during the autumn and winter seasons.

Factorial Analysis for the Significance of Different Studied Factors: The effect of two factors (years and date palm cultivars) on the number of insects counted on the leaflets of the date palm cultivars Samani, Siwi and Bartamoda from April 2021 to April 2023 was demonstrated by the data in Table (3). The numbers of insects in the two years of the study did not significantly differ, according to data analysis and comparison. Three tested cultivars have substantial variations from one another. The results showed that the Siwi cultivar had the highest value for the insect population, followed by the Bartamoda cultivar and then the Samani cultivar with averages 43.35, 34.23 and 30.01 insects/leaflet, respectively. There was a significant difference between the number of insects on the Siwi, Bartamoda and Samani cultivars, while there was no significant difference between the two cultivars of Bartamoda and Samani.

Effect of Weather Factors on the Population Density of *F. phoenicis* on Three Date Palm Cultivars from April 2021 to April 2023: Obtained pest dynamics over the three data palm varieties are presented in Figs. (1 and 2). It was noticed that the pest dynamics behavior had similar trend regardless the studied date palm cultivar. So population density (total population) over the two years of study was divided into three intervals (according to the pest density trend) regardless the studied cultivar.

Three intervals of activities were observed per year. The first interval was from April 15 to July 15. The second one was from July15 to October 1, while the third was from October 1 to next April 1. Three statistical models were considered. The first was the effect of weather factors (as partial regression). The second one was plant age (in weeks) as third degree of polynomial (to emulate the plant physiological behavior during these intervals). The third was the combined effect weather factors and plant age. The probability for each model was evaluated as the P value as well as the EV% (percent explained variance).

Results for applying the three models to obtained data are presented in Tables (4, 5 and 6). During 2021-2022 for Samani cultivar mean explained variance was 76.91, 87.83 and 99.60 % with P values of 0.0057, 0.0009 and 0.0001 for the three models respectively. During 2022-2023 mean explained variance was 61.35, 69.71 and 90.30 % with P values of 0.0290, 0.0079 and 0.0007 for the three models respectively.

During 2021-2022 for Siwi cultivar mean explained variance was 75.49, 80.69 and 99.20 % with P values of 0.0133, 0.0043 and 0.0001 for the three models respectively. During 2022-2023 mean explained variance was 57.03, 72.36 and 92.75 % with P values of 0.0810, 0.0206 and 0.0002 for the three models respectively.

The same trend was observed for the Bartamoda cultivar at the first year 2021-2022, where the recorded explained variance was 70.55, 78.75 and 99.10 % with P values of 0.0308, 0.005 and 0.0001 for the three models respectively. While in the second year 2022-2023, the explained variance was recorded 53.55, 70.24 and 89.15 % with P values of 0.1144, 0.0172 and 0.0018 for the three models respectively.

This means that both first and second model had obvious effects on recorded population density with higher effect for the second one Tables (4, 5 and 6). The combined effect for both models (i.e. model three) revealed the highest effect of the three cultivars.

The obtained results are similar to that reported in Egypt by Elwan *et al.* [20] when the daily mean temperature and %R.H. had a significant impact on the annual field generations of F. phoenicis on date palm at the Giza Governorate. The variations in the half-monthly counts of the nymph and adult populations across the two years could be attributed to the combined effects of these meteorological conditions varied from 66.1-69% for the first generation (early summer generation) to 48.1-49.2% for the second generation (late summer generation) to 65.4-74.0% for the third generation (fall generation) during the course of the two years, respectively.

Table 4: Statistical analysis for the relation between total pest counts, weather factors and plant age on Samani cultivar

		Partial regression values							
		2021/2022				2022/2023			
Inspection duration	Factor	b	F	P	EV %	b	F	P	EV %
1st interval from April 15 to July 15	Max. Temp.	-19.539	6.96	0.0101	69.89	0.483	9.71	0.0006	63.15
	Min. Temp.	12.751				-0.926			
	R.H.	-6.888				-2.423			
	Plant age-age³	-	11.48	0.002	79.28	-	7.71	0.0018	57.65
	Combined effect	-	158.53	<.0001	99.37	-	6.42	0.002	73.34
2nd interval from July15 to October 1	Max. Temp.	-2.459	9.72	0.0068	80.65	16.253	10.52	0.0055	81.84
	Min. Temp.	6.686				5.807			
	R.H.	4.001				9.189			
	Plant age-age³	-	23.78	0.0005	91.06	-	6.22	0.0219	72.73
	Combined effect	-	10399.6	<.0001	99.99	-	1045.32	<.0001	99.94
3rd. interval from October 1 to next April 1	Max. Temp.	-23.563	17.56	<.0001	80.2	0.499	2.78	0.0832	39.07
	Min. Temp.	31.359				3.204			
	R.H.	1.076				2.341			
	Plant age-age³	-	58.93	<.0001	93.15	-	16.07	0.0001	78.76
	Combined effect	-	289.44	<.0001	99.43	-	67.95	<.0001	97.61

Table 5: Statistical analysis for the relation between total pest counts, weather factors and plant age on Siwi cultivar

		Partial regression values							
		2021/2022				2022/2023			
Inspection duration	Factor	b	F	P	EV %	b	F	P	EV %
1st interval from April 15 to July 15	Max. Temp.	-38.581	4.34	0.0376	59.13	-2.074	7.77	0.0018	57.82
	Min. Temp.	23.487				2.552			
	R.H.	-7.771				-3.099			
	Plant age-age³	-	6.56	0.0121	68.62	-	21.54	<.0001	79.17
	Combined effect	-	83.82	<.0001	98.82	-	9.69	0.0003	80.6
2nd interval from July15 to October 1	Max. Temp.	4.185	14.54	0.0022	86.17	37.473	14.84	0.002	86.41
	Min. Temp.	11.333				26.150			
	R.H.	10.648				21.320			
	Plant age-age³	-	19.89	0.0008	89.5	-	3.94	0.0615	62.81
	Combined effect	-	1814.52	<.0001	99.96	-	1110.26	<.0001	99.94
3rd. interval from October 1 to next April 1	Max. Temp.	-43.617	18.65	<.0001	81.15	-1.322	1.59	0.2392	26.87
	Min. Temp.	56.494				2.868			
	R.H.	0.660				2.555			
	Plant age-age³	-	22.65	<.0001	83.94	-	13.07	0.0003	75.1
	Combined effect	-	140.78	<.0001	98.83	-	115.24	<.0001	97.72

Table 6: Statistical analysis for the relation between total pest counts, weather factors and plant age on Bartamoda cultivar

		Partial regression values							
		2021/2022				2022/2023			
Inspection duration	Factor	b	F	P	EV %	b	F	P	EV %
1st interval from April 15 to July 15	Max. Temp.	-17.571	4.21	0.0406	58.4	-3.084	5.5	0.0079	49.25
	Min. Temp.	10.152				2.602			
	R.H.	-3.384				-3.566			
	Plant age-age³	-	6.15	0.0146	67.23	-	9.51	0.0006	62.67
	Combined effect	-	97.56	<.0001	98.99	-	5.21	0.0052	69.05
2nd interval from July15 to October 1	Max. Temp.	2.150	6.33	0.021	73.07	39.941	19.11	0.0009	89.12
	Min. Temp.	0.393				19.900			
	R.H.	3.486				19.522			
	Plant age-age³	-	30.45	0.0002	92.88	-	4.31	0.0508	64.9
	Combined effect	-	4144.62	<.0001	99.98	-	1117.12	<.0001	99.94
3rd. interval from October 1 to next April 1	Max. Temp.	-74.583	17.53	<.0001	80.18	-0.847	1.24	0.3344	22.28
	Min. Temp.	94.562				2.134			
	R.H.	0.373				1.110			
	Plant age-age³	-	13.83	0.0002	76.14	-	21.38	<.0001	83.15
	Combined effect	-	97.47	<.0001	98.32	-	106.81	<.0001	98.46

Table 7: Mean percentages of *F. phoenicis* reduction as a result of applying different tested pesticides on date palm Siwi cultivar at Giza Governorate.

Treatment	After two weeks				After four weeks				After six weeks				
	Nymph	Adult female	Gravid female	Mean	Nymph	Adult female	Gravid female	Mean	Nymph	Adult female	Gravid female	Mean	Grand mean
Fresh oil 95 % EC	72.00	64.00	55.26	63.75 f	92.11	84.77	84.91	87.25 c	25.00	41.86	67.21	44.69 f	65.23 e
New oil 95 % EC	87.50	80.20	76.61	81.43 c	96.49	76.69	61.43	78.19 ef	80.00	52.71	63.57	65.42 c	75.02 cd
Kemithrene 25% SC	80.00	64.36	57.89	67.43 E	78.95	89.47	62.26	76.90 f	100.00	78.29	79.51	85.93 b	76.75 c
Admiral	84.21	85.71	50.94	73.62 d	85.00	88.12	78.95	84.02 d	80.00	91.47	83.61	85.02 b	80.89 b
New oil 95 % EC+Kemithrene 25% SC	95.00	95.05	95.32	95.16 a	98.25	94.36	48.01	80.25 e	100.00	95.35	75.96	90.44 a	88.58 a
Palmito gold 25% EC	100.00	98.02	76.32	91.47 b	100.00	98.12	84.91	94.34 b	10.00	86.05	79.51	58.52 e	81.43 b
Prev-AM 6% (W/V)	87.50	78.22	15.79	60.49 g	100.00	99.62	93.29	97.63 a	35.00	85.27	69.40	63.22 d	73.78 d
Grand mean	86.60 A	80.79 B	61.16 C	Pr = <.0001	92.96 A	90.17 B	73.39 C	Pr = <.0001	61.43 B	75.86 A	74.11 A	Pr = <.0001	Pr.= <.0001
Stages	Pr = <.0001 LSD = 2.53		LSD =2.19		Pr. =<.0001 LSD = 2.6475		LSD = 2.19		Pr. = <.0001 LSD = 2.32		LSD = 2.32		LSD=2.1929

While similar studies by Radwan [21], demonstrated that daily mean maximum and minimum temperatures as well as percent relative humidity had a substantial impact on the extend of seasonal activity of *F. phoenicis* nymphs and adults. In contrast, the combined effect of these factors on adult activity ranged from 53.9 to 76.3% in the first period and 84.9 to 87.9% in the second for the two years, respectively. The combined effect of these factors on nymphal activity ranged from 58.2-74.8% in the first period of activity and 66.9-74.8 % in the second. Youssef *et al.* [34] measured meteorological variables (daily mean temperatures and% RH) had a substantial impact on the extend of seasonal activity for both nymphal and adult phases. The cumulative impact of the meteorological variables examined on population activity varied from 71.2 to 63.4% in the first activity period, 59.9 to 69.7% in the second and 70.2 to 58.9% in the third for the two years, respectively. El-Zoghby [22], the daily mean minimum and maximum temperatures as well as the percent relative humidity had a substantial impact on the insect activity. For nymphs and adults (the first and second years, respectively), the variations in the half-monthly population counts that were impacted by the combined influence of these factors varied between (61.6 and 72.5% and 59.4 and 66.7%).

Chemical Control: The control experiment was carried out to evaluate seven treatment to control the date palm scale insect on the most affected date palm cultivar, Siwi at 3rd Jan.2023.Obtained data in Table (7) indicated that after 2 weeks of application, A mixture of (New oil + Kemithrene) achieved the highest percentage of reduction in the number of Fiorinnia scale insect on date palm leaves with an average of 95.16%, followed by Palmito gold 91.47% and New oil which recorded 81.43%. Moderate effect on reducing insect populations for each of Admiral, Kemithrene and Fresh oil, which recorded 73.62, 67.43 and 63.75% respectively. While the least reduction in insect population was Prev-AM with an average of 60.49%. After 4 weeks of application, the effect of Prev-AM increased to record the highest rate of reduction in the population of Fiorinnia scale insect on date palm leaves at a rate of 97.63 % followed by Palmito gold and Fresh oil with a reduction rates of 94.34 and 87.25%, respectively. While the effect of each of Admiral, New oil EC+Kemithrene and New oil was good in reducing the population of the insect by reduction rates, 84.02, 80.25 and 78.19 % respectively. Kemithrene recorded the least reduction in the number of the insect with an average of 76.90 %. After 6 weeks, The mixture of (New oil + Kemithrene) reached the highest reduction rate of Fiorinnia scale insect population on date palm leaves mean 90.44%, followed by Kemithrene 85.93% and Admiral which recorded 85.02%. Moderate effect on reducing insect populations for each of New oil, Prev-AM and Palmito gold (65.42, 63.22and 58.52 %). While the least effective pesticides in reducing the population in this after this duration was Fresh oil, with a reduction rate of44.69 %. Obtained results revealed that the nymphal stage of *F.phoenicis* was the most vulnerable to the tested treatments, followed by adult and gravid females.

By calculating the average of insect reduction rate for the three checks after two weeks, four weeks and six weeks, it was found that the mixture of New oil + Kimithrene showed the highest efficiency in reducing the insects population with an average of 88.58%, followed by Palmito gold with an average of 81.43%, then Admiral with an average of 80.89%, while the effect of the moderate reduction of the insect population of the pesticides Kemithrene, New oil and Prev-AM with averages of 76.74, 75.02 and 73.78% respectively, it had the least effect on reducing the number of Fresh oil pesticide with an average of 65.23%.

Current results are in the same context as the results of Ali *et al.* [35]) indicated that Palmito and Glister were considered as the most active materials gave 100 %

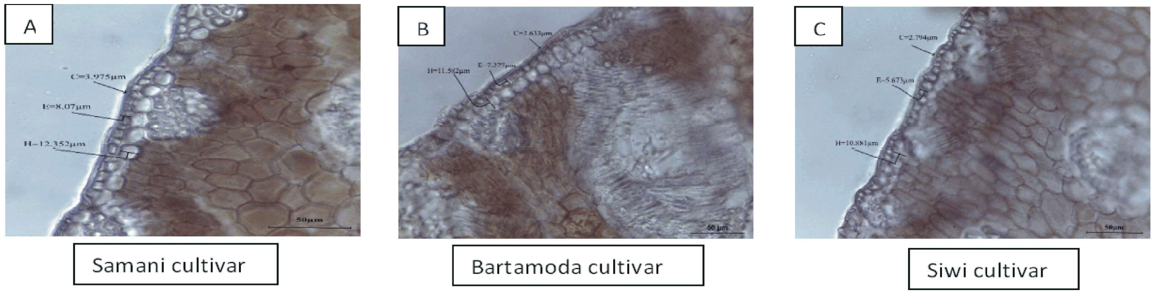

Fig. 3: (A) - Cross section of a palm leaf of the Samani cultivar
(B)- Cross section of a palm leaf of the Bartamodacultivar
(C)- Cross section of a palm leaf of the Siwi cultivar
* C= Cuticle, E =Epidermis and H= Hypodermis

Table 8: Some anatomical characteristics of leaflets of three cultivars of fresh, semi-dry and dry date palm.

	Leaflet Layer thickness (µm)		
Cultivars	Cuticle	Epidermis	Hypodermis
Samani	3.98 a	8.07 a	12.35 a
Bartamoda	3.63 a	7.38 b	11.58 b
Siwi	2.79 b	5.67 c	10.88 c
Pr	0.0020	<.0001	0.0009
LSD	0.4623	0.3871	0.479

mortalities against preadult stage of mango shield scale insect, (*Milviscutulus mangiferae* (Green) (Hemipetra: Coccidae) by utilizing the leaf dipping technique bioassay protocols. El Sahn *et al.* [36] revealed that, the insecticidal activity of the formulated oil of *Citrus sinensis* L. achieved high toxicity against nymphs, adults and gravid females of both *Aulacaspis tubercularis (Newstead)*and *Milviscutulus mangiferae (Green)* at all used concentrations.Ahmed *et al.* [37] revealed that, the two formulated oils of navel orange (*Citrus sinensis* L.) achieved high toxicity against nymphs and adults of *Ferrisia virgata Cockerell* and *Milviscutulus mangiferae (Green)*. According to Abd El-Mageed [38], the combination of chemical insecticides and mineral oils at half the recommended rate demonstrated significantly higher pesticidal efficacy than mineral oil or chemical insecticides alone at the full recommended rate in controlling of fig wax scale *Ceroplastes rusci* L. in Ismailia Governorate on ficus trees. According to Eskander *et al.* [39], mixing botanical synthetic ingredients with diesel oil improved their toxicity in controlling mealybug *Ferrisia virgata* (Cockerell) stages. In Sudan, the scale insect *Parlatoria blanchardii* Targ was effectively controlled by a combination of petroleum oil and dimethoate, malathion and methyl parathion, according to Ahmed Siddig [40]. This combination also increased the yield per palm tree by 46, 52 and 74% in the first, second and third seasons, respectively. Insect growth regulators (IGRs), according to Bakr *et al.* [41] In contrast to synthetic insecticides, which offered a very good efficacy at the beginning of the experiment and progressively reduced, Admiral 10% started to produce good efficacy after one month of spraying and continued to increase until the end, in addition to their safety effect.

Leaflet Anatomical Differences of the Three Studied Date Palm Cultivars: The results shown in Figure (3) and Table (8) indicated that the studied palm cultivars differ in terms of the thickness of the leaflet cuticle, epidermis and hypodermis where the Samani cultivar was significantly superior to the other two cultivars, as the thickness of the leaflet cuticle, epidermis and hypodermis reached 3.97, 8.07 and 12.35 µm respectively, while Siwi cultivar recorded the lowest thickness of the leaflet cuticle, epidermis and hypodermis (2.79, 5.67 and 10.88 µm) respectively. Moderate thickness of the three layers was recorded for Bartamoda cultivar 3.63, 7.37 and 11.58 µm of cuticle, epidermis and hypodermis respectively.

According to these results and the results of the population density during two years of this work, it was found that Samani date cultivar, which has the largest thickness of leaflet cuticle, epidermis and hypodermis layers, had the lowest number of Fiorina insect stages on it. While the thickness of the three layers in the Siwi date cultivar, which recorded the highest insect population, had the lowest layer thickness in the three tested cultivars, while the Bartamoda cultivar was medium in the three layers' thickness and moderate in insect population. Thus, It can be concluded that the relationship between the thickness of the epidermis layer in date palm leaves

Table 9: Chemical components in the leaves of healthy date palm tree cultivars and infested with *F. phoenicis*.

Date palm cultivars	Status	Total Phenols (mg/g f.w.)	Proline (mg/g f.w.)	Indoles (mg/g f.w.)	Total Amino acids (mg/g f.w.)	Total protein (mg/g f.w.)	Peroxidase (POD) activity µ/g?430	Polyphenol oxidase (PPO) activity µ/g?495	Chl a. mg L	Chl b. mg L
Samani	Healthy	0.468 b	0.0077 b	0.411 a	9.56 a	0.837 a	4.2497 b	2.783 b	3.773 a	1.375 a
	Infested	0.656 a	0.0098 a	0.399 b	9.29 b	0.647 b	6.732 a	4.565 a	2.882 b	1.243 a
	Pr	<.0001	<.0001	0.0013	0.0315	<.0001	<.0001	<.0001	0.0011	0.313
	L.S.D.	0.0032	0.0004	0.0044	0.2267	0.01	0.4423	0.2987	1.1326	0.295
Siwi	Healthy	0.646 b	0.0046 b	0.454 a	4.92 a	0.653 a	4.0297 b	2.5153 b	4.8473 a	2.2807 a
	Infested	0.787 a	0.0091 a	0.430 b	4.48 b	0.550 b	6.556 a	4.4147 a	3.2853 b	1.3273 b
	Pr	<.0001	<.0001	<.0001	0.0056	<.0001	0.0011	<.0001	0.0323	0.0024
	L.S.D.	0.0049	0.0006	0.0052	0.2267	0.01	0.8264	0.2836	1.347	0.386
Bartamoda	Healthy	0.365 b	0.0093 b	0.555 a	5.97 a	0.717 a	4.0003 b	2.7097 b	4.9353 a	1.6390 a
	Infested	0.459 a	0.0109 a	0.521 b	3.27 b	0.633 b	6.0573 a	4.0187 a	2.4493 b	1.1367 b
	Pr	<.0001	<.0001	<.0001	<.0001	0.00	0.0026	0.0345	0.0019	0.0092
	L.S.D.	0.0027	0.0002	0.0039	0.2267	0.02	0.8547	1.1531	0.9528	0.295

and the number of the Fiorinia insect stages is inversely related, that is, the greater the thickness of the date palm cultivar leaflet layers, the less it is infested with the Fiorinia insect, as happened with the Samani cultivar and vice versa, the less the thickness of the leaflet cuticle, epidermis and hypodermis layers, the greater the infestation with Fiorinia insect, as happened in Siwi cultivar.

The obtained results are in agreement with those obtained by Al-Najjar and Al-Hamad [42] finding that the thickness of the lower epidermal layer in the leaf of the Halawi cultivar representing the fresh cultivars recorded the largest thickness of 13.2 µm. followed by the thickness of the same layer in the Dairy cultivar of the dry cultivars had a length of 5.06 µm, while the semi-dry Zuhdi cultivar recorded less thickness of the lower epidermal layer in its leaflet was 4.84 µm. The same trend was recorded by the upper epidermis layer. The fresh cultivar Halawi recorded the largest thickness with a significant difference between it and the semi-dry Zuhdi and dry Dairy cultivars.

Differences in Chemical Components in the Leaflets of Healthy and Infested Date Palm Tested Cultivars by *Fiorinia phoenicis* Balachowsky: The results shown in Table (9) showed the difference in the chemical components in the leaves of healthy and infested date palm tested cultivars by *F. phoenicis* Balachowsky. Data in Table (9) showed significant increasing in total phenols and proline in the leaves of the infested date palm with *F. phoenicis* from cultivars, Samani, Siwi and Bartamoda compared to the healthy date palm (control) from each tested cultivar respectively. While the obtained results showed significant decreasing in total indoles, amino acids and total protein in the infested date palm tested cultivars, Samani, Siwi and Bartamoda compared to the health date palm (control) from each tested cultivar respectively. As for the activity of the oxidative defense enzymes peroxidase and polyphenol oxidase, they recorded a significant increase in the leaves of infested date palms with *F. phoenicis* of the three tested cultivars, Samani, Siwi and Bartamoda compared to healthy palm trees of the same tested cultivars. On the contrary, the dyes chlorophyll a and chlorophyll b recorded a significant decrease in the leaves of infested date palms with *F. phoenicis* of the three tested cultivars, Samani, Siwi and Bartamoda compared to healthy palm trees of the same tested cultivars. The current results are in accordance with El-Deeb *et al.* [43] who claimed that the chemical study of date palm tree cultivars tissues revealed distinct differences in the amounts of chemical components Total phenols, polyphenol oxides, peroxidase, total proteins and free amino acids showed substantial positive differences between infested palm trees by red palm weevil,*Rhynchophorus ferrugineus* and healthy date palm trees. Their obtained results recorded a significant increase in the amount of total phenols, polyphenol oxides and peroxidase in the infested tissues of date palm cultivars with the red palm weevil, compared to the amounts of the same compounds in the tissues of the healthy palm trees. While their results also recorded a decrease in the amount of total proteins and free amino acids in the tissues of infested date palms compared to healthy date palms. Norhayati *et al.* [44] Investigated the reaction of some defensive enzymes, including peroxidase POD, in three coconut palm cultivars in Malaysia, namely PANDAN, MAWA and MATAG, to infestation with the red palm weevil insect. It was found that infested palm trees showed an increase in the peroxidase enzyme as a result of the infestation, compared to the controls. Batt and Abd El-Raheem [45] determined the levels of chemicals (phenols, proline, total and proteins) in the stems and leaves of apple trees with and without an infestation by The clearwing moth (*Synanthedon myopaeformis* Borkh.). Data showed that the infested trees contained high amounts of proline and phenols in both stems and leaves, whereas total protein contents was low. Khan *et al.* [46] indicated that the infestation of the date palm in Tunisia with Dubas bug

(*Ommatissus lybicus* Bergevin) led to an increase in the proline content of palm leaves compared to healthy palms leaves.

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