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Effect of Weather Change and Plant Age on the Whitefly *Bemisia tabaci* (Gennadius) (Hemiptera: Aleyrodidae) on Tomato Plants and its Control in Dakhlia Region, Egypt

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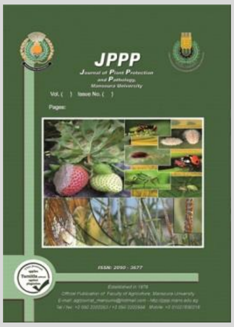

ABSTRACT

This experiment was carried out in two consecutive seasons (2022/2023 and 2023/2024) at Mansoura district of the Dakhlia Governorate, Egypt, to investigate population of the whitefly *Bemisia tabaci* (Gennadius) (Hemiptera: Aleyrodidae) on tomato plants (Fiona cultivar) and its relation to certain climate parameters. Data showed that 30 days from planting, or from the first week of October to the fourth week of January in both seasons, *B. tabaci* was found on tomato plants. Between the two seasons, the total counts of *B. tabaci* were 138.15 and 154.08 individuals per season, respectively. Over the course of the two seasons, the average number of *B. tabaci* per leaf was 8.63 and 9.63 individuals, respectivelyStatistically, the multiple linear regression method exhibited that the pooled impact of all climate parameters and plant age, reached 95.45% in 2022/2023 and 93.05 % in 2023/2024 on the variation in *B. tabaci* populations. However, these effects reached 97.77% in 2022/2023 and 94.39% in 2023/2024 on the percentage of damaged leaves.The activities of the tested insecticides varied, as it was exhibit that Cyantraniliprole was take place to be the most susceptible insecticide than the other tested pesticides on *B. tabaci* nymphs and adult females after 72 hours. While Azadirachtin pesticide was less toxic. Using the results of this study, whitefly populations on tomato plants can be effectively managed and the damage they cause can be reduced.

Keywords: Bemisia tabaci, population estimates, tomato plants, climate conditions, plant age.

INTRODUCTION

Tomato (*Lycopersicon spp*.) is one of the economically important vegetables (Govindappa *et al.* 2013). It is considered one of the most widely grown and consumed crop in the world (Mandaokar *et al.*, 2000). It is a staple ingredient in many cuisines and essential to the diets of billions of people globally (Jahel et al., 2017). In Egypt, it occupies an important place among vegetable crops (Shehata, 2021 a). Tomato plants are very popular among vegetables because of their versatility (Polston and Anderson, 1999).

Tomato is a main source of vitamin C, vitamin K, potassium, and the antioxidant lycopene. It provides many health benefits, including potentially reducing the risk of some cancers and cardiovascular disease. They are a significant cash crop for many farmers and contribute substantially to the global food supply (Sharma and Kumar, 2020).

Tomato plants are susceptible to several major insect pests (Shehata, 2021 b; Mahendra and Singh 2022). The whitefly *Bemisia tabaci* (Gennadius, 1889) (Hemiptera: Aleyrodidae) is one of the most important destructive pests of tomato plants (Stansly and Natwick, 2010; Jahel *et al.*, 2017). It is a harmful, cosmopolitan and polyphagous insect. Small, white, moth-like insects typically found on the undersides of leaves (Brown, 2010; Abdel-Razek *et al.*, 2010; Ramesh *et al.*, 2023). It can damage tomato plants by sucking the sap from the leaves, which can lead to wilting, yellowing, and stunted growth (Lima *et al.*, 2000). They also secrete a sticky substance called honeydew, which can promote the growth of sooty mold (Bakry *et al.*, 2023 a). Severe infestation can weaken and damage tomato plants, stunting plant growth and reducing productivity and transmits many viral diseases (Khan and Ahmed 2005; Hogenhout *et al.*, 2008).

Papisarta and Garzia (2002) reported that whitefly individuals cause a 20 to 100% reduction in tomato productivity.

Insects show different trends in how they occur and the damage they cause due to fluctuations in climatic conditions in different seasons (Pareek *et al.*, 2017). In addition, there are many known and unknown factors that are equally important in determining the extent of the pest (Walther et al., 2002; Janu and Dahiya, 2017). The presence of pest on the host plant varies depending on climate, plant development, and season (Bakry *et al.*, 2020).

Among the different methods of controlling whiteflies, the most common are the use of plant products and chemical insecticides. Many conventional chemicals and insecticides have been used to protect tomato crops. Organophosphates, carbamates and organochlorines have been used to control *B. tabaci* in Egypt (Eweis et al., 2022). However, the use of these insecticides leaves a persistent layer of poison on the foliage and fruits (Dikshit *et al.*, 2000).

The aim of this current work is to study estimates of whitefly numbers on tomato plants during the two seasons. As well as estimating the relationship between climatic factors and whitefly numbers in the two seasons. Also to evaluate different insecticides to see which one is more effective against whitefly nymphs and adults.

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MATERIALS AND METHODS

1- Seasonal activity of the whitefly, *Bemisia tabaci* on tomato plants:

During the two consecutive growing seasons (2022/2023 and 2023/2024), tomato plants (Fiona cultivar) were inspected weekly in the field to estimate the total number of whiteflies per leaf at Mansoura area, Dakhlia Governorate, Egypt. Four replicates, each measuring 7 m by 6 m log ≥ 42 m2. Around the autumn planting period, which occurs around the first week of September every year, the replicates were planted using a commercial tomato cultivar, namely the Fiona cultivar, and distributed in a completely randomized block configuration. All field practices were followed except for the use of chemical pest control. From each replicate, ten tomato leaves were randomly selected each week from different tomato plant levels (upper, middle, and lower) and from different parts of the field during the two seasons to monitor insect population.

After being gathered, these leaves were placed in various polythene bags and brought to the lab. Using a stereomicroscope, the total number of whitefly individuals (adults and nymphs) on each tomato leaf was calculated to demonstrate seasonal abundance. In the morning (6-9 AM), the examination is performed. In the field, sampling began at weekly intervals using 10x lenses, as soon as germination was observed on the soil surface, and continued until the tomato crop was harvested.

Direct counting of the whiteflies sample was performed on the same time as the examination as described by Aboul-Saad (2008).

2- Whitefly-days and the cumulative whitefly-days:

The cumulative values of whitefly days are computed here using data on whitefly counts in two consecutive growth seasons. This equation given by different authors was used to calculate this method according to the following formula (Bakry and Fathipour, 2023; Mohamed et al., 2021).

$$\text{Whitefly-days} = [7 \times [(d_1+d_2) / 2]$$

Where:

d_1= Mean of whitefly individuals per leaf on the preceding inspection date.
d_2= Mean of whitefly individuals per leaf at the present checking date.

For each sampling period, the running cumulative total is calculated as follows: cumulative whitefly-days = whitefly-days from the previous checking plus whitefly-days from the current checking. The rate of change in whiteflies estimates, it was evaluated according to Bakry et al. (2024 a) and Bakry and Fathipour (2023) as follows:

$$RC = (d / D)$$

Where:

RC = Rate of change
d = Mean whitefly estimates per leaf on the current checking date.
D = Mean whitefly estimates per leaf on the previous checking date.

3- Effects of the weather factors and plant age on whitefly estimates on tomato plants:

Population estimates of the whitefly *B. tabaci*, were correlated with weather factors [mean daily of temperature (maximum and minimum) and mean daily of relative humidity percentage and plant age] in the two seasons (2022/2023 and 2023/2024). The daily averages of these variables were obtained by adjusting the daily registrations within seven days of the whitefly estimate. We needed to submit all of the data for these meteorological variables for each examination day two weeks ahead of the sample day in order to get the accurate averages .

About the age of the plants determined on the day of the whitefly estimation for every inspection date. The third-order nonlinear equation was used to calculate this relationship. In 2023, Bakry and Abdel-Baky employed this approach. In order to fully understand the complex relationships between the weather, plant age, and the rate of whitefly infestation, they carefully examined the data they collected and applied multiple mathematical models (correlation and regression). Using SPSS software (1999) to analyze the data, they followed Fisher's (1950) formula.

Simple correlation values between different variables were calculated and plotted using R software (Mendiburu, 2015).

4- Toxicological study:

The work described in this paper focuses on comparing the relative toxicity of Cyantraniliprole, Sulfoxaflor, Imidacloprid, Indoxacarb and Azadirachtin. Essentially, the insecticidal activity of all target components were tested using leaf dip bioassay procedures (Bakry et al. 2023 b; El-Gaby et al. 2023; Gad et al. 2023).

In Plant Protection Research Institute Mansoura branch colonies of *B. tabaci* were collected from tomato fields during December 15[th] 2023. In this study, five concentrations of each components and 0.1% tween-20 were used. Three times, 50 nymphs and 50 adults of *B. tabaci* insects of approximately identical size were immersed in each concentration of generated compounds for 10 seconds (Bakry and Gad, 2023).

The control group of insects (which were merely dipped in distilled water and tween-20) was also used, and it was left to stand at room temperature for roughly 30 minutes. Applications were run at a humidity level of 60% and a temperature of 25 °C. The used insects were put into glass jars with dechlorinated water once they had dried. The mortality was measured using a binocular microscope after 24 hours of the test (Bakry et al., 2024 b), *B. tabaci* was deemed dead if it was immobile.

Statistical analysis:

The Abbott formula equalized mortality (Abbott 1925), the mortality setback line estimations were objectively examined using probability analysis. Sun formulae were utilized to take the Harmfulness Index very seriously (Finny 1952)

The mortality of adult insects and nymphs was calculated using probit analysis using a statistical (LDP-line) equation. The slope, upper confidence limit, and lower confidence limit of the LC50 values are estimated by the LDP-line equation with 95% confidence intervals (Sun, 1950)

Pesticides:

1- Cyantraniliprole, which is commercially available under the trade name of Benevia 10% OD, 2- Sulfoxaflor, which is commercially available under the trade name Closer 24% SC, 3- Imidacloprid, which is commercially available under the trade name Imidadzed 20% SC, 4- Indoxacarb, which is commercially available under the trade name Vaulent 150 EC and 5- Azadirachtin, which is commercially available under the trade name Neemix 4.5% EC were purchased from the Central Agricultural Pesticides Laboratory (CAPL) in Dokki, Giza, Egypt, Figure (1).

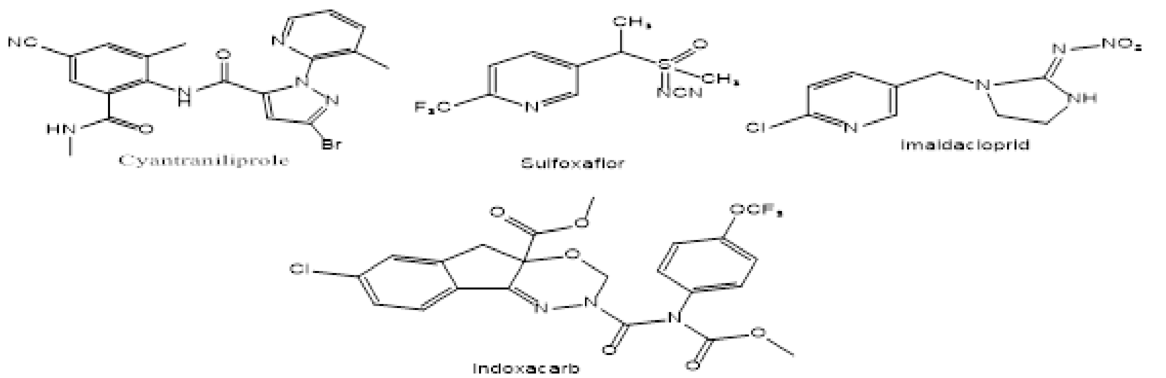

Figure 1. Chemical Stracture of Cyantraniliprole, Sulfoxaflor, Imidacloprid, and Indoxacarb.

RESULT AND DISCUSSION

1- Population studies:

Seasonal abundance of *B. tabaci* counts on tomato plants:

The weekly estimates of *B. tabaci* that attacked tomato plants planted in the field (Fiona cultivar) in the Mansoura region, Dakhlia Governorate during the two growing seasons (2022/2023 and 2023/2024). Additionally, over both growth seasons of the study, the weekly mean records of plant age and climatic conditions for tomato plants are presented in Tables (1 and 2) and Figures (2 and 3).

Table 1. Mean counts and % damaged leaves of *B. tabaci* on tomato plants in relation to plant age and certain weather factors, at Mansoura district, Dakhlia Governorate during the first season (2022/2023).

Inspection date		Plant age	No. of individuals per leaf	% No. whiteflies of total counts	Cumulative numbers	% Cumulative No.	Whitefly-Days	Cumulative whitefly-days	% Damaged leaves	Max. temp.	Min temp.	% R.H.
Oct., 2022	1	30	0.40	0.29	0.40	0.29	1.40	1.40	10.00	30.08	23.97	74.82
	7	37	0.95	0.69	1.35	0.98	4.73	6.13	17.50	29.61	23.63	74.65
	15	44	1.58	1.14	2.93	2.12	8.84	14.96	22.50	29.14	23.28	74.48
	22	51	3.20	2.32	6.13	4.43	16.71	31.68	27.50	28.88	23.38	73.73
Nov.	1	58	5.05	3.66	11.18	8.09	28.88	60.55	32.50	28.63	23.49	72.99
	7	65	2.73	1.97	13.90	10.06	27.21	87.76	27.50	24.23	22.27	79.40
	15	72	7.23	5.23	21.13	15.29	34.83	122.59	32.50	24.46	21.04	71.77
	22	79	8.50	6.15	29.63	21.44	55.04	177.63	35.00	24.69	19.72	75.46
Dec.	1	86	11.80	8.54	41.43	29.99	71.05	248.68	37.50	24.45	18.40	78.73
	7	93	16.45	11.91	57.88	41.89	98.88	347.55	32.50	18.76	18.46	73.48
	15	100	18.53	13.41	76.40	55.30	122.41	469.96	35.00	20.61	18.51	76.38
	22	107	20.30	14.69	96.70	70.00	135.89	605.85	40.00	22.47	18.48	79.27
Jan., 2023	1	114	16.45	11.91	113.15	81.90	128.63	734.48	32.50	21.88	18.45	86.85
	7	121	13.08	9.46	126.23	91.37	103.34	837.81	30.00	21.47	11.90	78.34
	15	128	6.08	4.40	132.30	95.77	67.03	904.84	27.50	20.29	10.00	79.90
	22	135	5.85	4.23	138.15	100.00	41.74	946.58	22.50	19.11	8.00	81.45
Total			138.15	100.00			946.58					
General average			8.63						28.91	24.30	18.94	76.98

Table 2. Mean counts and % damaged leaves of *B. tabaci* on tomato plants in relation to plant age and certain weather factors, at Mansoura district, Dakhlia Governorate during the second season (2023/2024).

Inspection date		Plant age	No. of individuals per leaf	% No. whiteflies of total counts	Cumulative numbers	% Cumulative No.	Whitefly-Days	Cumulative whitefly-days	% Damaged leaves	Max. temp.	Min temp.	% R.H.
Oct., 2023	1	30	1.00	0.65	1.00	0.65	3.50	3.50	7.50	29.68	21.81	75.33
	7	37	1.13	0.73	2.13	1.38	7.44	10.94	15.00	29.19	21.50	75.15
	15	44	2.45	1.59	4.58	2.97	12.51	23.45	20.00	28.71	20.18	74.97
	22	51	4.83	3.13	9.40	6.10	25.46	48.91	22.50	28.45	22.13	74.22
Nov.	1	58	7.30	4.74	16.70	10.84	42.44	91.35	25.00	28.19	21.37	73.46
	7	65	8.63	5.60	25.33	16.44	55.74	147.09	30.00	23.70	18.94	80.00
	15	72	11.45	7.43	36.78	23.87	70.26	217.35	37.50	23.94	17.00	72.21
	22	79	15.83	10.27	52.60	34.14	95.46	312.81	35.00	24.17	19.14	75.98
Dec.	1	86	17.70	11.49	70.30	45.63	117.34	430.15	27.50	23.93	16.74	79.31
	7	93	19.15	12.43	89.45	58.06	128.98	559.13	30.00	18.12	4.81	73.96
	15	100	20.30	13.18	109.75	71.23	138.08	697.20	32.50	20.01	10.83	76.92
	22	107	14.00	9.09	123.75	80.32	120.05	817.25	35.00	21.91	16.85	79.87
Jan., 2024	1	114	10.75	6.98	134.50	87.30	86.63	903.88	30.00	21.30	14.00	87.60
	7	121	8.80	5.71	143.30	93.01	68.43	972.30	27.50	20.89	10.00	78.92
	15	128	6.20	4.02	149.50	97.03	52.50	1024.80	25.00	19.68	8.94	80.51
	22	135	4.58	2.97	154.08	100.00	37.71	1062.51	20.00	18.48	5.00	82.10
Total			154.08	100.00			1062.51					
General average			9.63						26.25	23.77	15.58	77.53

The effects of plant age and climate on the population abundance of *B. tabaci* were computed using the average number of individuals (adults and nymphs) assessed per leaf in the successive examination times. According to the results, tomato plants contained *B. tabaci* individuals from October 1st to January 22nd; in other words, insect outbreaks first developed on tomato plants 30 days after planting per season.

Furthermore, compared to the second growing season (2023/2024), the total estimates of *B. tabaci* during the first growth season (2022/2023) were lower. Over the course of the two growing seasons, the average number of *B. tabaci* individuals per leaf was 8.63 and 9.63 individuals, respectively.

It was observed that the insect peak reached a single peak on December 22nd of the first season and on December 15th of the second season.

In both seasons, the average percentage of plants damaged by *B. tabaci* was 28.91 and 26.25%, respectively. The date for infestation and activity in the two seasons was 30 days after planting.

These results are consistent with Hegab (2017) reported that a single peak of *B. tabaci* on cucumber leaves was observed during the third week of July, which aligned with our results. According to Kamel et al. (2000), the infestation by *B. tabaci* gradually increased from mid-June to the end of July 1996. Conversely, Ahmed (1994) reported that on summer cucumber crops, three peaks of *B. tabaci* developed per season.

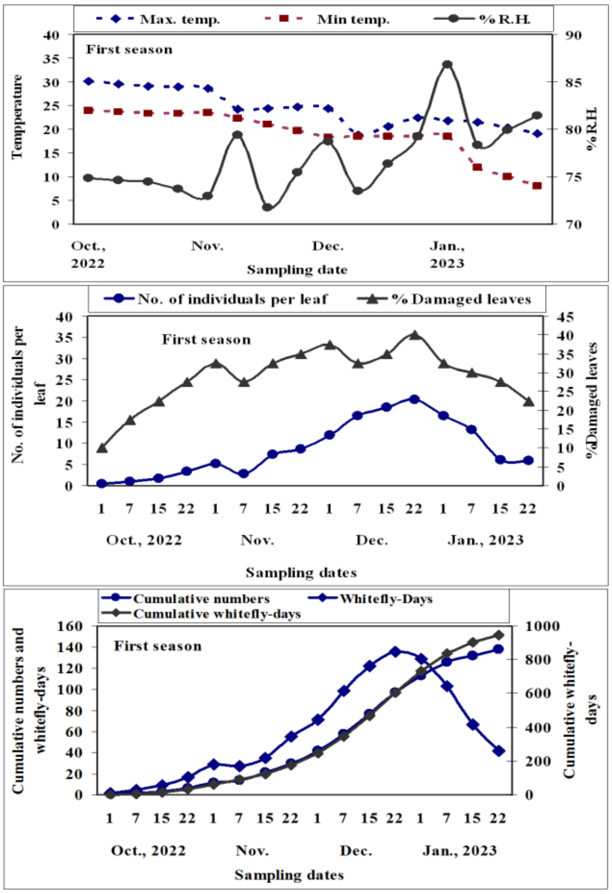

Fig. 2. Mean counts and % damaged leaves of *B. tabaci* on tomato plants in relation to plant age and certain weather factors, at Mansoura district, Dakhlia Governorate during the first season (2022/2023).

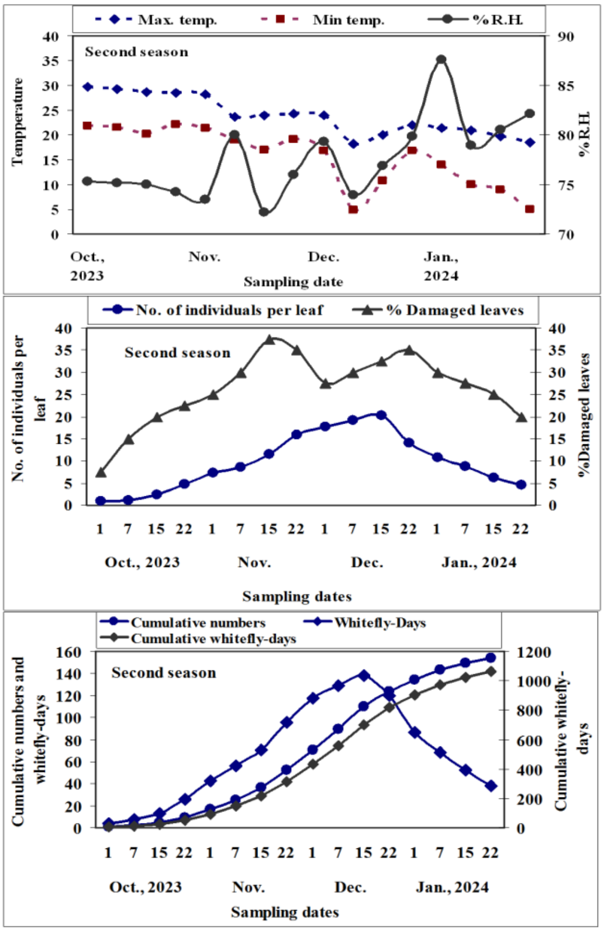

Fig. 3. Mean counts and % damaged leaves of *B. tabaci* on tomato plants in relation to plant age and certain weather factors, at Mansoura district, Dakhlia Governorate during the second season (2023/2024).

Cumulative Aphid-Days:

To demonstrate the overall effect of a constantly fluctuating individual over time, the data from Tables (1 and 2) and Figures (2 and 3) showed the whitefly-days and cumulative whitefly-days for *B. tabaci* on tomato plants. These findings showed that, compared to the first season (946.58 cumulative whitefly-days), the second season's effect of the *B. tabaci* population on cucumber plants was greater (1062.51 cumulative whitefly-days).

Rate of change in *B. tabaci* estimates:

Table (3) exhibited that the expected rate of change (R) in *B. tabaci* numbers on tomato plants. The rate of population change, which is defined as the week with the greatest rise in the insect's number for the season, indicates which week is best for the insect's activities. According to Bakry and Abdel-Baky (2023), an insect's activity is said to be more active when $R > 1$, less active when $R < 1$, and never varied when $R = 1$.

Based on the data shown in Table (1), it appears that the best weeks to see an increase in *B. tabaci* populations are those between October 7th and November 1st, and from November 22nd to December 22nd in the first season (2022/2023), while, the second season (2022) were from October 7th through December 15th, when the rates of increase were higher than one.

Data represented in Table (3) showed that the optimal periods for *B. tabaci* infestation rates during first season (2022/2023), were from October 7th to November 1st; from November 15th to December 1st, and from December 15th through December 22nd, however, the second season (2022) were from October 7th through November 15th, and from December 7th to December 22nd when the rates of increase were higher than one.

Therefore, the slow increase in *B. tabaci* populations on tomato throughout these times indicates that control of the pest should start during the seedling and vegetative growth stages, before it reaches its peak population. These findings align with the findings of El-Shazly *et al.* (2019).

It was evident that the increase in *B. tabaci* number and infestations during the inspection periods, which was greater than one, was interpreted as a sign that meteorological conditions were more favorable for *B. tabaci* development.

The relationship between *B. tabaci* estimates and the percentages of damaged leaves:

The relationships between *B. tabaci* estimates and proportions of damaged leaves were estimated using a third-order nonlinear regression equation, as shown in Figure (4). Bakry and Fathipour (2023) used this model.

The nonlinear equations as following:

First season (2022/2023):

$$Y_2 = 0.0143\ X^3 - 0.5035\ X^2 + 5.6985\ X + 11.924 \quad R^2= 0.812$$

Equation (1)

Second season (2023/2024):

$$Y_2 = -0.0002\ X^3 - 0.1098\ X^2 + 3.3658\ X + 8.5736 \quad R^2= 0.871$$

Equation (2)

The results showed highly statistically significant relationships between the *B. tabaci* estimates and the percentages of damaged leaves throughout the two years of study. The coefficient of determination percentages (R^2) was 81.20 and 87.06% in the two seasons, respectively, as presented in equations (1 and 2) and in Figure (4).

Table 3. Rate of change in *B. tabaci* populations and infestation incidences on tomato plants at Mansoura region, Dakhlia Governorate during the two growing seasons (2022/2023 and 2023/2024).

Sampling date		Rate of change			
		Population density		% Damaged leaves	
		2022/2023	2023/2024	2022/2023	2023/2024
Oct.	1	—	—	—	—
	7	2.38	1.13	1.75	2.00
	15	1.66	2.18	1.29	1.33
	22	2.03	1.97	1.22	1.13
Nov.	1	1.58	1.51	1.18	1.11
	7	0.54	1.18	0.85	1.20
	15	2.65	1.33	1.18	1.25
	22	1.18	1.38	1.08	0.93
Dec.	1	1.39	1.12	1.07	0.79
	7	1.39	1.08	0.87	1.09
	15	1.13	1.06	1.08	1.08
	22	1.10	0.69	1.14	1.08
Jan.	1	0.81	0.77	0.81	0.86
	7	0.79	0.82	0.92	0.92
	15	0.46	0.70	0.92	0.91
	22	0.96	0.74	0.82	0.80

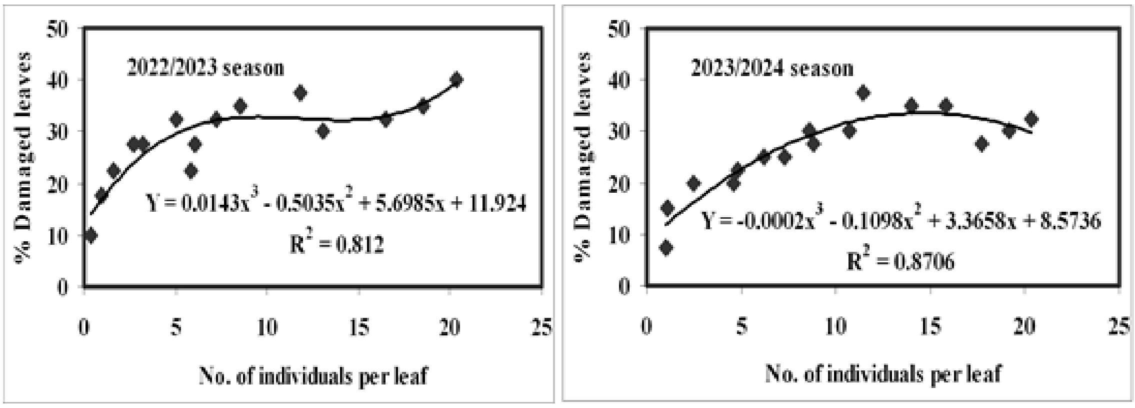

Fig. 4. The nonlinear relationship between the numbers of *B. tabaci* individuals per leaf and the damaged leaves in the two seasons (2022/2023 and 2023/2024).

2- Effect of the climatic factors and plant age on *B. tabaci* estimates on tomato plants:

Effect on three climatic factors (X_1, X_2 and X_3) and plant age (X_4)] on *B. tabaci* estimates (Y_1):

A- Effect of daily mean maximum temperature (X_1):

The data presented in Table (4) demonstrated a highly substantial negative simple correlation between this component and the *B. tabaci* numbers (r value was -0.70) in the first season and a significant negative (r value was -0.59) in the second season (Fig., 5). Furthermore, simple regression analysis shows that a 1°C rise in this factor would result in a drop of 1.18 and 0.93 individuals per leaf for the two seasons, respectively (Table 4). According to the partial regression estimations, this factor affected the *B. tabaci* numbers in the first season in an insignificantly negative way (P. reg. value: -0.33) and un a highly significant way (P. reg. value: -3.75).

B- Effect of daily mean minimum temperature (X_2):

The data collected in Table (4) showed non-significant negative correlations (r values: -0.34 and -0.39) between this factor and the numbers of *B. tabaci* for both seasons (Fig., 5). At the same time, according to the regression coefficient (b), every increase of 1°C in this variable leads to a decrease of 0.45 and 0.42 individuals per leaf during the two seasons. As indicated in Table (4), this variable had a highly significant positive influence on the number of *B. tabaci* during the first season (P. reg. value: +2.00) and a significant positive effect (P. reg. value: +0.66) during the second season.

C- Effect of the mean relative humidity (X_3):

Data represented in Table (4) showed that the simple correlation between mean relative humidity and the *B. tabaci* estimates was insignificantly positive (+0.36 and +0.06) in the two seasons, respectively, (Fig., 5). Simple regression also showed that increasing this factor by 1°C leads to an increase in insect numbers by 0.62 and 0.09 insects per leaf for two seasons, respectively (Table 4). Partial regression also showed non-significant negative impacts (P. reg. values; -0.37 and -0.60) between this factor and *B. tabaci* numbers for both seasons, respectively, Table (4).

D- Effect of the plant age (X_4):

Table (4) illustrates the effect of plant age on *B. tabaci* populations. Table (4) and Fig. (5) show that the correlation coefficient (r) was positive and non-significant (r value was 0.41) in the second season and positive and very significant (r value was 0.65) in the first. Simultaneously, the simple regression coefficient for this factor's effect showed that, throughout the course of the two study seasons, the number of *B. tabaci* would grow by 0.13 and 0.55 individuals per leaf, respectively, for every day that the tomato plant age increased. Partial regression findings (Table 4, Fig. 4) showed a substantially positive (P. reg. value of 0.39) association between tomato plant age and *B. tabaci* populations.

E- The combined effect of certain weather factors and plant age on *B. tabaci* numbers:

Table (4) shows that the combined effect of plant age and climate conditions on *B. tabaci* populations throughout the course of the two growing seasons was extremely significant, with «F» values of 6.23 and 13.23, respectively. The explained variance rates for the two seasons were 82.79% and 69.37, respectively.

Effect of plant ages:

The third-degree nonlinear equation, $Y= a+ b_1X+ b_2X^2+ b_3X^3$, was used to assess this relationship. A extremely substantial correlation was discovered with the variations in *B. tabaci* numbers.

For the two seasons, the corresponding explained variance percentages were 92.51% and 97.59 (Table, 4). In Figure (6), the regression equation was displayed.

First season (2021):

$$Y = -0.0001 X^3 + 0.0273 X^2 - 1.6181 X + 29.0201 \qquad R^2= 0.9068$$

Second season (2022):

$$Y = -05^{-7} X^3 + 0.0115 X^2 - 0.3053 X + 0.3095 \qquad R^2 = 0.8914$$

Additionally, there was a substantial combined influence of these factors on *B. tabaci* estimations, with «F» values of 38.93 and 32.83 for the two seasons, respectively (Table, 4).

Table 4. Correlation and regression for describing the relationship between some weather factors and plant age on *B. tabaci* estimates on tomato plants during the two seasons (2022/2023 and 2023/2024).

Season	Tested Variables	Simple correlation and regression values				Partial correlation and regression values				Analysis variance			
		r	b	S.E	t	P. cor.	P. reg.	S.E	t	F values	MR	R^2	E.V.%
2022/2023	Max. temp (X_1)	-0.70	-1.18	0.32	-3.63 **	-0.17	-0.33	0.58	-0.58	13.23 **	0.91	0.83	82.79
	Min. temp (X_2)	-0.34	-0.45	0.33	-1.35	0.82	2.00	0.43	4.68 **				
	R.H.% (X_3)	0.36	0.62	0.42	1.47	-0.34	-0.37	0.31	-1.20				
	Plant age (X_4)	0.65	0.13	0.04	3.17 **	0.73	0.39	0.11	3.55 **				
	Plant ages (X_4, X_4^2, X_4^3)									38.93 **	0.95	0.91	90.68
	Combined effect (X_1 to X_4^3)									31.46 **	0.98	0.95	95.45
2023/2024	Max. temp (X_1)	-0.59	-0.93	0.34	-2.73 *	-0.77	-3.75	0.94	-3.98 **	6.23 **	0.83	0.69	69.37
	Min. temp (X_2)	-0.39	-0.42	0.26	-1.59	0.66	1.41	0.49	2.88 *				
	R.H.% (X_3)	0.06	0.09	0.42	0.22	-0.42	-0.60	0.39	-1.54				
	Plant age (X_4)	0.41	0.55	0.32	1.70	-0.23	-0.53	0.67	-0.79				
	Plant ages (X_4, X_4^2, X_4^3)									32.83 **	0.94	0.89	89.14
	Combined effect (X_1 to X_4^3)									20.08 **	0.96	0.93	93.05

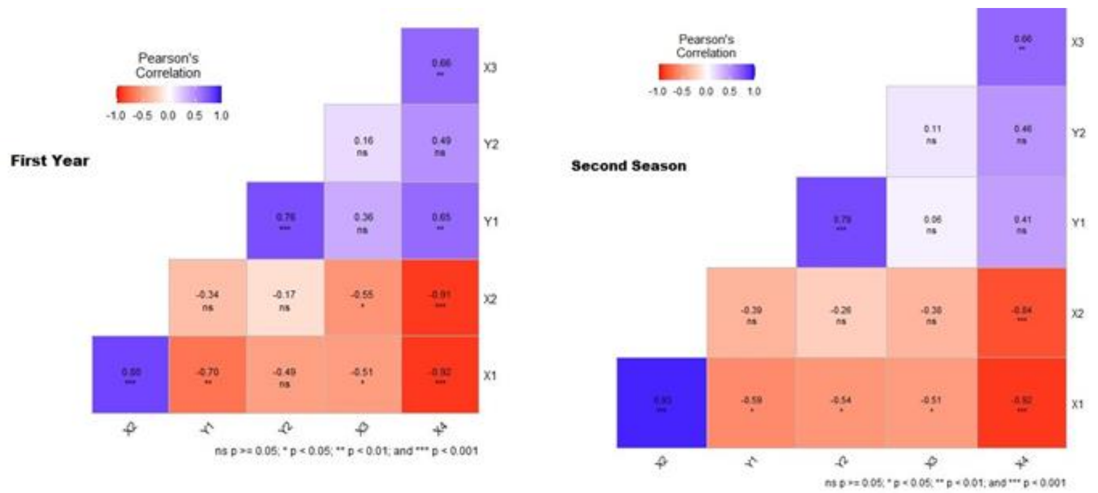

Fig. 5. The correlation between the numbers of *B. tabaci* individuals per leaf and certain weather factors and age plant in the two seasons (2022/2023 and 2023/2024).

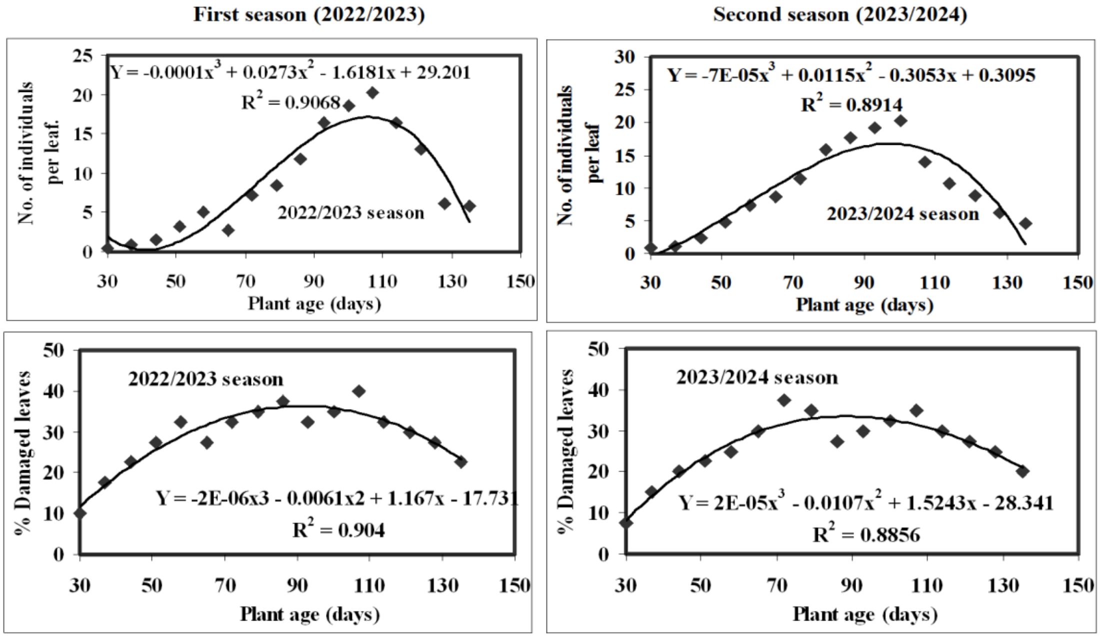

Fig. 6. The nonlinear relationship between the plant age and numbers of *B. tabaci* individuals per leaf, as well, the percentages of damaged leaves in the two seasons (2022/2023 and 2023/2024).

Effects of all tested variables on *B. tabaci* counts:

The impact of every variable examined on the numbers of *B. tabaci* The pooled effects of all three weather parameters and plant age that were investigated were shown to have an impact on *B. tabaci* numbers. All of these factors working together to affect *B. tabaci* numbers had a highly significant influence; for both seasons, the «F» value was 31.46 and 20.08 (Table, 4). Furthermore, Table (4) showed that the percentages of clarified differences for the two seasons were 90.68% and 93.05, respectively.

In recent years, research plans on pest management have placed a greater emphasis on the ecological requirements of different vegetable crop pests (Bakry *el al.*, 2023 a). Nonetheless, according to Abou-Zaid (2003), some research has been done on the impact of climatic circumstances on population changes in damage, losses, and pest control for vegetable crops.

According to Adam *et al.* (1997), there is a strong positive association between B. tabaci populations on cucumber plants grown in greenhouses and temperature and relative humidity. According to Bharadia and Patel (2005), the fourth week of October saw the highest concentration of whiteflies. According to Abdel-Hamed *et al.* (2011), in the 2009 and 2010 seasons, the relative humidity had a substantial negative impact on the population of *B. tabaci*, but the weather parameters (maximum, minimum, and mean temperature) and the age of the okra plant had a significant beneficial influence. Furthermore, during the two seasons, the proportion of variance explained by these covariates was 94.60% and 91.50, respectively.

According to Kumar and Gupta (2016), the incidence of *B. tabaci* in potato plants gradually declined as the maximum and lowest temperatures dropped. Hegab (2017), throughout the two seasons (2016 and 2017), weather factors had an impact on *B. tabaci* fluctuation of 21.5% and 67.2%, respectively, as percentages of explained variance. A significant link between the whitefly population and the capsicum's minimum and maximum temperatures was found by Moanaro and Choudhary (2018).

El-Shazly *et al.* (2019) found that mean counts of B. tabaci increased with decreasing relative humidity and that the quantity of *B. tabaci* increased with increasing temperatures per season. Moreover, B. tabaci activity was being impacted by the temperature and humidity combination. According to Kataria *et al.* (2019), there was a significant association with relative humidity and a negative association with the lowest and highest temperatures for whitefly counts. Additionally, whitefly populations and minimum and maximum temperatures were found to be considerably positively correlated by Ghongade *et al.* (2021), but relative humidity had an insignificantly detrimental effect on cucumber plant growth. On the other hand, *B. tabaci* incidence did not significantly correlate with meteorological conditions, according to Kumar *et al.* (2023).

Many researchers have found that plant age can have a significant impact on insect activity and the infestation rates of various insects. Example: the aphid *Schizaphis graminum* (Hemiptera: Aphididae) on wheat plants (Bakry *et al.*, 2020), the cotton mealybug, *Phenacoccus solenopsis* (Hemiptera: Pseudococcidae) on okra (Bakry and Fathipour, 2023), and whiteflies on cucumbers (Bakry *et al.*, 2023 a), the fall armyworm *Spodoptera frugiperda* (Lepidoptera: Noctuidae) on maize (Bakry and Abdel-Baky 2023), and the mealybug *Ferrisia virgata* on Acalypha shrubs (Bakry *et al.*, 2024 a).

3- Toxicological screening:

The concentration that eradicates 50% of the *B. tabici* population is a more statistically significant point for comparison, as shown in Table (5) and Figure (7). Using statistics (LDP-line) software, a probit analysis was applied to the aphid mortality data. The results produced LC_{50} values with 95% educible limits for the slope, standard error, chi-square, and correlation coefficient. The following describes the procedures used to evaluate each target synthetic chemical's insecticidal activity:

3.1- Toxicological activity test for nymphs of *B. tabici*:

Table (5) displays the outcomes of the toxicological testing against *B. tabici* for our target compounds Cyantraniliprole, Sulfoxaflor, Imidacloprid, Indoxacarb and Azadirachtin. After testing, some of the target five compounds were produces a range terms of their toxicological effects on the nymphs of *B. tabici* (LC_{50} values varied from 6.91 to 16.4 mg/L). For example, LC_{50} values of compounds Cyantraniliprole, Sulfoxaflor, Imidacloprid, Indoxacarb and Azadirachtin were 6.91, 8.43, 9.81, 10.9 and 16.4 mg/L, respectively. Furthermore, the toxicity index of Cyantraniliprole, Sulfoxaflor, Imidacloprid, Indoxacarb and Azadirachtin were 1, 0.81, 0.70, 0.63 and 0.42, respectively. From the results in above, the toxicity of compound Cyantraniliprole against the nymphs of *B. tabici* was most in activity than other target compounds after treatment.

Table 5. Insecticidal activity of Cyantraniliprole, Sulfoxaflor, Imidacloprid, Indoxacarb and Azadirachtin as reference insecticides against nymphs and adult female of *B. tabaci* insects.

Comps.	Nymphs				Adults female			
	LC_{50} (mg/L)	Slope	χ^2	Toxic ratio	LC_{50} (mg/L)	slope	χ^2	Toxic ratio
Cyantraniliprole	6.91	0.48 ± 0.24	0.22	1	19.6	0.47 ± 0.24	0.04	1
Sulfoxaflor	8.43	0.56 ± 0.24	0.47	0.81	21.5	0.53 ± 0.24	0.15	0.91
Imidacloprid	9.81	0.75 ± 0.25	0.04	0.70	28.8	0.53 ± 0.24	0.15	0.68
Indoxacarb	10.9	0.56 ± 0.24	0.15	0.63	30.7	0.56± 0.24	0.15	0.63
Azadirachtin	16.4	0.46 ± 0.24	0.16	0.42	34.1	0.54 ± 0.24	0.35	0.57

Notes: The Toxicity Ratio is determined by dividing the baseline toxicity of Malathion by the LC_{50} value of the molecule.

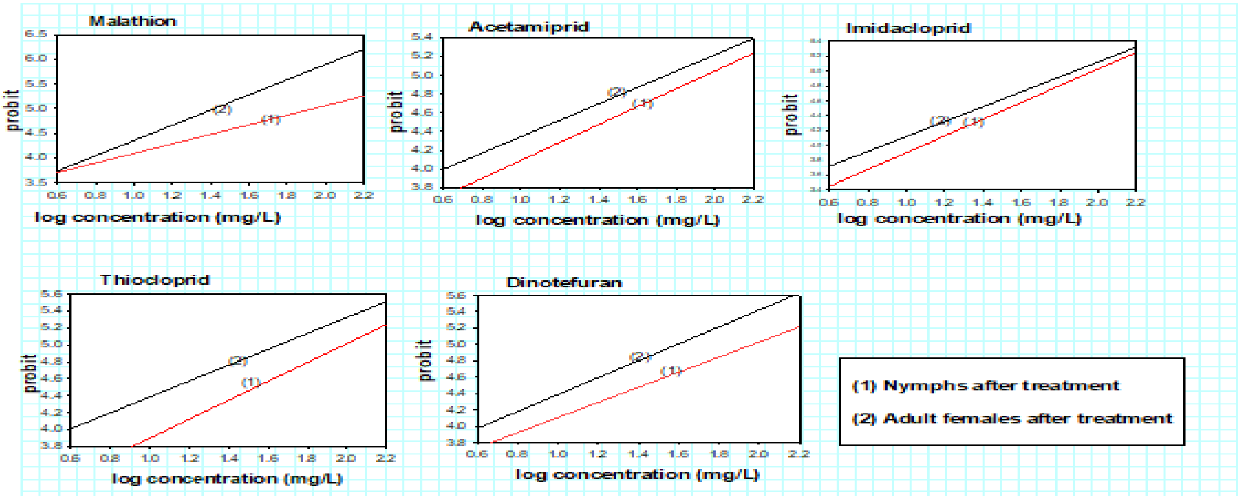

Fig. 7. Insecticidal activity of selective Cyantraniliprole, Sulfoxaflor, Imidacloprid, Indoxacarb and Azadirachtin insecticide against the adult and nymphs of *B. tabici.*

Toxicological activity test for adults of *B. tabici*:

All target compounds were evaluated for their bioactivity as insecticides against adults of *B. tabici* based on the studding results of the toxicity index, as shown in Table (5) and Figure (7).

Table (5) displays the outcomes of the toxicological testing against *B. tabici* for our target compounds Cyantraniliprole, Sulfoxaflor, Imidacloprid, Indoxacarb and Azadirachtin. After treatment, some of the target five compounds were produces a range terms of their toxicological effects on the nymphs of *B. tabici* (LC_{50} values varied from 19.6 to 34.1 mg/L).

For example, LC_{50} values of compounds Cyantraniliprole, Sulfoxaflor, Imidacloprid, Indoxacarb and Azadirachtin were 19.6, 21.5, 28.8, 30.7 and 34.1 mg/L, respectively. Furthermore, the toxicity index of Cyantraniliprole, Sulfoxaflor, Imidacloprid, Indoxacarb and Azadirachtin were 1, 0.91, 0.68, 0.63 and 0.57, respectively.

From the results in above, the toxicity of compound Cyantraniliprole against the nymphs of *B. tabici* was most in activity than other target compounds after treatment. Therefore, the Cyantraniliprole insecticide with good efficacy can be considered a good option in reducing whitefly populations in tomatoes. These results are consistent with Tomizawa and Casida (2001) mentioned that sulfoxaflor treatment was more toxic in reducing *B. tabaci*. Al-Kherb (2011) found that the most lethal pesticide for tomato whitefly individuals was thiamethoxam (10 g a.i./ha), which was followed by imidacloprid (10 g a.i./ha) and acetamiprid (10 ml a.i./ha). According to Meena and Ranju (2014), indoxacarb was the second most effective treatment for controlling whiteflies after profenophos. According to Das and Islam (2014), imidacloprid acts quickly to suppress the whitefly population. According to Gorri et al. (2015), adult whiteflies on tomatoes might be effectively reduced by using thiamethoxam and chlorpyrifos. According to Jahel et al. (2017), azadirachtin was shown to be the least active, whereas sulfoxafluor was the most harmful against the nymph and adult stages of whiteflies. Imidacloprid was the most active and successful insecticide in lowering whitefly populations, according to Jha and Kumar (2017).

Eweis et al. (2022) mentioned that *B. tabaci* on tomato plants could be significantly reduced by spraying cyantraniliprole and sulfoxaflor. Mahendra and Singh (2022) mentioned that Acetamiprid 20 SP (0.20 ml/lit.) and Imidacloprid 17.8 SL (0.22 ml/lit.) were exhibit to be more toxic in reducing *B. tabaci* on tomato.

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تأثير تغير الطقس و عمر النبات علي الذبابة البيضاء *Bemisia tabaci* (Gennadius) على نباتات الطماطم ومكافحتها في منطقة الدقهلية، مصر

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معهد بحوث وقاية النباتات - مركز البحوث الزراعية، 12619الجيزة، مصر.

الملخص

نفذ ت هذه التجربة في موسمين متتاليين (2023/2022 و2024/2023) بمركز المنصورة بمحافظة الدقهلية ، لدراسة تقديرات أعداد الذبابة البيضاء على نباتات الطماطم (صنف فيونا) وعلاقته ببعض العوامل الطقس المناخية ومكافحتها. أظهرت النتائج، أن حشرة الذبابة البيضاء على نباتات الطماطم ، اكتشفت بعد 30 يوماً من الزراعة، أى خلال الأسبوع الأول من أكتوبر حتى الأسبوع الرابع من شهر يناير خلال كل موسم، وبلغ إجمالي تعداد الحشرة 138.15 و 154.08 فردا خلال الموسمين على التوالى. وأيضا، على مدار الموسمين، بلغ متوسط التعداد الحشرى على الورقة الواحدة 8.63 و 9.63 فردا، على التوالى. إحصائياً، أظهرت طريقة الانحدار الخطي المتعدد أن التأثير المجمع لجميع العوامل المناخية وعمر النبات، وصل إلى 95.45% في 2023/2022 و93.05% في 2024/2023 على التباين في التعداد الحشرى. وكذلك، هذه التأثيرات بلغت 97.77% عام 2023/2022 و94.39% عام 2024/2023 على نسبة الأوراق المتضررة. أتضح من النتائج أنه بعد 72 ساعة من تقييم فعالية المبيدات الحشرية، تباينت فعالية المبيدات المختبرة،و تبين أن السيانترانيليبرول هو المبيد الأكثر حساسية من المبيدات الأخرى التي تم اختبارها على الحوريات والإناث البالغة لحشرة الذبابة البيضاء، بينما كان مبيد أزاديراختين أقل سمية. باستخدام نتائج هذه الدراسة، يمكن إدارة التعداد الحشرى للذبابة البيضاء على نباتات الطماطم بشكل فعال ويمكن تقليل الأضرار التي تسببها.