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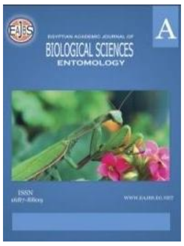

Weather Factors and Plant Age Influencing the Bionomics of The Tomato Leaf Miner, *Tuta absoluta* (Meyrick) and Its Control in Dakhlia Governorate, Egypt

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Tuta absoluta, population abundance, tomato plants, climate, plant age.

ABSTRACT

The present study examined the population estimates of tomato leaf miner *T. absoluta* larvae on tomato plants (Hybrid T4 84 cultivar) in relation to climate, plant age, and its control during two consecutive seasons (2022/2023 and 2023/2024) in the Dakhlia governorate, Egypt. According to the data, *T. absoluta* larvae were found on tomato plants thirty days after they were planted, or between October 2nd and January 23rd in both seasons. Over the course of the two seasons, the total number of *T. absoluta* larvae was 1365.00 and 371.00, respectively. Throughout the two seasons, the average number of *T. absoluta* larvae per 10 plants was 23.19 ± 1.56 and 22.81 ± 1.63, respectively.

According to statistical analysis using the multiple linear regression approach, the total impact of plant age and climate on the variation in *T. absoluta* larval population was 91.74 and 86.78% in both seasons, respectively. Following a three-day assessment of the four insecticides' effectiveness, the activities of the tested pesticides showed that chlorfenab was the least harmful and emamectin benzoate was the most susceptible of the evaluated insecticides on larvae in their second and fourth instars.

educe losses, growers might use the previous information to create a good management program for *T. absoluta* invasion in tomato fields.

INTRODUCTION

Tomatoes (*Lycopersicon* spp.) are a famous and important crop that is grown and eaten all over the world (Mandaokar *et al*., 2000). They are a common crop of many different cuisines and are necessary for diets around the world. Rich in vitamins C, element contents, and the antioxidant lycopene, tomatoes offer health advantages and make a substantial contribution to the world's food supply (Sharma and Kumar 2020). Tomato plants in the field are harmed by a variety of insect pests (Shehata *et al*., 2024). Among the most serious insect pests of tomatoes worldwide is *Tuta absoluta* (Meyrick), the scientific name for the tomato leaf miner (Abdel-Baky *et al*., 2019). Celini and Vaillant (2004) showed that this pest is multi-trophic and cosmopolitan. According to Blackman, and Eastop (2000), these pest infestations cause financial losses in crop quality and productivity.

The larvae of *T. absoluta* can cause nutritional damage to the entire plant. The larvae create amorphous leaf mines that have the potential to become necrotic after eating the mid-leaf tissue. Larvae can produce extensive galleries in stems, which can affect plant growth. The larvae also damage the fruits, and secondary diseases exploit the holes to induce fruit rot (Hogea, 2020). Almost every stage of the tomato plant is affected by this insect.

Infestations can result in yield losses of up to 100% if not effectively managed (Yankova, 2012).

T. absoluta has caused crop damage in countries around the world, destroyed agricultural production, and pushed prices beyond the reach of the average consumer in recent years (Sabour and Suleiman, 2016). *T. absoluta* must be managed right away because it is a serious threat to tomato production.

Due to seasonal variations in climate, insects exhibit varying patterns in their occurrence and the harm they inflict (Pareek *et al.*, 2017). Furthermore, the scope of the pest is determined by a number of identified and unidentified parameters that are equally significant (Walther *et al.*, 2002; Janu and Dahiya, 2017). The season, plant growth, and weather all affect the abundance of pests on the host plant (Bakry *et al*., 2020).

The two most popular approaches to managing tomato leaf miner are chemical pesticides and plant products. Tomato plants have been protected with a variety of traditional pesticides and chemicals. In Egypt, tomato leaf miner has been managed with the use of organophosphates, carbamates, and organochlorines (Eweis *et al*., 2022). However, the fruits and foliage are left with a persistent covering of poison after using these insecticides (Dikshit *et al*., 2000).

The focus of the current investigation is assessments of *T. absoluta* larval populations on tomato plants over the two seasons. Furthermore, assessing the impact of climate and plant age on the count of *T. absoluta* larvae during the two seasons. We also test several insecticides to determine which ones best control *T. absoluta* larvae.

MATERIALS AND METHODS

1- Population Oscillation of The Tomato Leaf Miner, *T. absoluta* on Tomato Plants:

Over the two consecutive growing seasons (2022/2023 and 2023/2024), tomato plants (Hybrid T_4 84 cultivar) were inspected weekly in the field to estimate the total number of tomato leaf miner larvae per 10 plants in the Mansoura region, Dakhlia Governorate, Egypt. During the autumn planting period (the first week of September of each season), four replicates, each measuring roughly 175 m2, were planted in a completely randomized block pattern. With the exception of using chemical pest management, all field procedures were followed. To monitor population changes over the two seasons, ten plants were chosen at random from each replication every week from various field parts.

After getting gathered and placed in various polythene bags, these plants were brought to the lab and examined under a stereomicroscope to determine their population abundance. The collection is performed in the morning between six and nine the morning. As soon as germination was noticed on the soil surface, sampling in the field started once a week and continued until the tomato harvest was over. By computing the average number of larvae per 10 plants, either plus or mines (±) the standard error, which was used to assess the population abundance, or weekly data on tomato plants were used to examine the *T. absoluta* population abundance.

2- Rate of Increase in Population Abundance:

To assess the extent of oscillation in population abundance throughout weekly observations, the rate of increase in larvae population abundance (weekly changes) was estimated by dividing the mean number in the sample data by that in the previous sample. This estimate is based on research conducted by Bakry and Fathipour (2023).

3- Effect of the Plant Age and Environmental Factors Influencing the Bionomics of the Tomato Leaf Miner Larvae on Tomato Plants:

The correlation between the counts of *T. absoluta* larvae and meteorological factors, including mean daily temperature (maximum and minimum), mean daily relative humidity%, and plant age throughout the two seasons (2022/2023 and 2023/2024), To obtain the daily averages within seven days of the tomato leaf miner larvae estimate, the daily registers of these variables were redone. In order to obtain the accurate averages, we had to return all of the values for these meteorological factors for every examination day, which took us one week prior to the sampling day.

Concerning the plant age determined on every examination time based on *T. absoluta* larvae assessment date. The nonlinear equation was used to establish this relationship. This approach was adopted by Bakry and Abdel-Baky (2023). To comprehend the detailed correlations between weather, plant age, and the abundance of *T. absoluta* larvae, scientists meticulously studied the data they gathered using two mathematical models: regression and correlation. The data was analyzed using SPSS software (1999) in accordance with Fisher's (1950) formula. R software was used to estimate and display simple correlation coefficients between various variables (Mendiburu, 2015).

4- Toxicological Study:

The toxicological efficacy of all target compounds was assessed using okra leaf dipping techniques in a laboratory setting at the Agricultural Research Station, Plant Protection Department in Mansoura branch, Mansoura district, Dakhlia Governorate (Bakry *et al.,* 2023; El-Gaby *et al.,* 2023; Gad *et al.,* 2023). Each chemical derivative was employed in five different concentrations, and 0.11% tween-20 was used as a surfactant. Only 10 larvae of *T. absoluta* insects in their second and fourth instars dipped for 10 seconds in each concentration of prepared components (three repetitions) (Bakry and Gad, 2023; Bakry *et al.,* 2024). The test insects were allowed to stand at 25ºC for approximately 30 minutes, during which time the control group of insects which were submerged in water and tween-20 only was also used. Applications are performed at room temperature and 50% relative humidity. Following their withering, the employed pests were moved to glass jars filled with distilled water. After one, two, and three days of exposure, the deceased and living were examined, measured, and registered using a new binocular microscope. Insects of *T. absoluta* that were immobile were deemed dead.

The Abbott formula equalized mortality (Abbott 1925), the mortality setback line estimations were objectively examined using probability analysis. The slope, upper confidence limit, and lower confidence limit of the LC_{50} values are estimated by the LDP-line equation with 95% confidence intervals. The mortality of the second and fourth instar larvae of *T. absoluta* was calculated using probit analysis using a statistical (LDP-line) equation (Sun, 1950). Emamectin benzoate, Chlorantraniliprole, Abamectin, Chlorfenapyr which is commercially available under the trade name **(**Emperor 0.5% EC), (Coragen 20% SC), (Vapcomic 1.8% EC) and Challenger (24% SC), respectively were purchased from the Central Agricultural Pesticides Laboratory (CAPL) in Dokki, Giza, Egypt.

RESULTS AND DISCUSSION

1- Population Studies:

1.1 – Seasonal Activity of *T. absoluta* Larval Counts on Tomato Plants:

The weekly assessments of *T. absoluta* larvae that invaded tomato plants (Hybrid T4 84 cultivar) cultivated in the field in the Mansoura district of the Dakhlia Governorate, Egypt, over the two growing seasons (2022/2023 and 2023/2024). Data represented in Tables (1 and 2) and Figures (2 and 3), exhibit the weekly mean observations of *T. absoluta* larvae per ten tomato plants in relation to climatic circumstances and plant age (in days) during both growth seasons of the study.

The results displayed that tomato plants harbored *T. absoluta* larvae from October 2^{nd} to January 23^{rd}. Therefore, pest invasions began on tomato plants thirty days after they were sown in each season. The overall assessments of *T. absoluta* larvae throughout the second season (2023/2024) were also greater than those during the first season (2022/2023). The general averages were 22.81± 1.63 and 23.19± 1.56 larvae per 10 plants over the two growing seasons, respectively.

It was noticed that the larvae of *T. absoluta* had three peaks per season and were recorded on October 8th, November 2nd, and December 16th.

Analysis of variance showed highly significant differences in the larvae of *T. absoluta* at different inspection times per season (F-values were 21.09 and 26.14; L.S.D. values were 7.62 and 6.71) for both years, respectively. At the same time, the coefficients of variation percentages were 23.51 and 20.36% for the two seasons, respectively (Tables 1 and 2).

Statistically, the numbers of *T. absoluta* larvae between the two seasons were highly statistically significant (F value was 47.02**, L.S.D value was 5.00, and coefficient of variation was 21.84%).

These outcomes are in line with Ahmed *et al*. (2024) report that the *T. absoluta* invasion fluctuating line showed four activity peaks in the first season and five peaks in the second. Plant age and weather conditions may therefore be linked to peak variations throughout the two seasons. Another study by Abolmaaty *et al*. (2010) predicted changes in *T. absoluta* population and the future climate. According to the data, *T. absoluta* has experienced an increase in generations due to climate variance; perhaps 12–14 generations per year in 2050 and 13–15 generations per year in 2100.

1.2- Weekly Occurrence, Accumulation and Percentage of larvae *T. absoluta* to Seasonal Total:

In order to depict an overall trend of population abundance, the percentages of cumulative counts for every week were also related to the total seasonal number, as indicated in Tables (1-2) and Figures (1 and 2). In order to depict the overall pattern of population abundance, the percentages of cumulative counts for every week were also related to the total seasonal count, as indicated in Tables (1-2) and Figures (1 and 2).

The largest percentages of *T. absoluta* larval counts on tomato plants were recorded on October 8th, November 2nd, and December 16th of each growing season, according to the data displayed in Tables (1 and 2) and illustrated in Figs. (1 and 2). The good climatic circumstances for the two seasons may be responsible for the percentages of 2.95, 7.95, and 11.37 percent and 3.10, 7.95, and 11.86%, respectively. According to the data in Tables 1 and 2, the total estimated number of *T. absoluta* larvae on tomato plants over the two growing seasons was 365.00 and 371.00 larvae each season, respectively. As the number of examination periods during the growing season increased, so did the percentages of cumulative *T. absoluta* larvae numbers on tomato plants.

1.3- Rate of Change in *B. tabaci* Estimates:

The rate of increase in *T. absoluta* larvae on tomato plants was shown by the data in Tables (1 and 2). It is said to be the week in which the insect's number increases the most during the season, indicating the optimal week for the insect's activity (Bakry and Fathipour, 2023; Bakry and Abdel-Baky, 2023 & 2024). According to the information in Tables (1 and 2), the weeks from October 8th, November 2nd, and from November 16 to December 16 of each season seem to be the ideal times for detecting an increase in T. absoluta larvae. Thus, the gradual rise in *T. absoluta* larvae on tomatoes during these periods suggests that pest management should begin in the germination and vegetative development phases, before the population peaks. These results are consistent with those of Salama *et al*. (2023). The number of *T. absoluta* larvae increased by more than one over the examined periods, it was evident that this was considered an indication that the weather was more conducive to the growth of *T. absoluta* larvae.

Table 1: Weekly observation of *T. absoluta* larvae on tomato plants in relation to weather and biotic parameters in the first season (2022/2023).

Inspection date		Plant age	No. of larvae per 10 plants	% No. larvae of total counts	Cumulative numbers	% Cumulative No.	Rate of increase	Weather factors		
								Max. temp.	Min temp.	% R.H.
Oct., 2022	2	30	4.00 ± 0.41	1.10	4.00	1.10		30.38	24.21	73.33
	8	37	10.75 ± 1.38	2.95	14.75	4.04	2.69	29.91	23.86	73.16
	16	44	8.50 ± 0.65	2.33	23.25	6.37	0.79	29.43	23.51	72.99
	23	51	19.25 ± 1.89	5.27	42.50	11.64	2.26	29.17	23.62	72.26
Nov.	2	58	29.00 ± 2.89	7.95	71.50	19.59	1.51	28.92	23.73	71.53
	8	65	15.25 ± 1.25	4.18	86.75	23.77	0.53	24.47	22.49	77.81
	16	72	16.00 ± 2.58	4.38	102.75	28.15	1.05	24.70	21.25	76.44
	23	79	19.00 ± 1.29	5.21	121.75	33.36	1.19	24.94	19.92	73.95
Dec.	2	86	27.50 ± 2.99	7.53	149.25	40.89	1.45	24.69	18.58	77.15
	8	93	39.50 ± 5.12	10.82	188.75	51.71	1.44	18.94	18.64	72.01
	16	100	41.50 ± 4.27	11.37	230.25	63.08	1.05	20.82	18.70	74.85
	23	107	40.50 ± 3.29	11.10	270.75	74.18	0.98	22.69	18.67	77.69
Jan., 2023	2	114	38.00 ± 4.90	10.41	308.75	84.59	0.94	22.10	18.63	78.40
	8	121	29.00 ± 1.91	7.95	337.75	92.53	0.76	21.68	12.02	76.77
	16	128	14.50 ± 0.96	3.97	352.25	96.51	0.50	20.49	10.10	78.30
	23	135	12.75 ± 1.49	3.49	365.00	100.00	0.88	19.30	8.08	79.83
Grand total / season			365.00	100.00						
Average			22.81 ± 1.63					24.54	19.13	75.40
F value			21.09 **							
L.S.D. at 0.05 level			7.62							
C.V.%			23.51							

Explanations: S.E. refers to the standard error; L.S.D. = Least significant difference; * Significant at P ≤ 0.05, ** Highly significant at P ≤ 0.01; C.V. = Coefficient of variation.

Table 2: Weekly observation of *T. absoluta* larvae on tomato plants in relation to weather and biotic parameters in the first season (2022/2023).

Inspection date		Plant age (in days)	No. of larvae per 10 plants	% No. larvae of total counts	Cumulative numbers	% Cumulative No.	Rate of increase	Weather factors		
								Max. temp.	Min temp.	% R.H.
Oct., 2023	2	30	3.50 ± 0.29	0.94	3.50	0.94		29.69	19.81	74.06
	8	37	11.50 ± 1.26	3.10	15.00	4.04	3.29	29.20	19.52	73.89
	16	44	9.00 ± 0.71	2.43	24.00	6.47	0.78	29.72	19.23	73.72
	23	51	20.50 ± 1.89	5.53	44.50	11.99	2.28	29.46	19.32	72.98
Nov.	2	58	29.50 ± 2.50	7.95	74.00	19.95	1.44	29.21	19.41	72.24
	8	65	16.00 ± 0.71	4.31	90.00	24.26	0.54	24.71	18.40	78.59
	16	72	17.00 ± 1.91	4.58	107.00	28.84	1.06	24.95	19.32	77.20
	23	79	19.50 ± 1.26	5.26	126.50	34.10	1.15	25.19	18.11	74.69
Dec.	2	86	28.50 ± 2.22	7.68	155.00	41.78	1.46	24.94	16.89	77.92
	8	93	38.50 ± 5.62	10.38	193.50	52.16	1.35	20.00	16.95	72.73
	16	100	44.00 ± 3.37	11.86	237.50	64.02	1.14	21.03	17.00	75.60
	23	107	38.50 ± 3.10	10.38	276.00	74.39	0.88	22.92	16.97	78.46
Jan., 2024	2	114	37.00 ± 3.32	9.97	313.00	84.37	0.96	22.32	16.94	79.18
	8	121	29.00 ± 1.29	7.82	342.00	92.18	0.78	21.90	10.92	77.54
	16	128	15.50 ± 1.71	4.18	357.50	96.36	0.53	20.70	9.18	79.08
	23	135	13.50 ± 0.96	3.64	371.00	100.00	0.87	19.50	7.34	76.00
Grand total / season			371.00	100.00						
Average			23.19 ± 1.56					24.71	16.58	75.87
F value			26.14 **							
L.S.D. at 0.05 level			6.71							
C.V.%			20.36							

Explanations: S.E. refers to the standard error; L.S.D. = Least significant difference; * Significant at P ≤ 0.05, ** Highly significant at P ≤ 0.01; C.V. = Coefficient of variation.

Statistically, the numbers of *T. absoluta* larvae between the two growing seasons were highly statistically significant (F value was 47.02**, L.S.D value was 5.00 and coefficient of variation was 21.84%).

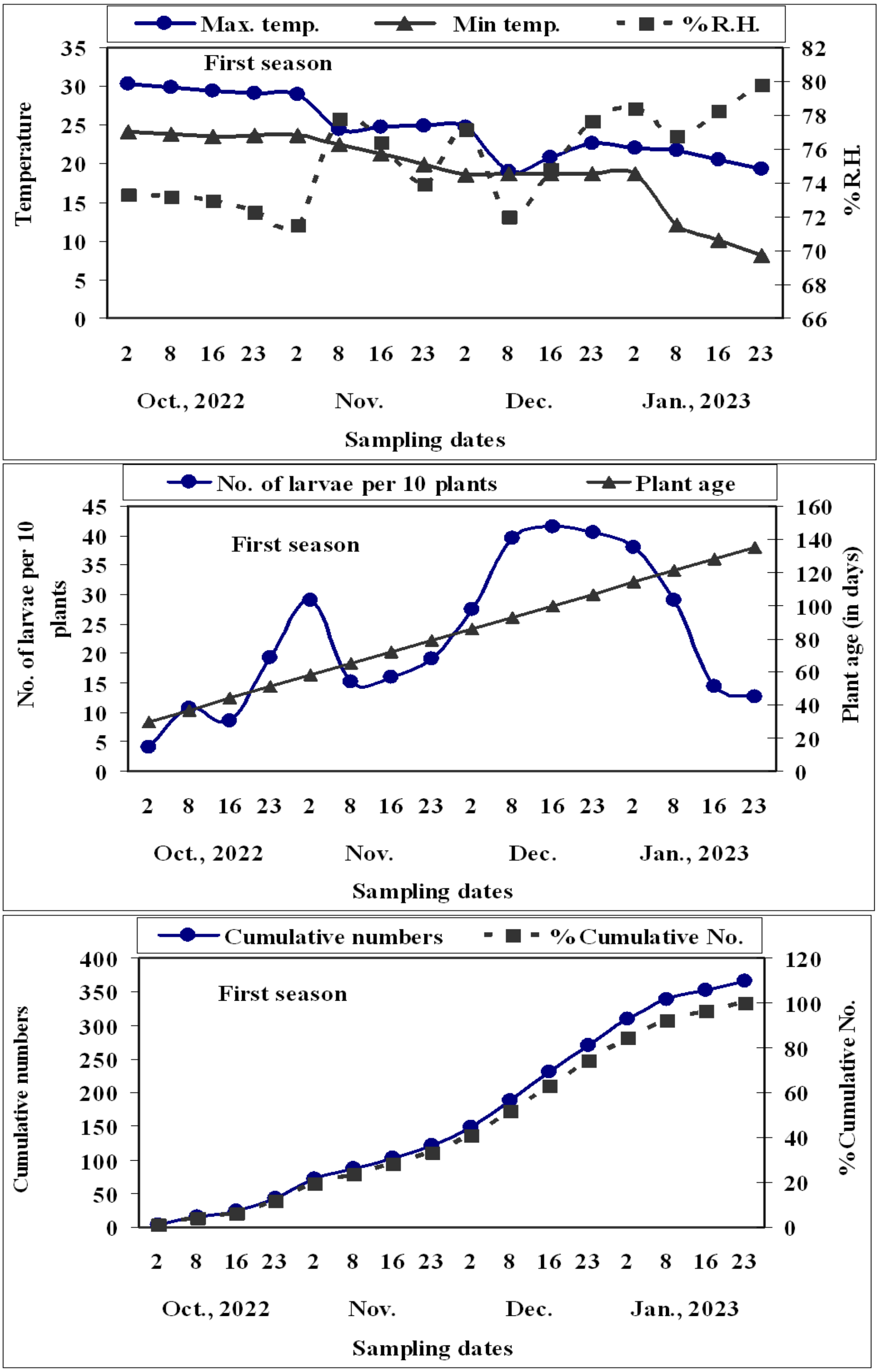

Fig. 1: Weekly monitoring of *T. absoluta* larvae, cumulative numbers, and % cumulative of larvae on tomato plants in relation to weather and biotic parameters in 2022/2023 season.

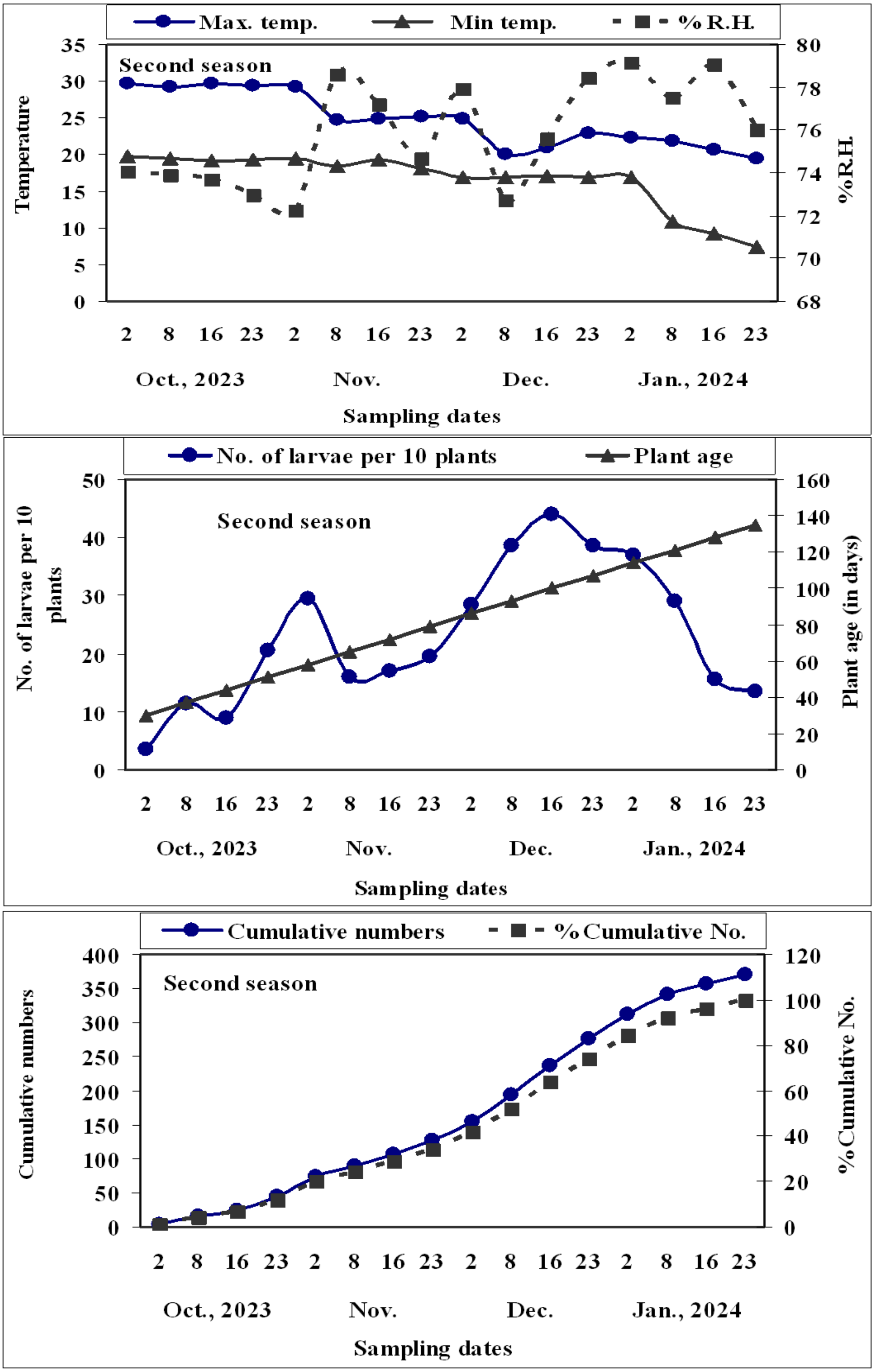

Fig. (2): Weekly monitoring of *T. absoluta* larvae, cumulative numbers, and % cumulative of larvae on tomato plants in relation to weather and biotic parameters in 2023/2024 season.

2- The Polynomial Relationships Between *T. absoluta* Larval Numbers and Age Plants:

We used a nonlinear regression equation, as illustrated in Figure (3), to compute mathematical formulas between tomato plant ages (X) as a dependent variable and *T. absoluta* larval counts (Y) as an independent factor. This approach was used by Bakry and Fathipour (2023). The following are the mathematical formulas:

First season (2022/2023):

$Y = -0.0002\ X^3 + 0.0373\ X^2 – 1.9331\ X_1 + 38.154$ E.V.= 73.85% Equation (1)

Second season (2023/2024):

$Y = -0.0002\ X^3 + 0.0327\ X^2 – 1.5907\ X_1 + 31.104$ E.V.= 73.43% Equation (2)

The findings demonstrated a strong statistical correlation between the tomato plant ages during the two-season investigation and the larvae of *T. absoluta*. In both years, the explained variance percentages (E.V.) were 73.43% and 73.85%, respectively, as shown in Figure (3) and Equations (1 and 2).

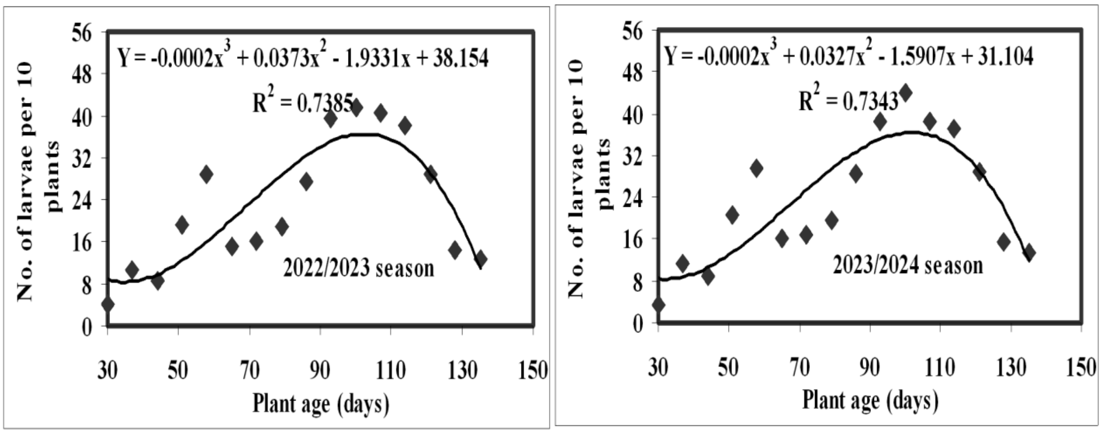

Fig. 3: The relationship between the tomato plant ages and the estimates of *T. absoluta* larvae per 10 plants over the two growing seasons (2022/2023 and 2023/2024).

3- Evaluating the Effect of The Climate and Plant Age on *T. absoluta* Larval Numbers on Tomato Plants:

3.1- The Correlation and Multiple Linear Regression Analyses:

According to Table (3) and in Figure (4), the population of *T. absoluta* larvae exhibited a significant negative correlation with maximum temperature (r values were -0.55 and -0.52) but an insignificant and negative link with minimum temperature (r = -0.15 and -0.03) over the course of both growth seasons.

T. absoluta larval counts were positively impacted by relative humidity and plant ages, but not significantly (r values were 0.07 and 0.49 in 2022/2023 and 0.18 and 0.49 in 2023/2024, respectively) (Table 3 and Fig. 4).

The following are the estimated results of a multiple linear regression model relating the number of *T. absoluta* larvae to climate and plant age:

First season (2022/2023):

$Y = 84.58 – 0.22\ X_1 + 4.08\ X_2^{**} – 2.28\ X_3^{**} + 0.85\ X_4^{**}$

F value = 22.70** MR= 0.94 E.V.= 89.20% Equation (3)

Second season (2023/2024):

$Y = 84.58 + 0.10\ X_1 + 4.35\ X_2^{**} – 1.90\ X_3^{**} + 0.70\ X_4^{**}$

F value = 13.04** MR= 0.91 E.V.= 82.58 % Equation (4)

Where, $X_{1=}$ maximum temperature; $X_{2=}$ minimum temperature; $X_{3=}$ relative humidity $X_{4=}$ plant ages; MR= multiple correlation; E.V.= explained variance.

Equations (3 and 4) showed that the explained variations between these tested weather and plant ages on *T. absoluta* larval estimates were 91.74 and 86.78% for the two seasons, respectively.

Table 3: Multiple linear regression to estimate the numbers of the tomato leaf miner larvae *T. absoluta* and their relationship to weather and biotic parameters 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)	-0.55	-1.71	0.70	-2.45 *	- 0.08	-0.22	0.80	-0.27	22.70 **	0.94	0.89	89.20
	Min. temp (X_2)	-0.15	-0.36	0.65	-0.56	0.90	4.08	0.60	6.76 **				
	R.H.% (X_3)	0.07	0.33	1.22	0.27	-0.71	-2.28	0.68	-3.35 **				
	Plant age (X_4)	0.49	0.18	0.09	2.11	0.87	0.85	0.15	5.89 **				
	Plant ages (X_4, X_4^2, X_4^3)									11.29 **	0.86	0.74	73.85
	Combined effect (X_1 to X_4^3)									16.66 **	0.96	0.92	91.74
2023/2024	Max. temp (X_1)	-0.52	-1.68	0.74	-2.29 *	0.03	0.10	1.08	0.09	13.04 **	0.91	0.83	82.58
	Min. temp (X_2)	-0.03	-0.09	0.83	-0.11	0.97	4.35	0.75	5.80 **				
	R.H.% (X_3)	0.18	0.87	1.30	0.67	-0.58	-1.90	0.81	-2.34*				
	Plant age (X_4)	0.49	0.18	0.08	2.11	0.79	0.70	0.16	4.24**				
	Plant ages (X_4, X_4^2, X_4^3)									11.05 **	0.86	0.73	73.43
	Combined effect (X_1 to X_4^3)									9.84 **	0.93	0.87	86.78

r = Simple correlation; b = Simple regression; P. cor. = Partial correlation; MR = Multiple correlation; P. reg.= Partial regression R^2= Coefficient of determination; E.V% = Explained variance; S.E = Standard error * Significant at $P \leq 0.05$ ** Highly significant at $P \leq 0.01$

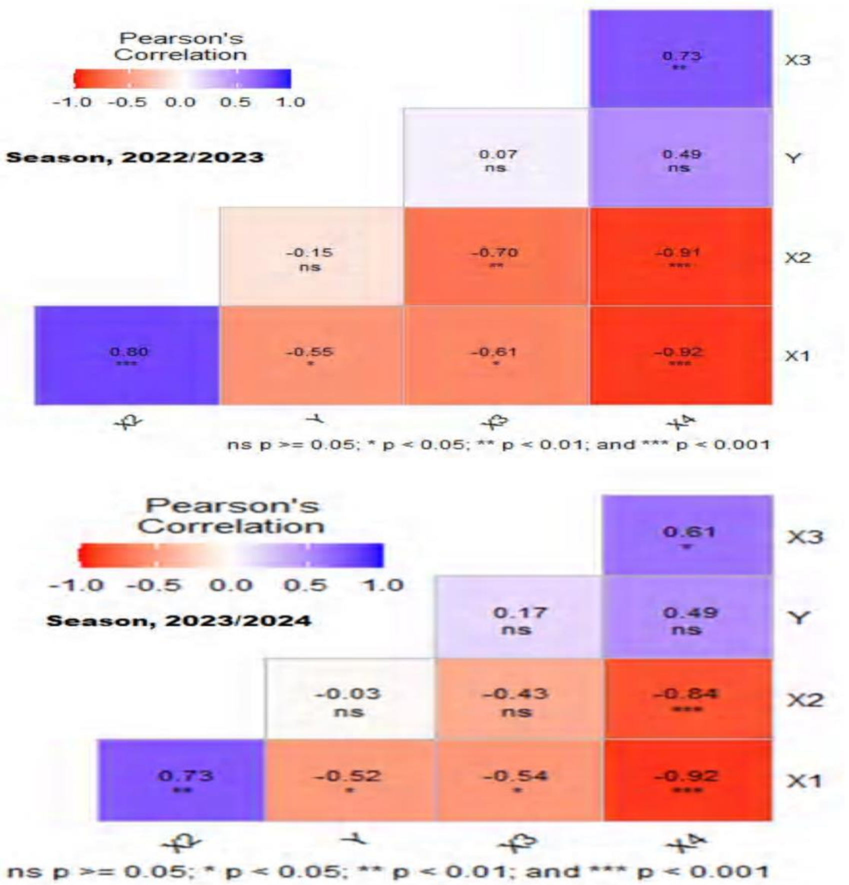

Fig. 4: The correlation between the numbers of the tomato leaf miner larvae *T. absoluta* and the weather & biotic parameters on tomato plants during the two seasons (2022/2023 and 2023/2024).

3.2- The Combined Impact of These Variables on *T. absoluta* Larval Estimates:

The combined impacts of these examined criteria on *T. absoluta* larval estimates throughout the two seasons were very significant and differed from season to season, as shown in Table (3). During the two years, the multiple correlation values were 0.92 and 0.93 and the F-values were 16.66 and 9.84, respectively. In the meantime, Table (3), showed that the explained variations between these tested meteorological conditions and plant age on *T. absoluta* larval estimations were 91.74 and 86.78% for the two years, respectively.

First of all, because climatic factors affecting insect population abundance vary by location, it is difficult to compare current findings with those from studies addressing various geographies (Mahmoud *et al.*, 2015). The main determinants influencing infestation rates are ambient environmental conditions, such as temperature and relative humidity, because of their effect on insect behavior (Abolmaaty *et al.* 2010).

Ata and Megahed (2014) discovered positive associations between environmental variables and tomato leaf miner activity, except for mean daily temperature, which was significant and positive. Ahmed *et al.* (2024) found that the larvae of *T. absoluta* population is significantly correlated negatively with plant age, air, and soil temperatures.

In open tomato fields, Bacci *et al*. (2021) discovered that *T. absoluta* infestation is influenced by plant phenology, environmental factors, and insecticides. According to Martins *et al*. (2016), one of the main climatic factors affecting *T. absoluta* populations is temperature. According to Salama *et al*. (2023), successful pest management against *T. absoluta* requires knowledge of plant age and meteorological conditions.

4- Toxicological Screening:

The concentration that eradicates 50% of the *T. absoluta* population is a more statistically significant point for comparison, as shown in Table (4). 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.

Table 4: Insecticidal activity of compounds Emamectin benzoate, Chlorantraniliprole, Abamectin and Chlorfenapyr as insecticide against second and fourth instar larvae of *T. absoluta*.

Treatments	2nd instar larvae				4th instar larvae			
	LC_{50} (mg/L)	Slope	χ^2	Toxic ratio	LC_{50} (mg/L)	slope	χ^2	Toxic ratio
Emamectin benzoate	0.26 (0.18-0.35)	0.35 ± 0.27	0.41	1.00	0.51 (0.40-0.68)	0.49 ± 0.23	0.40	1.00
Chlorantraniliprole	0.46 (0.31-0.56)	0.37 ± 0.27	0.21	0.56	0.75 (0.56-0.89)	0.52 ± 0.29	0.31	0.68
Abamectin	0.60 (0.44–0.76)	0.34 ± 0.27	0.15	0.43	1.0 (0.86-1.02)	0.43 ± 0.26	0.22	0.51
Chlorfenapyr	24.0 (16.1-31.7)	0.75 ± 0.25	0.65	0.01	53.3 (46.1-62.3)	0.62 ± 0.24	0.34	0.009

4.1- Toxicological Activity Test for 2nd Instar Larvae of *T. absoluta*:

Table (4), displays the outcomes of the toxicological testing against the second instar larvae of *T. absoluta* for our target compounds Emamectin benzoate, Chlorantraniliprole, Abamectin and Chlorfenapyr. After testing, some of the target five compounds were produces a range terms of their toxicological effects on the 2nd instar larvae of *T. absoluta* (LC_{50} values varied from 0.26 to 24.0 mg/L). For example, LC_{50} values of compounds Emamectin benzoate, Chlorantraniliprole, Abamectin and Chlorfenapyr were 0.26, 0.46, 0.60 and 24.0 mg/L, respectively. Furthermore, the toxicity index of Emamectin benzoate, Chlorantraniliprole, Abamectin and Chlorfenapyr were 1, 0.56, 0.43 and 0.01, respectively. From the results in above, the toxicity of compound **Emamectin benzoate** against the 2nd instar larvae of *T. absoluta* was most in activity than other target compounds after treatment.

4.2- Toxicological Activity Test for the 4th Instar Larvae of *T. absoluta*:

All target compounds were evaluated for their bioactivity as insecticides against the fourth instar larvae of *T. absoluta* based on the studding results of the toxicity index, as shown in Table (4). The outcomes of the toxicological testing against *T. absoluta* for our target compounds Emamectin benzoate, Chlorantraniliprole, Abamectin and Chlorfenapyr. After treatment, some of the target four compounds were produces a range terms of their toxicological effects on the nymphs of *T. absoluta* (LC_{50} values varied from 0.51-53.3 mg/L). For example, LC_{50} values of compounds Emamectin benzoate, Chlorantraniliprole, Abamectin and Chlorfenapyr were 0.51, 0.75, 1.0 and 53.3 mg/L, respectively. Furthermore, the toxicity index of Emamectin benzoate, Chlorantraniliprole, Abamectin and Chlorfenapyr were 1.0, 0.68, 0.51 and 0.009, respectively. From the results in above, the toxicity of compound Emamectin benzoate against *T. absoluta* was most in activity than other target compounds after treatment.

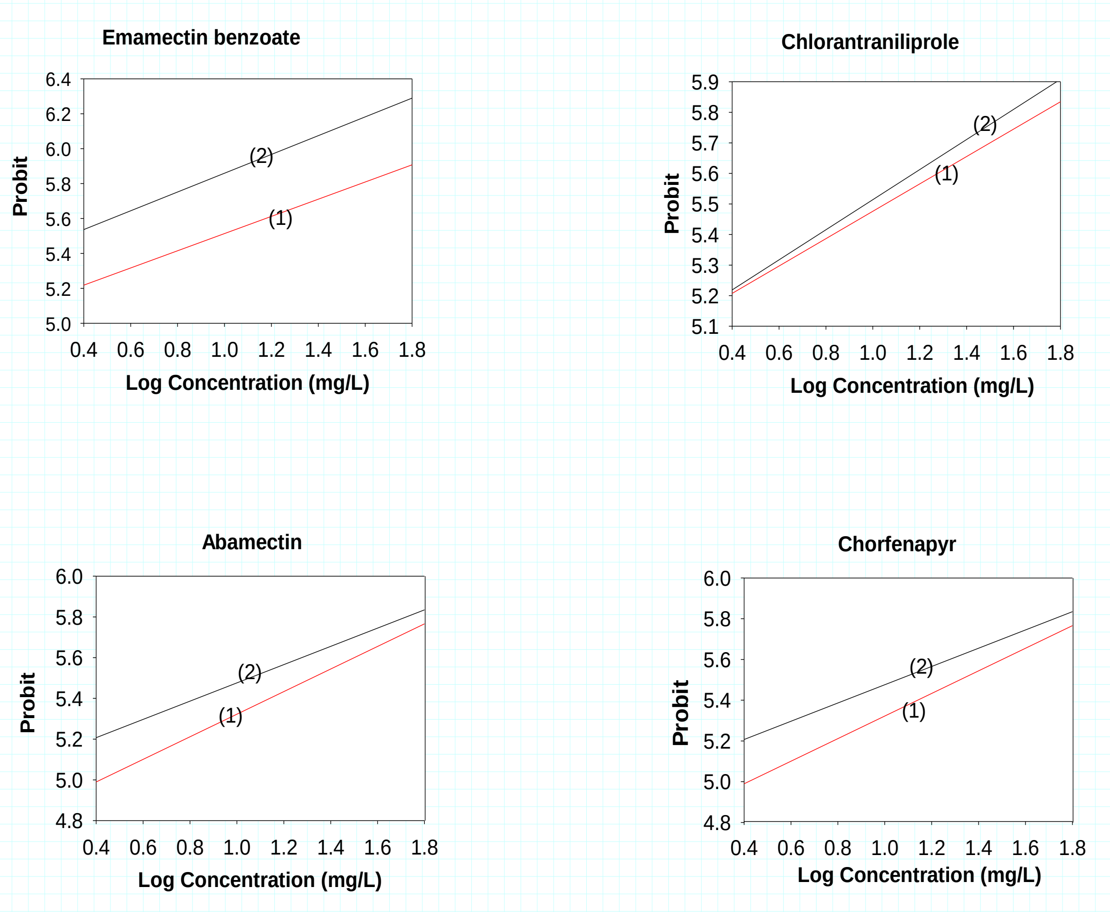

Fig. 5: Insecticidal effectiveness of selective products Emamectin benzoate, Chlorantraniliprole, Abamectin and Chlorfenapyr against 2nd & 4th instar larvae of *T. absoluta.*

Declarations:

Ethical Approval: Not applicable
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Conflicts Interests: The authors declare no conflict of interest.
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