



Original article

Effect of certain environmental factors on population dynamics of *Tuta absoluta* (Meyrick) in tomato plant (*Solanum lycopersicum*) at Giza Governorate

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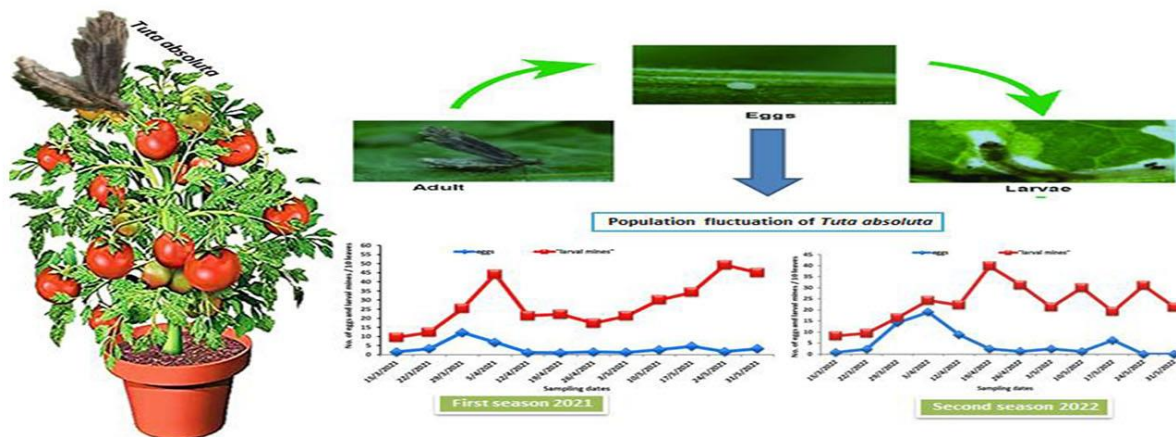
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ABSTRACT

The effect of plant age and environmental factors (minimum and maximum temperatures, and relative humidity) on the population dynamics of the tomato leafminer *Tuta absoluta* (Meyrick) was studied at Giza Governorate during the summer plantations of the tomato plant *Solanum lycopersicum* in 2021 and 2022. Tomato leaves were picked and inspected weekly to determine how many generations each living instar (eggs and larvae) had completed. Mines with and without larvae were counted. The population density was higher in the first growing season (2021) than in the second growing season (2022), with mean counts of 31.07 and 27.74 insects per 10 leaves, respectively. This pest was able to attain 3–4 peaks for both eggs and larvae, with the first peak occurring in the third week of March, followed by the third week of April, and the largest peaks occurring at the end of May in both seasons. Studies on the relationships between insect pest populations and environmental variables showed that *T. absoluta* eggs and environmental variables (minimum and maximum temperatures, relative humidity, and plant age, a biotic factor) throughout two growing seasons in 2021 and 2022 exhibited significant negative correlations but insignificant positive correlations. The population dynamics of *T. absoluta* (egg and larval mines) were affected by environmental conditions and plant age throughout both seasons (2021 and 2022) by 78%–75% and 71%–63%, respectively.

Graphical abstract



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## 1. Introduction

The tomato (*Solanum lycopersicum*) is one of the most essential vegetable crops farmed for human consumption across the world, notably in Egypt, whether fresh or industrially processed. It is the world's most popular garden crop and the second most eaten vegetable crop (after potatoes) [1]. Despite the large number of cultivars of this species that have been developed and commercialized, the majority are susceptible to a wide range of arthropod pests, some of which are capable of causing significant losses, including crop destruction [2]. Egypt is the second largest producer and exporter of tomatoes in the Mediterranean region, due to its favorable climate for tomato cultivation, and it is currently the largest producer of tomatoes in Africa, with an annual production of 8,533,803 metric tons on an area of 212,946 hectares (ha) of land and an estimated exportation of 30,878 metric tons of tomatoes [3]. A vital pest of tomato plants is the tomato leafminer, *Tuta absoluta*. It quickly invaded other European nations and spread throughout the Mediterranean basin after being first discovered in eastern Spain in 2006 [4, 5, 6, 7, 8]. Since 2009, the tomato leafminer *T. absoluta* has been reported in Egypt, quickly emerging as a major tomato crop pest [9]. This pest is thought to primarily feed on tomatoes; along these lines, no tomato cultivar is completely impervious to this bug, yet not all cultivars are similarly defenseless [10, 11, 12]. The leaves, fruits, flowers, buds, and stems of plants are the food of this multivoltine pest. By consuming the leaf mesophyll, which expands, the larvae cause harm. *Tuta absoluta* hatchlings can cause yield misfortunes of up to 80–100 percent by going after tomato leaves, blooms, stems, and particularly natural products in nurseries and open fields [8, 9]. The aim of this study is to determine how the combination of environmental factors and plant age affects the population dynamics of *T. absoluta* (egg and larval mines) throughout the duration of two growing seasons in 2021 and 2022.

## 2. Materials and Methods

Experiments were conducted in a greenhouse of protected cultivation at the Central Laboratory for Agriculture Climate, Dokki, Giza Governorate, throughout two growing seasons in 2021 and 2022. On February 1, 2021, and February 1, 2022, tomato seedlings were planted. After 30 days of sowing, seedlings were planted into raised beds with drip irrigation under normal agricultural practices. The greenhouse has a total area of  $9 \times 60 \times 4$ . Inspection began 15 days after sowing. Each sample had ten leaves (50 leaflets per replication); three replicates were employed, each with ten leaves from three plant levels (upper, mid, and lower). Each week, samples were collected between 8 and 10 a.m. and transferred to the laboratory in plastic bags; the upper and lower surfaces of the leaflets were inspected under a binocular microscope on the same day [13]. Normal agricultural practices were undertaken on a regular basis, with no chemical control. The weekly mean minimum

temperature, maximum temperature, and relative humidity (R.H.) percent were tested to clarify their simultaneous effects on the population dynamics of *T. absoluta* at Dokki, Giza Governorate, for the entire study period in 2021 and 2022, and then fluctuations of the insects were calculated and expressed in terms of the correlation coefficient ( $r$ ) and regression coefficients (b). The C-multiplier method was used to calculate the cumulative impacts of these components, which were then reported as a percentage of explained variance (EV) [14].

## 3. Results

### 1. Population fluctuations of the leafminer, *Tuta absoluta*, infesting the tomato plant, *Solanum lycopersicum*:

*Tuta absoluta* infested tomato plants were investigated by counting the number of eggs laid and the larval mines in leaves found on a weekly basis. With mean numbers of 31.07 and 27.74 pests per 10 leaves, respectively. The result indicated that the population density of *T. absoluta* in the first season of 2021 was higher than in the second season of 2022, as depicted in Figs. 1 and 2.

#### 1.1. Eggs:

According to the results, the mean number of *T. absoluta* eggs on tomato plants in the first and second seasons was 3.41 and 4.88 eggs per 10 leaves, respectively. In the first season (2021), *T. absoluta* eggs had a lower mean population density in the first week of March. After that, it fluctuated to increase gradually and recorded three peaks in the third week of March, second and fourth week of May, respectively, with mean numbers of population density of 12.2, 4.67 and 3.27 eggs per 10 leaves, as shown in Fig. 1a. Consequently, in the subsequent season (2022), the population density of *T. absoluta* eggs began to show up with not many numbers in the principal seven-day stretch of spring, then expanded progressively to record two tops on the first seven-day stretch of April and the third seven-day stretch of May, respectively, with mean quantities of population densities of 19 and 6.27 eggs for every 10 leaves, respectively. (Fig. 1b).

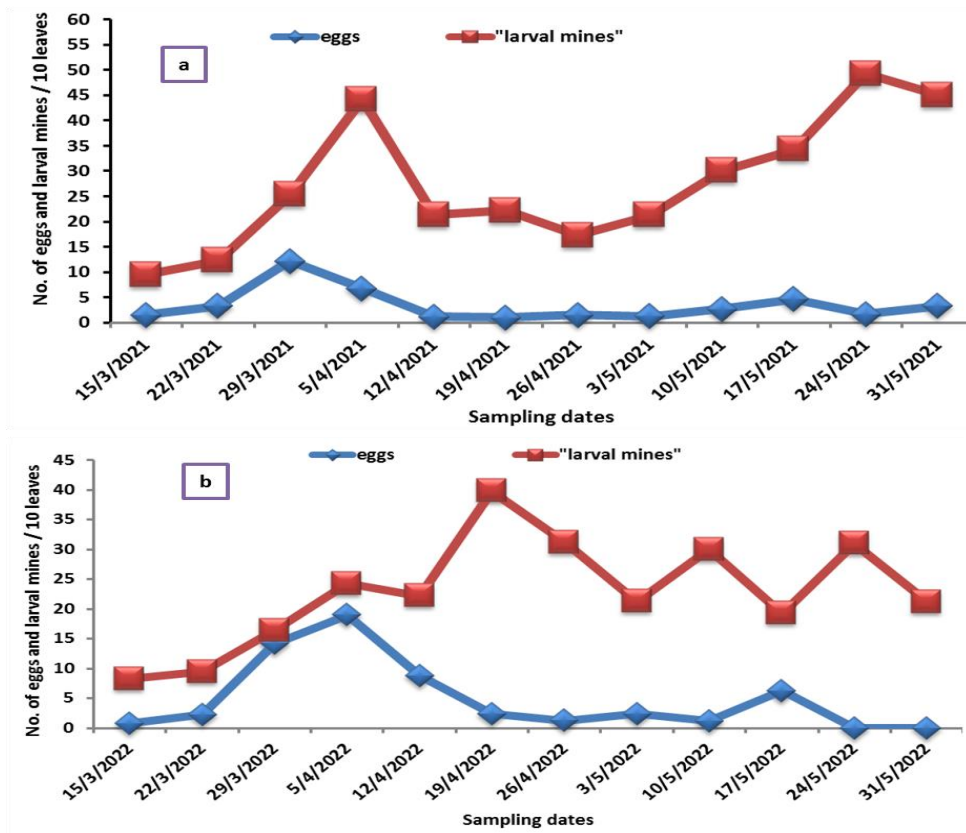
#### 1.2. Larval mines:

Results in Fig. (1) demonstrated that, with mean pest numbers of 27.66 and 22.86 per 10 leaves, respectively, the first season's mean *T. absoluta* larvae infestation on tomato plants (2021) was greater than the second season's mean (2022).

The population density of *T. absoluta* larval mines in the first season began to increase gradually, reaching three peaks on the first and third weeks of April and the fourth week of May, with mean numbers of 44.22, 22.2, and 49.27 pests per 10 leaves for the three peaks, respectively (Fig. 1a). *Tuta absoluta* larvae began to appear on tomato plants in the first week of March

during the second season, and their population density increased gradually to reach four peaks during the first and third weeks of April and the second and fourth

weeks of May, with mean numbers of 24.26, 39.8, 30, and 31 pests per 10 leaves, respectively (Fig. 1b).



**Fig. (1).** Seasonal fluctuation of *T. absoluta* (egg and larval mines) on tomato plant, *Solanum lycopersicum* during **a.** 2021 and **b.** 2022 seasons.

**2. Effect of certain environmental factors on population dynamics of tomato leafminer *Tuta absoluta*:**

In addition to the age of the plant (a biotic factor) at the investigated seasons, this study also examined the seasonal variation of the studied pests in connection to certain weekly averages of a biotic variables (maximum temperature, lowest temperature, and relative humidity (R.H.%)). The respective means of the chosen components were utilized as the independent variable, while weekly counts of the total number of eggs and larvae were employed as the dependent variable. Utilizing the regression coefficients and the simple correlation calculation, the influence of each item independently was determined. The C-multipliers algorithm was used to calculate the cumulative effects of every component, which were then represented as a proportion of explained variance (EV). Tables 1 and 2 provide statistical analysis for the impact of the three chosen abiotic variables and the age of the plant on the

population dynamics of *T. absoluta* (eggs and larvae) over both seasons (2021 and 2022).

**2.1. Eggs:**

According to data in table (1), the seasonal variations of *T. absoluta* eggs were significantly positively affected by the maximum temperature in both seasons, with "r" values of 0.549 and 0.593, respectively. The lowest temperature had a considerable negative effect in both seasons, with "r" values of -0.593 and -0.683, respectively. The findings demonstrated that the mean relative humidity % had substantial adverse impacts in both seasons, with "r" values of -0.624 and -0.680, respectively. Results, however, indicated that the plant's age had negligible negative impacts over both seasons, with "r" values of -0.260 and -0.399, respectively. The combined effect (E.V.) of these parameters revealed that they were all collectively responsible for 78% and 75% of the effects on the population dynamics of *T. absoluta* eggs over the two seasons (the "F" values were 6.36 and 5.28, respectively).

**Table (1).** Statistical analysis of correlation and partial regression values of three main weather factors and age of plant on *Tuta absoluta* eggs population density and corresponding percentage of explained variance on tomato summer plantation at the Central Laboratory for Agriculture Climate, Dokki, Giza Governorate during 2021 and 2022 seasons.

2021							
Tested factors	Correlation		Partial regression			E.V. %	F value
	r	P	b	S.E.	P		
Max. Temperature	0.549	0.04	-0.560	0.24	0.05	78%	6.36*
Min. Temperature	-0.593	0.05	-2.742	0.66	0.004		
Relative humidity (RH %)	-0.624	0.01	1.704	0.64	0.03		
Age of plant	-0.260	0.41	0.102	0.04	0.05		
2022							
Max. Temperature	0.593	0.04	-0.941	0.50	0.10	75%	5.28*
Min. Temperature	-0.683	0.01	-2.899	1.34	0.06		
Relative humidity (RH %)	-0.680	0.01	-0.205	1.29	0.07		
Age of plant	-0.399	0.19	0.193	0.09	0.07		

r=correlation coefficient, p=probability, b=partial regression, S.E.=standard error, E.V= explained variance.

## 2.2. Larval mines:

The data in table (2) show that maximum temperature had a significant negative effects on *T. absoluta* seasonal fluctuations throughout two growing seasons in 2021 and 2022, with "r" values of -0.564 and -0.658, respectively. Additionally, with "r" values of 0.354, 0.364, 0.458, and 0.356, respectively, the results showed insignificant positive effects of the lowest

temperature and mean percentage of relative humidity for the two seasons. In contrast, the plant's age had a significant positive effect, with "r" values of 0.512 and 0.684, respectively. The previously mentioned parameters' combined affects (E.V.) on *T. absoluta* mining showed that these elements were jointly in charge of 71% and 63% of the effects on *T. absoluta* population dynamics, throughout the two seasons ("F" values were 4.37 and 3.37, respectively).

**Table (2).** Statistical analysis of correlation and partial regression values of three main weather factors and age of plant on *Tuta absoluta* larval mines population density and corresponding percentage of explained variance on tomato summer plantation at the Central Laboratory for Agriculture Climate, Dokki, Giza Governorate during 2021 and 2022 seasons.

2021 season of summer plantation							
Tested factors	Correlation		Partial regression			E.V. %	F value
	r	P	b	S.E.	P		
Max. Temperature	-0.564	0.04	-0.552	1.15	0.64	71%	4.37*
Min. Temperature	0.354	0.25	-3.706	3.06	0.26		
Relative humidity(RH%)	0.364	0.24	1.020	2.96	0.74		
Age of plant	0.684	0.01	0.790	0.21	0.007		
2022 season of summer plantation							
Max. Temperature	-0.658	0.03	-0.0009	1.13	0.99	63%	3.37*
Min. Temperature	0.458	0.13	2.82	3.01	0.38		
Relative humidity(RH%)	0.356	0.25	-4.28	2.91	0.18		
Age of plant	0.512	0.05	0.17	0.20	0.41		

r=correlation coefficient, p=probability, b=partial regression, S.E.=standard error, E.V= explained variance.

#### 4. Discussion

Firstly, because various locations have varied climatic variables that influence insect population dynamics, there is no direct comparison between the current results and those obtained from research dealing with other geographies [15]. The findings were consistent with [16], who found that the maximum levels of tomato borer infection were detected in the spring. Furthermore, agreement with the results of [17] indicates that the *T. absoluta* population began to appear in the third and first weeks of March, then decreased and approximately declined in the fourth week of April. There are three stages to the biological invasion of an exotic pest species in a new geographic area: arrival, establishment, and dispersion [18]. The establishment may result from ecological or evolutionary phenomena, such as changes in the environment that enable a new fit between the introduced individuals and their environment or changes in the biological makeup of the pest that improve the compatibility of the introduced species with the exotic environment [19, 20]. Our results supported the findings of [21], which showed that the correlations between climatic factors (daily range, daily mean temperature, and daily relative humidity) and insect population activity were positive but insignificant, with the exception of the daily mean temperature, which was significant and positive. *Tuta absoluta* infestations on H6 and H7 hybrids peaked at a maximum of 50 and 28 larvae per 10 leaves, respectively, according to [22], who stated that the infection started while the plant was one month old. After then, the infestation gradually decreased until the end of the season. The relative effectiveness of the plant age factor was estimated to be 25% out of nearly 90%. In May, warm weather and moderate temperatures were observed to increase *T. absoluta* population, but higher temperatures caused it to fall [23]. Additionally, our results supported those of [24], who found that there were 1-2 peaks every season and that during the summer months, temperature and relative humidity showed a significant correlation with larval numbers.

#### 5. Conclusion:

*Tuta absoluta* population density was greater in the first season (2021) than in the second season (2022). It recorded 3-4 maxima for both (egg and larval mines), with the biggest peaks occurring in the fourth week of May and lasting until the end of May for both seasons. Correlation analyses between the *T. absoluta* population and environmental parameters revealed substantial negative correlations between *T. absoluta* eggs and environmental factors (minimum and maximum temperatures, relative humidity, and plant age, a biotic component) during the two seasons. While exhibiting negligible positive connections between the three main meteorological parameters and the age of the plant of *T. absoluta* mines over both seasons. The combination of

environmental conditions and plant age affects the population dynamics of *T. absoluta* (egg and larval mines) by 78%-75% and 71%-63%, respectively, throughout two growing seasons in 2021 and 2022.

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