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Performance of some Egyptian tomato cultivars to the tomato leaf miner *Tuta absoluta* (Lepidoptera: Gelechiidae) infestation and its distribution patterns

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Abstract

The current study examined the response of certain tomato cultivars to infestation by *Tuta absoluta* (Meyrick) (Lepidoptera: Gelechiidae) and its spatial distribution patterns in the Mansoura region, Dakhlia Governorate, Egypt, over the course of two consecutive seasons (2022/2023 and 2023/2024). The results demonstrated that *T. absoluta* larvae were present on all tomato varieties throughout the season. The vulnerability of these cultivars to *T. absoluta* larvae varied greatly. The tomato cultivar Hybrid T_4 84 had the greatest number of larvae and was classified as highly susceptible (H.S.) to *T. absoluta* larval infestation. The cultivars Maram and Rawan were found to be relatively resistant (RR), while Fiona and Hybrid T_4 70 cultivars seemed to be susceptible (S). However, during both seasons, the Beto 86 cultivar was evaluated as relatively resistant to pests and exhibited the lowest estimates of *T. absoluta* larvae. This tomato variety should be promoted in areas where T. absoluta larvae infestation is high. Using distribution indices, all evaluated tomato cultivars showed a significant clustering behavior throughout each season. Also, the cluster analysis method and the *T. absoluta* larvae estimates were examined using correlation analysis to differentiate the six tomato cultivars. Following principal component analysis, two-dimensional analysis was conducted on six tomato cultivars to confirm their association. This data can help farmers develop an integrated approach to controlling pests caused by *T. absoluta* on tomato plants.

Introduction

Tomatoes (*Lycopersicon* spp.) are a globally popular and economically significant vegetable, widely grown and consumed worldwide (Govindappa *et al*., 2013). They are a staple ingredient in various cuisines and essential to global diets. Tomatoes are rich in vitamin C, elements, and antioxidant lycopene, providing health benefits and contributing significantly to the global food supply (Sharma and Kumar, 2020). Numerous insect pests harm tomato plants in the field (Shehata *et al*., 2024) Among them, *Tuta absoluta* (Meyrick), the scientific name known for the tomato leaf miner, is one of the most harmful insect pests of tomatoes worldwide (Abdel-Baky *et al*., 2019). According to Celini and Vaillant

(2004), this pest is global and polyphagous. These infestations by pests result in financial losses in crop quality and output (Blackman and Eastop, 2000).

Tuta absoluta (Meyrick) (Lepidoptera: Gelechiidae) larvae are especially harmful because they consume the mesophyll found in tomato plant leaves, stems, and even fruits. Tomato leaf miner larvae consist of four instars. They produce distinctive mines in the form of blotches in the leaves, which can cause severe defoliation and necrosis. Plant development may be impacted by the large galleries that larvae can form in stems and fruits (Ahmed *et al*., 2024). The amount and quality of the crop may be harmed because the insect's larvae attack tomato fruits, which can result in secondary bacterial and fungal diseases that cause rot (Hogea, 2020).

In recent years, the tomato leaf miner has devastated agricultural production, destroying crops in countries around the world and raising prices beyond the reach of the average consumer (Sabbour and Solieman, 2016). *T. absoluta* poses a major threat to tomato crops and must be controlled immediately. If outbreaks are not adequately controlled, yield losses may reach 100% (Yankova, 2012).

In general, the spatial distribution of insect populations is one of their primary distinguishing characteristics (Cho *et al*., 2001, and Bakry and Arbab, 2020). It is a common characteristic of both insect populations and organisms (Debouzie and Thioulouse, 1986). Until the fundamental spatial distribution is completely recognized, observation in the field cannot be adequate (Taylor, 1984). Field research and the ecology of insect populations can benefit from the analysis of monitoring, whether it is aggregated, regular, or random (Binns *et al*., 2000).

The distribution pattern of a population is determined by how it interacts with its environment (Bakry, 2020 and Bakry *et al*., 2024). Knowing this tendency in the environment can help us describe and identify the population being studied more precisely and with more information (Arbabtafti *et al*., 2021). The spatial distribution pattern can be used for modeling, selecting the most effective sampling approach, and developing sampling strategies (Bakry *et al*., 2023, and Rajabpour and Yarahmadi, 2024). The type of pest and the control strategies used determine which sampling technique is used in pest management (Surendra, 2019). Adopting a suitable sampling technique is a crucial part of pest management programs since it provides information on crop and insect conditions to help with decision-making (Adam *et al*., 2010).

Depending on their physical characteristics or the chemical content of their leaves, tomato plants react differently to insect infestations. While morphological parameters primarily affect the pest's mechanisms of feeding, activity, and ingestion, biochemical factors have a significant impact on the pest's behavior and metabolic processes (McAuslane, 1996). The attraction of *T. absoluta* larvae to feeding is influenced by a variety of conditions. One of the internal elements that determines a plant's resistance or susceptibility may be genetic, or it may be phenotypic, resulting from variations in environmental variables such as the soil's nutritional content (Dale, 1988).

In order to minimize insect pest damage through plant tolerance to insect infestation, insect-resistant varieties are recommended for integrated pest management. One simple and effective strategy to reduce the harm caused by insect infestations is to plant cultivars that are resistant to pests (Horgan *et al*., 2020, and Bakry and Abdel-Baky, 2020).

Tomato varieties differ in their susceptibility to the tomato leaf miner infestation due to genetic diversity. To choose the best tomato cultivar for controlling *T. absoluta*, integrated pest control methods may include resistant cultivars. Consequently, this study's goal was to investigate the response of some tomato cultivars to *T. absoluta* infestation and their spatial distribution patterns to determine the most effective tomato cultivar for controlling this pest.

Materials and methods

1. Population abundance of *Tuta absoluta* on certain tomato cultivars:

Field experiments of tomato cultivars were conducted in the Mansoura district of the Dakhlia Governorate in Egypt over two consecutive seasons (2022/2023 and 2023/2024). There are six tomato commercial cultivars: hybrid T_4 70, Fiona, Maram, Beto 86, Rawan, and hybrid T_4 84. Each tomato cultivar had four replicates (the area of each cultivar was about 175 m^2), which were sown all cultivars in the first week of September in each season, using a randomized completely block arrangement. During the whole study period, all agricultural methods were used, with the exception of pest control.

After 30 days from the date of planting, samples of all different tomato plant varieties were collected randomly weekly until the crop harvest date in each season. Ten plants per replicate (40 plants per cultivar) made up the sample, which was packed separately in a plastic bag and inspected in a laboratory early in the morning.

The total number of larvae in all plant parts was counted and recorded, and a total of 3840 plants were sampled per season, i.e., 10 plants × 4 replicates × 6 varieties × 16 examination dates.

2. Susceptibility degrees:

The tested tomato varieties were classified according to their susceptibility levels into highly susceptible (HS), susceptible (S), relatively resistant (RR), moderately resistant (MR), and resistant (R), according to Semeada (1985) and Nosser (1996), as shown in Table (1).

Statistical analysis: The collected data were subjected to analysis of variance using the general linear model procedures of SPSS software (1999) and means comparison using Tukey's HSD test at a 5% significance level.

Table (1): Categorization of susceptibility of six-tomato cultivars to *Tuta absoluta* infestation.

Description	Category
> than (MN + UC)	Highly susceptible (HS)
From MN to (MN+UC).	Susceptible (S)
< than MN to (MN-UC).	Relative resistant (RR)
From < (MN-UC) to (MN-2UC).	Moderate resistant (MR)
< than (MN- 2UC).	Resistant (R)

Explanations: MN= General mean number of larvae; range of change= (Maximum number of larvae per cultivars- minimum number of larvae per cultivars) and UC= amount of change in cultivars.

3. Spatial distribution of *Tuta absoluta* infestation:

The mean larval density (m), variance (S^2), standard deviation (S), standard error (SE), median (Me), and coefficient of variation (C.V.) were determined in each sample. The most suitable movement pattern throughout the farm can be determined by using the relative variation (RV) (Hillhouse and Pitre, 1974).

$$R.V. = (SE / \bar{X}) \times 100$$

The spatial distribution estimates were estimated applying the formula shown in Table (2).

Table (2): Spatial distribution metrics and different distribution types.

Method	Formula	Distribution type	Reference
Variance to mean ratio	$S^2/\overline{X}$	= 1 random distribution, < 1 regular distribution, > 1 aggregated distribution	Patil and Stiteler (1974).
Index of Lewis (I_L):	$I_L=\sqrt{S^2/\overline{X}}$	= zero, random distribution, < zero, regular distribution, > zero, aggregated distribution	Cassie (1962)
Negative binomial distribution (K value	$K=\overline{x}/\left(S^2/\overline{x}-1\right)$	= zero, random distribution, < zero, regular distribution, > zero, aggregated distribution	Waters (1959)
I_D	$I_D=(n-1)S^2/\overline{X}$	I_D is approximately distributed as x^2 with n-1 degrees of freedom.	Patil and Stiteler (1974)
Z value	$Z=\sqrt{2I_D}-\sqrt{(2\nu-1)}$	1.96 ≥ Z ≥ -1.96, random distribution Z < -1.96, uniform Z > 1.96, aggregated	Patil and Stiteler (1974)
Index of mean clumping (I_{DM})	$(I_{DM})=(S^2/\overline{X})-1$	= zero, random distribution, < zero, regular distribution, > zero, aggregated distribution	David and Moore (1954)
Lloyd's mean crowding (X*)	$\overset{*}{X}=\overline{X}+[(S^2/\overline{X})-1]$	= 1 random distribution, < 1 regular distribution, > 1 aggregated distribution	Lloyd (1967)
Index of patchiness (I_P)	$\boldsymbol{I_P=X^*/m}$	= 1 random distribution, < 1 regular distribution, > 1 aggregated distribution	Lloyd (1967)
Green's index (GI)	$GI=[(S^2/\overline{X})-1]/(n-1)$	= zero, random distribution, < zero, regular distribution, > zero, aggregated distribution	Green (1966)
aggregation index (1/k)	$1/k=(\overset{*}{X}/\overline{X})-1$	= zero, random distribution, < zero, regular distribution, > zero, aggregated distribution	Southwood and Henderson (2000)

4. Principal component and cluster analysis:

Principal Component Analysis (PCA) was used to illustrate the multidimensionality of *T. absoluta* larval estimates on six tomato cultivars in a scatterplot applying R software (R Core Team, 2022). Based on the similarity matrix, a plot was made exhibiting the relationships between *T. absoluta* larval estimates on six tomato cultivars using hierarchical clustering analysis (HCA) of the unweighted pairwise group method with arithmetic mean (UPGMA) based on the Euclidean distance between clusters using the PAST program (Hammer *et al*., 2001).

Results and discussion

1. Population abundance of *Tuta absoluta* larvae on six tomato cultivars:

The data presented in Table (3) and illustrated in Figure (1) showed that the *T. absoluta* larvae population occurred on all different tomato varieties throughout the season.

Table (3): Average numbers of *Tuta absoluta* larvae per 10 plants and sensitivity degrees of certain tomato cultivars over the two growing seasons (2022/2023 and 2023/2024).

Tomato cultivars	Average no. of *Tuta absoluta* of insect per 10 plants ± S.E			
	First season (2022/2023)		Second season (2023/2024)	
	Mean ± SE	Sensitivity degree	Mean ± SE	Sensitivity degree
Hybrid T4 84	22.81 ± 1.63 A	HS	23.19 ± 1.56 A	HS
Fiona	17.61 ± 1.15 AB	S	17.25 ± 1.27 AB	S
Maram	13.23 ± 0.97 BC	RR	13.27 ± 1.16 BC	RR
Beto 86	9.02 ± 0.73 C	MR	8.77 ± 0.91 C	MR
Rawan	15.67 ± 1.06 B	RR	15.69 ± 1.23 BC	RR
Hybrid T4 70	19.31 ± 1.40 AB	S	17.89 ± 1.13 AB	S
Grand mean	16.28 ± 1.10 A		16.01 ± 1.15 B	
Coefficient of Variation (%)	23.18		27.23	

Means followed by the same letter (s), in each column, are not significantly different at 0.05 level probability, by Tukey's HSD test. The F value = 104.32, df= 285; P ≤ 0.0000 between the cultivars in the first season; the F value = 78.64, df= 285; P ≤ 0.0000 between the cultivars in the second season, and the F value = 47.01, df= 93; P ≤ 0.0000 between the two seasons.

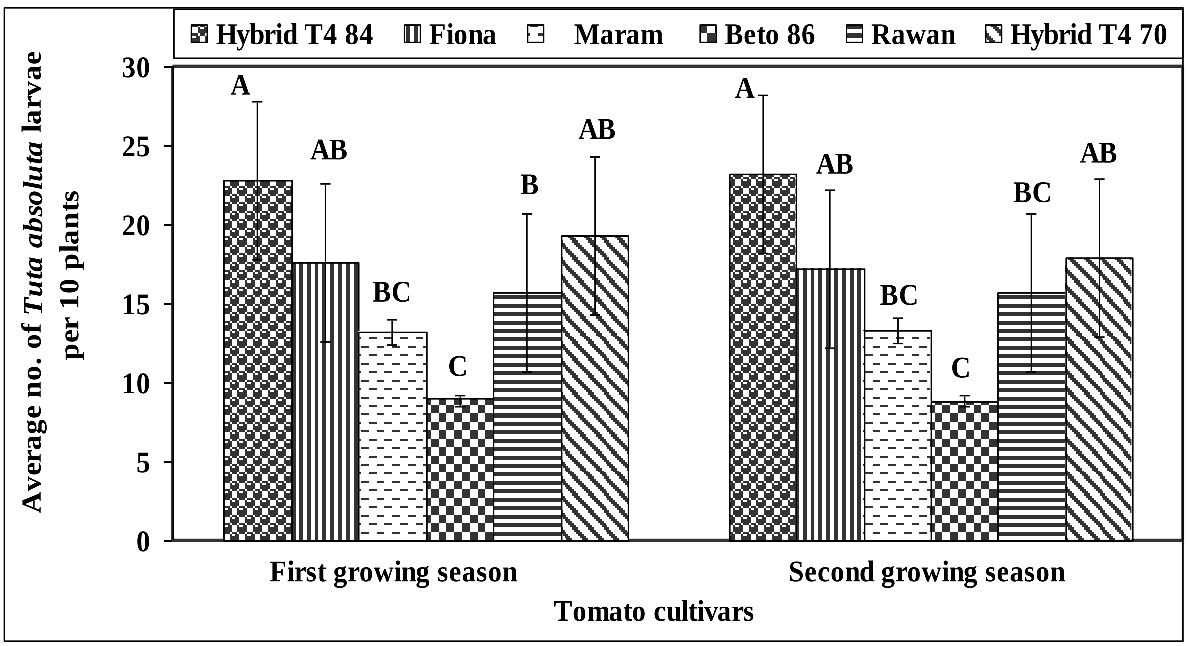

Figure (1): Average numbers of *Tuta absoluta* larvae per 10 plants on certain tomato cultivars during two successive growing seasons (2022/2023 and 2023/2024). Values indicated by different letters for the numbers of *Tuta absoluta* larvae between six tomato cultivars are statistically significant differences at P ≤ 0.05 (Tukey's HSD test).

The results obtained showed that the average *T. absoluta* larvae estimates throughout the entire season were 16.28 ± 1.10 and 16.01 ± 1.15 larvae per 10 plants during the two growing seasons, respectively. Statistical analysis of the data indicated that there were highly significant differences between tomato cultivars with respect to the numbers of *T. absoluta* larvae during both seasons. The F value = 104.32, df = 285; P ≤ 0.0000 in the first season; the F value = 78.64, df = 285; P ≤ 0.0000 in the second season; and the F value = 47.01, df = 93; P ≤ 0.0000 between the two seasons (Figure 1). Compared to the other tomato varieties tested, the hybrid T_4 84 had the highest number of *T. absoluta* larvae during the two growing seasons (an average of 22.81 ± 1.63

and 23.19 ± 1.56 larvae per 10 plants, respectively). This variety was categorized as highly susceptible (HS). However, the Beto 86 tomato variety was categorized as moderately resistant (MR) and had the lowest overall average number of *T. absoluta* larvae during the first and second seasons, respectively (9.02 ± 0.73 and 8.77 ± 0.91). This tomato variety should be promoted in areas where *T. absoluta* larvae infestation is high.

Statistical analysis of the data indicated that there were highly significant differences between tomato cultivars with respect to the numbers of *T. absoluta* larvae during both seasons. The F value = 104.32, df = 285; $P \leq 0.0000$ in the first season; the F value = 78.64, df = 285; $P \leq 0.0000$ in the second season; and the F value = 47.01, df = 93; $P \leq 0.0000$ between the two seasons (Figure 1). Compared to the other tomato varieties tested, the hybrid T_4 84 had the highest number of T. absoluta larvae during the two growing seasons (an average of 22.81 ± 1.63 and 23.19 ± 1.56 larvae per 10 plants, respectively). This variety was categorized as highly susceptible (HS). However, the Beto 86 tomato variety was categorized as moderately resistant (MR) and had the lowest overall average number of *T. absoluta* larvae during the first and second seasons, respectively (9.02 ± 0.73 and 8.77 ± 0.91). This tomato variety should be promoted in areas where *T. absoluta* larvae infestation is high. While the tomato cultivars Fiona and hybrid T_4 70 showed degrees of infestation as susceptible (S), with an overall average of (17.61 ± 1.15 and 19.31 ± 1.40) during the first season and (17.25 ± 1.27 and 17.89 ± 1.13) during the second growing season, respectively, Table (3). However, the two cultivars, Maram and Rawan, showed some resistance and appeared relatively resistant (RR) with an overall mean of (13.23 ± 0.97 and 15.67 ± 1.06) during the first season and (13.27 ± 1.16 and 15.69 ± 1.23) during the second season, respectively.

Dent (1991) explained that the abundance of insect counts in any location is affected by environmental factors and the ability of the host/species to infect. In general, it could be concluded that the hybrid T_4 84 tomato cultivar had the most preference for the tomato leaf miner, *T. absoluta* larvae, while the Beto 86 cultivar was a less preferable cultivar for this pest. The tested varieties could be arranged according to their susceptibility in a descending order as follows:

Hybrid T_4 84 > Hybrid T_4 70 > Fiona > Rawan > Maram > Beto 86.

It is clear that variations in *T. absoluta* larval estimates on various tomato cultivars could result from a variety of factors, including the leaflet trichomes (glandular and non-glandular) of the tomato cultivars, in addition to variations in environmental conditions (temperature and relative humidity). We came to the conclusion that the host plant affects how pests develop and that choosing a more resilient cultivar can lessen pest infestation, making it an extra element to be incorporated in tomato plant IPM. Sohrabi *et al*. (2016) revealed differences in aphid populations among tomato cultivars based on field conditions, including the number of mines per leaf, holes on the stem, and fruit. According to Azadi *et al*. (2018), cultivars with a high density of leaf trichomes exhibited greater resistance to the insect. The researchers came to the conclusion that resistance to *T. absoluta* larvae may be caused by the amount of trichomes on the leaves. Darbain *et al*. (2019) mentioned that the length of normal trichomes showed a strong negative correlation with *T. absoluta* infestation, whereas glandular trichome density and length showed a highly significant adverse correlation.

According to Navarro *et al*. (2005), *T. absoluta* females' rates of egg laying varied depending on the tomato cultivar (antixenosis). Nevertheless, none of the examined cultivars exhibited resistance to antibiotics. *T. absoluta* larvae fed on tomato cultivars with varying resistance levels performed differently, as Shahbaz *et al.* (2017) showed that larvae raised on susceptible cultivars achieved the largest body weight, whereas those fed on resistant cultivars achieved the lowest ultimate weight. Additionally, the physiology of *T. absoluta* is greatly impacted by host plant resistance. Also, the larvae raised on the susceptible cultivar exhibited the lowest enzymatic activity for fourth instar larvae, while larvae feeding on resistant cultivars exhibited the highest levels of amylolytic and proteolytic activity. The trichome structure of tomato leaves may have had a detrimental effect on *T. absoluta's* ability for oviposition, according to Aslan and Birgücü (2022).

2. Sampling program:

The values obtained in Tables (2 and 3) showed that the R.V. (%) of the initial sample data of *T. absoluta* larvae indicates that the population densities of the pest ranged from 6.55 to 8.11% in 2022/2023, and from 6.32 to 10.35% in 2023/2024 were recorded in the different tomato varieties studied. As shown by the relative variance variability of the initial sample data for *T. absoluta* larvae, the average population density was 6.76 and 7.20% during the two growing seasons, respectively (Tables 2 and 3). These values were very suitable for the sampling program.

3. Spatial distribution:

Data as shown in Tables 4 and 5 demonstrated that for every tomato variety studied, spatial distribution among the sample units was established using various distribution indices. In all tested tomato cultivars, the variance-to-mean ratio was greater than one because the distribution results using the variance of *T. absoluta* larvae population on various tomato cultivars were greater than the overall average of the population densities by *T. absoluta* larvae. All tomato cultivars and the full growing season were thus represented in the aggregated spatial distribution of *T. absoluta* larvae individuals. Compared to the index of infectious dispersion, the pest's Lewis index was noticeably higher. Analogous deductions were drawn from the Cassie index values. *T. absoluta* larvae on all tomato cultivars tested showed an aggregated distribution, as the mean population of *T. absoluta* was greater than zero. In all tomato cultivars over the course of two seasons, the K values of the negative binomial distribution of the *T. absoluta* larvae population were more than 2, indicating e-aggregation (Tables 4 and 5).

For all tomato cultivars, the mean clumping (I_{DM}) index values of the pest were positive for the negative binomial. The Z-test results exceeded 1.96. Green's index was more than zero, and the patchiness index was greater than one (Tables 4 and 5). During the two growing seasons, all of these indices displayed an aggregated distribution for the *T. absoluta* larvae population across all tomato cultivars (Tables 4 and 5). 1/k (the aggregation index) was used to assess the temporal changes in the spatial distribution pattern of the *T. absoluta* larvae population over the course of each growing season. In all tomato cultivars evaluated, and during the growing season, the value was greater than zero, suggesting an aggregated pattern that spread out over time (Tables 4 and 5). It is evident that the spatial distribution and population density of *T. absoluta* larvae are influenced by tomato cultivars. Thus, employing a variety of distribution indicators, the spatial distribution of the *T. absoluta* larvae population showed an aggregated distribution over all tomato cultivars throughout the course of the two consecutive seasons (Tables 4 and 5). Based on the variance-to-mean ratio results for all tomato cultivars evaluated, our findings in this instance are in line with those of other researchers who found that the larvae of the tomato leaf miner, *T. absoluta*, showed an aggregated distribution pattern (e.g., Ghaderi *et al*., 2017 and 2018).

Table (4): Estimated parameters for spatial distribution of *Tuta absoluta* larvae per 10 plants on certain tomato cultivars during the first growing season (2022/2023).

Parameters	Hybrid T_4 84	Fiona	Maram	Beto 86	Rawan	Hybrid T4 70	Average of cultivars
Max.	52.00	38.00	35.00	27.00	36.00	48.00	34.67
Min.	3.00	2.00	2.00	1.00	2.00	3.00	2.67
Mean	22.81	17.61	13.23	9.02	15.67	19.31	16.28
Range of mean	49.00	36.00	33.00	26.00	34.00	45.00	32.00
Median	20.00	15.50	12.00	8.50	13.50	17.00	13.92
S^2	170.12	85.13	60.79	34.17	71.46	125.04	77.43
S	13.04	9.23	7.80	5.85	8.45	11.18	8.80
SE	1.63	1.15	0.97	0.73	1.06	1.40	1.10
CV	57.18	52.40	58.91	64.84	53.94	57.90	54.06
RV	7.15	6.55	7.36	8.11	6.74	7.24	6.76
S^2/m	7.46	4.83	4.59	3.79	4.56	6.47	4.76
Lewis Index	2.73	2.20	2.14	1.95	2.14	2.54	2.18
Cassie index	0.28	0.22	0.27	0.31	0.23	0.28	0.23
K	3.53	4.59	3.68	3.23	4.40	3.53	4.33
I_D	469.82	304.57	289.36	238.81	287.27	407.91	299.72
Z value	19.47	13.50	12.88	10.67	12.79	17.38	13.30
I_{dm}	6.46	3.83	3.59	2.79	3.56	5.47	3.76
X*	29.27	21.44	16.83	11.81	19.23	24.79	20.03
X*/m	1.28	1.22	1.27	1.31	1.23	1.28	1.23
GI	0.10	0.06	0.06	0.04	0.06	0.09	0.06
1/*k*	0.28	0.22	0.27	0.31	0.23	0.28	0.23

Table (5): Estimated parameters for spatial distribution of *Tuta absoluta* larvae per 10 plants on certain tomato cultivars over the second growing season (2023/2024).

Parameters	Hybrid T_4 84	Fiona	Maram	Beto 86	Rawan	Hybrid T4 70	Average of cultivars
Max.	52.00	48.00	46.00	40.00	48.00	40.00	45.00
Min.	3.00	2.00	1.00	0.00	1.00	3.00	2.00
Mean	23.19	17.25	13.27	8.77	15.69	17.89	16.01
Range of mean	49.00	46.00	45.00	40.00	47.00	37.00	43.00
Median	20.00	15.00	12.00	8.00	13.50	16.50	13.83
S^2	156.12	103.52	86.74	52.66	96.85	81.72	85.05
S	12.49	10.17	9.31	7.26	9.84	9.04	9.22
SE	1.56	1.27	1.16	0.91	1.23	1.13	1.15
CV	53.89	58.98	70.21	82.78	62.73	50.53	57.61
RV	6.74	7.37	8.78	10.35	7.84	6.32	7.20
S^2/m	6.73	6.00	6.54	6.01	6.17	4.57	5.31
Lewis Index	2.59	2.45	2.56	2.45	2.48	2.14	2.31
Cassie index	0.25	0.29	0.42	0.57	0.33	0.20	0.27
K	4.04	3.45	2.40	1.75	3.03	5.01	3.71
I_D	424.18	378.09	411.93	378.47	388.96	287.76	334.72
Z value	17.95	16.32	17.52	16.33	16.71	12.81	14.69
I_{dm}	5.73	5.00	5.54	5.01	5.17	3.57	4.31
X*	28.92	22.25	18.80	13.77	20.86	21.46	20.32
X*/m	1.25	1.29	1.42	1.57	1.33	1.20	1.27
GI	0.09	0.08	0.09	0.08	0.08	0.06	0.07
1/*k*	0.25	0.29	0.42	0.57	0.33	0.20	0.27

4. Principal Component Analysis (PCA) and Hierarchical Clustering Analysis (HCA):

Principal Component Analysis (PCA) is a mathematical method that transforms a number of possibly correlated variables into a new set of uncorrelated variables called principal components (Wang and Battiti, 2005). The principal component analysis (PCA) revealed that the six tomato cultivars were highly affected by the *T. absoluta* larval estimates (Figure 2). The first two components of the PCA accounted for 97.30% of the total variance, whereas PCA1 accounted for 90.79% and PCA2 accounted for 6.51%. It was observed that the first component was negatively correlated with the following cultivars (Hybrid T_4 84 and Hybrid T_4 70) and *T. absoluta* larvae abundance (Figure 2). Interestingly, the PCA2 was positively correlated with the following cultivars (Fiona, Maram, Beto 86, and Rawan) and *T. absoluta* larval abundance (Figure 2). The tomato cultivar clustering tree dendrogram was confirmed based on *T. absoluta* larval estimates into four groups as follows (Figure 3). Group 1: The hybrid T_4 84 cultivar was in a separate group. Group 2: Maram and Rawan cultivars seemed to form a very close grouping in the dendrogram. Group 3: Fiona and Hybrid T_4 70 cultivars appeared to form a clustered group in the dendrogram. Group 4: The Beto 86 cultivar was in a separate group.

The tomato leaf miner *T. absoluta* is a cosmopolitan and polyphagous pest. This study aims to determine the preference of certain tomato cultivars to infestation by *T. absoluta* and its spatial distribution. The data concluded that *T. absoluta* larvae were present on all tomato varieties throughout the season. The susceptibility of these cultivars to infestation varied greatly. The Beto 86 cultivar was evaluated as relatively resistant (MR) to pests and exhibited the lowest estimates of *T. absoluta* larvae. This tomato variety should be promoted in areas where *T. absoluta* larvae infestation is high. However, the tomato cultivar Hybrid T4 84 had the greatest number of larvae and was classified as highly susceptible (H.S.) to *T. absoluta* larval infestation. The cultivars Maram and Rawan were found to be relatively resistant (RR), while Fiona and Hybrid T4 70 cultivars seemed to be susceptible (S). By applying distribution indices, all evaluated tomato cultivars showed significant aggregated behavior throughout each season. Integrated pest management techniques against this pest can be created using this information.

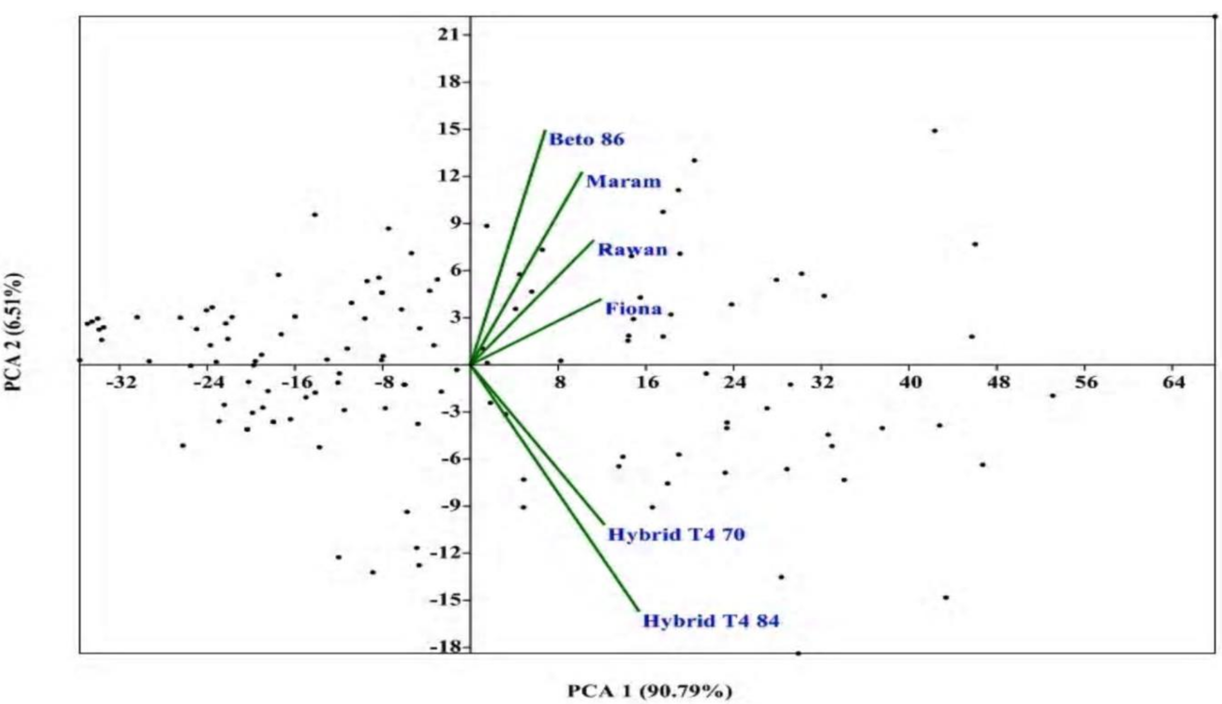

Figure (2): Biplot based on principal component analysis for *Tuta absoluta* larval estimates on six tomato cultivars.

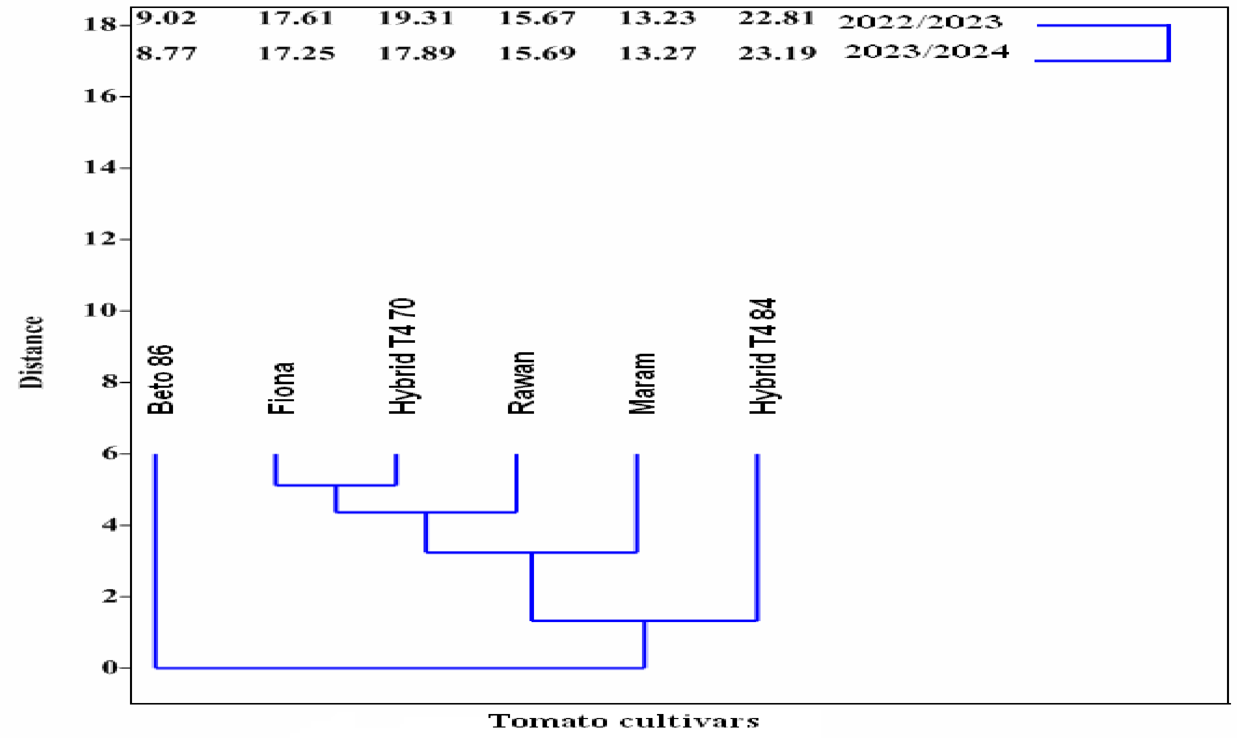

Figure (3): The classification of tested six tomato cultivars based on the two-season average *Tuta absoluta* larval estimates.

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