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Feeding Preference and Susceptibility of Seven Tomato Hybrids to the Tomato Borer, *Tuta absoluta* Larvae (Lepidoptera: Gelechiidae) under Field and Laboratory Conditions

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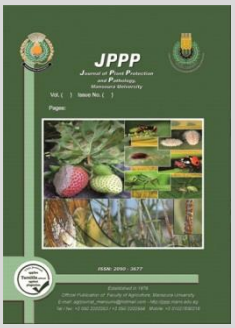

ABSTRACT

Susceptibility of seven tomato hybrids (both leaves and fruits) to infestation by the tomato borer *Tuta absoluta* larvae were examined under field conditions throughout 2018/2019 and 2019/2020 seasons. Further, the feeding preference of *T. absoluta* larvae to both leaves and fruits of the seven tomato hybrids were tested under laboratory conditions. The results showed that both leaves and fruits of tomato hybrids differed in their susceptibility or resistance degree to infestation by *T. absoluta* larvae. Tomato leaves of hybrids 65010, 83 and 039 were susceptible to larval infestation by *T. absoluta* in both seasons of the study, whereas tomato fruits of hybrids 65010, Super red and 039 were susceptible to larval infestation in both seasons. The feeding preference of *T. absoluta* larvae after 1 and 24 hours to both leaves and fruits of the seven tested tomato hybrids differed significantly either after 1 or 24 hours under laboratory conditions. After one hour, larvae exhibited the highest preference to leaves of hybrid 83, hybrid 102 and hybrid Lugen, whereas after 24 hours, hybrid 102 and hybrid 039 attracted the highest and lowest percentages of larvae. On fruits, the larvae of *T. absoluta* showed the highest preference after one hour to hybrid Super red and the lowest to hybrids 65010, 102, Lugen, 449 and 039. After 24 hours, the highest and the lowest percentages of attracted larvae to fruits were recorded on hybrid 039 and hybrid 65010, respectively.

Keywords: *Tuta absoluta*, preference, infestation, tomato hybrids

INTRODUCTION

Tomato, *Solanum lycopersicum* L. (Solanaceae), is one of the most widely cultivated and important vegetable crop in the world (Zhao et al., 2016). Tomatoes are produced locally by small- and medium-sized farmers for food and household use, as well as for business income (Ma, 2017). In Egypt, tomato is one of the main vegetable crops representing 46.2% of the total vegetable production value (Hassan and Ahmed, 2018). Annually, it produces about 9,204,097 tons of tomatoes from a cultivated area of 9,000 ha. Tomato crop is one of the most important vegetable crops in Egypt and is considered as the fifth largest tomato producer in the world (https://www. egypt. cropscience. bayer.com/en/Crops). One of the most important problems that facing the Egyptian tomato farmers is insect pests (Ahmed, 2016).

In Egypt, tomato is subjected to attack by a number of insect pests such as: *Bemisia tabaci* (Gennadius) (Hemiptera: Aleyrodidae); *Liriomyza trifolii* (Burgess) (Diptera: Agromyzidae); *Nesidicoris tenuis* Reuter (Hemiptera: Miridae); *Tuta absoluta* (Meyrick) (Lepidoptera: Gelechiidae); and *Heliocoverpa armigera* (Hübner) (Lepidoptera: Noctuidae) (Ridray, 2008; Szwejda and Rogowska, 2011; Radonjic and Hrncic, 2012; Mahmoud *et al.*, 2020 and Mukwa *et al*, 2021). All of these insects significantly affect the quality and quantity of the crop.

The tomato leafminer, *Tuta absoluta* (Meyrick) (Lepidoptera: Gelechiidae), has been an important pest of tomato in South America since the 1950s (Garcia and Espul, 1982; Desneux *et al*., 2010), and in Europe since 2006. Currently, this pest poses a serious threat not only to the Afro-Eurasian supercontinent, but also to global tomato production (Desneux *et al.*, 2010, 2011; Campos *et al.*, 2017; Biondi *et al.*, 2018; Mansour *et al.*, 2018). In early 2009, several reports confirmed the arrival of this pest to the Mediterranean basin viz, Algeria, Libya, Morocco, Tunisia, and Israel that causes several damages to tomato crop (EPPO, 2006; EPPO, 2009a, b, c, d; EPPO, 2008a, b; Seplyarsky *et al*., 2010; CABI, 2019), after which it spread steadily between 2010 and 2015 across 15 western countries (Campos *et al*., 2017; Han *et al.*, 2019). Except for the roots, the larvae attack all parts of the tomato plant viz, leaves, flowers, stems and both green and red fruits (Lo´pez, 1991; Apablaza, 1992; Barrientos, 1998; Guilardo´n, 2001). *Tuta absoluta* infestation may cause 50-100% reduction in the tomato crop (Potting, 2009).

Host – plant resistance within IPM strategies can represent a suitable method for pest control, as a way to reduce the dependence on chemical pesticides. Plant resistance can be expressed by antibiosis, antixenosis, tolerance, or combinations to these mechanisms (Smith, 2005). Tolerance as a particular mechanism for resistance in actively growing crops in the field is related to endurance to insect attack and repair capabilities once pests are established. Resistance is all those heritable traits of a plant, that lessen insect damage, while other plants of the same species and in the same environment receive greater

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damage. Resistance is therefore a relative phenomenon" (Owens, 1975; Smith, 2005).

So, the present study was conducted to investigate the feeding preference and susceptibility of tomato hybrids to infestation by *T. absoluta*.

MATERIALS AND METHODS

Field evaluation:

An area of about 2800 m^2, divided into 28 blocks (about 100 m^2/plot) was cultivated with seven tomato hybrids (65010, super red, 102, 449, 83, 039 and Lugen). Seedlings were transplanted in the field on 1st September in 2018/2019 and 2019/2020 seasons as winter plantation. Each hybrid was cultivated in four replicates and evaluated in complete randomized design. All normal and recommended agricultural practices were followed, however, no pesticide treatments during the whole period of the experiment was applied. To determine number of *T. absoluta* larvae that infesting tomato leaves, 20 leaves were taken randomly from the three plant height, i.e., lower, middle and top of tomato, then kept in polyethylene bags and transferred to the laboratory for examination. Sampling started after 15 days of transplanting date and continued until harvest at weekly intervals (from 15th September to 23rd February). In addition, to determine numbers of larvae that infesting fruits, a sample of 10 fruits were randomly taken from each plot, kept in polyethylene bags and transferred to laboratory for examination. The sampling started from 17th November to end of two seasons (23rd February). The mean numbers of insect pests were used to determine the relative susceptibility degree of the tested hybrids as described by Chiang and Talekar (1980) equation as follows: Relative susceptibility degree was dependent on the general mean number of the pest ($\overline{X}$) and the standard deviation (SD). Hybrids that had mean numbers > $\overline{X}$ +2SD were considered highly susceptible (HS); between $\overline{X}$ and $\overline{X}$ +2SD were susceptible (S); between $\overline{X}$ and $\overline{X}$ -1SD were low resistant (LR), between $\overline{X}$ -1SD and $\overline{X}$ -2SD were moderately resistant (MR) and < $\overline{X}$ -2SD were considered highly resistant (HR).

Laboratory evaluation:

All laboratory experiments were conducted under room condition of 25 ◦C, and varied RH% from 44% to 60% at laboratory of Plant protection, Shandweel Agricultural Research Station, Sohag Governorate. The host preference of *Tuta absoluta* larvae to leaves and fruits of seven tomato hybrids were examined. At that time, the infested tomato leaves were collected from tomato field at Farm of Shandaweel Agriculture Research Station, then the larvae of *T. absoluta* were isolated in laboratory. This test was conducted in plastic cups (25 cm diameter with 10 cm in height). One leaflet with the same size was chosen from each hybrid and arranged inside the plastic cup. After that 20 larvae, starved for two hours, were released in the center of each cup for two hours. Ten replicates were used. The number of larvae attracted to each leaflet was recorded after 1 and 24 hours. One tomato fruits, plastic cups (50 cm diameter with 10 cm in height) were used. One fruit in the same size was chosen from each hybrid and arranged inside the plastic cup. After that 20 larvae, starved for two hours, were released in the center of each cup. Ten replicates were used. The number of larvae attracted to each fruit was recorded after 1 and 24 hours.

The host preference of larvae to each hybrid (leaves or fruits) was calculated according to the following formula:

Host preference % = (Y/X) × 100

Where X is total number of tested larvae and Y is the number of larvae attracted to the tested hybrid.

Data analysis:

Data were analyzed by one – way ANOVA. Means were compared using the Duncan's Multiple Range Test (Snedecor, 1967).

RESULTS AND DISCUSSION

Data in Table (1) present the susceptibility of seven tomato hybrids leaves to infestation by *T. absoluta* during 2018/2019 and 2019/2020 seasons. It is clear that differences between the tested hybrids were significant during the two seasons. The lowest infestation was recorded on hybrid Super red with 0.92 and 0.97 larvae/ 10 leaves during the first and second seasons, respectively. However, the highest infestation was recorded on Hybrid 65010 with 1.85 and 2.09 larvae/ 10 leaves during the two seasons, respectively. Super red hybrid showed a moderately resistant (MR) in both seasons, while Hybrids 102 and Lugen showed low resistant (LR) in both seasons. Hybrids 65010, 83 and 039 were susceptible (S) to infestation by *T. absoluta* in both seasons of the study. However, Hybrid 449 varied in its resistance degree according to season. It was susceptible (S) in the first season and exhibited low resistance (LR) in the second season.

Table 1. Susceptibility of seven tomato hybrids leaves to infestation by *Tuta absoluta* during 2018\2019 and 2019\2020 seasons at Sohag governorate.

Tomato hybrid	Mean No./ 10 leaves		Relative susceptibility degree	
	2018/ 2019 season	2019/2020 season	2018/ 2019 season	2019/2020 season
Hybrid65010	1.85 a	2.09 a	S	S
Super red	0.92 d	0.97 c	MR	MR
Hybrid 83	1.59 bc	1.75 ab	S	S
Hybrid 102	1.24 cd	1.45 b	LR	LR
Logen	1.28 c	1.46 b	LR	LR
Hybrid 449	1.44 bc	1.49 b	S	LR
Hybrid 039	1.76 ab	2.02 a	S	S
F. value	7.85*	6.29*	-----	-----
Mean ± SD	1.44 ± 0.33	1.60 ± 0.39	-----	-----

(*): The F value is significant at P ≤ 0.05.

S=Susceptible LR= Low Resistant MR= Moderately Resistant

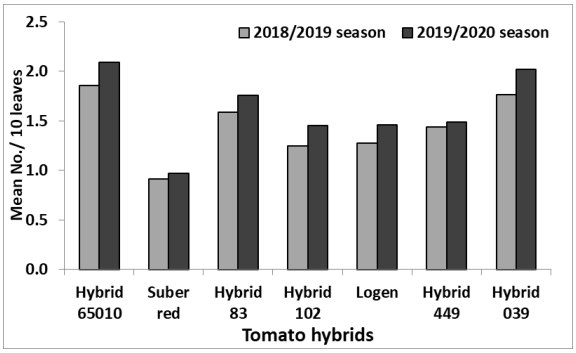

Figure 1. Susceptibility of seven tomato hybrids leaves to infestation by *Tuta absoluta* larvae at Sohag Governorate during 2018 / 2019 and 2019 / 2020 seasons.

Data in Table (2) showed that the susceptibility of seven tomato hybrids fruits to infestation by *T. absoluta* during two successive seasons 2018/2019 and 2019/2020. it is clear that differences between the tested hybrids were significant during the two seasons. In the first season, the lowest infestation was recorded on hybrid Lugen with 0.54 larvae/ 10 fruits followed by hybrid Super red, Hybrid 83, Hybrid 102, Hybrid 449 and Hybrid 039. However, the highest infestation was recorded on Hybrid 65010 with 1.14 larvae/ 10 fruits followed by Hybrid 102 and Hybrid 039. In the second season, the lowest infestation was recorded on Hybrid 449 with 0.58 larvae/ 10 fruits followed by Super red, Hybrid 83, Hybrid 102, Hybrid 449 and hybrid Lugen. Whereas, the highest infestation was recorded on Hybrid 65010 with 1.24 larvae/ 10 fruits followed by Hybrid 039. Hybrid 83 and hybrid lugen showed low resistance (LR) in both seasons, while hybrids 65010, hybrid Super red and Hybrid 039 were susceptible (S) in both seasons of the study. Hybrids 102 and 449 varied in their resistance degree from season to season. Hybird 102 was susceptible (S) in the first season and showed low resistant (LR) in the second season. Hybrid 449 exhibited low resistant (LR) in the first season and moderately resistant (MR) in the second season.

Similar results were obtained by Galaraz (1984), Oliveira *et al.* (2009) and Abou-Ghadir *et al.* (2015)

Table 2. Susceptibility of seven tomato hybrids fruits to infestation by *Tuta absoluta* at Sohag Governorate during 2018 / 2019 and 2019 / 2020 seasons.

Tomato hybrid	Mean No./ 10 fruits		Relative susceptibility degree	
	2018/ 2019 season	2019/2020 season	2018/ 2019 season	2019/2020 season
Hybrid65010	1.14 a	1.24 a	S	S
Super red	0.79 b	0.85 bc	S	S
Hybrid 83	0.60 b	0.74 c	LR	LR
Hybrid 102	0.83 ab	0.72 c	S	LR
Logen	0.54 b	0.76 c	LR	LR
Hybrid 449	0.55 b	0.58 c	LR	MR
Hybrid 039	0.87 ab	1.06 ab	S	S
F. value	4.54*	5.37*	-----	-----
Mean ± SD	0.76 ± 0.22	0.85 ± 0.23	-----	-----

(*): The F value is significant at P ≤ 0.05.
S=Susceptible LR= Low Resistant MR= Moderately Resistant

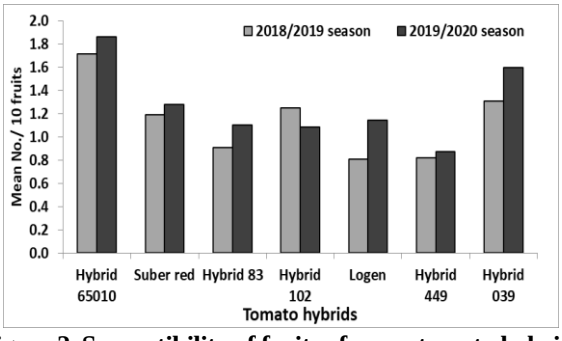

Figure 2. Susceptibility of fruits of seven tomato hybrids to infestation by *Tuta absoluta* larvae during 2018\2019 and 2019/2020 seasons at Sohag Governorate.

Data in Table (3) show the feeding preference of *T. absoluta* larvae on leaves of the seven tested tomato hybrids. Results indicated that the differences between hybrids were significantly after 1 and 24 hours. After one hour, the seven hybrids arranged into three groups that differed significantly. The first group, with highest preference, included hybrid 83, Hybrid 102 and hybrid Lugen with preference of 20.10%, 22.19% and 18.73%, respectively. The second group, with moderate preference, consisted of Hybrid 65010, Hybrid 449 and Hybrid 039 with preference of 10.51%, 13.92% and 11.02%, respectively. The third group, with lowest preference, involved hybrid Super red with 3.53% preference. No significant differences were obtained between the second group and the other two groups. After 24 hours, Hybrid 102 attracted the highest percentage of larvae (27.56%) followed by Hybrid 83 (23.36%). Hybrid Super red attracted the lowest number of larvae with percentage of 9.03% followed by hybrid 65010, hybrid 039, hybrid Lugen and hybrid 449 with 12.01%, 4.05%, 14.61% and 9.38%, respectively (Fig. 3).

Table 3. Feeding preference of *Tuta absoluta* larvae after 1 and 24 hours to leaves of seven tomato hybrids.

Tomato hybrid	Mean number of larvae after		% of larvae after	
	1 hour	24 hours	1 hour	24 hours
Hybrid 65010	1.3	1.00	10.51 ab	12.01 bc
Hybrid Super red	0.50	0.50	3.53 b	4.05 c
Hybrid 83	2.40	2.30	20.10 a	23.36 ab
Hybrid 102	2.80	2.90	22.19 a	27.56 a
Hybrid Lugen	2.10	1.70	18.73 a	14.61 bc
Hybrid 449	1.60	1.10	13.92 ab	9.38 c
Hybrid 039	1.40	0.90	11.02 ab	9.03 c
F. value			2.74*	4.66**
Response	12.10	10.40	60.50	52.00
Non-response	7.90	9.60	39.50	48.00

(*): The F value is significant at P ≤ 0.05.

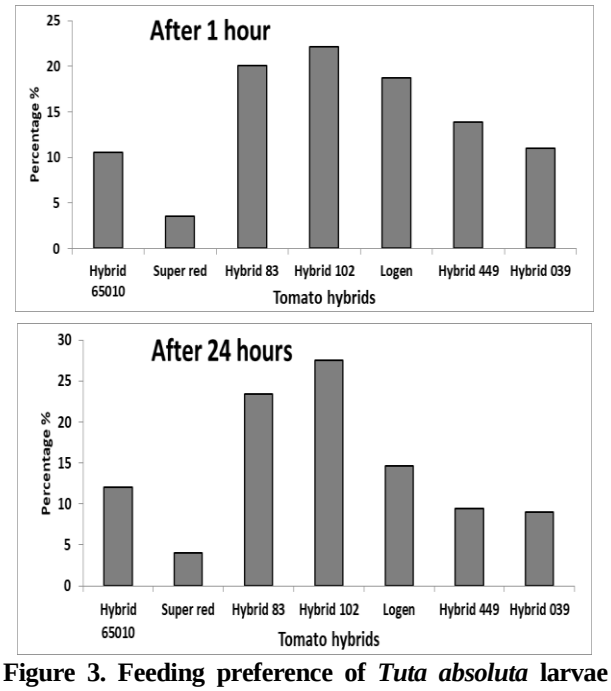

Figure 3. Feeding preference of *Tuta absoluta* larvae after 1 and 24 hours to leaves of seven tomato hybrids.

Data in Table (4) show the feeding preference of *T. absoluta* larvae to fruits of seven tested tomato hybrids. Results indicated that the differences between hybrids were significant and non-significant after 1 and 24 hours, respectively. After one hour, the seven hybrids arranged into three groups, the first group, with the highest preference,

contained hybrid Super red with 24.14% preference; the second, with moderate preference, involved Hybrid 83 with 17.98% preference; and the third one, with the lowest preference, included hybrid 65010, hybrid 102, hybrid Lugen, hybrid 449 and hybrid 039 with host preference of 11.43%, 12.62%, 12.37, 13.68 and 7.78%, respectively. The second group hybrids did not significantly differ from the other two groups. After 24 hours, the highest (16.15 %) and lowest (8.92%) percentages of attracted larvae were recorded on hybrid 039 and hybrid 65010, respectively.

The present results are in partial agreement with Oliveira et al. (2009), Gharekhani and Salek-Ebrahimi (2014), Salem *et al.* (2016) and Ghaderi *et al.* (2017).

Table 4. Feeding preference of *Tuta absoluta* larvae after 1 and 24 hours to fruits of seven tomato hybrids (ANOVA, α = 0.05).

Tomato hybrids	Mean number of larvae after		% of larvae after	
	1 hour	24 hours	1 hour	24 hours
Hybrid 65010	1.80	1.10	11.43 b	8.92 a
Hybrid Super red	3.70	1.80	24.14 a	15.04 a
Hybrid 83	2.80	1.70	17.98 ab	14.76 a
Hybrid 102	2.00	1.60	12.62 b	14.29 a
Hybrid Lugen	1.80	1.80	12.37 b	15.31 a
Hybrid 449	2.20	1.90	13.68 b	15.54 a
Hybrid 039	1.30	1.90	7.78 b	16.15 a
F. value			2.34*	$0.92^{N.S.}$
Response	15.60	11.80	78.00	59.00
Non-response	4.40	8.20	22.00	41.00

(*): The F value is significant, (NS): is not significant.

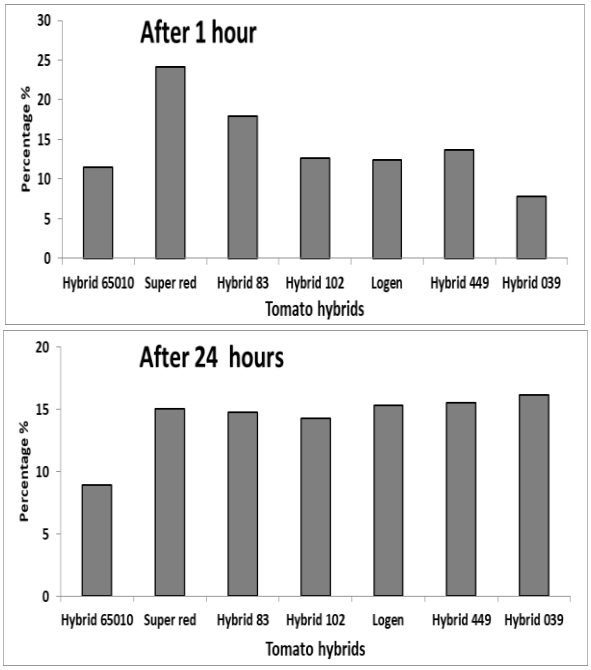

Figure 4. Feeding preference of *Tuta absoluta* larvae after 1 and 24 hours to fruits of seven tomato hybrids (ANOVA, α = 0.05).

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حساسية وتفضيل تغذية يرقات حفار الطماطم *T. absoluta* لبعض هجن الطماطم تحت الظروف الحقلية والمعملية

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تم فحص حساسية أوراق وثمار سبعة هجن من الطماطم للإصابة بيرقات حفار الطماطم *T. Absoluta* خلال موسمي ٢٠١٨/٢٠١٩ و ٢٠١٩/٢٠٢٠. علاوة علي ذلك تم اختبار التفضيل الغذائي ليرقات حفار الطماطم تجاه أوراق وثمار الطماطم للهجن السبعة تحت الظروف المعملية . أظهرت النتائج أن كل من أوراق وثمار الطماطم للأصناف المختلفة اختلفت في درجة حساسيتها أو مناعتها للإصابة بيرقات حفار الطماطم. أظهرت النتائج أن أوراق الطماطم لهجن الطماطم ٦٥٠١٠ ، ٨٣، ٠٣٩ كانت حساسة للإصابة بيرقات حفار الطماطم خلال موسمي الدراسة، في حين أن ثمار الطماطم للهجن ٦٥٠١٠ و super red و ٠٣٩ كانت حساسة للإصابة بيرقات حفار الطماطم في كلا موسمي الدراسة. أما بالنسبة للدراسات المعملية فقد أظهرت النتائج أن التفضيل الغذائي ليرقات حفار الطماطم بعد ساعة و٢٤ ساعة لأوراق وثمار السبع هجن من الطماطم اختلفت معنويا بعد ساعة وبعد ٢٤ ساعة. أظهرت النتائج أن اليرقات أبدت بعد ساعة من التعريض تفضيل عالي لأوراق هجن ٨٣، ١٠٢، و Lugen، بينما بعد ٢٤ ساعة جذبت الهجن ١٠٢ و ٠٣٩ أعلي وأقل نسب من اليرقات علي التوالي. أما علي ثمار الطماطم، فان يرقات حفار الطماطم أظهرت أعلي تفضيل بعد ساعة لهجين الطماطم Super red وأقل تفضيل للهجن ٦٥٠١٠، Lugen، ٤٤٩، ٠٣٩ ، بينما بعد ٢٤ ساعة فان اعلي واقل نسب من اليرقات المنجذبة لثمار الطماطم سجلت علي الهجين ٠٣٩ و ٦٥٠١٠ علي التوالي.