Susceptibility of different tomato, Solanum lycopersicum L., varieties to infestation with some insect pests in Egypt

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Abstract

Background: Tomato, Solanum lycopersicum L (=Lycopersicon esculentum Miller), is one of the most economically important crops in the world. In Egypt, tomato is infested with different pests causing damages in both quantity and quality of the yields. Six varieties of tomato, ‘Strain B,’ ‘Beto,’ ‘El bandora,’ ‘GS,’ ‘Casterlok,’ and ‘Super strain B,’ were evaluated for their susceptibility to some insect pest infestations during summer plantation under field conditions.

Results: According to the infestation with Tuta absoluta, the highly susceptible varieties that received the highest number of eggs were El bandora, followed by Strain B, while Super strain was the lowest. The obtained results indicated that the tomato Super strain B variety had much tolerance to the infestation by T. absoluta. GS variety recorded the highest mean number of eggs deposited by Phthorimaea operculella, but no eggs were observed on the leaves of El bandora and Super strain B varieties. Results also indicated that mean number of Liriomyza trifolii larvae/20 leaflets was the highest in Strain B and GS varieties. Strain B variety recorded the highest mean number of Bemisia tabaci eggs and nymphs/20 leaflets than GS, which recorded the lowest value. Casterlok variety had the lowest mean number of Aphis gossypii, while, Super strain B and Strain B recorded the highest values.

Conclusions: Generally, all the six tested varieties were susceptible to infestation with several insect pests. The most susceptible variety was Strain B, followed by El bandora and GS while the lowest ones were the varieties Beto 86 and Super strain B.

Keywords: Tomato varieties, Insect pests’ infestation, Susceptibility, Summer plantation

Background

Tomato, Solanum lycopersicum L. (=Lycopersicon esculentum Miller) (Solanaceae), is one of the most economically important crops in the world. Many insect species are reported to attack tomatoes worldwide, which cause considerable damage to both quantity and quality of the fruits (Faragalla 2005). These pests cause damages to the fruit yield quantity and quality (Žnidarčič et al. 2003). Some of these insect species are known to be of great economic importance, such as the tomato leaf miner, Tuta absoluta (Meyrick), (Lepidoptera: Gelechiidae) (Mohamed 2010; Bekheit and Impiglia 2011; Khidr et al. 2013; Mahmoud et al. 2015; Tayeb et al. 2018), the potato tuber moth, Phthorimaea operculella Zeller (Lepidoptera: Gelechiidae) where the larvae penetrate the tomato fruit through the stem end and present a serious threat to crop quality (Filgueira 2003), the American serpentine leafminer, Liriomyza trifolii (Burgess) (Diptera: Agromyzidae) where both larvae and adults cause damage: larvae primarily mine the palisade mesophyll and adult females tunnel puncture both upper and lower leaf surfaces to feed and lay eggs. The feeding of the
leafminers can drastically reduce the photosynthesis and respiration consequently affecting crop production (Leibee 1984), and the tobacco whitefly, *Bemisia tabaci* (Genn.) (Hemiptera: Aleyrodidae) is a pest that causes direct damage by feeding on the phloem sap and it produces honeydew on which sooty molds can grow (Nomi-kou et al. 2004). This may result in physiological disorders of the plant, such as leaf wilting and irregular ripening of the fruit. However, the main problem caused by *B. tabaci* is the damage done by the viruses they transmit (McCollum et al. 2004). Also, tomato plants are attacked by the cotton aphid, *Aphis gossypii* (Glover), Hemiptera: Aphididae) (Fargalla 2005), which causes indirect damage by transmitting several microorganisms such as viral and fungal diseases from infected to healthy plants. (Abd-El-wahab et al. 1996; Saethre et al. 2011).

The objective of this study was to determine the susceptibility of six common tomato varieties/strains in Egypt to infestation with some insect pests under the field and laboratory conditions.

**Materials and methods**

**Field experiment**

The present study was carried out at the southern region of Assiut Governorate (Dairut District), Egypt, in the summer season (summer plantation) of tomato to evaluate the infestation of different tomato varieties with some insect pests.

An area of about 240 m² (divided into 18 blocks (of about 12 m² /block) was cultivated with the 6 tomato varieties (Strain B, Beto 86, El bandora, GS, Casterlok, and Super strain B). Every block was separated from the other by uncultivated two rows. The seeds were obtained from the Ministry of Agriculture, Egypt, and seedlings were transplanted on the first week of February, 2013 as summer plantation. Three replicates of each variety were transplanted and evaluated in complete randomized design. All regular recommended agricultural practices were followed without any pesticide treatments during the whole period of the experiment. Sampling started 15 days post-planting, whereas 20 leaves from each replicate were collected at weekly interval up to the end of the season (23 June). The leaves were picked manually, placed in paper bags, and transferred to the laboratory for examination under a stereomicroscope to determine the number of tunnels, larvae, and eggs/leaflets, and the number of immature stages/leaf of the tested plants (Rabie 2014).

**Laboratory experiments**

**Susceptibility of the tomato varieties to infestation with Tuta absoluta**

Two methods were applied for evaluating the susceptibility of the six tomato varieties to the infestation by *T. absoluta* according to external (epiphylaxis) and internal (endophylaxis) factors.

In order to determine the ovipositional preference of the tomato leafminer to different tomato varieties, the following experiments were conducted

**Epiphylaxis factors**

**Multiple choice test** An experiment was carried out in a cage (30 × 30 × 60 cm) under the laboratory conditions of (26 ± 2 °C and 65 ± 5% RH). Twelve pots of tomato (2 pots/variety) were arranged inside the experimental cage. Thirty pairs of virgin females and males of *T. absoluta* were introduced into a cage, which contained one pot from each tested tomato variety arranged in a circle inside the cage. Each test was replicated five times. After 8 days, the numbers of deposited eggs on the plant of each pot variety was counted in order to determine the susceptibility of different tomato varieties to tomato leafminer infestation.

**No-choice test** Each variety was also tested under a non-choice experiment for comparison by placing 3–4 leaves of each tested tomato variety in a separate Petri dish (10 cm in dia. containing a thin layer of moist cotton), and then one pair of virgin female and male of *T. absoluta* was released into the Petri dish. Experiments were carried out under the laboratory conditions. After 5 days, number of deposited eggs/female was counted and compared with those on other varieties.

**Endophylaxis factors**

This experiment was conducted according to the method of Rabei (2014) to study the feeding preference of neonate larvae of *T. absoluta* toward the tested tomato varieties; this experiment was conducted in Petri dishes (10 cm in dia.) with one leaflet of each variety was separately placed inside a Petri dish and five neonate larvae were placed on the leaflets. After 5 days, the percentage of penetrating larvae was estimated according to the following equation:

\[
\text{Penetrating larvae} \% = \left( \frac{Y}{X} \right) \times 100
\]

Where *X* is total number of tested neonate larvae

\[Y\] is the number of larvae inside tested variety.

Mean duration of larval stage was calculated.

**Statistical analysis**

The data were subjected to analysis of variance (ANOVA) through SPSS computer program and significant differences among means of different varieties were separated using the least significant difference (LSD at 5%)
Results

Field experiment

The leaf miners (T. absoluta), (Ph. operculella), and (L. trifolii); cotton aphid (A. gossypii); and tobacco whitefly (B. tabaci) were the target insect pests in the field study.

Infestation with T. absoluta, Ph. operculella, and L. trifolii

Insignificant differences (p > 0.05) were found among the tested varieties of tomato plants to the infestation (mean number of tunnels, larvae, and eggs/leaflet) with T. absoluta, Ph. operculella, and L. trifolii during the study period (Table 1). According to the infestation by T. absoluta, the highly susceptible varieties, based on the highest number of eggs was in El bandeora variety (1.13 ± 0.2), followed by Strain B (0.93 ± 0.2), while Super strain B recorded the lowest value (0.5 ± 0.2). Mean number of tunnels/leaflet reached the highest number (3.0 ± 0.41) in GS variety than the other tested varieties, while Super strain B variety recorded the lowest number (1.8 ± 0.2). The mean number of larvae/20 leaflets reached the maximum in the most tested varieties, but the lowest number was recorded in Super strain B (0.26 ± 0.1). The results indicated that the tomato Super strain B had more tolerance to the infestation with T. absoluta.

Regarding the Ph. operculella infestation, significant differences were recorded among the tested varieties in the number of eggs/leaflet. GS variety recorded the highest number (19 ± 0.53) deposited by Ph. Operculella, but no eggs were found on the leaves of El bandeora and Super strain B.

With regard to L. trifolii infestation, El bandeora variety had the highest number of tunnels/leaflet (18.0 ± 2.15), followed by Strain B (17.6 ± 2.3) and Casterlok (15.3 ± 2.27), while Super strain B had the lowest number of tunnels (12.4 ± 2.35). Results also indicated that mean number of larvae/leaflet was the highest in case of Strain B (10.8 ± 0.16) and GS varieties (10 ± 1.3), but had the lowest value (6.3 ± 1.5) for the Beto 86 variety.

Susceptibility data of the tested tomato varieties to infestation with B. tabaci was represented in Table 2. The data showed that there were insignificant differences in the mean numbers of eggs and nymphs/leaflet among the tomato varieties. Strain B variety recorded the highest mean number of eggs (24.42 ± 3.68) and nymphs (34.2 ± 6.8)/leaflet in comparison with GS, which recorded the lowest values (19.8 ± 3.21 and 19.5 ± 3.2 for eggs and nymphs, respectively).

Infestation with A. gossypii

Regarding the infestation with A. gossypii, the results are summarized in Table 2 indicating that significant differences were found in the mean number of immature stages/leaflet among the tested tomato varieties. Casterlok variety had the lowest mean number of immature stages (2.6/leaflet), while the Super strain B and Strain B recorded the highest values (5.7 and 9.8/leaflet, respectively).

Laboratory experiments

Epiphylaxis factors (ovipositional preference for T. absoluta)

The data presented in Table 3 show the role of the nature, external feel and external structures of the leaves of different tomato varieties in the selection of T. absoluta to the site of oviposition. The data of choice and no-choice tests showed that there were insignificant differences (p > 0.05) among the six varieties according to the number of eggs deposited on each variety.

Endophylaxis factors

To evaluate the susceptibility of six tomato cultivars according to endophylaxis factors, the feeding preference of the tomato leafminer was determined through the following points.

Table 1 Susceptibility of different tomato varieties to infestation with some insect pests during summer plantation (2013) at Assiut Governorate

| Tomato varieties | Tuta absoluta | Phthorimaea operculella | Liriomyza trifolii |
|------------------|--------------|------------------------|-------------------|
|                  | Mean no./20 leaflets (±SE) | Mean no./20 leaflets (±SE) | Mean no./20 leaflets (±SE) |
|                  | Tunnels | Eggs | Larvae | Tunnels | Eggs | Larvae | Tunnels | Eggs | Larvae |
| Strain B         | 2.0 ± 0.3ab | 0.93 ± 0.24a | 0.93 ± 0.2a | 0.8 ± 0.17a | 0.46 ± 0.1ab | 0.6 ± 0.13a | 17.6 ± 2.3a | N/I | 10.8 ± 0.1a |
| Beto 86          | 2.26 ± 0.2ab | 0.73 ± 0.28a | 0.73 ± 0.2a | 0.8 ± 0.2a | 0.33 ± 0.1ab | 0.4 ± 0.16a | 14.0 ± 2.0a | N/I | 8.1 ± 1.8a |
| El bandeora      | 2.8 ± 0.43ab | 1.13 ± 0.25a | 0.93 ± 0.2a | 0.4 ± 0.16a | 0.00c | 0.3 ± 0.15a | 18.0 ± 2.1a | N/I | 10.8 ± 0.16a |
| GS               | 3.0 ± 0.41a | 0.6 ± 0.21a | 0.93 ± 0.2a | 0.6 ± 0.21a | 0.53 ± 0.1a | 0.2 ± 0.11 | 15.2 ± 2.1a | N/I | 8.4 ± 1.5a |
| Casterlok        | 2.2 ± 0.4ab | 0.8 ± 0.21a | 0.66 ± 0.1a | 0.8 ± 0.17a | 0.13 ± 0.0bc | 0.2 ± 0.15a | 15.3 ± 2.2a | N/I | 9.7 ± 0.9a |
| Super strain B   | 1.8 ± 0.2b | 0.5 ± 0.2a | 0.26 ± 0.1a | 0.4 ± 0.1a | 0.00c | 0.5 ± 0.19a | 12.4 ± 2.3a | N/I | 6.3 ± 1.5a |
| F                | 1.911ns | 0.844ns | 1.26ns | 0.988ns | 3.7 | 0.811ns | 0.898ns | 1.277ns |

Means in rows with the same letters are not significantly different (p ≥ 0.05)

N/I not identified, ns not significant
showed that no tomato cultivars were entirely resistant to T. absoluta. Some tomato strains to infestation with T. absoluta were tested by Mahmoud et al. (2020) for their susceptibility to infestation by B. tabaci and A. gossypii. The results indicated that all tested tomato varieties were more or less susceptible to infestation with different insect pests in Egypt. Also, the data indicated that the susceptibility level of all tested varieties to infestation by L. trifolii and B. tabaci was identically the same. In this respect, the susceptibility of 24 bean, Vicia faba L. cultivars to whitefly B. tabaci, with special reference to yield and pad characteristics was studied by Faris et al. (1991), they stated that the cultivars of bean revealed clear differences in their susceptibility to infestation with B. tabaci, these differences may be attributed to the leaf thickness and the characters of each bean variety and to the quantity and quality of the sap occupied in each one. The results about A. gossypii indicated that all tested tomato varieties were more or less attacked by aphids. Casterlok variety was less infested while Strain B variety recorded the highest infestation with eggs, larvae, and mines (tunnels) recorded during this season on the leaves of this strain. These findings clearly indicate the variations in the susceptibility of some tomato strains to infestation with T. absoluta and showed that no tomato cultivars were entirely resistant to T. absoluta, but not all cultivars were equally susceptible. Gharekhani and Salek-Ebrahimi (2014) evaluated the damage of T. absoluta on 11 tomato cultivars and reported that damaged leaves, active mines, and damaged terminal buds were significantly different among the tomato cultivars. Ibrahim (2015) evaluated the susceptibility of different strains of tomato to this pest during the early summer and Nile rotations in 2012 and also during summer and winter rotations in 2013. It appears that the native strain was more susceptible to infestation, compared to GS and super hybrid strains in the early summer rotation of 2012. In the Nile rotation, the strain 77 was more susceptible to infestation than the strain 010, where the number of eggs, larvae and mines on the leaves of the strain 77 were significantly higher than the strain 010. In the summer rotation of 2013, the strain 2243 was more susceptible to infestation with T. absoluta than GS. On the other hand, the strain coded 5656 showed to be more susceptible to infestation than the strain 010, judged from the number of eggs, larvae and mines (tunnels) recorded during this season on the leaves of this strain. These findings clearly indicate the variations in the susceptibility of the most dominant tomato strains to infestation with different insect pests in Egypt. Also, the data indicated that the susceptibility level of all tested varieties to infestation by L. trifolii and B. tabaci was identically the same.

Penetration and survival of larvae inside leaflets
The results (Table 4) indicated that the highest number of surviving larvae (88%) was recorded inside the leaflets of Super strain B. The other varieties were arranged in a descending order as follows: El bandora > GS > Strain B > Beto 86 > Casterlok; being 86, 86, 76, 76, and 74%, respectively.

Larval duration inside the leaf
Table 4 showed that the duration of the larval stage inside tomato leaflets were not significantly different among the six varieties.

Discussion
Our results showed that all the tested six varieties are susceptible to infestation by T. absoluta, Ph. operculella, L. trifolii, B. tabaci, and A. gossypii. Bogorni et al. (2003) and Oliveira et al. (2009) studied the susceptibility of some tomato strains to infestation with T. absoluta and showed that no tomato cultivars were entirely resistant to T. absoluta, but not all cultivars were equally susceptible. 

Table 2 Susceptibility of different tomato varieties to infestation with Bemisia tabaci and Aphis gossypii during summer plantation 2013 at Assiut Governorate

| Tomato varieties | B. tabaci (±SE) | A. gossypii (±SE) |
|------------------|----------------|------------------|
|                  | Eggs          | Nymphs          | Eggs          | Nymphs          |
| Strain B         | 24.2 ± 3.68a  | 34.2 ± 6.8a     | 9.8 ± 2.5a    | 13.8 ± 0.20a    |
| Beto 86          | 21.9 ± 4.95a  | 22.3 ± 4.4a     | 2.7 ± 0.5b    | 14.2 ± 0.20a    |
| El bandora       | 21.3 ± 3.67a  | 25.2 ± 5.7a     | 2.8 ± 0.5b    | 13.8 ± 0.20a    |
| G.S              | 19.8 ± 3.21a  | 19.5 ± 3.2a     | 8.7 ± 2.2a    | 13.7 ± 0.20a    |
| Casterlok        | 24.0 ± 4.87a  | 29.0 ± 6.09a    | 2.6 ± 0.6b    | 14.1 ± 0.19a    |
| Super strain B   | 21.0 ± 3.4a   | 25.0 ± 5.9a     | 5.7 ± 2.1ab   | 14.0 ± 0.20a    |
| F                | 0.17**       | 0.87**          | 3.63          |                 |

Means in rows with the same letters are not significantly different (p > 0.05)

Table 3 Ovipositional preference of the tomato leaf miner, T. absoluta, on six tomato varieties

| Tomato varieties | No. of deposited eggs/female (mean ± SE) |
|------------------|----------------------------------------|
|                  | Choice test | No-choice test |
| Strain B         | 6.17 ± 1.31a | 47.0 ± 2.90a   |
| Beto 86          | 4.9 ± 0.66a  | 51.8 ± 4.80a   |
| El bandora       | 8.05 ± 1.23a | 45.4 ± 4.00a   |
| G.S              | 6.0 ± 1.26a  | 48.2 ± 1.8a    |
| Casterlok        | 6.5 ± 0.93a  | 50.0 ± 2.26a   |
| Super strain B   | 8.0 ± 0.70a  | 49.0 ± 1.25a   |
| F                | 1.35         | 0.69           |

Means in rows with the same letters are not significantly different (p > 0.05)

Table 4 Feeding preference and larval duration of the tomato leafminner, T. absoluta, in six tomato varieties

| Tomato varieties | % Survived larvae | Larval stage duration (days) (M ± SE) |
|------------------|-------------------|--------------------------------------|
| Strain B         | 76                | 13.8 ± 0.20a                         |
| Beto 86          | 76                | 14.2 ± 0.20a                         |
| El bandora       | 86                | 13.8 ± 0.20a                         |
| G.S              | 86                | 13.7 ± 0.20a                         |
| Casterlok        | 74                | 14.1 ± 0.19a                         |
| Super strain B   | 88                | 14.0 ± 0.20a                         |
| F                | –                 | 0.8                                   |

Means in rows with the same letters are not significantly different (p > 0.05)
Craig variety. Pupae developed fastest on the Moneymaker into adults. Larval development was fastest on the Ailsa larvae accepted all tested tomato plant leaves and developed into adults. Larval development was fastest on the Ailsa Craig variety. Pupae developed fastest on the Moneymaker variety and slowest on LA3475.

Conclusion
The results of this research indicated that all six tested tomato varieties were susceptible to infestation with all tested insect pests, but it differed among varieties. The most susceptible variety to all the previous pests was Strain B, followed by El bandora and GS, while the Beto 86 and Super strain B showed the lowest infestation. Therefore, among all tested tomato varieties, Beto 86 is the most recommended variety for field production.

Abbreviations
T. absoluta: Tuta absoluta; Ph. operculella: Phthorimaea operculella; L. trifolii: Liriomyza trifolii; A. gossypii: Aphis gossypii

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Authors’ contributions
This work was carried out in collaboration between all authors. Authors YAM, SM, and IMAE designed the study, performed the statistical analysis, wrote the protocol, and wrote the first draft of the manuscript. Authors WA and NO managed the analyses of the study. Author TEA and author HS managed the literature searches. All authors read and approved the final manuscript.

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Consent for publication
Not applicable

Competing interests
All authors declare that they have no competing interest.

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