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Research Article

Resistance of tomato cultivars to *Tuta absoluta* (Lepidoptera: Gelechiidae) under field condition

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Abstract: Tomato leaf miner, *Tuta absoluta*, is the most destructive pest of tomato in Iran. Resistance levels of six tomato cultivars to the pest damage were evaluated during two tomato growing seasons (2014-2015). Samplings were done weekly. Leaf and fruit damages as well as the total yield of the cultivars were compared. Furthermore, leaf trichome density was evaluated. The highest to lowest leaf infestation rates were recorded for the Primo early, CaljN3, Petomek, Rio grande, Early urbana and Super 2270 cultivars respectively. Fruit infestation rate in Early urbana was significantly lower than the other cultivars in both growing seasons. Total yield of tomato (from the highest to the lowest) belonged to Super 2270, Early urbana, Rio grande, Petomek, Calj N3 and Primo early cultivars.

Keywords: Tomato leaf miner, Host plant resistance, Leaf and fruit damage, Ramin, Khuzestan

Introduction

The tomato leaf miner (TLM), *Tuta absoluta* (Meyrick) (Lepidoptera: Gelechiidae), is considered as one of the most dangerous pests in greenhouse and field grown tomatoes. The pest is an invasive pest native to South America (Yankova, 2012) and it is newly distributed in Iran (Baniameri and Cheraghian, 2011). The female usually lays eggs on leaves, stems, and to a lesser extent on fruits. The young larvae mine the leaves or stems producing large galleries and burrow into the fruit. On leaves, the larvae feed only on mesophyll cells, leave the epidermis intact and make irregular leaf mines, which may later become necrotic (OEPP/EPPO, 2005) and affect photosynthesis in the plant (Desneux *et al.*, 2010). Damage from this pest throughout the entire growing cycle of tomatoes can significantly reduce both yield and fruit quality by the direct feeding of *T. absoluta* and secondary pathogens that may enter through the wounds made by the insect. In the absence of control strategies, larval feeding damage can reach up to 100% (Yankova, 2012). Large amounts of chemical insecticides have been applied against the pest in both field and greenhouse (Lietti *et al.*, 2005). The applications cause many problems such as increase the insecticide costs, destroy natural enemy populations, leave pesticide residues in fruits and make the pest population resistant to chemical compounds (Braham and Hajji, 2012). Also, the general endophytic behaviour of the larval instars makes it difficult to conduct

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effective control practices against this pest (Lietti *et al.*, 2005; Guedes and Picanço, 2012).

Host plant resistance is economic and ecologically friendly strategy in integrated pest management (IPM) programs (Pedigo, 2002; Sharma and Ortiz, 2002). Use of cultivars resistant to the pest cause a major reduction in chemical insecticide application that can lead to increase in beneficial organism activity and decrease of pesticide residues in the environment and human food (Sharma and Ortiz, 2002). In many cases, use of resistant host plant is nearby compatible with other control strategies in IPM programs (Pedigo, 2002). Finding cultivars resistant to a pest is the primary step in the use of host plant resistance in IPM programs (Panda and Khush, 1995). Host plant defense in resistant cultivars may be related to morphological, biochemical and molecular traits to counter/offset herbivore attack (War *et al.*, 2012). Trichomes are hair-like appendages that develop from cells of the aerial epidermis and are produced by most plant species and contribute to host plant resistance against herbivore insects (Dalin *et al.*, 2008).

Resistance levels of some tomato cultivars to *T. absoluta* have been previously investigated by some researchers (Gharekhani and Salek-Ebrahimi, 2014a, b; Proffit *et al.*, 2011; Oliveira *et al.*, 2009; Sohrabi *et al.*, 2016; Ghaderi et al., 2017). In this study, resistance level of six tomato cultivars to *T. absoluta* were studied in field condition. Also, the effect of leaf trichome on the resistance levels was evaluated.

Materials and Methods

Experimental design

Experiments were done in an experimental field, 5000m^2, in Chogha Kabod region, Kermanshah, West Iran, during two tomato growing seasons 2015-2016. Six tomato cultivars including Rio gande, Super 2270, Calj N3, Early Urbana, Primo early and Petomek were cultivated (18000 plants per hectare). Between each plot (150m^2) a ridge (2m) was made. Experiments were arranged in a randomized complete block design with four replications (plots). Cultural practices were conducted according to instructions of the Kermanshah province agricultural organization.

Sampling

Sampling was performed weekly from primary phnelogical step, 5-7 leaves, to end of the growing season. At each sampling date, ten randomly selected plants were checked by traveling in an X-shaped pattern through each plot. From each selected plant, three leaves and fruit were randomly chosen and the numbers of the pest larval mines in each leaf and fruit were separately recorded. At the end of growing season, total fruit yield in each plot was separately weighed.

Effect of leaf trichome

For evaluation of leaf trichome effect on host plant resistance level, three cultivars with high, moderate and the low resistance level were chosen. Seeds of the cultivars were sown in plastic pots (12cm diameter and 22cm height). Ten pots were provided for each selected cultivar. The pots were kept in germinator at 27 ± 2 ºC, photoperiod 16: 8 (light: dark) and RH 60 ± 5%. At the eight leaf stage, six leaves were randomly detached from the potted plants. A paper quadrat, 5 × 5 mm, was randomly placed under each leaf and number of trichomes in each quadrate was recorded under stereomicroscope.

Data analysis

The data were statistically analyzed by one way analysis of variance (one-way ANOVA) and the group means were compared by Duncan's multiple range test using SAS program (SAS Institute, 2003).

Result

Leaf and fruit damage

Leaf and fruit Infestation rates in various experimental cultivars during first (2015) and second (2016) growing seasons are presented in Table 1. Significant differences were observed between leaf infestation rates in various experimental varieties. In both growing

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seasons, infestation levels in Primo early were significantly higher than the other cultivars (22.7 and 26.6% in the first and second growing season, respectively). While, infestation of Super 2270 was significantly lower than other cultivars (9.5 and 10.3% in the two growing seasons, respectively). Totally, order of infestation rates to TLM (from the highest to the lowest) was Primo early, CaljN3, Petomek, Rio grande, Early urbana and Super 2270.

Fruit infestation rate between various experimental cultivars was significantly different. Fruit infestation rates in Early Urbana were significantly lower than other cultivars in both growing seasons (0.5 and 6.5% during the first and second growing season, respectively). The highest fruit infestation rate was observed in Calj N3 (4.82%) and Petomek (12.42%) during the first and second growing season, respectively.

Table 1 Percentages of damaged leaf, damaged fruit and total yield in tomato cultivars in response to *Tuta absoluta*.

Cultivars	Damaged leaf (%)		Damaged fruit (%)		Total yield (kg/m^2)	
	2015	2016	2015	2016	2015	2016
Primo early	22.7 ± 3.3a*	26.6 ± 6.4a	2.2 ± 0.4b	9.9 ± 1.0b	127.4 ± 8.5c	131.8 ± 8.8c
Calj N3	18.7 ± 0.5b	24.1 ± 2.4a	4.8 ± 0.2a	7.6 ± 1.2c	133.6 ± 1.0c	141.9 ± 9.8bc
Early Urbana	8.0 ± 0.4d	12.4 ± 3.2b	0.5 ± 0.5e	6.5 ± 0.9c	112.6 ± 4.3d	157.0 ± 21.3b
Peto mek	18.0 ± 2.8b	22.7 ± 2.6a	1.6 ± 0.2c	12.4 ± 1.2a	178.9 ± 4.6a	156.0 ± 14.7b
Supper 2270	9.5 ± 1.9dc	10.4 ± 1.7b	1.0 ± 1.9d	7.8 ± 1.5c	175.4 ± 6.6a	207.3 ± 5.8a
Rio grande	12.0 ± 0.8c	14.7 ± 3.8b	1.5 ± 0c	8.4 ± 1.4bc	163.4 ± 2.8b	159.3 ± 14.8b
F (df = 5, 23)	33.29	13.55	106.8	8.5	93.6	12.22
P-value	< 0.001	< 0.001	< 0.001	0.0002	< 0.001	< 0.001

Means followed by the same letters in each column indicate non-significant differences (Duncan's Multiple Range Test, P ≤ 0.05).

Total Yield

Total fruit yield of different cultivars in the first (2015) and second (2016) growing seasons is presented in Table 1.

Results indicated that there were significant differences between total yields of various cultivars. In both growing season, the highest fruit yield was obtained in Super 2270 (207.35 and 175.4 kg per plot and the lowest yield was that of Primo early (131.85 and 127.4 kg per plot). In the first growing season, total yield in decreasing order was that of Petomek, Super 2270, Rio grande, Calj n3, Primo early and Early Urbana. Whereas in in the second growing season it was that of Super 2270, Early Urbana, Rio grande, Petomek, Calj N3 and Primo early.

Trichome density

According to the results of leaf infestation rates with TLM larvae, Super 2270, Early urbana and Primo early were selected as experimental cultivars with the highest, moderate and lowest resistance level to the pest, respectively. Trichome densities in these cultivars indicate significant difference among them (Table 2). The highest and lowest trichome density were recorded in Super 2270 (the most resistant cultivar) and Primo early (the most susceptible cultivar), respectively (Table 2). Moreover, significant positive correlation was observed between trichome density and resistance level to TLM larvae (r = 0.740).

Table 2 Density of leaf trichome in tomato cultivars.

Cultivars	Trichome density ± SE (cm^2)	Level
Primo early	7.94 ± 1.57a*	Low
Early Urbana	23.38 ± 2.34b	Medium
Super 2270	73.11 ± 4.56c	High
F (df = 2, 5)	120.92	
P-value	< 0.0001	

Means followed by the same letters in each column indicate non-significant differences (Duncan's Multiple Range Test, P ≤ 0.05).

Discussion

The study revealed that there are significant differences between leaf damage, fruit damage

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and total yield caused by TLM in the tested tomato cultivars. The relative resistance of the cultivars according to leaf damage and total yield data were in the decreasing order of: Super 2270, Early Urbana, Rio grande, Petomek, Calj N3 and Primo early.

Our findings are in line with the results of Gharehkhani and Salek-Ebrahimi (2014a, b) who demonstrated that different resistance levels can be observed in various tomato cultivars. Resistance levels of ten tomato cultivars to *T. absoluta* were investigated by Sohrabi *et al.* (2016) based on number of mines per leaf, holes on the stem and holes per fruit in field condition. Among the tested cultivars, those with high density of leaf trichome, were more resistant to the pest. The researchers concluded that leaf trichome density is possibly the reason of resistance to TLM larvae. Similarly, Mulusew *et al.* (2013) showed that resistance level of different tomato cultivars was related to leaf trichome density. Navarro *et al.* (2015) reported that oviposition rates of TLM females were different in various tomato cultivars (antixenosis). But there was no antibiosis based resistance among the tested cultivars (Navarro *et al*., 2015). Life table parameters of TLM on seven tomato cultivars, Primo early, Rio grande, Calj N3, Petomek, Early Urbanam, Super 2270 and Super strain B showed that the longest and the shortest developmental times of immature stages of TLM were on Early Urbana and Calj N3, respectively (Ghaderi *et al*., 2017). The lowest and the highest values of the intrinsic rate of increase (r) and finite rate of increase (λ) were on Early Urbana Y and Cal JN3, respectively. This laboratory study showed that Calj N3 and Primo early were the most susceptible and most resistant cultivars, respectively (Ghaderi *et al.*, 2017). Difference in susceptibility of the cultivars may be due to different experimental conditions in laboratory and/ or field. Shahbaz *et al.* (2017) demonstrated that performance of TLM larvae fed on tomato cultivars with different resistance level was different. The larvae feeding on resistant cultivars reached the lowest final weight, whereas those reared on the susceptible cultivars reached the highest body weight. Also, host plant resistance significantly affects the TLM physiology. The highest proteolytic and amylolytic activity were detected in larvae feeding on resistant cultivars, whereas larvae reared on the susceptible cultivar had the lowest enzymatic activity for both third and fourth instar larvae.

In conclusion, there are different resistance levels in tomato cultivars to TLM damage. The cultivars with dense leaf trichome are more resistant to the pest. These cultivars can be considered as candidates for use in integrated management programs of the TLM.

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مقاومت ارقام گوجه‌فرنگی به شب‌پره مینوز برگ گوجه‌فرنگی *Tuta absoluta* (Lep: Gelechiidae) در شرایط مزرعه‌ای

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چکیده: شب‌پره مینوز برگ گوجه‌فرنگی (*Tuta absoluta*) خطرناک‌ترین آفت گوجه‌فرنگی در ایران است. سطوح مقاومت شش رقم گوجه‌فرنگی به خسارت این آفت طی دو فصل زراعی (۱۳۹۴-۱۳۹۵) مورد ارزیابی قرار گرفت. نمونه‌برداری به‌صورت هفتگی انجام شد. خسارت‌های برگی و میوه به‌همراه عملکرد کل میوه در این ارقام مورد مقایسه قرار گرفت. علاوه بر این، تراکم تریموم‌های برگی نیز مشخص شد. ترتیب بیش‌تری به کم‌ترین نرخ آلودگی برگی ارقام پریموارلی، کالج ان۳، پتومک، ریوگرند، ارلی اربانا و سوپر 2270 بود. در هر دو فصل زراعی، نرخ آلودگی در ارلی اربانا به‌صورت معنی‌داری کم‌تر از سایر ارقام بود. ترتیب عملکرد کل گوجه‌فرنگی (از بیش‌ترین به کم‌ترین) به ارقام سوپر ۲۲۷۰، ارلی اربانا، ریوگرند، پتومک، کالج ان۳ و پریموارلی تعلق داشت.

واژگان کلیدی: شب‌پره مینوز برگ گوجه‌فرنگی، مقاومت گیاه میزبان، خسارت برگی و میوه، عملکرد کل

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