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DETERMINATION OF THE RESPONSES OF DIFFERENT TOMATO SPECIES TO *TUTA ABSOLUTA*

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Abstract

In this study, the harmful effect of Tuta absoluta on different tomato species was investigated. Six tomato genotypes which are Solanum chmielewskii (LA1028), Solanum neorickii (LA0247), Solanum hirsutum (LA777), Solanum pimpinellifolium (LA0722), and Solanum lycopersicum cv. Cuatomate and Solanum lycopersicum cv. Ailsa Craig (LA2838A) species were used as plant material in the study. To determine the incidence of Tuta absoluta on the plants, the egg and larvae were counted weekly by taking 5 leaves from the species. According to eggs and larvae counts, the plants were exposed to 5 types of severe damage while Solanum lycopersicum cv. Cuatomate was found to be later and less effective than the others. These results indicate that this species exhibits antixenosis properties against Tuta absoluta pests and that the other species that have been exposed to earlier and more severe damage lack such property.

Key words: *Tuta absoluta, Solanum species, antixenosis.*

INTRODUCTION

Tomato (*Solanum lycopersicum* L.) is one of the most important food crops in the world in terms of human consumption, while total global production exceeds 5 million hectares worldwide with an average annual production of more than 170 million metric tons (FAO, 2017). However, declining agricultural areas and increasing pests and diseases are affecting yield and tomato fruit quality negatively. Chemical control methods have been trusted to control this insect, but the feeding habits of the larvae, the increasing number of resistant strains of this pest, together with the negative impact of the chemical into the environment makes the chemical control method not sustainable (Moreno, 2011; Cocco et al., 2012). Thus, the use of nature-friendly biological control methods and tolerance varieties has been preferred in recent years. Therefore, the implementation of environmentally safe measures that reduce the use of chemicals will contribute to the sustainability of productions. There are many insects, diseases and weeds which cause significant damage to tomato production. The most widespread of these are the whitefly (*Bemisia tabaci*), leaf miner (*Liriomyza trifolii*), and red spider (*Tetranychus urticae*) (Uygun et al., 1998). The tomato leaf miner is one of the major devastating pests of processing and fresh tomatoes, both in greenhouse and open field condition. *Tuta absoluta* larvae can absolutely destroy the tomato canopy by excavating the leaves, stems and buds; and burrows into fruits causing the quality decline of fresh tomato and yield loss (Cocco et al., 2012). It is an oligophagous insect that feeds on at least 39 species belonging to ten families, including *Amaranthaceae*, *Asteraceae*, *Chenopodiaceae* and *Poaceae* (Siqueira et al., 2000).

Other cultivated *Solanaceous* species host-plants are *Solanum tuberosum*, *S. melongena* and *Nicotiana tabacum* are cited (García and Espul, 1982).

Tuta absoluta was detected in Europe for the first time in the northern part of eastern Spain at the end of 2006. Since then, it has rapidly invaded other European countries, including Norway and threatening tomato cultivation (Sundheim, 2017), and spread throughout the Mediterranean area, including parts of North Africa and the Middle East where it immediately reached damaging levels and fruits (Desneux et al., 2010). At present, *T. absoluta* is considered to be one of the most devastating pests for tomato crops (*Solanum lycopersicum* L.) and a serious threat in all of these newly infested areas. It is still one of the major pests in many areas of Turkey. As a result, it has damaged the tomato production, both in open field and greenhouse areas. *Tuta absoluta* larvae can absolutely destroy the tomato canopy by excavating the leaves, stems, and buds and burrows into fruits causing the quality decline of fresh tomato and yield loss that range from 50% to 100% (Cocco et al., 2012). According to literature, against *T. absoluta* many control strategies have been used such as cultural hygiene, pheromone, biological control and resistant genotypes. Nowadays, most of the European countries producers fulfil the GLOBALGAP requirements, which also implies more environmentally friendly technologies. One of the most important ways of sustainable nature-friendly growth is the development of disease-tolerant plants. The plants have shown 3 basic mechanisms against insects. One of them is antixenosis. According to this defensive mechanism, the plants cannot be damaged by insects in terms of the plant's characteristics and cannot feed and lay eggs on the plants. The second mechanism is antibiosis. This feature is a deterioration of the biology of the insect with respect to the characteristics of the plants. The third mechanism is tolerant plants. This attribute is different from the first two, in which case there is no relationship between plant and insect. As an example of this feature; wild relatives of tomato have been used as sources of insect resistance (Oliveira et al., 2009). Insect resistance is generally associated with the presence of trichome, of different types and densities (McDowell et al., 2011; Tissier, 2012; Glas et al., 2012). Antibiosis and antixenosis are the two resistance mechanisms reported in *S. hirsutum* (Weston et al., 1989; Channarayappa et al., 1992; Eigenbrode et al., 1993; Eigenbrode et al., 1994; Kumar et al., 1995). Sesquiterpenes present on leaf glandular trichomes of *S. hirsutum* f. typical, mainly type IV and VI, are commonly reported in the literature as the chemical causes of insect resistance in this genotype (Snyder and Hyatt, 1984; Lin et al., 1987; Carter et al., 1989; Eigenbrode et al., 1993; Eigenbrode et al., 1996; Snyder et al., 1998). Although several studies have shown that the accession LA1777 of *L. hirsutum* f. typicum constitutes a resistance source to tomato insect-pests, its resistance to *T. absoluta* and the variability of pest resistance among plants of this accession, especially as related to plant chemical composition, are unknown. Host plant resistance can be an important component of IPM programs. Resistant plants can help maintain pest populations below economic injury levels and are usually compatible with other control methods (Smith, 2005). Sources of resistance to several insect pests have been identified in wild tomato species (Oliveira et al., 2012; Bottega et al., 2015).

In this study, we investigated interactions among some different tomato genotypes and *Tuta absoluta* by assessing on number of larvae and eggs reared.

MATERIALS AND METHODS

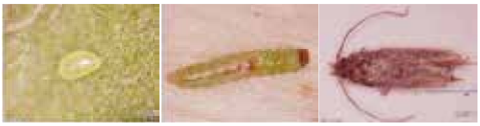
In the experiment, *Solanum chmielewskii (*LA1028), *Solanum neorickii* (LA0247), *Solanum hirsutum* (LA1777) *S. pimpinellifolium* (LA0722)*, Solanum lycopersicum* cv. Cuatomate, and *Solanum lycopersicum* cv. Ailsa Craig (LA2838A) were used as plant material. Seeds were germinated in a mixture of peat: perlite: vermiculite in 7:2:1 ratio. After 15 days, tomato seedlings at the second-true leaf stage were transferred to 8 L plastic pods included peat: perlite (2:1) mixture. The experiment was carried out in a glass greenhouse, with day temperature 28-30^{o}C, night temperature 20-22^{o}C and 60-70% relative humidity in summer time (June-August). Plants were grown up until 8-10 real leaf stages for *Tuta absulta* application in the greenhouse equipped with automatically-controlled side walls, ventilation fans and wet-pads for humidity control and in order to maintain a maximum temperature of 30°C. The seedling, irrigated with a nutrient solution of EC: 2.2-2.5 and pH: 5.5-6.0 were planted to 8 L pods after 7 days. The concentrations of the following elements were determined for the nutrient solution: (M): 3.0x/10-3 $Ca(NO_3)_2$; 0.9x/10-3 K_2SO_4; 1.0x/10-3 $MgSO_4$; 0.2x/10-3 KH_2PO_4; 1.0/10-5 H_3BO_3; 1.0x10-6 $MnSO_4$; 1.0x/10-7 $CuSO_4$; 1.0x/10-8 $(NH_4)_6Mo_7O_{24}$; 1.0x10-6 ZnSO4; 1.0x/10-4 Fe EDTA.

When the tomato plants reached 8-10 true leaf stage, were taken in a 2000 lux illuminated climate chamber with *T. absoluta* production temperature of 25 ± 1°C and 60 ± 5% relative humidity conditions.

The plants were left in this room for 7 days with *T. absoluta*. After this period, the plants were moved into the insect-proof climate chamber under 25°C, 65% relative humidity, and 2000 lux illumination, where the phenotype experiments were performed for six weeks.

Six different genotypes were arranged in a randomized complete design with five replications. *T. absoluta* was regenerated one times a week and maintained by feeding the clean tomato plant, *S. lycopersicum* cv. Ailsa Craig. Each week 5 leaves were taken from each tomato genotype and eggs and larvae were counted at intervals of 7 days. Larvae and eggs were counted under a Leica® S6D stereo microscope. Other pictures were taken by Canon® D600 digital camera (Figure 1).

All analyses were performed with SPSS software package Version 18.0 (SPSS Inc., Chicago, IL) for Windows by General Linear Model univariate test. Normality of variance was checked before analysis, and the, mean was compared using an LSD test.



Egg Larvae Adult

Figure 1. Larvae, egg, and adult of *Tuta absoluta*

RESULTS AND DISCUSSIONS

According to results, LA1028, LA0247, LA1777, LA0722, and LA2838A were determined more sensitive than *Solanum lycopersicum* cv. Cuatomate to *Tuta absoluta* (Figure 2).

Figure 2. *S. lycopersicum* cv. Cuatomate and other used genotypes in the study at the 2nd week

However, in a previous study, the accession line LA1777 (*S. hirsutum*) was found more tolerant genotype to *Tuta absulta* (Ecole et al., 1999). To examine the survival ability of the insect the number of the eggs was determined for all genotypes. In the first-week egg counts, *S. chmielewskii*, S. *pimpinellifolium, S. lycopersicum* cv. Cuatomate, *S. neorickii*, *S. lyocpersicum* and *S. hirsutum* genotypes were found to have average 4.4, 3.0, 3.0, 3.4, 3.2 and 3.2 eggs respectively on the leaves. In the second week 0.8, 0.8, 0.8, 0.4, 1.2 and 1.2 eggs were observed respectively (Table 1).

After the second week only *S. lycopersicum* cv. Cuatomate survived, all other genotypes of the green canopy being completely destroyed by *Tuta absoluta*. For this reason, subsequent counts continued with *S. lycopersicum* cv. Cuatomate. The number of eggs during 6 weeks was 3.0, 0.8, 0.2, 0.4, and 0.0, respectively. It was observed that this resistant genotype died after the 5th week as well (Table 1).

Table 1. Number of the eggs according to tomato varieties during the six weeks (Sc: *S. chmielewskii,* Sp: *S. pimpinellifolium*, SlC: *S. lycopersicum* cv. Cuatomate, Sn: *S. neorickii*, Sl: *S. lyocpersicum,* Sh: *S. hirsutum*)

	Genotypes					
	Sc	Sp	SlC	Sn	Sl	Sh
1. Week	4.4	3.0	3.0	3.4	3.2	3.2
2. Week	0.8	0.8	0.8	0.4	1.2	1.2
3. Week	0.0	0.0	0.8	0.0	0.0	0.0
4. Week	0.0	0.0	0.2	0.0	0.0	0.0
5. Week	0.0	0.0	0.4	0.0	0.0	0.0
6. Week	0.0	0.0	0.0	0.0	0.0	0.0

In the first week of larval counts, *S. chmielewskii, S. pimpinellifolium, S. lycopersicum* cv. Cuatomate, *S. neorickii, S. lyocpersicum, S. hirsutum* genotypes were observed to have average 6.4, 3.6, 3.6, 2.8, 3.4 and 3.4 larvae, respectively. In the second week counts, mean 11.6, 6.2, 6.2, 4.4, 5.8 and 5.8 larvae were determined, respectively. After two weeks, only one tomato genotype (*S. lycopersicum* cv. Cuatomate) survived while other genotypes were found to be completely dead. On this genotype, the counts in the third, fourth and fifth weeks, the average number of larvae was found as 5.4, 5.8 and 7.4, respectively (Table 2).

As a result of both counting of eggs and larvae, 5 species were severely damaged by the *T. absoluta* attack, while *S. lycopersicum* cv. Cuatomate has been found to be more tolerant. These results indicate that S. *lycopersicum* cv. Cuatomate genotype could be more tolerant to *T. absoluta* then others.

Table 2. Number of the larvae according to tomato varieties during the six weeks (Sc: *S. chmielewskii,* Sp: *S. pimpinellifolium*, SlC: *S. lycopersicum* cv. Cuatomate, Sn: *S. neorickii*, Sl: *S. lyocpersicum,* Sh: *S. hirsutum*)

	Genotypes					
	Sc	Sp	SlC	Sn	Sl	Sh
1. Week	6.4	3.6	3.6	2.8	3.4	3.4
2. Week	11.6	6.2	6.2	4.4	5.8	5.8
3. Week	0.0	0.0	5.4	0.0	0.0	0.0
4. Week	0.0	0.0	5.8	0.0	0.0	0.0
5. Week	0.0	0.0	7.4	0.0	0.0	0.0
6. Week	0.0	0.0	0.0	0.0	0.0	0.0

It is known that besides the reactions of the wild lines tomato against the tomato leaf miner, different kinds of reactions are given within themselves in some commercial varieties as well. Indeed, in a study by Çekin and Yaşar (2015) they determined the life schedule parameters of *T. absoluta* on comercial tomato varieties of Newton, Caracas, Torry, and Simsek.

The oviposition rate of *T. absoluta* were significantly different among varieties. The lowest oviposition rate was found in Simsek tomato genotype. As a result, it was seen that tomato was less preferred than other tomato varieties.

As shown in Table 3, egg counts were found to be close to each other as a result of the first two weeks of counting and there was no statistical difference between them ($P > 0.05$).

Table 3. Mean the number of larvae and eggs of *T. absoluta* after 2 weeks (mean ± SE). Different letters indicate significant differences at LSD, $p<0.05$

	Eggs/per leaf	Larvea /per leaf
S. chmielewskii	2,60±0,670 **a**	9,00±1,170 **a**
S. pimpinellifolium	1,90±0,482 **a**	4,90±1,040 **bc**
S. lyc. cv. Cuatomate	2,20±0,772 **a**	1,60±0,221 **c**
S. neorickii	1,90±0,567 **a**	3,60±0,581 **bc**
S. lycopersicum	2,20±0,593 **a**	4,60±0,968 **bc**
S. hirsutum	2,90±0,888 **a**	6,00±0,943 **ab**
	***P= 0.883 > 0,05**	****P=0.000 < 0,05**

However, in the larva counts, low amount of larvae were determined on *S. lycopersicum* cv. Cuatomate and it was determined that the difference between the other species was statistically significant ($P < 0.05$).

According to other studies, sources of resistance to several insect pests have been identified in wild tomato species (Baldin et al., 2005; Oliveira et al., 2012; Bottega et al., 2015), and the corresponding genes have been introgressed into commercial cultivars.

For example, tomato plants possess glandular trichomes that accumulate metabolites toxic to herbivorous insects (Weinhold and Balwin, 2011).

CONCLUSIONS

S. lycopersicum cv. Cuatomate tomato variety was determined to be more resistant to *T. absoluta* than other varieties. On the other hand, *S. chmielewskii*, *S. neorickii*, *S. hirsutum*, *S. pimpinellifolium* and S. *lycopersicum* tomato varieties had a high number of total eggs per female on the first two weeks (Table 3). We saw that the larvae did not choose the *S. lycopersicum* cv. Cuatomate when compared to others. For this reason, it is thought that this variety can be used by breeders for its resistance to *Tuta absoluta*.

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