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Determination of Oviposition Preference of *Tuta absoluta* to Tomato, Pepper and Eggplant

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ABSTRACT—*Tuta absoluta (Meyrick, 1917) (Lepidoptera: Gelechiidae) which is originated from South America is an oligophagous pest on cultivars and weeds from Solanaceae family. The study found out the oviposition preference of the pest to tomato, pepper and eggplant in a restricted flight area, and tendency of the pest to host plants through olfactometer. T. absoluta laid average 19.82, 0.03 and 8.03 eggs on tomato, pepper and eggplant in a restricted flight area, respectively. The average number of larvae counted on these host plants were 14.68, 0.03 and 5.15, respectively. These larvae caused total 28.03 mines on leaves of host plants, including 21.53 mines on tomato, 0.03 mines on pepper and 6.47 mines on eggplant. The egg-laid preference ranking of T. absoluta on host plants in olfactometer system was determined as tomatoes (average 18.20 eggs), eggplant (average 6.93 eggs) and pepper (average 0.53 eggs) from more to less. Consequently, tomato plant was more preferred by T. absoluta among all host plants, including tomato, pepper and eggplant. Also, the pest showed tendency to eggplant more than pepper. In addition, it was concluded that the attractive feature of black color can be used in biotechnical control against the pest.*

Keywords—*Tuta absoluta*, Tomato leafminer, host preference, olfactometer, Solanaceae

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1. INTRODUCTION

Tuta absoluta (Meyrick, 1917) (Lepidoptera: Gelechiidae) (tomato leafminer), which is originated from South America, was firstly seen by Meyrick in Peru in 1917. Then, it was detected in Argentina in 1964. In Turkey, the pest was recorded on tomato plants grown in the open fields of İzmir's Urla district in 2009 (Kılıç, 2010). *T. absoluta* is an oligophagous pest fed on cultivated plants and weeds from Solanaceae family (Squeira et al., 2000; EPPO, 2005; Pereyraand Sánchez, 2006; Harizanova et al., 2009; Roditakis et al., 2010; Durmuşoğlu et al., 2011; Karut et al., 2011; Ünlü, 2012; CaparrosMegidoet al., 2013; Bawin et al., 2014; Ögür et al., 2014). It is known that *T. absoluta* has many hosts, also including vegetables, as well as tomato (Miranda et al., 1998; Squeira et al., 2000; EPPO, 2005; Pereyraand Sánchez, 2006; Harizanova et al., 2009; BloemandSpaltenstein, 2011; Loni et al., 2011; Karabüyük, 2011; Karut et al., 2011; Leite et al., 2001; BalzanandMoonen, 2012; Öztemiz, 2012; Mohamed et al., 2012; Bayram et al., 2014; Mohammad, 2014; Ögür et al., 2014).

Vegetables with important production in the world and Turkey have a great place in human nutrition. Although vegetable consumption dates back to very old times, vegetable farming in a modern sense began in the 19^{th}century (Karabüyük, 2011). According to data of the United Nations Food and Agriculture Organization (FAO) from the year 2012, 1.1 billion tons of raw vegetable were produced on a total of 57.2 million hectares of area in the world with an increase of 1.7% compared to 2011 (FAO, 2014). Tomato, watermelon, onion, cabbage, cucumber, eggplant, carrots and peppers have the largest share in terms of production amounts and economic values among these vegetables.

It has been adopted the intensive use of chemicals in the control of *T. absoluta* since it was seen for the first time in Turkey. It has been determined that the available studies in the literature were conducted mostly on chemical control against the pest. However, it is a known fact that the pest developed resistance to active substances such as abamectine, cartap, methamidophos, permethrine and deltamethrine (Siqueira et al., 2000, 2001; Lietti et al., 2005). Therefore, researchers turned towards alternative methods against the pest (Lietti, 2005; Birgücü, 2014, 2015). However, although there are many studies on ecology and integrated management of *T. absoluta*, the available information related to the control of the pest in the open field cultivation is limited (BalzanandMoonen, 2012). In addition, even though there are studies conducted on the behavior and host preference of the pest, there are still deficiencies in the literature on this topic. Studies to be conducted on the behavior of the pest are important to determine control methods that can be applied against the pest and to increase the success rate of these control methods.

For the reasons mentioned above, it was aimed to determine egg-laying preferences of *T. absoluta* on its different host plants, including tomato, pepper and eggplant, in the scope of this study. To this end, egg-laying preferences of *T. absoluta* adults on aforesaid plants in a restricted flight area and the number of mines formed by hatched larvae were identified. Also, tendencies of the adults to these host plants through olfactometer system with one input and four output ends were determined.

2. MATERIAL AND METHODS

2.1 Productions of plants and Tuta absoluta

Tomato (*Solanum lycopersicum* L.) (var. Alexander), pepper (*Capsicum annuum* L.) (var. Hunty 180) and eggplant (*Solanum melongena* L.) (var. Phaselis F1) seedlings were sown in 1.5 l plastic pots containing a mixture of soil and peat (1:1 v/v). Larvae and adults of *Tuta absoluta* (Meyrick, 1917) (Lepidoptera: Gelechiidae) collected from tomato greenhouses in Antalya in 2014 were brought to laboratory within culture plates containing plant parts. Leaves of tomato plants reached 15–20 cm height were infected with these larvae brought to the laboratory, gently using the fine paintbrush. Daily maintenance and control for the plant and the pest were done regularly, and irrigation was made when considered necessary. Tomato plants in climate rooms were renovated if needed in order to increase pest population and ensure the continuity of insect stock culture. No fertilizer and chemical control against any pest or pathogen was performed during plant production. The conditions of climate rooms performed productions of plants and *T. absoluta* were set to 26±1ºC temperature, 60±5% RH and 16:8 h photoperiod. Also, all experiments were conducted under the same conditions in the laboratory.

2.2 Establishment of the experiment on the oviposition preference of the pest in a restricted flight area

In the experiment regarding egg-laying preferences of the pestin a restricted flight area, tomato, pepper and eggplant grown in 1.5 l plastic pots were positioned so as to form a “triangle” in a plexiglass cage in 30x50x60 cm dimensions, of which the upper and lateral sides covered by net. Then, an opened falcon tube containing 15 adults of *T. absoluta* was placed at the center of this triangle. The experiment was repeated 60 times in a specific order so as to coincide in equal number from each plant to each corner of the triangle. The adults were taken back from the cage by a mouth aspirator after 3 days of experiment establishment, and eggs laid by the adults on the plants were counted. Also, after 10 days of experiment establishment, the number of hatched larvae from these eggs and the number of mines formed by hatched larvae were recorded.

2.3 Establishment of the experiment on the host-preference of the pest in the olfactometer system

Primarily, 12 adults of *T. absoluta* were sucked into a 50 ml transparent falcon tube by using a mouth aspirator from the pest stock culture. Then, leaves of tomato, pepper and eggplant in 0.75 g pieces were placed in falcon tubes, of which bottom side was perforated 20-25 times by an insect pin no: 2 to allow air flow. Later, the falcon tubes with leaf piece were connected to an olfactometer with one input and four output arms, consisting of glass tubes in 50 cm length and 2 cm diameter. Next, an empty transparent falcon tube was fixed to last output end of the olfactometer as a control. Finally, the falcon tube with insects was attached to the input end of the olfactometer. After connecting all falcon tubes to the olfactometer, the individuals passed forward from 10 cm distance in a 50 cm output arm of the olfactometer were considered and recorded to be prone to the plants. The experiment was repeated 60 times in a specific order so as to coincide in equal number from each falcon tube used for the plants and control to each output end of the olfactometer. The olfactometer was cleaned with 96% alcohol and distilled water before each iteration. In addition, the number of the eggs laid to leaf pieces by female adults was separately counted at the end of each iteration.

2.4 Establishment of the experiment on the tendency of the pest to binary combinations of the host plants in the olfactometer system

Two of perforated falcon tubes with 0.75 g leaf pieces of tomato, pepper and eggplant were installed to two of four output ends of the olfactometer in a binary combination while closing other two output ends. Then, a falcon tube with 10 adults of the pest was connected to the input end of the olfactometer. After connecting all falcon tubes to the olfactometer, the individuals passed forward from 10 cm distance in a 50 cm output arm of the olfactometer were considered and recorded to be prone to the plants. As in the previous experiment, the closed ends and each falcon tube used for the plants were iteratively attached in a specific order so as to coincide in equal number to each output end of the olfactometer. The olfactometer was cleaned with 96% alcohol and distilled water before each iteration.

2.5 Establishment of the experiment on the preference of the pest between the color and host plants

In this experiment, an empty transparent falcon tube as a control and an empty falcon tube covered with black tape were fixed to two output ends of the olfactometer. Then, two of perforated falcon tubes with 0.75 g leaf pieces of tomato and eggplant were installed to other two ends. Next, the falcon tube with 12 adults of the pest was secured to the input end of the olfactometer. After connecting all falcon tubes to the olfactometer, the individuals passed forward from 10 cm distance in a 50 cm output arm of the olfactometer were considered and recorded to be prone to the plants. As in previous experiment, black and control falcon tubes, and falcon tubes containing plant parts were iteratively attached in a specific order so as to coincide in equal number to each output end of the olfactometer. The olfactometer was cleaned with 96% alcohol and distilled water before each iteration.

2.6 Statistical data analyses

Observations in the experiment on the oviposition preference of the pest in a restricted flight area were carried out at the 3rd and 10th days after experiment establishment. As for the experiment performed using the olfactometer, censuses were done 6 times, including at the 1^{st}, 3^{rd}, 5^{th}, 7^{th}, 9^{th} and 24^{th} hours after experiment establishment. Also, in the experiment on the host-preference of the pest in the olfactometer system, the number of the eggs laid to leaf pieces by female adults was separately counted at the end of each replication.

The experiments on the oviposition preference in a restricted flight, the host-preference in the olfactometer and the preference between the color and host plants in the olfactometer were repeated 60 times. However, each experiment on the tendency of the pest to binary combinations of the host plants in the olfactometer was carried out in 20 replications.

The data obtained from all experiments were firstly subjected to homogeneity test and Kolmogorov-Smirnov or Shapiro-Wilk normality tests. Then, Kruskal-Wallis H test (Kruskal, 1952; Kruskaland Wallis, 1952) was applied to the data, which were understood as non-parametric, to determine whether the difference between groups. Finally, Mann-Whitney U test (Mann and Whitney, 1947; Zar, 1996) was conducted by applying Bonferroni correction (VialatteandCichocki, 2008) to determine that the difference was caused by which group or groups. The statistical data analyses were done by using IBM® SPSS® Statistics (Version 20.0, August 2011, SPSS Inc., Chicago, IL, USA.) software package.

3. RESULTS AND DISCUSSION

3.1 Oviposition preference of the pest in a restricted flight area

The results of the data analyses showed that there were significant differences between the number of eggs laid by *Tuta absoluta* adults, the number of survival hatched larvae from these eggs and the number of mines formed by these larvae on tomato, pepper and eggplant in the restricted flight area. Considering the data of mean ranks in Table 1, it was seen that the pest preferred primarily tomato, secondly eggplant and finally pepper in respect to the number of eggs, larvae and mines (Table 1).

Table 1: The mean numbers of eggs, larvae and mines of *Tuta absoluta* on tomato, pepper and eggplant plants in a restricted flight area*

	Plants	N	Means	Standard deviation	Mean rank	df	H	p
Number of eggs	**Tomato**	60	19.82 **a**	16.633	141.79	2	144.179	0.000
	Pepper	60	0.03 **c**	0.181	30.55			
	Eggplant	60	8.03 **b**	10.253	99.16			
Number of larvae	**Tomato**	60	14.68 **a**	11.861	142.03	2	136.785	0.000
	Pepper	60	0.03 **c**	0.181	33.75			
	Eggplant	60	5.15 **b**	7.265	95.73			
Number of mines	**Tomato**	60	21.53 **a**	18.192	142.00	2	136.728	0.000
	Pepper	60	0.03 **c**	0.181	33.72			
	Eggplant	60	6.47 **b**	7.862	95.78			

*The means followed by the same letters within the same column for each numbers of eggs, larvae and mines are not significantly different from each other according to the Mann-Whitney U test (p>0.0167) conducted by applying Bonferroni correction after performing the Kruskal-Wallis H test (p>0.05).

A study conducted by Pereyraand Sanchez (2006) regarding the impact of host plant on development of *T. absoluta* determined that the development of the pest on tomato plant was better than that on potato plant. Karabüyük (2011) studied on the population development, spread and hosts of *T. absoluta* in the vegetable fields of the Eastern Mediterranean region, and stated that the pest damaged further to tomato rather than eggplant, *Convolvulus* spp. and *Solanum nigrum*. In addition, the results of several studies demonstrated that the pest caused highly damage in open field and greenhouse tomato cultivations. In the study of Portakaldalı et al. (2013a) in regard with population monitoring of *T. absoluta* and its natural enemies in open field tomatoes cultivation in Adana, It was found that adult and immature stage populations of the pest showed an increasing during the season, even 15-fold increasing at the end of the season according to starting was determined. Also, in this study, it was pointed out that larvae of the pest have formed more mines and damage as they developed. Likewise, several studies were decelerated that the density of the pest showed initially a slow increase, but a rapid increase in subsequent periods (Leite et al., 2004; Karut et al., 2011; Portakaldalı et al., 2013b).

3.2 Host-preference of the pest in the olfactometer system

It was understood that numbers of *T. absoluta* adults tended towards leaf pieces of host plants and transparent tube (Control tube) in the olfactometer system at the 1st, 3rd, 5th, 7th, 9th and 24th hours were statistically different. Additionally, tomato was the most preferred plant by the pest, followed by eggplant and control tube (Table 2).

Table 2: The mean numbers of *Tuta absoluta* adults showed tendency to parts of tomato, pepper and eggplant at the 1st, 3rd, 5th, 7th, 9th and 24th hours in the olfactometer system*

	Plants	N	Means	Standard deviation	Mean rank	df	H	P
1st hour	**Tomato**	60	4.63 **a**	1.594	255.06	4	161.350	0.000
	Pepper	60	1.33 **c**	0.914	92.87			
	Eggplant	60	2.75 **b**	0.985	184.51			
	Control	60	1.90 **c**	1.231	127.09			
	Other	60	1.38 **c**	0.739	92.98			
3rd hour	**Tomato**	60	4.97 **a**	1.484	263.13	4	187.970	0.000
	Pepper	60	1.22 **c**	0.922	88.50			
	Eggplant	60	2.83 **b**	0.905	189.63			
	Control	60	1.73 **c**	1.071	122.60			
	Other	60	1.23 **c**	0.698	88.63			
5th hour	**Tomato**	60	4.93 **a**	1.448	259.63	4	190.618	0.000
	Pepper	60	1.27 **cd**	0,800	93.53			
	Eggplant	60	3.05 **b**	1.080	197.88			
	Control	60	1.65 **c**	1.087	118.12			
	Other	60	1.12 **d**	0.739	83.34			
7th hour	**Tomato**	60	5.30 **a**	1.465	261.47	4	208.034	0.000
	Pepper	60	1.05 **cd**	0.852	89.57			
	Eggplant	60	3.28 **b**	1.075	204.98			
	Control	60	1.45 **c**	0.946	115.24			
	Other	60	0.92 **d**	0.619	81.24			
9th hour	**Tomato**	60	5.32 **a**	1.479	260.59	4	211.733	0.000
	Pepper	60	1.08 **c**	0.787	94.58			
	Eggplant	60	3.42 **b**	1.109	209.94			
	Control	60	1.28 **c**	1.027	106.72			
	Other	60	0.87 **c**	0.650	80.67			
24th hour	**Tomato**	60	5.43 **a**	1.489	261.01	4	213.735	0.000
	Pepper	60	1.08 **cd**	0.850	98.07			
	Eggplant	60	3.48 **b**	1.081	209.88			
	Control	60	1.28 **c**	1.027	108.20			
	Other	60	0.72 **d**	0.715	75.35			

*The means followed by the same letters, including separately for each hour are not significantly different from each other according to the Mann-Whitney U test (p>0.005) conducted by applying Bonferroni correction after performing the Kruskal-Wallis H test (p>0.05).

According to the results of statistical analyses, the mean numbers of eggs laid by *T. absoluta*to parts of tomato, pepper and eggplant in the olfactometer system at the end of all replications were statistically different from each other (Table 3).

Table 3: The mean numbers of eggs laid by *Tuta absoluta* on parts of tomato, pepper and eggplant in the olfactometer system*

Plants	N	Means	Standard deviation	Mean rank	df	H	p
Tomato	60	18.20 **a**	20.164	137.22			
Pepper	60	0.53 **c**	0.812	41.83	2	103.185	0.000
Eggplant	60	6.93 **b**	14.816	92.45			

*The means followed by the same letters are not significantly different from each other according to the Mann-Whitney U test (p>0.0167) conducted by applying Bonferroni correction after performing the Kruskal-Wallis H test (p>0.05).

In a study of Proffit et al. (2011) conducted about effects of leaf volatiles of different tomato varieties on attraction and oviposition behavior of *T. absoluta*females, it was determined that tomato leaf odor encouraged mated females to fly upwind, followed by landing as well as egg-laying. Also, it was found that the pest preferred culture tomato variety, *Solanum lycopersicum* rather than wild tomato variety, *S. habrochaites*. Also in this present study, it was demonstrated that female adults of *T. absoluta*laid their eggs on leaf part of tomato more than those of eggplant and pepper as well as tendency in the olfactometer system. It was understood because *T. absoluta*laid more eggs on tomato than other host plants that the plant attracted the pest more than other plants by its leaf odor in the olfactometer system. Several studies proved that the pest preferred and caused damage further to tomato (Leite et al., 2001; Pereyraand Sánchez, 2006; BloemandSpaltenstein, 2011). Additionally, a field study performed in the Eastern Mediterranean region of Turkey identified that *T. absoluta* was found on tomato and eggplant among cultivated plants, *Solanum nigrum* and *Convolvulus* spp. among weeds, and the pest damaged on tomato and leaf part of the plant more than other plants and parts (Karabüyük, 2011). In a study conducted by TatlıandGöçmen (2011) on spread and population fluctuations of *T. absoluta* in tomato production fields of the Western Mediterranean region of Turkey, it was stated that the pest was common in tomato fields, especially at spring and fall seasons.

3.3 Tendency of the pest to binary combinations of the host plants

The mean numbers of *T. absoluta* adults tended towards binary combinations of host plants in the olfactometer system at all observation times were significantly different. Based on the data obtained from the experiment conducted on the tendency of *T. absoluta* to binary combinations of the host plants, the tendency ranking of the pest from the most to the least was determined in the manner of tomato, eggplant and pepper (Table 4-6).

CaparrosMedigo et al. (2013) investigated the development of *T. absoluta* on four potato varieties. In this study, developments of *T. absoluta* on the most common four potato varieties, and one tomato plant were investigated under laboratory conditions, and it was reported that the pest had a potential to damage on potato. In another study entitled impact of plant volatiles from the Solanaceae family on host-finding behaviors of *T. absoluta*, females of the pest preferred to feed on "Moneymaker" tomato plant and "Cherlotte", "Nicola" and "Brintje" potato varieties from the most to the least, respectively (CaparrosMedigo et al., 2014).

However, lifetables of the pest on different host plants were formed, and some important bioecological characteristics which may be important in the pest management were calculated in several studies. In a study on the ecological life table of *T. absoluta* performed by Miranda et al. (1998), mortalities at egg, larvae and adult stages were computed, and the biggest mortality was found at egg stage of the pest. Also, development time of the pest showed difference based on tomato variety in the studies on biological characteristics of the pest on different tomato varieties (ÇekinandYaşar, 2015; GharekhaniandSalek-Ebrahimi, 2014; Tosun, 2014). A study of Bawin et al. (2014) demonstrated that *T. absoluta* preferred clean tomato plant for egg-laying, more than tomato plants infected 10 and 20 larvae. It was showed that the pest could not be attracted by odor of wounded plants. However, females of the pest were influenced to lay their eggs on the plant by larval density. Nevertheless, this present study proved that the pest was attracted by odor of wounded leaf pieces of tomato plant in olfactory system, and females of the pest preferred tomato leaf for egg deposition, followed by eggplant and pepper leaves.

Table 4: The mean numbers of *Tuta absoluta* adults showed tendency to parts of pepper and tomato at the 1st, 3rd, 5th, 7th, 9th and 24th hours in the olfactometer system*

	Plants	N	Means	Standard deviation	Mean rank	df	H	p
1st hour	**Pepper**	20	2.50 **b**	1.504	25.23	2	34.491	0.000
	Tomato	20	5.80 **a**	1.704	48.20			
	Other	20	1.70 **b**	0.733	18.08			
3rd hour	**Pepper**	20	2.65 **b**	1.843	27.98	2	34.520	0.000
	Tomato	20	6.10 **a**	1.832	47.45			
	Other	20	1.30 **c**	0.865	16.08			
5th hour	**Pepper**	20	2.60 **b**	1.875	28.20	2	35.990	0.000
	Tomato	20	6.25 **a**	1.832	47.78			
	Other	20	1.15 **c**	0.875	15.53			
7th hour	**Pepper**	20	2.70 **b**	1.922	29.00	2	34.128	0.000
	Tomato	20	6.25 **a**	2.049	47.13			
	Other	20	1.05 **c**	0.945	15.38			
9th hour	**Pepper**	20	2.55 **b**	2.188	28.10	2	35.159	0.000
	Tomato	20	6.50 **a**	2.090	47.70			
	Other	20	0.95 **c**	0.826	15.70			
24th hour	**Pepper**	20	2.50 **b**	2.164	28.28	2	34.589	0.000
	Tomato	20	6.65 **a**	2.323	47.53			
	Other	20	0.85 **c**	0.813	15.70			

*The means followed by the same letters, including separately for each hour are not significantly different from each other according to the Mann-Whitney U test ($p>0.0167$) conducted by applying Bonferroni correction after performing the Kruskal-Wallis H test ($p>0.05$).

Table 5: The mean numbers of *Tuta absoluta* adults showed tendency to parts of pepper and eggplant at the 1st, 3rd, 5th, 7th, 9th and 24th hours in the olfactometer system*

	Plants	N	Means	Standard deviation	Mean rank	df	H	p
1st hour	**Pepper**	20	2.80 **b**	1.152	28.33	2	41.242	0.000
	Eggplant	20	5.90 **a**	1.619	49.05			
	Other	20	1.30 **c**	0.979	14.13			
3rd hour	**Pepper**	20	2.45 **b**	1.276	26.23	2	40.892	0.000
	Eggplant	20	6.20 **a**	1.508	49.65			
	Other	20	1.35 **c**	0.813	15.63			
5th hour	**Pepper**	20	2.70 **b**	1.218	28.15	2	44.117	0.000
	Eggplant	20	6.15 **a**	1.424	49.65			
	Other	20	1.20 **c**	0.768	13.70			
7th hour	**Pepper**	20	2.80 **b**	1.240	28.68	2	43.479	0.000
	Eggplant	20	6.10 **a**	1.483	49.38			
	Other	20	1.10 **c**	1.021	13.45			
9th hour	**Pepper**	20	2.65 **b**	1.268	29.08	2	45.422	0.000
	Eggplant	20	6.35 **a**	1.531	49.55			
	Other	20	1.00 **c**	0.725	12.88			
24th hour	**Pepper**	20	2.60 **b**	1.603	29.25	2	42.286	0.000
	Eggplant	20	6.50 **a**	1.732	48.80			
	Other	20	0.90 **c**	0.718	13.45			

*The means followed by the same letters, including separately for each hour are not significantly different from each other according to the Mann-Whitney U test (p>0.0167) conducted by applying Bonferroni correction after performing the Kruskal-Wallis H test (p>0.05).

Table 6: The mean numbers of *Tuta absoluta* adults showed tendency to parts of tomato and eggplant plants at the 1st, 3rd, 5th, 7th, 9th and 24th hours in the olfactometer system*

	Plants	N	Means	Standard deviation	Mean rank	df	H	p
1st hour	**Tomato**	20	5.20 **a**	1.673	44.63	2	39.881	0.000
	Eggplant	20	3.95 **a**	1.504	35.58			
	Other	20	0.85 **b**	0.671	11.30			
3rd hour	**Tomato**	20	5.20 **a**	1.508	44.90	2	40.014	0.000
	Eggplant	20	4.00 **b**	1.451	35.30			
	Other	20	0.80 **c**	0.768	11.30			
5th hour	**Tomato**	20	5.10 **a**	1.483	43.75	2	41.727	0.000
	Eggplant	20	4.30 **a**	1.302	37.25			
	Other	20	0.60 **b**	0.503	10.50			
7th hour	**Tomato**	20	5.10 **a**	1.553	42.28	2	40.790	0.000
	Eggplant	20	4.65 **a**	1.424	38.73			
	Other	20	0.30 **b**	0.470	10.50			
9th hour	**Tomato**	20	5.25 **a**	1.618	43.20	2	41.248	0.000
	Eggplant	20	4.50 **a**	1.539	37.80			
	Other	20	0.30 **b**	0.470	10.50			
24th hour	**Tomato**	20	5.30 **a**	1.559	43.75	2	41.889	0.000
	Eggplant	20	4.45 **a**	1.356	37.25			
	Other	20	0.25 **b**	0.444	10.50			

*The means followed by the same letters, including separately for each hour are not significantly different from each other according to the Mann-Whitney U test (p>0.0167) conducted by applying Bonferroni correction after performing the Kruskal-Wallis H test (p>0.05).

3.4 Preferences of the pest between the color and host plants

The statistical analyses showed that there were significant differences between numbers of *T. absoluta* adults preferred to color and host plants at the 1st, 3rd, 5th, 7th, 9th and 24th hours in the olfactometer system (Table 7).

T. absoluta larvae have sufficient foods do not enter diapause, and the pest can give 10-12 generations under suitable conditions (EPPO, 2005). The control of this pest is difficult due to reasons such as broad host range, rapid and many reproductive. Therefore, studies on controlling of this pest are increasing more with each passing day. Biotechnical methods of pest control comprise one part of these studies.

In this present study, the preference of the pest among the color and host plants was determined.According to the results of the analyses, it was understood that black color was preferred by the pest, more than its host plants. Average 3.37 adults among 12 adults of *T. absoluta* released in the olfactometer system preferred to the black tube. Numbers of the pest preferred to leaf pieces of tomato and eggplant were average 2.98 and 2.63 adults at the end of the 1st hour. Average 1.88 adults among 12 adults of *T. absoluta* preferred to transparent control tube at the end of the 1st hour.

The pest preferred to black tube than its host plants in all the observations made during the experiment. The pest also tended towards tomato more than other hosts. The preference ranking of the pest at the end of the experiment become in the form of black color, tomato, eggplant and transparent control tube from the most to the least, respectively (Table 7). In another study, it was announced that black sticky trap can be effective in the control of *T. absoluta* in the greenhouse cultivation (Anonymous, 2015). Again, black sticky traps with pheromone and without pheromone were used against *T. absoluta*, and attraction effects of these traps on *T. absoluta* adults were investigated in a study conducted in a tomato greenhouse by Oba et al. (2014). The results of the study showed that the black color in both traps with and without pheromone was effective to attract the pest. Additionally in this study, shades at different wavelengths of black sticky trap were used, and numbers of adults captured these traps were found significantly different (Oba et al., 2014). As for the present study performed by using the olfactometer, it was determined that the black color was more preferred by *T.*

absoluta than the odor of tomato leaf. This last point should receive attention because the data suggest that the black color can be effective in the scope of biotechnical control for the pest.

Table 7: The mean numbers of *Tuta absoluta* adults showed tendency to parts of pepper and tomato as well as transparent and black tubes at the 1st, 3rd, 5th, 7th, 9th and 24th hours in the olfactometer system*

	Plants	N	Means	Standard deviation	Mean rank	df	H	p
1st hour	**Tomato**	60	2.98 **a**	1.359	186.20	4	90.936	0.000
	Eggplant	60	2.63 **a**	1.288	168.55			
	Control tube	60	1.88 **b**	1.541	119.32			
	Black Tube	60	3.37 **a**	1.594	202.53			
	Other	60	1.13 **b**	0.833	75.90			
3rd hour	**Tomato**	60	2.88 **ab**	1.354	182.79	4	115.933	0.000
	Eggplant	60	2.57 **b**	1.226	167.69			
	Control tube	60	1.87 **c**	1.512	120.63			
	Black Tube	60	3.78 **a**	1.786	216.69			
	Other	60	0.88 **d**	0.761	64.70			
5th hour	**Tomato**	60	2.95 **ab**	1.346	185.61	4	119.937	0.000
	Eggplant	60	2.63 **b**	1.193	170.38			
	Control tube	60	1.75 **c**	1.361	112.88			
	Black tube	60	3.70 **a**	1.640	216.68			
	Other	60	0.98 **d**	0.770	66.96			
7th hour	**Tomato**	60	3.12 **ab**	1.277	193.14	4	151.575	0.000
	Eggplant	60	2.72 **b**	1.106	174.03			
	Control tube	60	1.62 **c**	1.303	107.68			
	Black tube	60	3.80 **a**	1.471	222.09			
	Other	60	0.73 **d**	0.660	55.56			
9th hour	**Tomato**	60	3.33 **ab**	1.446	200.23	4	145.198	0.000
	Eggplant	60	2.83 **b**	1.330	177.23			
	Control tube	60	1.60 **c**	1.417	109.71			
	Black tube	60	3.63 **a**	1.573	210.64			
	Other	60	0.60 **d**	0.718	54.70			
24th hour	**Tomato**	60	3.27 **ab**	1.471	196.96	4	141.422	0.000
	Eggplant	60	2.77 **b**	1.212	174.38			
	Control tube	60	1.58 **c**	1.293	105.88			
	Black tube	60	3.65 **a**	1.459	215.33			
	Other	60	0.73 **d**	0.899	59.95			

*The means followed by the same letters, including separately for each hour are not significantly different from each other according to the Mann-Whitney U test (p>0.005) conducted by applying Bonferroni correction after performing the Kruskal-Wallis H test (p>0.05).

4. CONCLUSION

Tuta absoluta preferred tomato more than eggplant and pepper. Also, eggplant was more preferred by the pest than pepper. Although pepper is a hos plant of the pest, this plant was almost no preferred by the pest in the restricted fly area. However, even if it was less when compared with other host plants, pepper was preferred by the pest to lay egg in the olfactometer system. The data showed that the pest can use pepper as host plant in compulsory cases. In addition, it was concluded that attractive feature of the black color can be used in the scope of biotechnical control against the pest.

5. POTENTIAL CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

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