INTERNATIONAL JOURNAL OF ENVIRONMENTAL SCIENCE AND ENGINEERING (IJESE)
Vol. 5: 99- 109 (2014)
http://www.pvamu.edu/research/activeresearch/researchcenters/texged/international-journal
Prairie View A&M University, Texas, USA

Evaluation of pheromone lures for trapping the tomato borer moths, *Tuta absoluta* in tomato fields in Egypt.

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ARTICLE INFO
Article History
Received: Oct. 12, 2014
Accepted: Dec. 15, 2014
Available online: Jan.2015

Keywords:
Gelechiidae
Lepidoptera
Moths
Pheromone lures
Tuta absoluta
Tomato borer

ABSTRACT
The tomato borer, *Tuta absoluta* (Lepidoptera: Gelechiidae) is now considered to be one of the most damaging invasive pests of tomatoes in the world. In the present study, we examined the effect of four trap designs on the capture of male *T. absoluta*; the performance efficacy and longevity of five commercial available sex pheromone formulations in Egypt. In response to trap design in the field, the best results were obtained with the delta-baited sex pheromone trap being 269.67 average numbers of *T. absoluta* males/ trap. However, the lowest results were recorded by the Pherocon-V baited sex pheromone trap being 139.17 average numbers of *T. absoluta* males/ trap. Results showed that attractiveness of the commercial sex pheromone formulations tested, except pheromone lure type Tutasan, remained highly attractive to male tomato borer for up to 4 weeks in tomato fields. The mean total number of males captured did not differ significantly among delta traps baited with: pheromone type, Tuta lure (292.33 average numbers of moths/ trap) baited with 0.5 mg of synthetic pheromone (E3.z8.z11 Tetradecatrieny acetate/ E3.z8. Tetradecatrieny acetate); pheromone type, Tutacap longlife (294.60 average numbers of moths/ trap) baited with 1.5 mg of synthetic pheromone ((E,Z,Z)- 3,8,11- Tetradecatrieny acetate) and pheromone type, Tryferron (269.47 average numbers of moths/ trap) baited with 0.6 mg of synthetic pheromone (E3Z8Z11-14AC (3,8,11- Tertacatrien-1-ylacetate-(E,Z,Z)). Data showed that there was significant degradation of lure performance (attractiveness) over the period of the experiment. The Tuta 100N commercial sex pheromone lure was the best dispenser for catching the *Tuta absoluta* males for long times post pheromone application. The high biological activity of the synthetic pheromone lures suggests that it could be useful for pest monitoring, in mating disruption and IPM of *T. absoluta* in tomato fields.

1. INTRODUCTION
The tomato borer, *Tuta absoluta* (Meyrick) (Lepidoptera: Gelechiidae) is an invasive pest of tomato native to South America (Urbaneja *et al.*, 2009).

ISSN 2156-7530

In 2009, it was detected in Marsa Matrouh Governorate near the border of Libya and subsequently spread rapidly in all Egyptian Governorates with variable levels (Temerak, 2011). Since the initial detection, the pest caused serious damage to tomato in invaded areas (Mohamed, 2011), and it is currently considered a key agricultural threat to tomato production. The caterpillars of this species feed on the leaf mesophyll and also damage tomato flowers, fruit and stems. The tomato borer major sex pheromone components have been identified as (3E, 8Z, 11Z) -3, 8, 11- tetradecatrien-1-yl acetate (E3 Z8 Z11-14 Ac) (Attygalle *et al.*, 1995). In addition to the major component, a miner constituent (<10 of volatile material) was identified as (3E, 8Z)- 3,8- tetradecadien-1-yl acetate (3E,8Z-14 Ac)(Griepink *et al.*, 1996 ; Fihlo *et al.*, 2000). Zalom *et al.* (2008) used pherocon 1-C traps in monitoring surveys for the tomato pinworm, *Keiferia lycopersicella*. Pherocon 1-C traps operate similarly to delta traps. The efficacy of 6 commercial pheromone traps (Biagro, Opennatur, Trece, Trece 178, Susbin and Trece 179) in trapping *T. absoluta* were measured by Alfaro *et al.* (2009) over 14 weeks in Spain. They determined the pheromone load of the traps and the lifetime of the trap emissions. The initial pheromone load of the first 3 traps was 318.2, 419.9 and 535.5 µg, respectively. While those of the last 3 traps listed above were 1615.5, 1886.6 and 2850.9 µg, respectively. From week 10, the most effective trap was Opennatur, which suggested that trap lifetime was 6-9 weeks. Trece 179 was the only trap that maintained emission up to 14 weeks. The efficacy of five trap designs was evaluated by Ferrara *et al.* (2001) using 1 µg of the synthetic major component (3E, 8Z, 11Z)-3,8,11-tetradecatrienyl acetate (TDTA) of the sex pheromone emitted by *T. absoluta* females. They found that the synthetic major component was highly attractive to conspecific males. Bavaresco *et al.* (2005) evaluated the seasonal fluctuation of the tomato leaf worm, *T. absoluta* adults using pheromone lures baited in delta traps in Brazil. In Venezuela, Salas (2004 and 2007) studied the capture of *T. absoluta* in traps baited with its sex pheromone ((3E, 8Z, 11Z) -3, 8, 11-tetradecatrienyl acetate (95%) + (3E, 8Z)-3,8- tetradecadienyl acetate (5%)), dispensed in rubber septa in experimental tomato plots, using water traps and delta sticky traps. He showed that water trap had a greater number of captures with differences compared to delta sticky trap.

The tomato borer synthetic sex pheromone has been efficiently used for monitoring (Harizanova *et al.*, 2009; Braham, 2014), mass trapping (Taha *et al.*, 2013), and mating disruption (Fihlo *et al.*, 2000). Efficiency of pheromone baited traps or matting disruption could be affected by many factors, such as trap design, pheromone composition, pheromone dispenser, duration of lures and climate, etc. (Carde' and Minks, 1995; Reddy and Urs, 1996; Môttus *et al.*, 1997). Since the tomato borer is a serious pest in tomato fields, the above mentioned factors should be considered in designing a good trap to capture the males. Therefore, the objectives of this study were: i) to determine the effect of four trap designs on the capture of male *T. absoluta*; ii) to compare the performance of five marks of the most used sex pheromone capsules in Egypt and iii) to compare efficacy and longevity of five commercial available sex pheromone formulations.

2. MATERIALS AND METHODS

Three experiments were performed at a commercial farm in El-Manawat village (Giza Governorate) to determine the effect of four trap designs on the capture of male *T. absoluta* and to compare efficacy and longevity of five commercial available sex pheromone formulations. All the experiments were conducted during the period between May and July 2012.

2.1 Trap design evaluation:

The four trap designs evaluated were: (1) Pherocon IIB-baited sex pheromone trap; (2) delta-baited sex pheromone trap; (3) Pherocon V-baited sex pheromone trap and (4) Storgard thinline-baited sex pheromone trap. Each trap was baited with a pheromone lure (TUTA- 100N) containing 3mg/ dispenser of synthetic pheromone [(E,Z,Z) -3,8,11-Tetradecatrienyl acetate]. Traps with lures were hung approximately 50 cm above the ground on 5th of May when tomato plants were 65 days old, and were randomly assigned to position within a straight line (30 m between traps) that was perpendicular to the prevailing wind direction.

Tuta absoluta moths on each trap surface were counted on 7, 10, 12, 14, 17 and 19 of May 2012. After each count, the stickem sheet was removed and replaced by new one, and the trap designs were rerandomized their position. Moths' catches were recorded every 2-3 days. The number of captured *T. absoluta* males per cm^2 were calculated, and also the percentage of attraction for each trap designs were recorded.

2.2 Lure evaluation:

Five commercially available *T. absoluta* sex pheromone lures were evaluated in commercial field in El-Manwat village, Giza governorate (Table 1). The treatments were arranged in a fully randomized block design with three replicates of each treatment. The replicate blocks were arranged in parallel lines approximately 30m apart within the field. Standard red delta traps (obtained from Russell Company) were installed 60 cm above the ground level by strong metal wire and were baited with individual lures. Trap capture were recorded every 2-3 days from 25 May to 9 July 2012. Thus a total count of *T. absoluta* male observations was carried out. On each trap observation date, traps within the same replicate were rerandomized in order to minimize the influence of trapping location. After each count, the sticky surface was replaced.

Table 1: The selective used of pheromone lures.

Trade name	Active ingredient	Concentration /dispenser	Rate of application (monitoring)
TUTA-100N	(E,Z,Z) -3,8,11-Tetradecatrienyl acetate	3 mg/ dispenser	2 dispenser/ fedden
Tuta lure	E3.z8.z11 Tetradecatrieny acetate/ E3.z8. Tetradecatrieny acetate	0.5 mg/ dispenser	2 dispenser/ fedden
Tryferron-	‡AC (3,8,11- Tertacatrien-1- ylacetate-(E,Z,Z)	0. 6 mg/ dispenser	2 dispenser/ fedden
Tutacap-long life	(E,Z,Z)- 3,8,11- Tetradecatrieny acetate	1.5 mg/ dispenser	2 dispenser/ fedden
Tutasan	pherodis	0. 8 mg/ dispenser	2 dispenser/ fedden

2.3 Longevity evaluation:

The longevity of five commercial available *T. absoluta* lures was evaluated under field conditions. Field evaluations were performed by placing red delta traps baited with the commercial lures (Table 1) under field conditions for period ranging from 2-6 weeks. In addition to the traps baited with aged lures, control traps baited with fresh lures also were placed in the field. Treatments were set up in a randomized block (line) design (30 m between traps) with three replicates. The numbers of moths captured in all traps in each treatment were recorded.

3. RESULTS

The capture of some commercial pheromone formulations, trap designs and longevity of lures were evaluated as a first step to maximize the effectiveness of pheromone traps for developing a system for monitoring tomato borer *T. absoluta* in tomato fields.

3.1 Trap design evaluation:

An experiment was conducted in a tomato field to evaluate the efficiency of four designs of traps for monitoring male

tomato borer, *T. absoluta*. The total mean number of captured tomato borer males for all traps pooled through the study was 884.17 males with a mean of 331.6 moths per trap per night (Table 2). The highest mean number of captured tomato borer males per trap per day was 269.83 males with delta trap, whereas, the lowest was 139.17 males in case of Pherocon V-baited sex pheromone trap. On the other hand, the caught tomato borer, *T. absoluta* male moths per trap per night was ranged between 52.20 and 101.20 males per trap per night.

Table 2: Effect of trap design baited with Tuta 100N on the capture of *T. absoluta* male in tomato field during summer season.

Trap design	Baited trap		Unbaited trap	
	Mean no. of moths/ trap/day	Mean no. of moths/night/trap	Mean no. of moths/trap/day	Mean no. of moths/night/trap
Pherocon-IIB	238.67 a	89.50 b	14.67 a	5.50 c
Delta	269.83 a	101.20 a	13.67 a	5.10 c
Pherocon-V	139.17 b	52.20 c	34.83 a	13.10 a
Storgard thinline	236.50 a	88.70 b	20.83 a	7.80 b
Overall mean	884.17	331.6	84	31.5
F value	7.82	562.07	1.75	136.63
LSD value	59.79	2.923	21.75	1.027

Means with the same letter in the same column are not significantly different.

Pheromone baited delta traps caught significantly more males (36.0%) than baited Pherocon-V traps which caught only 15.74% of the total males captured, whereas there was no significant difference between Delta traps, Pherocon-IIB and Storgard thinline traps which caught 36.00%, 26.90% and 26.70% of the total count, respectively (Table 3). The trapping surface area of four trap designs was different with about 2.46 times between the smallest (Delta) and the largest (Storgard thinline) traps. Comparison of the mean number of males per square centimeter of trapping surface indicated significant difference in their relative efficiency (Table 3).

Table 3: Trapping surface area, mean number of *T. absoluta* males captured per unit of trapping surface area, percentage of attraction and trapping ratio.

Trap design	**Trapping surface area (cm^2)**	**Mean no. of trapped /cm^2**	**Attraction % of trap**	**Trapping ratio***
Pherocon-IIB	609.50 c	0.39 b	26.90 b	16.27 a
Delta	503.50 d	0.54 a	36.00 a	19.74 a
Pherocon-V	1176.00 b	0.12 c	16.70 c	3.99 c
Storgard thinline	1239.00 a	0.19 c	26.70 b	11.39 b
F value	724.29	21.42	12.49	25.71
LSD value	45.952	0.135	7.664	4.391

Means with the same letter in the same column are not significantly different.
*Trapping ratio = Attraction in baited trap: Attraction in unbaited trap.

Delta (0.54 mean of males/cm^2) and Pherocon-IIB traps (0.39 mean no. of males/cm^2) captured significantly more males per unit of trapping surface than Storgard Thinline (0.19 mean no. of males/cm^2) or Pherocon-V (0.12 mean no. of males/cm^2) traps (Table 3). Unbaited traps of all designs caught the fewer number of males than the

same baited traps. The Pherocon-V traps with pheromone captured approximately four times more males than the same unbaited traps. Baited Storgard thinline traps captured 11.39 times more males than unbaited traps. Baited delta traps caught 19.74 times more than unbaited delta traps. While baited pherocon-IIB traps captured 16.27 times more than control traps (Table 3). In response to trap design in field, the best results were obtained with the delta-baited sex pheromone trap being 269.67 average numbers of *T. absoluta* males/ trap. However, the lowest counts were recorded by the Pherocon-V baited sex pheromone trap being 139.17 average numbers of *T. absoluta* males/ trap (Table 2).

3.2 Lure evaluation:

Total number of moths recorded during the period of experiment is presented in Table (4). Data showed that attractiveness of the commercial sex pheromone formulations tested except pheromone type, Tutasan remained highly attractive to male tomato borer for up to approximately 4 weeks in tomato fields. Therefore, the attractiveness of all lures declined steady till the end of experiment. Red delta traps baited with sex pheromone type, Tuta 100N with 3mg of synthetic pheromone ((E,Z,Z) -3,8,11-Tetradecatrienyl acetate) caught significantly more male *T. absoluta* moths (24.6%) than those baited with pheromone type, Tutasan with 0.8 mg of synthetic pheromone (pherodis) which caught only 13.4% of the total males captured. The average number of trapped males in tomato crop was 341.20 moths/ trap with Tuta 100N lure. The maximum caught of *T. absoluta* males was recorded at 9th June 2012 being 517 moths/ trap in Tuta 100N commercial lure. The attractiveness of adults was 186.47 average numbers of males per trap in Tutasan lure. The maximum number of captured *T. absoluta* males was 293 moths per trap at 6 June 2012 in case of Tutasan commercial lure (Table 4).

Table 4: Effect of synthetic five pheromone lure formulations baited in Delta trap on number of captured *T. absoluta* males during summer.

inspection date	number of captured *T. absoluta* males/ trap					control
	Tuta 100 N	Tuta lure	Tutacap longlife	Tryferron	Tutasan	
May, 25th 2012	433	337	410	378	357	14
27th	337	307	328	286	329	11
29th	477	374	423	370	303	5
31rd	379	343	323	277	251	0
June, 2nd 2012	458	343	369	325	342	3
4	365	347	350	341	284	0
6	459	430	421	295	293	2
9	517	396	434	386	205	2
1	348	367	347	346	106	2
1	437	396	423	346	153	0
23rd	342	372	333	362	131	0
2	195	135	53	71	23	0
July, 3rd 2012	271	167	148	197	14	0
6	64	56	53	59	6	0
9	36	15	4	3	0	0
Total	5118	4385	4419	4042	2797	39
Mean	341.2 a	292.33a	294.6 a	269.47 ab	186.47 b	2.6 c
F value	14.36					
LSD value	91.257					

Means with the same letter in the same row are not significantly different.

The mean total number of males captured did not differ significantly among delta traps baited with pheromone type, Tuta lure (292.33 average numbers of moths/ trap) baited with 0.5 mg of synthetic pheromone (E3.z8.z11 Tetradecatrieny acetate/ E3.z8. Tetradecatrieny acetate), pheromone type

Tutacap longlife (294.60 average numbers of moths/ trap) baited with 1.5 mg of synthetic pheromone ((E,Z,Z)- 3,8,11-Tetradecatrieny acetate) or pheromone type Tryferron (269.47 average numbers of moths/ trap) baited with 0.6 mg of synthetic pheromone (E3Z8Z11-14AC (3,8,11- Tertacatrien-1-ylacetate-(E,Z,Z)). Unbaited control traps caught relatively few numbers of males than baited traps (Table 4).

3.3 Longevity evaluation:

Data presented in Table (5) showed that there was a significant degradation of lure performance (attractiveness) over the period of experiment. Red delta traps baited with 3mg of Tuta 100N synthetic pheromone remained attractive to male *T. absoluta* moths for at least 30 days. Significant difference in male *T. absoluta* captures were found among traps baited with fresh lures and lures aged for 15, 30 and 45 days. The number of males trapped was found to be 442/348, 220/195 and 62/36 for fresh/ aged lure at 15, 30 and 45 days, respectively (Table 5). The relative attractancy of lures after 45 days was 58.06% of aged lures (Fig. 1). Traps baited with 0.5 mg of Tuta lure synthetic pheromone appeared to behave like the traps baited with pheromone type Tuta 100N. There was a significant difference in male captures between traps baited with fresh lures and traps baited with lures aged outdoors for 15, 30 and 45 days. The number of male captures was found to be 427/367, 169/135 and 31/15 for fresh/ aged lure at 15, 30 and 45 days, respectively (Table 5). The relative attractancy of aged lure after 45 days was 48.39% of aged Tuta lure (Fig. 1).

Table 5: Effect of different pheromone lures age on the number of attracted *T. absoluta* males by Delta trap.

Trade name \ Inspection date		1st day (25/5/2012)	15th day (12/6/2012)	30th day (26/6/2012)	45th day (9/7/2012)
Tuta 100 N	Fresh*		442[a]	220[a]	62[a]
	Aged	433	348[b]	195[b]	36[b]
		Probability	0.0001	0.0025	0.0034
Tuta lure	Fresh		427[a]	169[a]	31[a]
	Aged	337	367 [b]	135[b]	15[b]
		Probability	0.0009	0.0008	0.0006
Tutacap longlife	Fresh		347[a]	109[a]	14[a]
	Aged	410	273[b]	53[b]	4[b]
		Probability	0.0005	0.0001	0.0036
Tryferron	Fresh		346[a]	86[a]	9[a]
	Aged	378	204[b]	71[b]	3[b]
		Probability	0.0001	0.0227	0.0303
Tutasan	Fresh		275[a]	216[a]	10[a]
	Aged	357	106[b]	23 [b]	0[b]
		Probability	0.0001	0.0001	0.0010

Red delta traps baited with fresh lures, Tutacap longlife with 1.5mg of synthetic pheromone caught significantly more moths than traps baited with lures aged for 15, 30 and 45 days. The number of males captured was 347/ 273; 109/ 53 and 14/ 4 for fresh (1-day old)/ aged lure at 15, 30 and 45 days, respectively (Table 5). The relative attractancy of lures after 45 days was 28.57% of aged Tutacap longlife type (Fig. 1). Red delta traps baited with 0.6mg of Tryferron synthetic pheromone aged for 15, 30 and 45 days in the field prior to the experiment caught significantly less male moths than those baited with fresh (1-day old) lures. The

number of males captured was to be 346/204, 86/71 and 9/3 for fresh/ aged Tryferron at 15, 30 and 45 days, respectively (Table 5). The relative attractancy of aged Tryferron after 45 days was 33.33% from the standard lures (Fig. 1).

In case of pheromone type Tutasan, the captures of lures decreased rapidly as compared with fresh lures (Table 5). Red delta traps baited with fresh lures caught significantly more male moths than those baited with lures aged for 15, 30 and 45 days. The number of males captured was to be 275/106, 216/23 and 10/0 for fresh/ aged at 15, 30 and 45 days, respectively. The relative attractancy of aged Tutasan lure after 45 days was zero% from fresh lures (Fig. 1). Generally, the Tuta 100N commercial sex pheromone lure was the best dispenser for catching the *Tuta absoluta* males for long times post pheromone application.

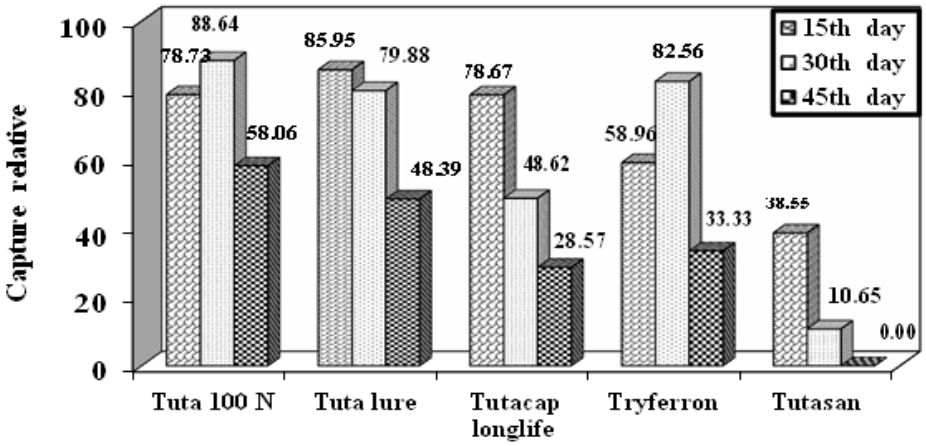

Fig. 1: Effect of lure age upon capture rates of male moths.

4. DISCUSSION

4.1 Trap design evaluation:

To assess the efficiency of four designs of traps, the field experiments were conducted to determine the attractiveness of *T. absoluta* male moths. In response to trap design in the field, the best results were obtained with the red delta trap baited with sex pheromone being 269.83 average numbers of *T. absoluta* males per trap. However, the lowest results were recorded by pherocon-V trap baited with pheromone lure being 139.17 average numbers of *T. absoluta* males/trap. Pheromone baited delta traps caught significantly more males (36.0%) than baited pherocon-V traps which caught only 15.7% of the total males captured. In the same field, Abbes and Chermiti (2011) suggested that the utilization of the sex pheromone delta trap was a good indicator of the infestation rate of the crop.

The capture of *T. absoluta* males caught per four trap designs was arranged descendible i.e. red delta, pherocon-IIB, storgard thinline and pherocon-V. Similarly, Vitullo *et al.* (2007) deployed green delta, pherocon-IIB, pherocon-V, Jakson and storgard thinline traps for monitoring pink hibiscus mealy bug, *Maconellicocus hirsutus* (Hemiptera: Pseudococcidae). They recorded that pheromone-baited trap with larger trapping surfaces (green delta, pherocon-IIB and pherocon-V traps) captured more males per trap than those with smaller surfaces (Jakson and storgard thinline traps). Moreover, Ferrara *et al.* (2001) evaluated the efficacy of five types of traps to determine the attractiveness of *T. absoluta*, and reported that the best results were obtained with the CICA-R trap design, which was probably due to its completely open shape.

The obtained results showed that the red delta trap catches about 269.83 males caught per delta trap design which was probably due to its completely open shape and easy to collect the insects. High trap efficiency was related to ease access of insects to traps (Wyman, 1979). Admittedly, red delta sex pheromone trap attracts a considerable number of males and therefore may reduce possibilities of mating and oviposition on tomato plants. Habib *et al.* (2011) stated that delta trap are more efficient than water traps for attractiveness of *T. absoluta* males in open field, but the water trap was more efficient than delta trap in glasshouse conditions. Also, Herman *et al.* (2005) stated that 'DESE' sticky traps (delta trap) caught more potato tuber moths than 'A-trap' sticky trap (cylinder shaped) and funnel traps. Salas (2004 and 2007) evaluated the attractiveness of water traps and delta sticky traps for *T. absoluta* moths. He showed that water trap captures ranged from 1.25 and 4.33 adults per trap per night and delta sticky trap between 0.52 and 2.75 a/t/n during five weeks. However, water trap had a greater number with differences compared to delta trap. Bavaresco *et al.* (2005) showed that seasonal fluctuation of *T. absoluta* effect on the quantity of males captured in delta traps. Sharidi *et al.* (2011) used the delta type of pheromone traps for monitoring *T. absoluta* in the Kingdom of Saudi Arabia. However in Iraq, Alasady *et al.* (2011) conducted that green and yellow delta traps recorded 98 and 96 adults/trap/week, respectively, but the maximum number (538 adults) of *T. absoluta* was recorded in open water trap designs. While, Zalom *et al.* (2008) routinely used pherocon 1-C traps in monitoring surveys for the tomato pinworm, *Keiferia lycopersicella*. They reported that pherocon1-C traps operate similarly to delta traps that used to survey *T. absoluta*. In conclusion, the obtained results showed that the red delta and pherocon-IIB traps catch about 269.83 and 238.67 males caught per trap, respectively, which were probably due to its completely open shape and easy to collect the insects. This means that the same number of pheromone dispenser more *T. absoluta* could be captured by two trap designs which reduce the cost of using pheromone traps in an IPM program.

4.2 Lure evaluation:

In the present study, results indicated that pheromone have become important tools for monitoring and controlling agricultural pest populations, as such, a large compendium of over 1600 pheromones and sex attracts had been published in the past four decades (Reddy and Guerrero, 2010). The obtained data showed that the highest attractiveness of *T. absoluta* males was recorded with Tuta 100N commercial sex pheromone baited in red delta trap (consisted of (E,Z,Z) -3,8,11-tetradecatrienyl acetate with 3 mg/ dispenser as major component lure), but the lowest captured of *T. absoluta* male moths was obtained by Tutasan commercial sex pheromone baited in red delta trap (consisted of pherodis with 0.8 mg/ dispenser). It was frequent according to Svatos *et al.* (1996), who reported that the major and minor components should be used in a 90: 10 proportion, respectively. Moreover, Ferrara *et al.* (2001) found that the synthetic major component (3E,8Z, 11Z)-3,8,11-tetradecatrienyl acetate (TDTA) was highly attractive to conspecific males; they recorded that the best trap baited with 100µg of the synthetic sex pheromone caught an average of 1200 males per trap per night. While, Abbes and Chermiti (2011) indicated that the average of weekly catches in traps with pherodis dispensers had apparently better performance due to the relatively higher number of trapped males even four weeks after their installation.

The attractiveness of *T. absoluta* male was descending arranged as Tuta 100N, Tutacap longlife, Tuta lure, Tryferron and Tutasan as 341.2, 294.6,

292.33, 269.47, and 186.47 males/ trap under field conditions, respectively. Otherwise, Chermiti and Abbes (2012) recorded the comparison between the three types of tested capsule (Koppert 0.5 mg; Russell 0.5 mg; Optima 0.8 mg). They showed that Optima type dispensers can attract more males than others. Also, Habib *et al.* (2011) compared the efficiency of different commercial lures of *T. absoluta* males as Russell Optima, Russell longlife, Atlas Agro, Atlas Agro (gray, white and red) and Koppert. They found that Russell Optima lures showed better effect than gray Atlas Agro, Koppert and Russell longlife. As in the present study, the large concentrated dispenser by active ingredient viz. Tuta 100N (concentrated 3 mg/ dispenser) was recorded the highest captured of *T. absoluta* males.

4.3 Longevity evaluation:

The present data showed that there was significant degradation of lure performance (attractiveness) over the period of the experiment. After 15 days, the level of catches was high, which is likely to be due to the high density of sex pheromone lure dispenser. The relative attractancy of lures after 45 days was 58.06%, 48.39%, 28.57%, 33.33 and zero% for fresh lures in comparison with aged lures in case of Tuta 100N, Tuta lure, Tutacap longlife, Tryferron and Tutasan lures, respectively. Results showed that the Tuta 100N commercial sex pheromone lure was the best dispenser for catching of the *T. absoluta* males for long times post application up to about four weeks. Similarly, Alfaro *et al.* (2009) determined the pheromone load of the traps and the lifetime of the trap emissions, and they found that the most effective traps (in terms of individuals trapped per day) were those with the highest pheromone load (Trece 178, Susbin and Trece 179) up to 9th week. However, the most effective trap was Opennatur, which suggested that trap lifetime was 6-9 weeks; Trece 179 was the only trap that maintained emission up to 14 weeks. They concluded that Trece 179 has a higher level of capture and a better longevity. Otherwise, Nunez *et al*. (2009) detected that the trap captures recorded 96% for the first 78 days after dispenser installation, falling to 92% at 106 days. Moreover, Chermiti and Abbes (2011) showed that the long lifespan of the three types of tested capsules (Koppert 0.5 mg; Russell 0.5 mg; Optima 0.8 mg), as they found that the higher attraction by Russell–type capsules was detected, but Koppert-type emitters showed more stability. From another perspective, the long lifetime of sex pheromone of *T. absoluta* males could be an important tool to control this pest.

The lifetime or longevity of dispenser may be affecting by different factors viz. kind and composition of a rubber septum of capsule, concentration and formulation of active ingredient, percent of emission of dispenser, intensity of the wind and exposed temperature. As like as, McNeil (1991) reported that several factors affect the emission and reception of pheromones, mainly temperature.

In our study, the best pheromone lure types are Tuta 100N, Tutacap longlife. Although, no significant difference was evident in their attractancy Tuta 100N showed the greatest longevity of the tested lure type. These results suggested that a monitoring program for the tomato borer, *T. absoluta* should consist of sex pheromone lure type Tuta 100N with 3mg/ dispenser placed in red delta trap and lures should be replaced at least every 4 week.

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