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Evaluating the Role of Sex Pheromone in Monitoring and Controlling Tomato Leaf Miner, *Tuta absoluta* (Meyrick), Under the Egyptian North Western Coast Conditions

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ABSTRACT

The status of tomato leaf-miner, *Tuta absoluta* (Meyrick), at Matrouh Governorate, Egypt was investigated under the greenhouse conditions during 2010 season as the first documented data concerning the crossing of this pest into the Egyptian borders coming from Libya. In both El-Kasr region and Siwa Oasis, the periodical monitoring of *T. absoluta* male moths on both tomato and eggplant were carried out using the sex pheromone lure baited traps. Also, the influence of male collection technique and one tracer spraying on declining the larval infestation were evaluated. Data declared that, tomato was the most preferable host for *T. absoluta* than other solanaceous crops, the in-time hanging of sex pheromone baited traps inside the tomato or eggplant greenhouse besides tracer spraying when necessary were the factors that ensured the achievement of less larval infestation. In addition, the influence of neighbor solanaceous crops on the infestation outbreak was also considered. Also, the detection of *T. absoluta* larvae on the wild solanaceous shrub, *Solanum nigrum* (Black nightshade) was documented for the first time within the valleys of Matrouh Governorate. Mass trapping and lure and kill application of pheromone have been found to be effective for controlling *T. absoluta*.

Key words: *Tuta absoluta*, solanaceous crops, wild solanaceous shrubs, sex pheromones, tracer, Egypt.

INTRODUCTION

The tomato leaf miner, *Tuta absoluta* (Meyrick) (Lepidoptera: Gelechiidae), is the most devastating pest of both wild and cultivated solanaceous plants. Tomato yield reduction due to *T. absoluta* ranged from 50 to 100 %. Among other solanaceous plants, potato and aubergine (eggplant) have been also reported as hosts (Galarza, 1984 and Notz, 1992), together with *Lycopersicon hirsutum*, *Solanum lyratum* and various wild solanaceous species such as; *Solanum nigrum*, *S. elaeagnifolium*, *S. puberulum*, *Datura stramonium*, *D. ferox* and *Nicotia naglauca*. This economic pest originated from and threatened tomato crop in South America several decades ago. Its first detection in Spain was in 2007 and one year later in Morocco, Algeria, Tunisia and some European countries. Through its crossing the Libyan's borders, the pest was firstly detected in Egypt in the beginning of 2010, threating national production of solanaceous crops. It poses extremely significant threat to greenhouse and open field tomatoes.

Accordingly, this study aimed to evaluate current status of the pest in Matrouh Governorate (the closest Egyptian Governorate to the Libyan's borders), to induce yield loss in some solanaceous crops and to estimate efficacy of sex pheromone lure in mass trapping and consequently its influence on yield production.

MATERIALS AND METHODS

Study sites

Two sites in Matrouh Governorate were chosen to implement this experiment. These sites represent the most Egyptian-Libyan border areas that characterized by several solanaceous crop cultivations (tomato, eggplant and pepper... *etc.*).

The first experimental site was at El-Kasr region (25 km western of Matrouh City). In this site, two greenhouses (270 m^2) were cultivated by the tomato seedlings of Vito variety (ground variety) on 5/4/2010. In order to estimate the behavior of the pest on tomato plant, one Delta sticky sex pheromone baited trap (the lure with its sticky board) was hanged ten days after seedling cultivation per one greenhouse (on April 15th). The sticky board was replaced each 2 or 3 days according to the intensity of male catches, while the dispenser replacement was done every 40 days. To estimate the efficacy of this pheromone trap in reducing tomato crop losses, periodical samples of 40 tomato branches (about 10 cm length with its 3 or 4 carrying leaves) were taken every 4 days from both tomato greenhouses in order to compare the intensity of larval infestation between trap hanged greenhouse and the control one. At the beginning of the fruiting season, periodical tomato fruit samples (30 fruits) were also collected to estimate the progress of tomato fruit injury in both greenhouses. Larval attack of *T. absoluta* on both eggplant and pepper cultivations under nearby greenhouses (leaves and fruits) was also monitored.

Siwa Oasis, approximately 70 km of the Libyan's borders, was the second experimental location. In this location, several solanaceous crops are cultivated annually under the greenhouse conditions (including; tomato, eggplant and pepper). To

estimate the previous parameters, 2 sex pheromone lures with their sticky boards were hanged on 15/5/2010 in two eggplant greenhouses (one lure per each greenhouse). The cultivated eggplant seedlings were of Keem variety and the greenhouses were of 360 m^2 area. The influence of the neighbor tomato cultivation on the behavior of *T. absoluta* adult and larval stages was considered.

Beside these experimental locations, one sex pheromone baited trap was hanged in the neighbor wild solanaceous black nightshade shrub, *Solanum nigrum*, in Habbes valley (17 km western Matrouh city) in order to explore if *Tuta* invasion reached such wild solanaceous herb or not. Accordingly, periodical visits to such valley were done for inspecting *Tuta* larval attack.

RESULTS AND DISCUSSION

Monitoring of *T. absoluta* at El-Kasr location

Response of male moths to the female pheromone dispenser at El-Kasr location was graphically represented in Fig.1, where, male landing to the sticky board was immediate and male accumulation recorded about 538 males per 3 nights, following pheromone trap hanging. Monitoring of the successive inspection dates revealed continues progress in the number of male catching till April 30th (Fig. 1). A total of 538 male moths were caught, three nights following pheromone hanging, 758 males were recorded holding on the stick board of the trap on April 21st. Subsequent increase in the number of male catches was noticed till 30/4/2010. Where, on the later inspection date, number of male catches recorded about 2 folds its value (1107 males) in the first inspection date. By early May (4/5/2010), intensive male capture gradually declined up to May 23rd. As the number of stuck males on the trap sticky board recorded about 1069 males on May 4th, continuous diminish in the number of male catches through the successive inspection dates was recorded till reached about ¼ its initial value (237 males) on May 23rd. During the interval period between the later inspection date and the following one (May 23rd to May 28th), sudden flux in the caught male moths occurred. Such increment in the number of male catch (about 466 males) may be resulted by the removal of the severely attacked tomato plants cultivated in a nearby greenhouse. Such action may cause the massive migration of *T. absoluta* moths to the treated greenhouse, which was reflected in the increased number of caught males on the pheromone trap sticky board (Fig. 2). Accordingly, two precautions were considered in order to face this action; the first was the spraying of the trap hanged greenhouse on June 5th with the suggested dose of the biocide "tracer", which previously proved its lethal effect on *Tuta* caterpillars. Tracer spraying was done due to the outbreak of leaf infestation that was graphically represented in Fig. 3. The second action was exchange of the trap lure at end of May (May 29th), in order to increase the male attraction force, which also synchronized with the recommendation mentioned on the flyer of the lure production company (dispensers were replaced every 4-6 weeks). Monitoring of the male catches through the subsequent inspection dates (Fig. 1) exhibited re-diminishing in the number of male catch. As 314 males were recorded stuck in the pheromone trap on May 31st, about 1/6 this value was recorded at the last inspection date (about 47 male moths on June 21th), with gradual decrease in the number of caught males during in-between inspections.

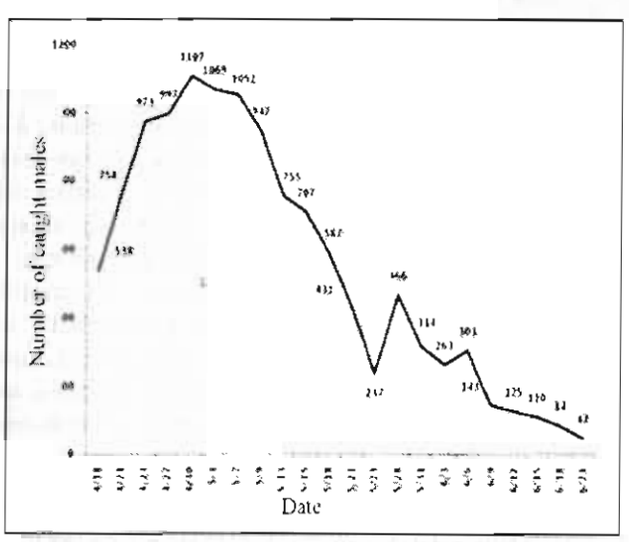

Fig. (1): Monitoring of tomato leafminer male moths on tomato plants under greenhouse conditions at El-Kasr locality, Matrouh Governorate, Egypt, season 2010.

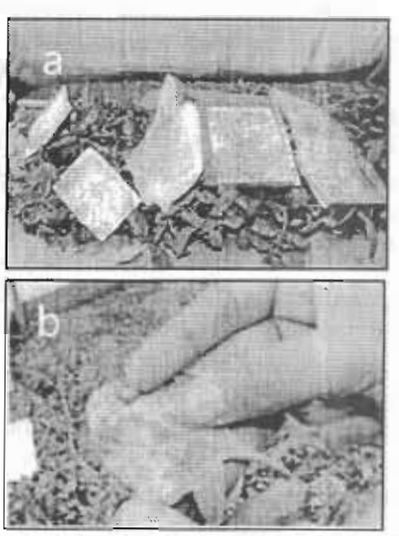

Fig.(2): (a): Catches of *T. absoluta* moths on the sticky boards of the sex pheromone traps. (b): Mines or galleries of *Tuta* larvae in tomato leaf.

Fernando *et al.* (2001) concluded that dispensers loaded with 1-ug of the synthetic major component (3E; 8Z; 11Z)-3, 8, 11-tetradecatrienyl acetate (TDTA) of the sex pheromone emitted by *T. absoluta* females were found to be highly attractive to conspecific males. Also, in their field experiments they found that the trap that baited with 100-ug of the synthetic sex pheromone caught on average 1200 males per trap per night, while those baited with virgin females caught only 201 males. The male response to this pheromone was restricted to the same early-morning time window during which females exhibited calling behavior of mating. The high biological activity of the synthetic pheromone suggests that it could be useful for pest monitoring and mass trapping of the adult males. In synchrony, Miguel *et al.* (2000) stated comparable trend in such concern.

Leaf infestation of tomato plants

In synchrony with the monitoring of *T. absoluta* male moths, periodical estimations of larval infestation in trap hanged greenhouse comparing with that in the untreated one (without sex pheromone trap) was scheduled. In Fig. 3, such correlation was graphically represented. On May 19th, the first tomato leaf sample was taken. As no larval infestation in the treated tomato leaf sample was noticed, 41 larval infestations were in the untreated sample. Five days later (on May 24th), larval infestation increased up to 56 and 2 larvae in the untreated and treated samples, respectively. Following the period at which the neighbor severely attacked tomato plants were removed (from May 23rd till May 28th), sudden increase in larval infestation in the treated greenhouse due to this action was observed. Larval infestation in the treated samples increased from 2 larvae on May 24th to 6 and 13 ones on May 31st and June 4th, respectively.

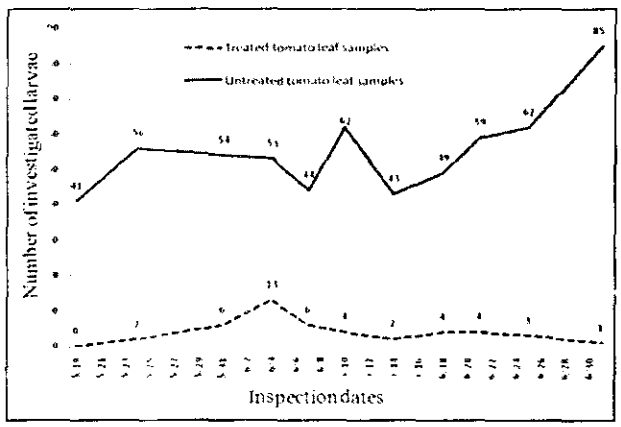

Fig. (3): Monitoring of tomato leafminer larvae found in tomato leaves under greenhouse conditions at El-Kasr regoin, Matrouh Governorate, Egypt, season 2010

Accordingly, on June 5th tracer spraying at 30 ml/100 L was applied to face such larval infestation. 2 days later (June 7th) the recorded larval count within the treated sample was 6 larvae comparing with 44 ones in the untreated sample. The salient point was the gradient diminishing in the larval count within the treated sample at the later inspection date till reached about ½ its value at that recorded in the previous inspection date. Investigating tomato leaves of the treated sample on June 7th revealed that, 4 larvae from the 6 recorded ones were being dead within their leaf tunnels. Tracer spraying may be the reason of such larval mortality. Similar trend was typically repeated on June 10th inspection date. During the period that extended from June 14th till July 1st, larval infestation in the treated samples were fluctuated from 4 detected larvae to only one larva comparing with an average of about 60 larvae within the untreated samples during the same period.

Presence of the severely attacked tomato plants that were in the neighbor of the treated greenhouse was the most important reason for protecting experimental greenhouse from attack by *Tuta* larvae. As, the seedlings of the severely attacked tomato plants were being cultivated earlier (on March 22nd) than the treated tomato, *Tuta* moths were attracted in huge numbers to attack them causing great losses (Fig. 3); *i.e.*, the early cultivated tomato plants in the neighbor greenhouse acted as a natural trap for *Tuta* moths and consequently serve in protecting the late cultivated ones. Also, early hanging of the traps played a vital role in the continuous diminishing of male moths and consequently decreased both mating opportunity and egg deposition.

Fruit infestation of tomato plants

While the onset of the fruiting system, sequential samples of tomato fruits were picked up (30 fruits)

Table (1): Monitoring of *T. absoluta* larval infestation in tomato fruits under greenhouse conditions at El-Kasr regoin, Matrouh Governorate, Egypt, season 2010

Date	Number of *T. absoluta* larvae	
	Trap hanged greenhouse	Untreated greenhouse
31/5	0	25
7/6	0	30
14/6	0	22
21/6	0	27
1/7	0	27

from trap hanged greenhouse and the control one to compare the progress of *Tuta* larval infestation to tomato fruits (Table 1). The salient point was the zero larval infestation recorded on the tomato fruits among the treated samples. The combined effect of both male catching technique through the hanged sex pheromone baited trap as well as the in-time tracer spraying (one immediate spraying during the leaf infestation outbreak) acted as a firewall against the progress of larval injury to tomato fruits. Also, the proper timing of sex pheromone hanging that early synchronized with the tomato seedling cultivation gave the chance of the specific lure to well-done its mission in trapping the early invasive waves of *Tuta* male moths and consequently decreased the mating and egg laying chances. Over time, the more male moths catching, the less tomato infestation occurred. Whereas, among the 30 tomato fruit sample, that periodically collected from the untreated greenhouse, *Tuta* larval infestation fluctuated from totally infested fruits, which being 30 larvae/ 30 fruits on June 7th to 22 ones per 30 fruits on June 14th.

Application of the bio-pesticide "Tracer" for controlling *T. absoluta* was highly promising. According to the FERA (The Food and the Environment Research Agency), three insecticidal active ingredients have exhibited satisfactory efficacy against *T. absoluta* larval infestations in Spanish outbreaks; *Bacillus thuringiensis* subsp. *kurstaki* (Dipel DF), indoxacarb (Steward) and spinosad (Conserve/ Tracer). The three insecticides are approved for use in the UK, on protected tomato, pepper and aubergine, as well as ornamental plant production. Tracer (Spinosad) is effective against a broad range of lepidopteran insect pests (Wanner *et al.*, 2000 and Crouse *etal.*, 2001). In addition to its ovicidal activity, spinosad according to Thompson *et al.* (2000) is especially insecticidal to small caterpillars by ingestion and contact, but especially by ingestion. The ability of spinosad to penetrate plant cuticle, although it isn't a plant systemic (Cowles *et al.*, 2000) gave it additional flexibility for controlling the existing borer.

Continuous monitoring of other solanaceous crops cultivated in the greenhouses nearby was also carried out in order to rank the status of *Tuta* larval attack on such crops. It was worth to note that, both eggplant and pepper (sweet and spicy) were the main cultivated solanaceous crops. Among which, moderate leaf infestation of both was recorded with greater attack of eggplant leaves than the sweet pepper ones. In contrary, no larval invasion was recorded attacking spicy pepper at-all (either leaves or fruits) throughout the whole monitoring period. The spicy material content may play a certain role in protecting the spicy pepper from being attacked by *T. absoluta*. Concerning the eggplant fruits, the periodical monitoring exhibited that, the progress of larval infestation was stopped and didn't exceed the leaves to fruits.

Such pre-mentioned observation could be analyzed as follow, as tomato plant (both leaves and fruits) is the main and the most favorable host for *Tuta* larvae, the presence of tomato cultivation in the neighbor of other solanaceous ones may protect them from being attacked by *Tuta* caterpillars; *i.e.*, *Tuta* larvae direct their move to invade tomato plants and consequently any neighbor solanaceous crop become much less infested, which maybe the noticed scenario in this study.

Monitoring of *T. absoluta* male moths in Siwa Oasis

Effect of sex pheromone baited traps hanged in the second experimental location (Siwa Oasis) on male catches was graphically represented in Fig. 4. From such figure, it was worth to note that although *Tuta* moths preffered to attack tomato plants than eggplants, huge number of catched *T. absoluta* male moths was recorded in the first trap comparing with that occuurred at El-Kasr location (the first location). The delaying in the pheromone lure suspension till an advanced stage of eggplant development (on May 15th) allowed the intensive build up of *Tuta* moths into the eggplant greenhouse from the beginning of seedling cultivation, which was reflected by the great male catch. Also, in contrary with that occurred at El-Kasr regoin, the severely invaded tomato greenhouse in the neighbor of the eggplant one was completely removed. This action may lead to the sever invasion of *Tuta* moths to the eggplant greenhouse. Concerning the second pheromone trap hanged in the greenhouse, it was easy to observe that the rate of male catches was in-general less than that achieved in the first eggplant greenhouse. The distance of the second greenhouse

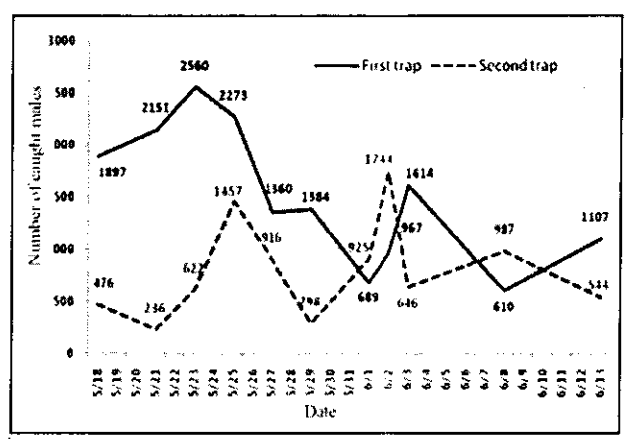

Fig. (4): Monitoring of *T. absoluta* moths on eggplant under greenhouse conditions in Siwa Oasis, Matrouh Governorate, Egypt, season 2010.

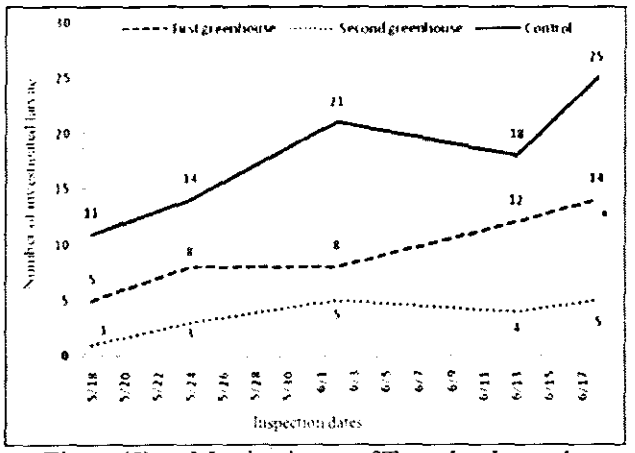

Fig. (5): Monitoring of*T. absoluta* larvae attacking eggplant leaves under greenhouse conditions in Siwa Oasis, Matrouh Governorate, Egypt, season 2010.

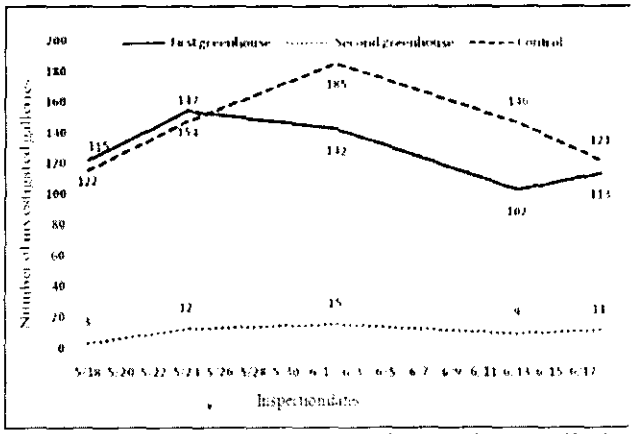

Fig. (6): Monitoring of *T. absoluta* making galleries on eggplant leaves under greenhouse conditions in Siwa Oasis, Matrouh Governorate, Egypt, season 2010.

from the removed tomato one may play a vital role in reducing the continuous supply of *Tuta* moths within this greenhouse. In spite of this, mass male catching was done in such greenhouse on June 3th and 8th. Also, the smaller sized greenhouse at El-Kasr location may enhance the powerful attraction of *Tuta* males more than that occurred in the wider greenhouse in Siwa Oasis. Thus, the emission sources for the male attracting odour must be overlaped to cover everywhere within the greenhouse; that may be the case in the small sized greenhouse at El-Kasr regoin. The minor detection of leaf injury in the latter greenhouse may support such remark. In contrary, more than one male lure may be required in the wider greenhouses in Siwa Oasis, with a special arrangemment that insure complete coverage of the emited male attractive odour, which requires furthur study.

Estimating leaf infestation in eggplant

Comparing leaf infestation of eggplant within both Siwa's greenhouses, it was easy to observe that both larval infestation and symptoms (the larval feeding galleries) were highy represented in the leaf samples of the 1st greenhouse. As the larval infestation within the leaf sample of the 1st greenhouse ranged between 14 and 5 larvae on May 18th and June 18th, respectively, that of the 2nd greenhouse didn't exceed 5 larvae. The leaf infestation average could be arranged in an ascending manner as following; the 2nd greenhouse with an average of about 3.6 larvae then the 1st one with about 9.4 larvae and finally about 17.8 larvae represented the average infestation in the check greenhouse (Fig. 5).

In order to simulate what was happened at El-Kasr regoin, tracer spraying was done with the same concentration (at 30 ml. /100 L.) on June 7th. In contrary with that occurred at El-Kasr regoin and as shown in fig.(5) , larval infestation following tracer spraying wasn't reduced within the leaf samples of both greenhouses. After tracer spraying in the 1st greenhouse, leaf infestation recorded 12 and 14 larvae on June 13th and 18th, respectively. In the 2nd greenhouse similar trend was observed. Delay in decision making for trap hanging and tracer spraying may lead to massive increase of *T. absoluta* invasion in such a way that neither continuous male catch nor ovilarvicidal properties of tracer could achieve satisfying results.

In contrary to the tomato leaf, eggplant has a wide leaf area which enable counting number of the galleries of by *T. absoluta* larvae. As shown in Fig. 6, great number of galleries (about 126.6) was easily counted on the leaf samples that collected from the first greenhouse conferming the intensive migration of *Tuta* moths inside this greenhouse and consequently the sever attack of its caterpillers. Whereas, the little number of such galleries on the leaf samples of the 2nd greenhouse was due to the moderate attack of *Tuta* larval stage.

In conclusion:

- Continuous investigations of the wild flora that inhabited Matrouh valleys declared that, *Tuta* male moths were attracted to the hanged pheromone traps and its larval stage was recorded attacking the leaves of the wild solanaceous black night shade; *Solanum nigrum*. Accordingly, it is important to explore the wild solanaceous herbs in Matrouh valleys to detect their suitability for *Tuta* attacks.
- Detection of *Tuta* invasion to the leaves of wild solanaceous shrubs in Matrouh valleys showed a need for giving attention to the pest on its wild hosts.

- Wrong practices of getting rid of infested and/ or waste plants may assist in infestation and dispersal to the economic neighbor cultivations.

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