J. Crop Prot. **2021, 10 (4): 701-710**

Research Article

Performance of light traps in the capture of tomato leafminer, *Tuta absoluta* (Lepidoptera: Gelechiidae)

Mohammad Javad Ardeh[1*], Tahere Kheirkhah[2] and Majeed Askari Seyahooei[3]

1. Department of Entomology, Iranian Research Institute of Plant Protection (IRIPP), Tehran, Iran.
2. Department of Plant Protection, Faculty of Agriculture, University of Zanjan, Zanjan, Iran.
3. Plant Protection Research Department, Hormozgan Agricultural and Natural Resources Research and Education Center, Agricultural Research Education and Extension Organization (AREEO), Bandar Abbas, Iran.

Abstract: Tomato leafminer moth *Tuta absoluta* (Meyrick) is an important pest of the tomato plant. Light traps can play an influential role in reducing the pest population. Different light colors, three trap sizes, and three installation heights were evaluated under laboratory conditions. The light colors were white, yellow, green, red, blue, and blacklight blue (BLB). The traps, transparent containers of three sizes were 8.5, 10.5, and 14.5 cm in diameter and 15, 19, and 26 cm in height, respectively. The trap installation heights were 50, 75, and 100 cm above the plants' canopy. The BLB color proved significantly more attractive to *T. absoluta,* followed by yellow and white colors. The light traps captured more males than females and more mated females than virgin ones. Both of the larger traps (10.5 cm d × 19 cm h and 14.5 cm d × 26 cm h), and higher installed ones (100 cm and 75 cm above the plants), captured a significantly higher number of moths compared to the smaller trap size and lower installation height. Accordingly, for mass trapping of moths, light traps with BLB source of light, with 10.5 cm in diameters and 19 cm in height, and installation at 75 cm above the canopy is recommended in greenhouses.

Keywords: Tomato leafminer, non-chemical control, BLB light, insect trapping, greenhouses

Introduction

Tomato leafminer, *Tuta absoluta* (Meyrick) (Lepidoptera: Gelechiidae), is considered one of the most important tomato pests in the world (Oerke *et al*., 1994; Desneux *et al*., 2011). This pest was introduced into Iran in 2011, and it is considered a threat to tomato production (Baniameri and Cheraghian, 2012). Larvae of the pest devour the host plants at any developmental stage, from seedlings to full-grown plants, but they prefer apical buds and immature fruits. This pest has a high reproductive potential (about 250 eggs) and is capable of producing several generations (10-12) in a year (Desneux *et al*., 2010). Therefore several strategies are necessary to manage its damages, including cultural, biological, and chemical control. Chemical control seems to be an effective method (Abd El-Ghany *et al*., 2016). However, it has side effects on the environment, natural enemies, and human health (Gacemi and Guenaoui, 2012; Campos *et al*., 2015). Meanwhile, the short generation times result in resistance to insecticides rapidly (Lietti *et al*., 2005). Hence, the application of pesticides causes a significant threat to the sustainability of biological control programs in tomato

Handling Editor: Jafar Mohaghegh-Neyshabouri

* Corresponding author: ardeh@iripp.ir
Received: 20 April 2021, Accepted: 07 December 2021
Published online: 22 December 2021

[Downloaded from jcp.modares.ac.ir on 2024-11-30]
[DOR: 20.1001.1.22519041.2021.10.4.5.5]

greenhouses (Arno and Gabarra, 2011). Therefore, eco-friendly and sustainable control methods have been suggested for the pest (Batalla-Carrera *et al*., 2010; Molla *et al*., 2011; Vacas *et al*., 2011). For example, several parasitoids have been reported as biological control agents against tomato leafminer (de Medeiros *et al*., 2009, Luna *et al*., 2010, Ferracini *et al*., 2012, Zappalà *et al*., 2013). For instance, native parasitoids (belonging to 13 genera) are used against the pest in Europe (Zappalà *et al*., 2012). In addition to parasitoids, several predator species are reported, such as mirid bugs, *Macrolophus pygmaeus,* and *Nesidiocoris tenuis,* which can be used alongside other biocontrol agents (Molla *et al*., 2009). For example, the control level of *T. absoluta* was significantly increased when *M. pygmaeus* was released along with parasitoids (*Trichogramma* spp.) (Chailleux *et al*., 2013). The biological agents might even be used along with *Bacillus thuringiensis* application (González-Cabrera *et al*., 2010).

Mass trapping is also an attractive alternative method for capturing the adults of *T. absoluta.* It could significantly reduce the damage percentage compared to insecticide-treatments (Aksoy and Kovanci, 2016). Since the adults are nocturnal and fly towards a light source at night, several light traps are developed to capture them (de Oliveira *et al*., 2008, Cocco *et al*., 2012, Salama *et al.,* 2015). For example, by adding a pheromone dispenser, a modified light trap was developed to capture thousands of males and a substantial number of females per night (Bloem and Spaltenstein, 2011). Adding a specific light source to a pheromone trap could improve the effectiveness (over the standard pheromone trap alone) up to three folds. These traps were installed near the entry doors of greenhouses during sunset and sundown (Bloem and Spaltenstein, 2011). In the meantime, the light traps should be used in greenhouses where insect-proof screens are used for the windows that prevent entrances to the pest (Bloem and Spaltenstein, 2011).

Nevertheless, more properties and factors of light traps should be considered, e. g., light source, trap size, and trap installation height, to choose the most efficient one for *T. absoluta.* Therefore, this research aimed to evaluate these properties and factors of light traps for capturing *T. absoluta.*

Materials and Methods

Preparation of insects

Infested tomato plants with tomato leaf miner larvae were collected from the Varamin region (Tehran province, Iran). The plants were put in a climate room (11 m^2) (26 ± 2 °C, 60 ± 10% RH, and 16L: 8D). Emerged adults were provided a sugar solution of 10% (cotton pieces soaked) to enhance maturation. Some green fruits were also added to feed the pest larvae and complete their life cycle. The infested plants were renewed every two weeks or, the experiments were continued with a new source of infested plants.

Traps design

Transparent cylindrical containers made from clear plastic (polyethylene terephthalate (PET), were chosen as traps. The primer trap size was 8.5 cm in diameter and 15 cm in height. Two hundred thirty holes (0.5 cm in diameter) were made in the trap walls for moth entrance, except the basal part (2.5 cm) into which 0.5% detergent solution was poured to entrap captured moths. Then a light source was installed in each trap (Fig. 1).

Figure 1 The blacklight trap designed for *Tuta absoluta.*

[Downloaded from jcp.modares.ac.ir on 2024-11-30]

[DOR: 20.1001.1.22519041.2021.10.4.5.5]

Light sources experiment

Different light sources (220 V, 24-28 W, and T3 coil bulbs specified in Table 1) were compared in a completely randomized design. Light sources were installed in 4 different primary traps (8.5 cm diameter × 15 cm height). Then each of them was established in the corner of a frame of wooden (1.5 m × 1.5 m) hung about two meters above the infested plants (2.5 m above the floor) in the climate room in three experiments. After each experiment, the light source (sometimes two) with the highest captured moths was chosen to compare with the other light sources in the following experiment. Different light sources were found for yellow and blue lights in the market labeled as blue2 and yellow2 used in the experiments (Table 2).

Table 1 Light colors used as trap components for trapping *Tuta absoluta* moths.

Lights	Watts (w)	Wave length (nm)	Peak light codes	Company
Red	24	640-680	FF3300	Noavaran
Yellow	24	570-590	FFCC00-FFCC33	Noavaran
Green	24	570-600	009933	Noavaran
Blue	24	450-495	0033CC-0033FF	Noavaran
Yellow2	28	580-610	FFCC00-FFCC33	Amanoor
Blue2	28	470-495	333399-3333CC	Zomorrod
White	28	400-700	FFFFCC	Pars
Blacklight blue	26	360-390	BLB	Rashed light

Table 2 Number of *Tuta absoluta* moths caught in different light color traps.

Experiments	Light colors[1]	No. of moths per trap (Mean ± SE)			
		Total	Males	Females	
				Mated	Virgin
Exp. 1	Blue1	32.0 ± 10.6a	14.8a	8.3a	8.9a
	Green	7.1 ± 1.4b	3.8b	1.6b	1.7b
	Yellow	3.6 ± 1.1c	2.1c	0.9c	0.7c
Exp. 2	Yellow2	129.8 ± 36.4a	67.5a	28.9a	33.3a
	Blue2	65.1 ± 19.5b	32.4b	14.8b	17.9b
	Blue1	34.1 ± 12.2bc	16.6c	8.4c	9.1c
	Green	4.9 ± 0.9d	2.7d	0.7d	1.5d
Exp. 3	BLB light	145.3 ± 8.6a	92.8a	32.9a	19.6a
	Yellow2	12.8 ± 5.2b	8.1b	3.2b	1.5b
	White	11.1 ± 3.5b	7.8b	2.5bc	0.9b
	Blue2	6.9 ± 2.0c	4.0c	1.7c	1.2b

[1] For light colors, refer to table 1.
Comparison by post-hoc z-test, $P < 0.01$.

In exp. 1, the light sources that emitted the primary colors (red, green, and blue) and yellow light (a day-like); in exp 2, a light source emitting green, blue, yellow2, and blue2 colors, and in exp. 3, BLB (blacklight blue), blue2, white and yellow2, light sources were tested.

Trap sizes experiment

Three sizes of plastic containers: small (8.5 cm diameter × 15 cm height), medium (10.5 cm diameter ×19 cm height), and large (14.5 cm diameter × 26 cm height) were compared. Each trap was installed in the corner of a triangular wooden frame (1.3 m long on each side) at the 2 m height, while the most attractive light source was installed in each one (based on the experiment of trap light sources).

Trap height experiment

Finally, three traps, namely, the proper light source and the appropriate trap size based on the previous experiments, were chosen to select

[Downloaded from jcp.modares.ac.ir on 2024-11-30]

[DOR: 20.1001.1.22519041.2021.10.4.5.5]

the best installation height. Each trap was installed in the corner of the imaginary triangle as mentioned above at three different heights, 50, 75, and 100 cm (above the infested plants).

All experiments were done in a completely randomized design with eight replications (eight days). The light sources of the traps were turned on for 4 h, from the beginning of the night 8.30 pm). The next day, the captured moths in each trap were counted and separated by sexes. Then the females were dissected under a stereomicroscope and checked if their spermatheca were empty or contained sperms.

Statistical analysis

Except for the red light that did not attract moths, the results of all other light experiments were analyzed using generalized linear models (GLM). A Poisson distribution was chosen in the GLM model for all experiments to cover the count data where the response variable was the number of trapped insects. Meanwhile, the number of captured moths were statistically compared, in terms of their sex (f/m) and female virginities, using a post-hoc z-test. The free statistical software R ver. 3.1.0 (Therneau and Grambsch, 2000; R Core Team, 2015) was used for all comparisons.

Results

All light sources attracted the adult moths except red light, and the data analysis showed that the numbers of trapped moths were significantly different. The means comparison revealed that the highest attraction rate was recorded for blue light (32 moths per trap), which was significantly different from the attraction rate of yellow and green light sources (Z = 38.99, $P < 0.001$). The density of trapped moths for the green and yellow lights (7 and 3.6 moths/trap; respectively) was also significantly different (Z = 14.17, $P < 0.001$) (Table 2).

In the next trial, the numbers of trapped moths by different light sources were statistically different; yellow2 = 129.8 (Z = 115.99, $P < 0.001$), blue2 = 65.14 (Z = 84.69, $P < 0.001$), blue = 34.14, and the green = 4.93 (Z = 58.04, $P < 0.001$) (Table 2). In the last test BLB light was grouped in the first position (145.27 moths per trap; Z = 110.32, P < 0.001), where yellow2 and white lights (with 12.8 and 11.14 moths/trap respectively; Z = 1.318, P = 0.187) were grouped in the second position and the blue2 light (6.86; Z = 14.77, P = 0.001) was placed in the last group (Table 2).

Overall, the number of males by each light trap was higher than the females, and the mated females were greater than the virgin ones. However, no significant interactions were recorded among the sexes and the light sources (Table 2).

The number of trapped moths by the three sizes of traps (small, medium, and large sizes) were significantly different ($\chi^2 = 23.94$, df = 2, $P < 0.001$). The differences were also found between the number of males and females captured with the traps (Table 3, $\chi^2 = 561.02$, df = 2, $P < 0.001$). However, there were not any interaction effect among sexes and the trap sizes ($\chi^2 = 2.61$, df = 4, $P = 0.62$). A post-hoc Z-test revealed the highest attraction rate for the medium size (28.0 moths/trap), which was statistically similar to the large size (26.25 moths/trap) (Z = 1.16, $P = 0.24$).

Table 3 Number of *Tuta absoluta* moths caught in different trap sizes and trap installation heights above the plants.

Experiments	Entries	No. of moths per trap (Mean ± SE)			
		Total	Males	Females	
				Mated	Virgin
Trap sizes	Small	26.3 ± 7.8a	12.5a	8.3a	3.5a
	Medium	28.0 ± 6.9a	16.1a	8.3a	3.7a
	Large	21.3 ± 4.2b	14.5a	6.3a	2.4b
Installation trap height (cm)	100	37.9 ± 6.5a	20.8a	17.7a	11.2a
	75	34.5 ± 8.4a	8.0a	8.3b	4.5b
	50	21.1 ± 7.0b	9.0b	8.5b	5.4b

Comparison by post-hoc z-test, $P < 0.01$.
Small: 8.5 cm d × 15 cm h; Mediyum: 10.5 cm d × 19 cm h; Large: 14.5 cm d × 26 cm h.

[Downloaded from jcp.modares.ac.ir on 2024-11-30]

[DOR: 20.1001.1.22519041.2021.10.4.5.5]

Comparing trapped moths by their sexuality and virginity of females; the highest attraction rate was recorded for the males (Z = 20.61, $P <$ 0.001) and mated females ranked in the following position, which significantly was higher than the virgin females (Z = 12.01, $P <$ 0.001) (Table 3).

The density of moths was significantly different among the three installation heights (χ^2 = 128.33, df = 2, $P < 0.001$). The attractions of the light trap for different sexes were also found to be significantly different (χ^2 = 8.99, df = 1, P = 0.0027). However, no interaction effect was recorded among sexes and the trap heights (χ^2 = 2.21, df = 2, P = 0.32). A post-hoc Z-test revealed that the two installation heights of traps, at 75 and 100 cm above the infested plants, were not significantly different (Z = 1.94, P = 0.052), while the trapped moths were significantly more in 50 cm (Z = 52.34, $P < 0.001$).

The males were significantly greater than females (Z = 21.74, $P < 0.001$). However, the trapped females were not affected by the virginity of the females (Z = 1.29, P = 0.19) (Table 3).

Discussion

Mass trapping is a pest control strategy in the IPM program for several crops (El-Sayed *et al*., 2006). This technique is a non-poisonous and non-hazardous method for many natural enemies. Therefore it can be a part of environmentally friendly programs (Braham, 2014). Hence, it can be used along with other pest control methods to achieve successful pest management (Matos *et al*., 2012; Li et al., 2017). Our study was also motivated by the earlier works that mentioned mass trapping methods for controlling *T. absoluta* (de Oliveira *et al*., 2008; Lobos *et al*., 2013). Mass trapping of *T. absoluta* is usually achieved by pheromone traps. Each trap has a pheromone dispenser traditionally installed above a water pan to seize the attracted moths (Cocco *et al*., 2012; Caparros *et al*., 2013; Braham, 2014). The pheromone traps could only capture *T. absoluta* males (Witzgall *et al*., 2010), but each *T. absoluta* male can mate with several females, while parthenogenesis is also reported in the females (Silva, 2008; Caparros *et al*., 2012). Therefore, using pheromone traps for controlling the pest population is debatable. In contrast, light traps usually capture both males and females.

Consequently, it is mentioned that adding a light source to a conventional pheromone trap can improve the mass trapping method by capturing both sexes of *T. absoluta* (Cocco *et al*., 2012). It is also reported that the effectiveness of mass trapping for reducing pest damages is more achievable at low or moderate population densities (Aksoy and Kovanci, 2016). Yet, several aspects of a light trap could be optimized to develop an effective mass trapping technique (El-Sayed *et al.,* 2006). Accordingly, this study revealed a way to optimize the light sources, the trap sizes, and the trap installation heights for mass trapping of *T. absoluta.*

Light properties, particularly wavelength, color saturation, and brightness, strongly affect insects' behaviors (Antignus, 2000). For example, even insects might attract a light source, but the responses to that light might vary when different light sources are available. Accordingly, except for the red light, all light sources that were tested could attract *T. absoluta* moths. However, the numbers of the moths captured by the same light were varied among the experimental phases. Moreover, we tried the commercial light sources, where some limitations were for choosing the light sources (e.g., the wattage of the bulbs (24 or 28 watts)). Yet, the results showed that those slight differences in light sources have less influence than the light color for capturing *T. absoluta*.

Traps attract many insect species with UV light sources (Shimoda and Honda, 2013). Comparison of light traps with different color light sources (including yellow, green, black, light blue, and black) proved that black light-blue could catch significantly higher leafhoppers in sugarcane fields (Thein *et al*., 2011). Our results also demonstrated that the traps with BLB light sources are better than other color light traps for catching *T. absoluta* moths.

[Downloaded from jcp.modares.ac.ir on 2024-11-30]

[DOR: 20.1001.1.22519041.2021.10.4.5.5]

Since the pupae mainly occur in the soil, the pheromone traps are usually installed close to the ground to capture the emerged adults (Lobos *et al*., 2013). Even light traps are installed on the ground to capture males and females (Cocco *et al*., 2012; Braham, 2014). The tomato plant foliage could make barriers for lights to be received by the adults, whereas pheromone is dispensed everywhere and attracts the males regardless of those barriers. Yet, the adult moths can emerge during the daytime and escape before being caught by those light traps and could fly away and disperse easily and quickly (El-Rahman Salama *et al*., 2015). Therefore, when delta traps were installed above the canopy of tomato plants, many males were seized (Aksoy and Kovanci, 2016). Our results also demonstrated that installing the light traps above the infested plants could solve the challenges, and a successful mass trapping of the T. absoluta moths could occur. Meanwhile, the BLB light traps could capture many females, including mated ones. They would lose the chances of oviposition.

It is reported that the sizes and installation heights of traps influence the number of moths captured (Muirhead-Thompson, 1991). For example, a trap that was installed in a higher position caught more *Vitacea polistiformis* (Harris) (Lep.: Sesiidae) than a trap that was installed at a lower position (Liburd *et al*., 2018). Our results also showed that the number of captured tomato leafminer moths were greater in the two upper installation heights (75 cm and 100 cm above the canopy) than in the lower position (50 cm), with no significant differences. However, installing traps at about 75 cm above the canopy is more applicable, although growing tomato plants face challenges.

Meanwhile, it has been shown that a pheromone trap with a bigger adhesive size caught more *Zeuzera pyrina* L. (Lep. Cossidae) than a pheromone trap with a smaller adhesive size (Ardeh *et al*., 2014). We also found that the two bigger sizes of the light traps caught significantly more moths than the smaller ones.

Conclusions

A light trap with a BLB light source, with a minimum size of 10.5 cm in diameters and 19 cm in height at 75 cm above the plants, could be the most effective trap for mass trapping. However, all the possible entrances for nocturnal pests (doors and windows) should be closed or have appropriate anti-insect screens during mass trapping in greenhouses. Still, more studies should be realized, e. g., the density of light traps per ha. and portable energy sources under field conditions, to increase the chances of the mass trapping method.

Acknowledgments

We would like to thank Mr. A. Mohammadipour and A. Sheikhi for helping in the preparation of the traps and setting up the experiments.

References

Abd El-Ghany, N. M., Abdel-Razek, A. S., Ebadah, I. M. A. and Mahmoud, Y. A. 2016. Evaluation of some microbial agents, natural and chemical compounds for controlling tomato leaf miner, *Tuta absoluta* (Meyrick) (Lepidoptera: Gelechiidae). Journal of Plant Protection Research, 56: 372-379. doi:10.1515/jppr-2016-0055.

Aksoy, E. and Kovanci, O. B. 2016. Mass trapping low-density populations of *Tuta absoluta* with various types of traps in field-grown tomatoes. Journal of Plant Diseases and Protection, 123: 51-57.

Antignus, Y. 2000. Manipulation of wavelength dependent behavior of insects: an IPM tool to impede insects and restrict epidemics of insect borne viruses. Virus Research, 71: 213-220 (doi:10.1016/S0168-1702(00)00199-4).

Ardeh, M. J., Mohammadipour, A., Kolyaee, R., Rahimi, H. and Zohdi, H. 2014. Effect of pheromone trap sizes and colors on capture of Leopard moth, *Zeuzera pyrina* (Lepidoptera: Cossidae). Journal of Crop Protection, 3: 631-636.

[Downloaded from jcp.modares.ac.ir on 2024-11-30]

[DOR: 20.1001.1.22519041.2021.10.4.5.5]

Arno, J. and Gabarra, R. 2011. Side effects of selected insecticides on the *Tuta absoluta* (Lepidoptera: Gelechiidae) predators *Macrolophus pygmaeus* and *Nesidiocoris tenuis* (Hemiptera: Miridae). Journal of Crop Protection, 84: 513-520.

Baniameri, V. and Cheraghian, A. 2012. The first report and control strategies of *Tuta absoluta* in Iran. EPPO Bulletin. 42: 322-324.

Batalla-Carrera, L., Morton, A. and Garcia-del-Pino, F. 2010. Efficacy of entomopathogenic nematodes against the tomato leafminer *Tuta absoluta* in laboratory and greenhouse conditions. Biocontrol, 55: 523-530.

Bloem, S. and Spaltenstein, E. 2011. New Pest Response Guidelines: Tomato Leafminer (*Tuta absoluta*). USDA. Emergency and Domestic Program, Riverdale, Maryland. https://www.aphis.usda.gov/import_export/plants/manuals/emergency/downloads/Tuta-absoluta.pdf.

Braham, M. 2014. Is mass trapping technique useful for the control of the tomato leafminer, *Tuta absoluta* (Lepidoptera: Gelechiidae)?. Greener Journal of Agronomy, Forestry and Horticulture, 2: 44-61.

Campos, M. R., Silva, T. B. M., Silva, W. M., Silva, J. E. and Siqueira, H. A. A. 2015. Spinosyn resistance in the tomato borer Tuta absoluta (Meyrick) (Lepidoptera: Gelechiidae). Journal of Crop Protection, 88: 405-412.

Caparros, M. R., Brostaux, Y., Haubruge, E. and Verheggen, F. J. 2013. Pheromone-based management strategies to control the tomato leafminer, *Tuta absoluta* (Lepidoptera: Gelechiidae). Biotechnology, Agronomy, Society and Environment, 17: 475-482.

Caparros, M. R., Haubruge, E. and Verheggen, F. J. 2012. First evidence of deuterotokous parthenogenesis in the tomato leafminer, *Tuta absoluta* (Meyrick) (Lepidoptera: Gelechiidae). Journal of Crop Protection, 85: 409-412.

Chailleux, A. Bearez, P. Pizzol, J. Amiens-Desneux, E. Ramirez-Romero, R. and Desneux, N. 2013. Potential for combined use of parasitoids and generalist predators for biological control of the key invasive tomato pest, *Tuta absoluta*. Journal of Crop Protection, 86: 533-541 doi:10.1007/s10340-013-0498-6.

Cocco, A., Deliperi, S. and Delrio, G. 2012. Potential of mass trapping for *Tuta absoluta* management in greenhouse tomato crops using light and pheromone traps. Integrated Control in Protected Crops, Mediterranean Climate IOBC-WPRS Bulletin, 80: 319-324.

de Medeiros, M. A., Boas, G. L. V., Vilela, N. J. and Carrijo, O. A. 2009. A preliminary survey on the biological control of South American tomato pinworm with the parasitoid *Trichogramma pretiosum* in greenhouse models. Horticultura Brasileira, 27: 80-85.

de Oliveira, A. C., Veloso, V. R., Barros, R. G., Fernandes, P. M. and Souza, E. R. 2008. Capture of *Tuta absoluta* (Meyrick) (Lepidoptera: Gelechiidae) with light trap in tomato crop [abstract]. Pesquisa Agropecuária Tropical, 38: 153-157.

Desneux, N., Luna, M. G., Guillemaud, T. and Urbaneja, A. 2011. The invasive South American tomato pinworm, *Tuta absoluta*, continues to spread in Afro-Eurasia and beyond: the new threat to tomato world production. Journal of Crop Protection, 84: 403-408.

Desneux, N., Wajnberg, E., Wyckhuys, K. A. G., Burgio, G., Arpaia, S., Narváez-Vasquez, C. A., González-Cabrera, J., Catalán Ruescas, D., Tabone, E., Frandon, J., Pizzol, J., Poncet, C., Cabello, T. and Urbaneja, A. 2010. Biological invasion of European tomato crops by *Tuta absoluta:* ecology, history of invasion and prospects for biological control. Journal of Crop Protection, 83: 197-215.

El-Rahman Salama, H. S., Ismail, I. A. K., Fouda, M., Ebadah, I. and Shehata, I. 2015. Some ecological and behavioral aspects of the tomato leaf miner *Tuta absoluta*. Ecologia Balkanica, 7: 35-44.

El-Sayed, A. M., Suckling, D. M., Wearing, C. H. and Byers, J. A. 2006. Potential of mass trapping for long-term pest management and

[Downloaded from jcp.modares.ac.ir on 2024-11-30]

[DOR: 20.1001.1.22519041.2021.10.4.5.5]

eradication of invasive species. Journal of Economic Entomology, 99: 1550-1564.
Ferracini, C., Ingegno, B. L., Navone, P., Ferrari, E., Mosti, M., Tavella, L. and Alma, A. 2012. Adaptation of indigenous larval parasitoids to *Tuta absoluta* (Lepidoptera: Gelechiidae) in Italy. Journal of Economic Entomology 105, 1311-1319 doi: 10.1603/EC11394.
Gacemi, A. and Guenaoui, Y. 2012. Efficacy of Emamectin Benzoate on Tuta absoluta Meyrick (Lepidoptera: Gelechiidae) Infesting a Protected Tomato Crop in Algeria. Academic Journal of Entomology, 5: 37-40.
González-Cabrera, J. Mollá, O. Montón, H. and Urbaneja, A. 2010. Efficacy of *Bacillus thuringiensis* (Berliner) in controlling the tomato borer, *Tuta absoluta* (Meyrick) (Lepidoptera: Gelechiidae). Biocontrol, 56: 71-80.
Li, X., Geng, S., Chen, H., Jung, C., Wang, C., Tu, H. and Zhang, J. 2017. Mass trapping of apple leafminer, *Phyllonorycter ringoniella* with sex pheromone traps in apple orchards. Journal of Asia Pacific Entomology, 20: 43-46.
Liburd, O. E., Razze, J. M. and Nyoike, T. W. 2018. Relative captures of grape root borer, *Vitacea polistiformis* (Lepidoptera: Sesiidae) in pheromone traps within vineyards and adjacent woodlands. Crop Protection, 105: 35-40.
Lietti, M. M., Botto, E. and Alzogaray, R. A. 2005. Insecticide resistance in argentine populations of *Tuta absoluta* (Meyrick) (Lepidoptera: Gelechiidae). Neotropical Entomology, 34: 113-119.
Lobos, E., Occhionero, M., Werenitzky, D., Fernandez, J., Gonzalez, L. M., Rodriguez, C., Calvo, C., Lopez, G. and Oehlschlager, A. C. 2013. Optimization of a trap for *Tuta absoluta* Meyrick (Lepidoptera: Gelechiidae) and trials to determine the effectiveness of mass trapping. Neotropical Entomology, 42: 448-457.
Luna, M. G., Wada, V. and Sánchez, N. E. 2010. Biology of *Dineulophus phtorimaeae* (Hymenoptera: Eulophidae), and field interaction with *Pseudapanteles dignus* (Hymenoptera: Braconidae), larval parasitoids of *Tuta absoluta* (Lepidoptera: Gelechiidae) in tomato. Annals of the Entomological Society of America, 106: 936-942.
Matos, T., Figueiredo, E. and Mexia, A. 2012. Sexual pheromone traps with light for mass trapping of *Tuta absoluta* (Meyrick), yes or no? Revista de Ciências Agrárias (Portugal), 35: 282-286.
Molla, O., Gonzalez-Cabrera, J. and Urbaneja, A. 2011. The combined use of *Bacillus thuringiensis* and *Nesidiocoris tenuis* against the tomato borer *Tuta absoluta*. Biocontrol, 56: 883-891.
Molla, O., Monton, H., Vanaclocha, P., Beitia, F. and Urbaneja, A. 2009. Predation by the mirids *Nesidiocoris tenuis* and *Macrolophus pygmaeus* on the tomato borer *Tuta absoluta*. IOBC/WPRS Bulletin, 49: 209-214.
Muirhead-Thompson, R. 1991. Trap Responses of Flying Insects: the Influence of Trap Design on Capture Efficiency. Elsevier Academic Press, Burligton, 304 p.
Oerke, E.C., Dehne, H.W., Schönbeck, F. and Weber, A. 1994. Crop Production and Crop Protection: Estimated Losses in Major Food and Cash Crops. Elsevier, 808 p.
R Core Team 2015. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/.
Salama, H. A. S., Ismail, I. A., Fouda, M., Ebadah, I. and Shehata, I. 2015. Some ecological and behavioral aspects of the tomato leaf miner *Tuta absoluta* (Meyrick) (Lepidoptera: Gelechiidae). Ecologia Balkanica, 7: 35-44.
Shimoda, M. and Honda, K. 2013. Insect reactions to light and its applications to pest management. Applied Entomology and Zoology, 48: 413-421.
Silva, S. S. 2008. Fatores da biologia reprodutiva que influenciam o manejo comportamental de *Tuta absoluta* (Meyrick) (Lepidoptera: Gelechiidae). MS thesis: Universidade Federal Rural de Pernambuco, 63 p. (Brasil).

[DOR: 20.1001.1.22519041.2021.10.4.5.5]
[Downloaded from jcp.modares.ac.ir on 2024-11-30]

Thein, M. M., Jamjanya, T. and Hanboonsong Y. 2011. Evaluation of colour traps to monitor insect vectors of sugarcane white leaf phytoplasma. Bulletin of Insectology. (Supplement), 64: 117-118.

Therneau, T. M. and Grambsch, P. M. 2000. Modeling Survival Data: Extending the Cox model, Springer, New York.

Vacas, S., Alfaro, C., Primo, J. and Navarro-Llopis, V. 2011. Studies on the development of a mating disruption system to control the tomato leafminer, *Tuta absoluta* Povolny (Lepidoptera: Gelechiidae). Pest Management Science, 67: 1473-1480.

Witzgall, P., Kirsch, P. and Cork, A. 2010. Sex pheromones and their impact on pest management. Journal of Chemical Ecology, 36: 80-100.

Zappalà, L., Bernardo, U., Biondi, A., Cocco, A., Deliperi, S., Delrio, G., Giorgini, M. Pedata, P., Rapisarda, C., Garzia, G. T. and Siscaro, G. 2012. Recruitment of native parasitoids by the exotic pest *Tuta absoluta* (Meyrick) in Southern Italy. Bulletin of Insectology, 65: 51-61.

Zappalà, L., Biondi, A., Alma, A., Al-Jboory, I. J., Arno, J., Bayram, A., Chailleux, A., El-Arnaouty, A., Gerling, D., Guenaoui, Y., Shaltiel-Harpaz, L., Siscaro, G., Stavrinides, M., Tavella, L., Aznar, R. V., Urbaneja, A. and Desneux, N. 2013. Natural enemies of the South American moth, *Tuta absoluta*, in Europe, North Africa and Middle East, and their potential use in pest control strategies. Journal of Crop Protection, 86: 635-647.

[Downloaded from jcp.modares.ac.ir on 2024-11-30]

[DOR: 20.1001.1.22519041.2021.10.4.5.5]

ارزیابی تله‌های نوری برای شکار بید گوجه‌فرنگی *Tuta absoluta* (Lepidoptera: Gelechiidae)

محمدجواد ارده[1]، طاهره خیرخواه[1] و مجید عسکری سیاهویی[2]

۱- بخش تحقیقات حشره‌شناسی، مؤسسه تحقیقات گیاه‌پزشکی کشور، سازمان تحقیقات، آموزش و ترویج کشاورزی، تهران، ایران.
۲- گروه گیاه‌پزشکی، دانشکده کشاورزی، دانشگاه زنجان، زنجان، ایران.
۳- بخش تحقیقات گیاه‌پزشکی، مرکز تحقیقات کشاورزی و منابع طبیعی استان هرمزگان، سازمان تحقیقات، آموزش و ترویج کشاورزی، بندرعباس، ایران.
پست الکترونیکی نویسنده مسئول مکاتبه: ardeh@iripp.ir
دریافت: ۳۱ فروردین ۱۴۰۰؛ پذیرش: ۱۶ آذر ۱۴۰۰

چکیده: بید گوجه‌فرنگی *Tuta absoluta* (Meyrick) یکی از آفات مهم گیاه گوجه‌فرنگی می‌باشد. تله‌های نوری می‌توانند نقش مؤثری در کاهش جمعیت این آفت، به‌ویژه در گلخانه‌ها، داشته باشند. برای انتخاب یک تله نوری مناسب، چندین شاخص باید مدنظر باشد. بنابراین، رنگ‌های مختلف نور، سه اندازه تله و سه ارتفاع نصب در شرایط آزمایشگاهی ارزیابی شد. نورهای مورد مقایسه شامل رنگ‌های سفید، زرد، سبز، قرمز، آبی و نورک سیاه (BLB) بودند. اندازه تله‌ها شامل سه سری از ظرف‌های پلاستیکی شفاف به‌ترتیب با قطرهای ۸/۵، ۱۰/۵، و ۱۴/۵ سانتی‌متر و ارتفاع ۱۵، ۱۹ و ۲۶ سانتی‌متر بود. ارتفاع نصب تله‌ها ۵۰، ۷۵ و ۱۰۰ سانتی‌متری بالاتر از بوته‌ها بود. تعداد حشرات نر و ماده شکار شده به‌وسیله این تله‌ها مورد مقایسه قرار گرفت. نور سیاه (BLB) جلب‌کنندگی بیش‌تری نسبت نورهای دیگر برای *T. absoluta* داشت و بعد از آن نورهای زرد و سفید قرار گرفتند. به‌طور کلی در تله‌های نوری مورد بررسی، تعداد حشرات نر شکار شده بیش‌تر از تعداد ماده‌ها و تعداد ماده‌های جفت‌گیری کرده بیش‌تر از تعداد ماده‌های جفت‌گیری نکرده بود. دو اندازه بزرگ‌تر تله‌ها (تله‌های با قطر ۱۰/۵ و ارتفاع ۱۹سانتی‌متر و تله‌های با قطر ۱۴/۵ و ارتفاع ۲۶ سانتی‌متر) در مقایسه با اندازه کوچک‌تر تله‌ها و دو ارتفاع بالاتر نصب (۷۵ و ۱۰۰ سانتی‌متر) در مقایسه با ارتفاع پایین‌تر (۵۰ سانتی‌متر) به‌طور معنی‌داری تعداد شکار بیش‌تری داشتند. در نتیجه، تله‌های نوری با منبع نور BLB، و اندازه تله به قطر ۱۰/۵ سانتی‌متر و ارتفاع ۱۹ سانتی‌متر، که حداقل در ارتفاع ۷۵ سانتی‌متر بالاتر از بوته‌ها نصب شوند برای شکار حداکثر بید گوجه‌فرنگی، قابل توصیه می‌باشد.

واژگان کلیدی: بید گوجه‌فرنگی،کنترل غیرشیمیایی، نور BLB، شکار حشرات، گلخانه

[Downloaded from jcp.modares.ac.ir on 2024-11-30]

[DOR: 20.1001.1.22519041.2021.10.4.5.5]