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Cherif Asma
Laboratory of Entomology-Acarology, National Agronomic Institute of Tunisia, 43 avenue Charles Nicolle, Cité Mahrajène, 1082 Tunis, Tunisia

Lebdi-Grissa Kaouthar
Laboratory of Entomology-Acarology, National Agronomic Institute of Tunisia, 43 avenue Charles Nicolle, Cité Mahrajène, 1082 Tunis, Tunisia

Correspondence
Cherif Asma
Laboratory of Entomology-Acarology, National Agronomic Institute of Tunisia, 43 avenue Charles Nicolle, Cité Mahrajène, 1082 Tunis, Tunisia

Population dynamics of the tomato leaf miner *Tuta absoluta* (Meyrick) (Lepidoptera: Gelechiidae) in Tunisia natural conditions

Cherif Asma and Lebdi-Grissa Kaouthar

Abstract
Tuta absoluta (Meyrick) (Lepidoptera: Gelechiidae) is a key pest of tomato crops in Tunisia causing heavy losses to its production. The population dynamics of this pest was surveyed during spring-summer tomato growing season in Zaghouan and Nabeul provinces between 2014 and 2016. *T. absoluta* was monitored using two sex pheromone water traps. Tomato leaves were harvested and inspected weekly in order to determine the number of generation accomplish by each alive instar (eggs, larvae and pupae). Mines with and without larvae are also counted. Results showed that this pest was able to achieve 4-5 flight peaks. Three generations of eggs and larvae were recorded with a significant preference to laid eggs in the underside of leaves. High correlations were found between traps catches, eggs laid, active and total mines. Obtained data may help Tunisian farmers to detect early infestations, therefore to establish and to apply efficient control methods.

Keywords: *Tuta absoluta*, tomato open field crops, population dynamics, linear regression

1. Introduction
Tomato (*Solanum lycopersicon* L.) is considered in Africa and especially in Tunisia as a strategic culture thanks to income, food and nutrition that provides to farmers [6, 16, 19, 29]. Tomato was cultivated throughout the year under protected and open field crops [21]. Nevertheless, this important vegetable crop may be threatened by several diseases and pests [9, 22, 29]. Among pests, *Tuta absoluta* (Meyrick) (Lepidoptera: Gelechiidae) was cited as the most harmful lepidopteran which can cause serious damages mainly to this crop [8, 9, 22]. Other cultivated and weed species belonging to the families of Solanacae and fabacae have been classified as host plants [2, 15, 20]. Damages were caused by larvae which feed on all areal parts of the plant (leaves, stem and fruits) causing characteristic mines [3, 21]. *Tuta absoluta* may perform several generations per year in field conditions which may reach 7-8 generations as reported for Chile [27]. In Turkey, this pest completed 5 generations during summer-winter growing season [21]. In Tunisia, studies have demonstrated that *T. absoluta* was able to achieve 3 generations in protected crops for the period extending from January to May [7]. Development cycle of *T. absoluta* depends on availability of host plants as well as suitability of climatic conditions especially temperature [11, 13, 20]. Data studying its biological and ecological characteristics are needed to establish effective management of this pest [21]. Thus, various factors must be taken into consideration such as climate interactions with the biology of the pest and multi-species interactions such as competition and predation [24]. Several control strategies were carried out to limit damages caused by this pest including chemical sprays, the use of sex pheromone for mass trapping or mating disruption and releases of natural enemies [4, 5, 10, 12, 26, 28].
The aim of this work was to investigate the population dynamics of *T. absoluta* in open field tomato crops over two years in two Tunisia regions (Bou Slim and Takelsa). The relationship between male captures and specific parameters (eggs laid, mines with larvae and total mines), correlations between mines with and without mines as well as distribution of eggs per side of leaf, was also examined

2. Materials and methods
2.1 Study sites
This study was carried out in two Tunisia counties: Bou Slim (North-East, Governorate of Zaghouan, Latitude.

36° 24' 10.48" N, Longitude. 10° 08' 34.51" E) and Takelsa (North-East, Governorate of Nabeul, Latitude. 36°27.3636′N, Longitude. 10°44.2578′E), characterized by favorable climatic conditions to *Tuta* attacks.

2.2 Insect monitoring
Population dynamics of *Tuta absoluta* was surveyed over two years under open field crops through spring-summer main growing season. *T. absoluta* was monitored using two sex pheromone water traps (Pherodis®) set up on 15/04/2014 and 14/04/2016 respectively for Bou slim and Takelsa regions and placed at a distance of 40 cm above the ground. A distance of about 20 m was respected between these traps.
The renewal of sex pheromone capsules was realized every 4 weeks. Dirty contents of traps (water and a thyn vegetable oils) were removed and replaced by others. For each open field crop, tomato plants were drip-irrigated under plastic mulch. Chemical applications were done by farmers by spraying to runoff insecticides at the recommended doses using a compressed air sprayer. Insecticides sprays were started when captures in water traps reached 50 moths/trap as recommended by the Tunisian ministry of Agriculture. Specific characteristics of studied sites are given by Table 1.

2.3 Sampling
Samplings were carried out in the three chosen open field crops. Forty tomato leaves taken weekly at random, were put individually in plastic bugs and then brought back to the laboratory. Sampled leaves were inspected for their both leaflets surfaces as well stems using a binocular microscope (Leica® Model MS5). Thus, the number of eggs, larvae, pupae and mines found on the whole leaves were counted.

2.4 Climatic data
The climatic data for Zaghouna and Nabeul provinces are given by the Tunisian Meteorological Institute (Table 2).

2.5 Statistical analysis
A one-way ANOVA and a post hoc mean comparison test (Duncan test at $p<0.05$) was carried out to test linear regression of parameters cited above and the distribution of eggs per side of leaf. Statistical analysis was performed using SPSS version 21 (2012).

3. Results
3.1 Male flight activity
The study was initiated in middle April and continued to 05/08/2014 and 12/07/2016 respectively for tomato growing areas of Bou Slim and Takelsa counties. Five generations were recorded on April, May, June, July and August in Bou Slim region. However, in Takelsa, only 4 peaks were registered within the he above mentioned time frame (Figure 1).
Figure 1 showed that catches were more frequent in summer at high temperature especially in Takelsa. The highest trap counts were recorded on 13/06/2014 in Bou Slim (142 males/trap/week) and on 03/06/2016 in Takelsa (380.5 males/trap/week).

3.2 Population dynamics
Figure 2 showed that, in Zaghouan province, *T. absoluta* was able to achieve three generations of eggs and larvae recorded in June, early and late July, 2014. The number of larvae found was the greater compared to it of eggs and may reach 9.5 larvae/40 tomato leaves on 11/07/2014 (Figure 2a). Likewise, in Nabeul province, *T. absoluta* performed three generations for both eggs and larvae for the study period extending from April to July, 2016 (Figure 2b). Oviposition on leaves started low and rose up to 7.5 on 24/06/2014 and 164 on 03/06/2016 respectively for Bou Slim and Takelsa locations (Figure 2). Whereas, during the survey, all development stages were more abundant in Takelsa and started to appear early compared to them in Bou Slim (Figure 2). The number of pupae recorded in the two study sites was very low and did not exceed 5 pupae /40 tomato leaves for example in Takelsa region on 03/06/2016.

3.3 Distribution of eggs per side of leaf
For the two study sites, figure 3 showed that the number of eggs laid in the underside of tomato leaves (85%) was significantly more important compared to it found in the upper side ($F_{1, 43}=10.67$; $p=0.002<0.05$).

3.4 Relationship between trap catches, number of eggs laid and mines
Figure 4a indicated a significant linear regression demonstrated for trap catches/eggs laid in the surveyed open field crops ($R^2=0.78$; $F_{1, 43}=27.81$; $p=0.000<0.05$). Likewise, for the two experimental sites, captured adults/mines with larvae were highly and significantly correlated ($R^2=0.74$; $F_{1, 87}= 25.88$; $p=0.000<0.05$) (Figure 4b). A high linear regression between trapped adults/ total mines (with and without larvae) was noted, despite there is no significant statistical analysis found ($R^2=0.75$; $F_{1, 87}=0.722$; $p=0.398$) (Figure 4c).
Figure 5 indicated a high and significant linear regression between mines with larvae/ mines without larvae in tomato open field crops for Bou Slim and Takelsa counties ($R^2= 0.83$; $F_{1, 87}= 7.76$; $p=0.007<0.05$).

Table 1: Some characteristics of selected open field crops in the two study sites

Years	Harvest	Area	Tomato plants	Distance (m)		Insecticides application
				Row	Plant	
2014	*Main crop season *2 open field crops in Bou slim region	1 Ha each	*33000 plants each *Crop 1: var. cxd 255 *Crop 2: var. Podium	1.6	0.20	*23/04/2014: Cyromazin 750, 30g/hl *10/06/2014: Indoxacarb, 50cc/hl *11/07/2014: Spirotetramat, 50cc/hl
2016	*Main crop season *1 open field crops in Takelsa region	1 Ha	*30000 plants *var. Chams	1.5	0.3	*21/04/2016: Flubendiamid, 30g/hl *01/06/2016: Indoxacarb, 50cc/hl *02/07/2016: Diafenthiuron, 100cc/hl

Table 2 (A, B): Climatic data for Zaghouan (A) and Nabeul (B) provinces (year 2014 and 2016)

Year	Parameter (A)	April	May	June	July	August
2014	Temperature (°C)	16.70	19.50	25.20	27.20	28.60
	Relative humidity (%)	66	63	50	37	35

Year	Parameter (B)	April	May	June	July	August
2016	Temperature (°C)	20.40	19.50	23.20	26.30	26.20
	Relative humidity (%)	79	69	68	68	70

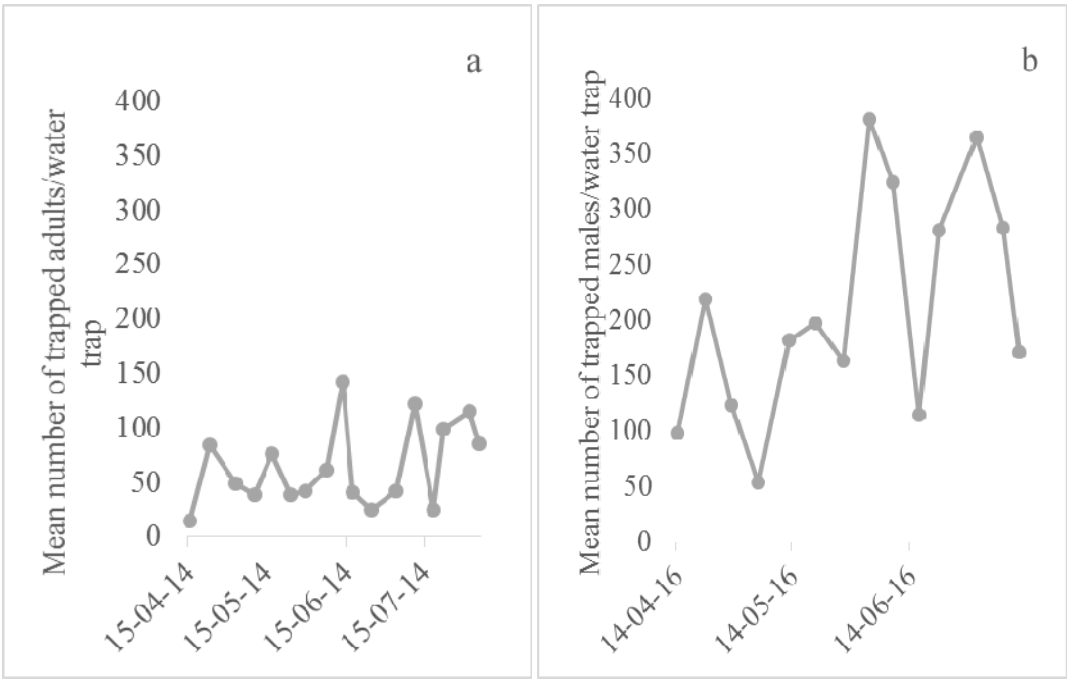

Fig 1: Male flight activity of *T. absoluta* in Bou slim (a) and Takelsa (b) tomato open field crops

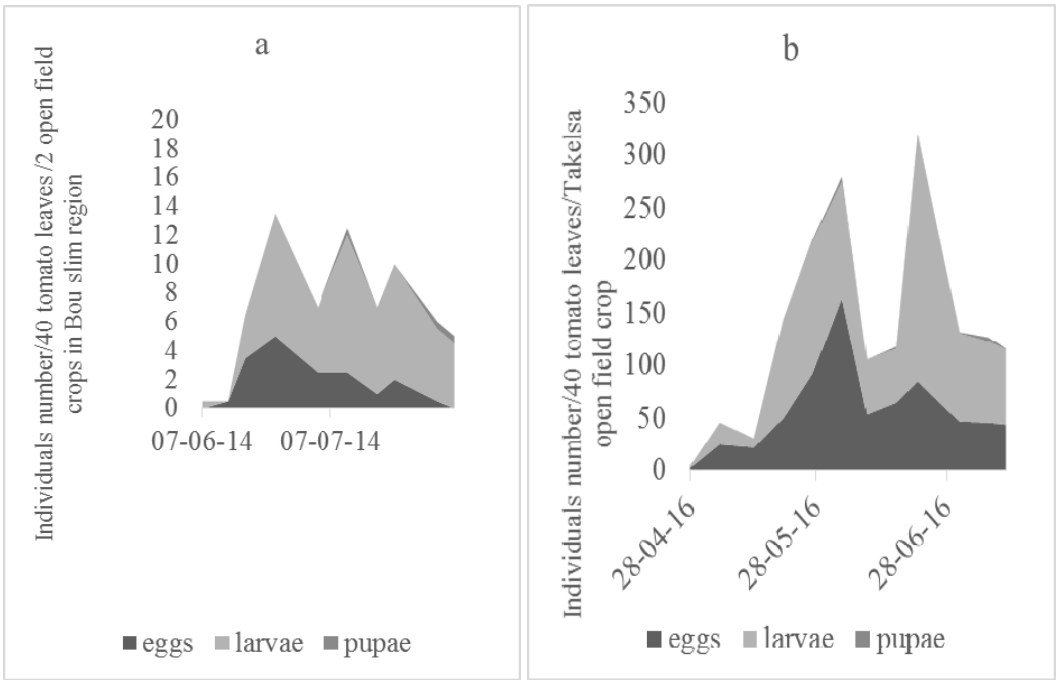

Fig 2: Leaf density of *T. absoluta* eggs, larvae and pupae in Bou Slim (a) and Takelsa (b) open field crops

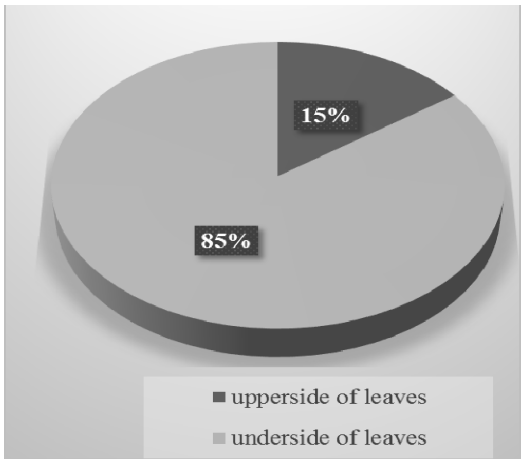

Fig 3: Number of eggs laid per side of leaf recorded in Bou Slim and Takelsa open field crops

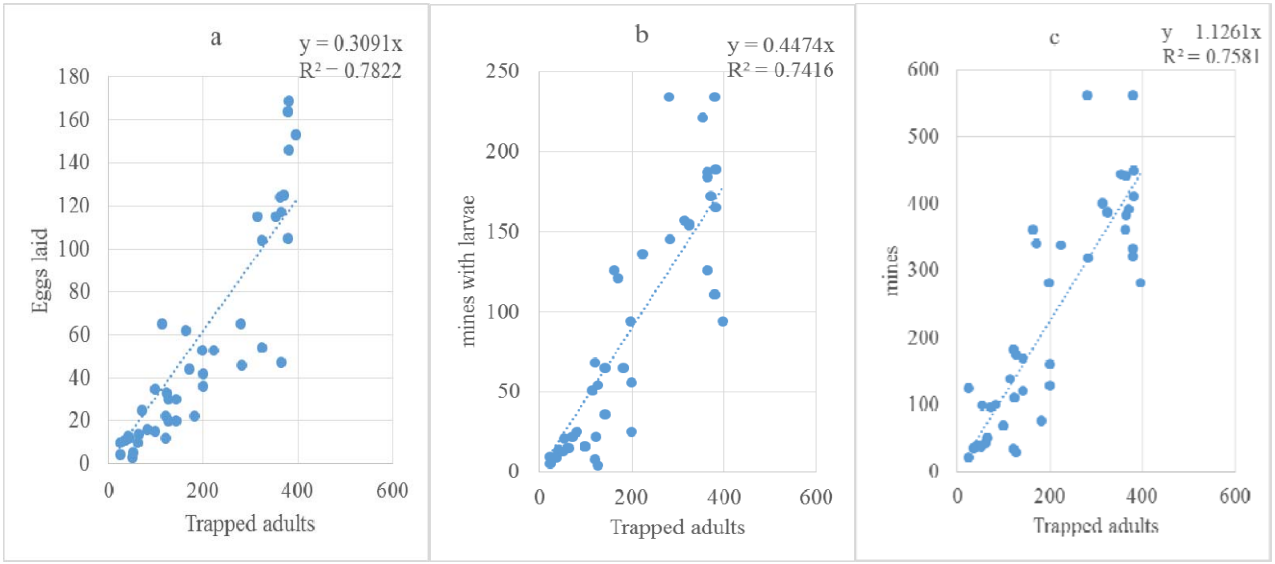

Fig 4: Relationship between trap catches /eggs laid (a); trap catches/ mines with larvae (b) and trap catches/ total mines (with and without larvae) (c) in Bou Slim and Takelsa counties

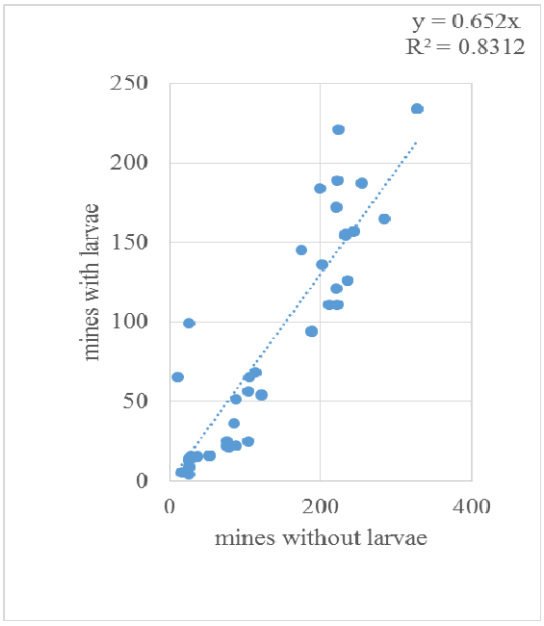

Fig 5: Linear regression between mines with larvae/ mines without larvae in tomato open field crops (Bou Slim and Takelsa regions)

4. Discussion

Tuta absoluta is a major pest of tomato crops in Tunisia causing heavy losses [1, 7, 8]. The knowledge of its population dynamics under field conditions is considered as major step to plan effective management strategies. Our results highlighted the occurrence of 4 and 5 flight peaks registered respectively in Takelsa and Bou Slim locations. Also, three generations of eggs and larvae were detected in the two study regions. Pupae were found with a low number on tomato leaves given that pupation occurs in most of case in the soil [18].

Several research studied the population dynamics of *T. absoluta*. In Tunisia, Cherif and Lebdi-Grissa, [8] indicated that *T. absoluta* developed two flight peaks during autumn-winter late growing season in Zaghouan province. According to Polat *et al*. [21], *T. absoluta* may accomplish 5 generations in Çanakkale province, Turkey, through summer-winter growing season.

The number of adults, eggs and larvae recorded differs for the two studied counties (Zaghouan and Nabeul provinces) which may be explained mainly by differences in environmental conditions especially temperature and relative humidity. In fact, from April to August, the temperature values ranged from 16.70 to 28.60 and from 20.40 to 26.20 respectively in Zaghouan and Takelsa provinces. Relative humidity values

are higher in Takelsa compared to those in Zaghouan. For example, the relative humidity recorded during the month of July was 37% in Zaghouan and 68 % in Takelsa. In this study period, the number of larvae recorded was 8/40 leaves on 22/07/2014 in Zaghouan region. However, in Takelsa, on 12/07/2016, the number of recorded larvae was 71/40 leaves.

These data explain that, the severity of *Tuta* attacks was related to relative humidty, therefore, attacks decrease with low relative humidity values.

Our findings are in accordance with other results indicating that environmental conditions such as temperature affected generation time and biological proprieties of *T. absoluta* [21]. Likewise, Cherif and Lebdi-Grissa, [8] proved in a previous study realized in Zaghouan province, that the low density of recorded eggs and larvae was linked to cold weather registered in the study period extending from October to December, 2011.

In the present study, we assessed the preference of *T. absoluta* to lay eggs on the underside of leaves (85%) which proved results of Torres *et al*. [25].

Here, we indicated the existence of a high and significant linear regression between trap catches and eggs laid (R^2=0.78) or trap catches and actives mines (R^2=0.74). Likewise, mines with and without larvae were highly correlated (R^2=0.75). In a previous study, Abbes and Chermitti, [1] indicated the presence of a significant relationship between trapped adults and infested leaves in protected tomato crops.

This paper provides population dynamics data in two Tunisian provinces (Zaghouan and Nabeul) where *T. absoluta* attacks level differs. With the resulting information's, we will be able to estimate infestation rate caused by this pest. Obtained data can be considered as a vital step towards early detections and therefore developing efficient Integrated Pest Management programs against this pest.

5. Acknowledgements

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6. References

1. Abbes K, Chermiti B. Comparison of two marks of sex pheromone dispensers commercialized in Tunisia for their efficiency to monitor and to control by mass-trapping *Tuta absoluta* under greenhouses. Tunisian Journal of Plant Protection 2011; 6:133-148.
2. Abdul-Rassoul MS. A new host record for Tomato Leaf Miner *Tuta absoluta (*Meyrick, 1917) in Baghdad province, Iraq. Bulletin of the Iraq Natural History Museum. 2014; 13(1):15-18.
3. Bawin T, Collard F, De Backer L, Yaroua BB, Compère P, Francis F *et al*. Structure and distribution of the sensilla on the antennae of Tuta absoluta (Lepidoptera: Gelechiidae). Micron. 2017; 96:16-28.
4. Caparros Megido R, Haubruge E, Verheggen FJ. First evidence of deuterotokous parthenogenesis in the tomato leafminer, Tuta absoluta (Meyrick) (Lep., Gelechiidae). Journal of Pest Science. 2012; 85(4):409-412.
5. Carvalho GA, Godoy MS, Parreira DS, Rezende DT. Effect of chemical insecticides used in tomato crops on immature *Trichogramma pretiosum* (Hymenoptera: Trichogrammatidae). Revista Colombiana de Entomología. 2010; 36(1):10-15.
6. Cetin B, Vardar A. An economic analysis of energy requirements and input costs for tomato production in Turkey. Renewable Energy. 2008; 33:428-433.
7. Cherif A, Mansour R, Grissa-Lebdi K. Biological aspects of tomato leafminer Tuta absoluta (Lepidoptera: Gelechiidae) in conditions of northeastern Tunisia: possible implications for pest management. Environmental and Experimental Biology 2013; 11:179-184.
8. Cherif A, Lebdi-Grissa K. Control of the tomato leafminer *Tuta absoluta* (Lepidoptera; Gelechiidae) using the mass trapping tool in tomato open field plot and greenhouses in Tunisia. Agriculture Science Research Journal. 2014; 4(10):161-173.
9. Cifuentes D, Chynoweth R, Bielza P. Genetic study of Mediterranean and South American populations of tomato leaf miner Tuta absoluta (Povolny, 1994) (Lepidoptera: Gelechiidae) using ribosomal and mitochondrial markers. Pest Management Science. 2011; 67:1155-1162.
10. Cocco A, Deliperi S, Delrio G. Control of *Tuta absoluta* (Meyrick) (Lepidoptera: Gelechiidae) in greenhouse tomato crops using the mating disruption technique. Journal of Applied Entomolology. 2013; 137:16-28, http://dx.doi.org/10.1111/j. 1439-0418.2012.01735x.
11. Cocco A, Deliperi S, Lentini A, Mannu R, Delrio G. Seasonal phenology of *Tuta absoluta* (Lepidoptera: Gelechiidae) in protected and open-field crops under Mediterranean climatic conditions. Phytoparasitica. 2015; 43:713-724.
12. De Backer L, Caparros Megido R, Haubruge E, Verheggen FJ. *Macrolophus pygmaeus* (Rambur) as an efficient predator of the tomato leafminer Tuta absoluta (Meyrick) in Europe. A review. Biotechnologie, Agronomie, Société et Environnement 2014; 18:536-543.
13. EPPO. European and Mediterranean Plant Protection Organization. *Tuta absoluta*. Data sheets on quarantine pests. EPPO Bulletin. 2005; 35:434-435.
14. Haddi K, Berger M, Bielza P, Cifuentes D, Field LM, Gorman K *et al*. Identification of mutations associated with pyrethroid resistance in the voltage-gated sodium channel of the tomato leaf miner (Tuta absoluta). Insect Biochemistry and Molecular Biology. 2012; 42:506-513, http://dx.doi. org/10.1016/j.ibmb.2012.03.008.
15. Harizanova V, Steva A, Mohamedova M. Tomato leaf miner, *Tuta absoluta* (Povolny) (Lepidoptera; Gelechiidae) - first record in Bulgaria. Agricultural Science and Technology. 2009; 1(3):95-98.
16. Lebdi Grissa K, Skander M, Mhafdhi M, Belhadj R. Lutte intégrée contre la mineuse de la tomate, *Tuta absoluta* Meyrick (Lepidoptera: Gelechiidae) en Tunisie. Entomologie faunistique. 2010; 63(3):125-132.
17. Lietti MMM, Botto E, Alzogaray RA. Insecticide resistance in Argentine populations of *Tuta absoluta* (Meyrick) (Lepidoptera: Gelechiidae). Neotropical Entomology 2005; 34:113-119, http://dx.doi.org/10.1590/S1519-566x2005000100016
18. Michereff FM, Vilela EF. Traça-dotomateiro, *Tuta absoluta* (Lepidoptera: Gelechiidae), 81-84. In: E.F. Vilela, R.A. Zucchi & F. Cantor (eds.), Histórico e impacto das pragas introduzidas no Brasil. Ribeirão Preto Holos. 2001, 81-84.
19. Oerke EC, Dehne HW, Schönbeck F, Weber A. Crop production and crop protection: Estimated losses in major food and cash crops. Elsevier, 2012.
20. Özgokce MS, Bayindir A, Karaca İ. Temperature-dependent development of the tomato leaf miner, *Tuta absoluta* (Meyrick) (Lepidoptera: Gelechiidae) on tomato plant *Lycopersicon esculentum* Mill. (Solanaceae).

Turkish journal of Entomology dergiParck 2016: 40(1):51-59.
21. Polat B, Özpınar A, Kürşat Şahin A. Studies of selected biological parameters of tomato leafminer Tuta absoluta (Meyrick), (Lepidoptera: Gelechiidae) under natural conditions. Phytoparasitica, 2016. DOI 10.1007/s12600-016-0511-8
22. Retta AN, Berhe DH. Tomato leaf miner Tuta absoluta (Meyrick), a devastating pest of tomatoes in the highlands of Northern Ethiopia: A call for attention and action. Research Journal of Agriculture and Environmental Management, 2015; 4:264-269.
23. Reyes M, Rocha K, Alarcón L, Siegwart M, Sauphanor B. Metabolic mechanisms involved in the resistance of field populations of Tuta absoluta (Meyrick) (Lepidoptera: Gelechiidae) to spinosad. Pesticide Biochemistry Physiology. 2012; 102:45-50. http://dx.doi.org/10.1016/j.pestbp.2011.10.008.
24. Tonnang HEZ, Mohamed SF, Khamis F, Ekesi S. Identification and Risk Assessment for Worldwide Invasion and Spread of *Tuta absoluta* with a Focus on Sub-Saharan Africa: Implications for Phytosanitary Measures and Management. PLOS ONE, 2015. DOI: 10.1371/journal.pone.0135283.
25. Torres JB, Faria CA, Evangelista Jr WS, Pratissoli D. Within-plant distribution of the leaf miner *Tuta absoluta* (Meyrick) immatures in processing tomatoes, with notes on plant phenology. International Journal of Pest Management. 2001; 47:173-178.
26. Urbaneja A, Gonzalez-Cabrera j, Arno j, Gabrarra R. Prospects for the biological control of Tuta absoluta in tomatoes of the Mediterranean Basin. Pest management sciences. 2012; 68:1215-1222.
27. Vargas H. Observaciones sobre la biología y enemigos naturales de la polilla del tomate, *Gnorimoschema absoluta* (Meyrick) (Lepidoptera: Gelechiidae). Idesia 1970; 1:75-110.
28. Zappalà L, Biondi A, Alma A, Al-Jboory IJ, Arnó J, Bayram A *et al.* 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 Pest Science. 2013; 86:635-647.
29. Zekeya N, Chacha M, Ndakidemi PA, Materu C, Chidege M, Mbega ER. Tomato Leafminer *Tuta absoluta* (Meyrick 1917): A Threat to Tomato Production in Africa. Journal of Agriculture and Ecology Research International. 2017; 10(1): 1-10.