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Tuta Absoluta: A Global Looming Challenge in Tomato Production, Review Paper

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Abstract
Tomato is very important vegetable crop of the world. It is consumed as fresh table tomato and as raw material for food processing industries. However, the production of this important vegetable crop is facing unprecedented challenge from South American originated pest known by the local name tomato leaf miner and scientific name Tuta absoluta (Lepidoptera: Gelechiidae). Tomato leaf miner is a devastating pest of tomato and other Solanaceous crops in many vegetable crop growing areas around the world. Despite its recent introduction, it has become a major economical pest of both outdoor and greenhouse tomatoes in the Middle East, Mediterranean basin of Europe and North and Eastern Africa. Under heavy infestation yield loss in the range of 80-100% is common. Regarding its life cycle, this pest has high rate of reproduction and short life cycle. The damaging stage of tomato leaf miner is the larval stage. After egg hatching, the larvae make a way into tomato fruits, leaves, flower buds and young shoots on which they feed and develop creating mines and galleries.
Key words: *Tuta absoluta; tomato, Distribution, Chemical control, Bio-control, Damage*

Introduction

Tomato (*Solanum lycopersicum* Mill.), which belongs to the nightshade family *Solanaceae* is one of the most widely cultivated and consumed food crops among vegetables in the world. World annual production of the crop accounts for 107 million metric tons with fresh market tomato representing 72 % of the total (FAO, 2002). The crop is a warm season crop sensitive to freezing temperature and frost. Tomato can be produced under open fields and green house condition. The crop is rich in nutrients such as vitamin, minerals and antioxidants which are essential to well-balanced human diet (Srinivasan, 2010). Tomato is one of the most important vegetable crops in Ethiopia grown for fresh market and processing. It is the third important vegetable crop after red pepper and Ethiopian cabbage with acreage and production share of 4.53% and 10.82%, respectively (CSA, 2012).It grows under irrigated and non irrigated areas in small and large scale farming system.

Tomato production has been facing many biotic and environmental constraints. Prominent among such constraints are pests and diseases which reduce yields and the quality of marketable fruits. Many insect pests are associated directly with tomato damage and yield losses. *Tuta absoluta* (Meyrick) is considered as one of the most important and devastating tomato insect pest (Cuthbertson et al., 2013; Öztemiz, 2013). *T. absoluta* is a nocturnal moth of the *Gelechiidae* family under the order Lepidoptera. It is originated from South America mainly Peru. Tomato leafminer moth was first found in Ethiopia in 2012 infesting open-field tomato plants (NAPPO, 2012). Afterwards of its introduction, the insect has spread quickly and it is currently considered a key challenge on tomato production. It is believed to have been introduced through the northern part of the country from Yemen or Sudan. The rapidly growing regional, national and international travel and trade drastically increase the potential for moving noxious pest species to new geographic regions and locations. Potting et al. (2013) indicated four possible pathways for the entry of this pest to non-infested area. These entry pathways are, in order of their importance, tomato fruits from infested areas, containers and packaging equipment and transportation vehicles, plants for planting of tomato and plants for planting of ornamental *Solanaceae*. Similarly, Karadjova et al. (2013) identified packing materials for import of tomatoes, peppers and eggplants, as well as imported planting material as the most likely entry, establishment and spread means for the pest.

Geographical Distribution of the Pest

The tomato leaf miner is also known as South American tomato moth, tomato borer and South American tomato pinworm. As indicated in its local name, this important tomato pest is native to South America. Tomato leaf miner was first described in 1917 by Meyrick as *Phthorimaea absoluta* from specimens collected in Peru and given the scientific name *Tuta absoluta* by Povolny in 1994 (Muniappan, 2013). The initial European record of the pest was in 2006 on tomato crops in Castellón, Spain and by 2007 its presence was reported in several places along the Mediterranean coast in the province of Valencia (David and Catania, 2009). The tomato borer invaded Egypt in 2009 (Temerak, 2011). The first report of the pest in Greece and Cyprus was in July 2009 and in November 2009, respectively (Roditakis and Seraphides, 2011). The earliest report of a UK interception for this pest was in a tomato packing facility in March 2009, and in the following July an outbreak of *T. absoluta* established in a UK tomato crop for the first time (Gorman, et al., 2011). The pest was for the first time detected in Sudan in 2010 and the invasion has subsequently crossed the Sahara desert, being found in Kenya in 2014

(Maroo, 2015). Tomato leaf minor was first detected in Ethiopia in 2012 (NAPPO, 2012) and has subsequently spread throughout the country causing severe damages to tomato in invaded areas. Despite its recent introduction into Europe, Asia and Africa, tomato leaf miner has become widespread and an important pest throughout these regions in both open field and green house tomato production.

Biology of tomato leaf miner (*Tuta absoluta* (Meyrick))

The taxonomic position of tomato leaf miner, also known as by other common English names as tomato borer, South American tomato moth, and South American tomato pinworm, is as follow:

Class: Insecta
Order: Lepidoptera
Family: Gelechiidae
Genus: Tuta
Species: *Tuta absoluta*

Tuta absoluta is a holometabolous insect with a high rate of reproduction. Its life-cycle comprises four development stages viz. egg, larva, pupa and adult, and is completed within 24 days at 27^0C (NAPPO, 2012). The life cycle of this insect begins when the adult insect lays its egg on underside of leaves, buds, stems and calyx of unripe fruits. The newly deposited eggs are oval in shape and creamy white in color then turn to yellow and finally black before hatching (Salama et al., 2014). The pre-oviposition period of this insect is short and ranged from 2.3 to 4.6 days depending on temperature. The egg production showed to be affected by temperature variation and the highest production occurred at 20 ˚C being 162 ± 30.94 eggs/female, with slight decrease when temperature decreased to 15˚C (Salama et al., 2014).

T. absoluta has a high reproductive potential and a life cycle that can take from 24 to 76 days, depending on the environmental conditions (Arnó and Gabarra, 2010). The most prolific ovipositing period is 7 days after first mating, and females lay 76% of their eggs at that time (Uchoa Fernandes et al. 1995), with a maximum lifetime fecundity of 260 eggs per female (Harizanova et al., 2009). It clearly appeared that *T. absoluta* mated females exhibited a preference to lay eggs on leaves of the plant apex, compared to laying eggs on leaves of the two other parts of tomato host plant (Cherif et al. 2013). In the same way, Muniappan (2013) indicated that this insect lays 73%, 21%, 5%, and 1% on leaves, veins and stems, sepals and fruits, respectively. Eggs of this insect are oval or cylindrical in shape and creamy white to yellow in color with 0.35 mm long. Egg hatching takes place 4-6 days after egg lying. After hatching, the larvae wandered around the leaf surface for an average of 12 minutes and approximately 15 mm from its egg shell before starting to graze on the leaf surface (Cuthbertson et al., 2013). The young larvae penetrate into tomato fruits, leaves or stems on which they feed and develop, thus creating conspicuous mines and galleries (USDA–APHIS, 2011). The insect develops through four larval instars before transforming into the pupal stage (NAPPO, 2012).

Fully-grown larvae usually drop to the ground on a silk thread and pupate in the soil. Pupae are cylindrical in shape and greenish when just formed, becoming darker in color as they near adult emergence (NAPPO, 2012). Adults are about 1 cm long, with a wingspan of about 1 cm with mottled gray in color (USDA–APHIS, 2011).

Economic Importance and Damage

T. absoluta is a major pest of both field and greenhouse tomato productions. The pest has been responsible for losses of 80-100% in tomato plantations in both protected cultivation and open fields (NAPPO, 2012). Yield and fruit quality are both considerably impacted by direct feeding of the pest as well as secondary pathogens entering host plants through wounds made by the pest (Kaoud, 2014). Feeding damage is caused by all larval instars and throughout the entire crop cycle (Harizanova et al., 2009). After hatching, larvae penetrate apical buds, flowers, new fruit, leaves, or stems. On leaves, the larvae feed on the mesophyll tissue, forming irregular leaf mines which may later become necrotic. Larvae can form extensive galleries in the stems which alter the general development of the plants. Fruits are also attacked by the larvae, forming galleries which represent open areas for invasion by secondary pathogens, leading to fruit rot (USDA–APHIS, 2011).

Host Plants

The tomato leaf miner is neotropical oligophagous moth associated with solanaceous crops (Toševski et al., 2011). This insect pest feeds on the leaves of several species of plants in this family. Although *T. absoluta* prefers tomato, it can also feed, develop and reproduce on weeds and this gives a great advantage to continue its existence during the absence of tomato (Ögür et al., 2014). These authors observed conspicuous mines and galleries between leaf epidermal layers which contained black larval frass, on the leaves of *Chenopodium album* during field monitoring and the laboratory examinations. Abdul-Rassoul (2014) reported tomato leaf miner feeding on alfalfa, *Medicogo sativa,* in Iraq.

The USDA-APHIS (20111) citing different authors listed the following hosts of tomato leaf miner.

Host	Common Name	Source
Capsicum annuum L.	pepper	Ministero delle Politiche Agricole Alimentarie Forestali, (2009)
Datura quercifolia Kunth	long-spined thorn apple	EPPO (2005)
Datura stramonium L.	jimson weed	Vargas (1970)
Nicotiana tabacum L.	tobacco	Galarza (1984), Fernandez & Montagne (1990b)
Solanum lycopersicum L.	Tomato	Vargas (1970), Fernandez & Montagne (1990b)
Solanum melongena L	Eggplant	Galarza (1984), Fernandez & Montagne (1990b), Ministero delle Politiche Agricole Alimentarie Forestali (2009), Viggiani et al. (2009)
Solanum nigrum L.	black nightshade	Vargas (1970)
Solanum tuberosum L.	potato	Pastrana (1967), Vargas (1970), Galarza (1984), Fernandez & Montagne (1990b), FREDON-Corse (2009b), Maiche (2009
Phaseolus vulgaris L	common bean	EPPO (2009i), Ministero delle Politiche Agricole Alimentarie Forestali (2009)
Solanum americanum Miller	American nightshade	Fernandez & Montagne (1990b)

Source: USDA–APHIS (2011).

Control measures

Given its vicious nature and crop destruction potential, tomato leaf miner has quickly become a key pest of concern in these invaded areas. If no specific control measures are applied against tomato leaf miner, damage to tomato production can be very high, because also fruits can be mined, which may induce unacceptable levels of cosmetic damage (Potting, et al., 2013). Following up the serious jeopardy of *T. absoluta* to tomato production under outdoor and green house production, many control programs have been explored in many countries affected by *T. absoluta*.

Biological control

In this method of pest management, the population of tomato leaf minor is contained by the use of antagonist natural enemies (predators, parasitoids and pathogens). According to Desneux et al. (2010) the following areas need to be considered in developing feasible biological control: (1) detailed survey and works need to be conducted on the nature of the endemic natural enemy complex associated with T. absoluta in tomato production regions, (2) assess the potential of native natural enemies to control the pest, (3) define economical thresholds and intervention levels for T. absoluta that account for biological control and (4) carefully balance costs and benefits of classical biological control. Several biological control agents have been recently evaluated against tomato leaf miner. A study conducted to evaluate the effect of *Bacillus thuringiensis* on *T. absoluta* showed high efficacy in reducing the damage caused by T. absoluta at high infestation levels when compared with non-treated controls. However, *B. thuringiensis* proved to be highly efficient in reducing the damage produced by first, second, and third *T. absoluta* larval instars (Gonza´lez-Cabrera, 2011). Oliveira et al. (2007) observed Pyemotes species from the mite group of arthropods feeding on caterpillars and adults of tomato leaf miner, with one or more mites per host. They observed that larvae and adults of Tuta absoluta being paralyzed by the toxins and made sound recommendation for Pyemotes sp. to be considered as a biological control agent against tomato leaf miner. A recent preliminary study conducted in Jordan identified four natural enemies associated with tomato leaf miner (Al-Jboory et al., 2012). Cabello et al. (2012) evaluated the biotic potential of two species from the genus *Trichogramma* viz. *T. achaeae and T. urquijoi*. These authors found that *T. achaeae* was better at controlling tomato leaf miner populations than the other species. Similarly, Zouba et al. (2013) studied host suitability of tomato leaf miner for two *Trichogramma* species. The authors found that the parasitism rates of *T. absoluta* eggs were 63.92% and 57.05% for T. bourarachae and T. cacoeciae, respectively, while damage reduction was 87.62% and 78.89%, respectively, as compared to control greenhouses.

Eradication

Eradication involves complete elimination of the pest from an area. According to USDA–APHIS, (2011) this control method is more feasible when pest population is confined to a small area, detection occurs soon after the introduction, or pest population density is low.

Chemical control

Chemical pesticides continue to be an important component of insect pest management even with the development of other control methods. Chemical applications play a crucial role in controlling *T. absoluta* infestation. The effectiveness of many insecticides against this pest have been tried in different part of the world. Braham and Hajji (2012) from Tunisia reported the effectiveness of three insecticides viz. indoxacarb, triflumuron and diafenthiuron against *T. absoluta*. Their results confirmed significantly reduction of *T. absoluta* larvae when compared with non treated control. A study conducted under laboratory condition indicated that insecticides like azadirachtin, emamectin benzoate, spinosad, metaflumizone and chlorantraniliprole caused 90-100% larval mortality (Delva and Harizanova, 2014). Hanafy and El-Sayed (2013) investigated the efficacy of three bio-insecticides (Spinetoram, Spinosad and Emamectin) and four chemical insecticides (Pyridalyl, Indoxcarb, Coragen and Chlorfenapyr) in the control of tomato leaf miner under a field condition. The bio-insecticides were more effective in the control of *T. absoluta* than the selected chemical insecticides. Application of bio-insecticides at different doses caused reduction of 55.5 to 62.5 % pretreatment infestation to between 7.5% and 23.3% while application of any of the four chemical insecticides caused a gradual decrease in *T. absoluta* infestation between 13.8 to 36.2% at the termination of the experiment. According to Gacemi and Guenaoui (2012), three times foliar application of Emamectinbenzoate at 7 days interval in a tomato greenhouse caused 87% mortality of tomato leaf miner larvae.

The organophosphates chlorpyrifos and methamidophos and the pyrethroid deltamethrin are broad-spectrum insecticides effective against a wide range of pests. In the United States, methamidophos and deltamethrin are registered for control of tomato pinworm on tomato. However, most organophosphates and pyrethroids are highly toxic to bees and beneficial insects (USDA–APHIS, 2011). Radwan and Taha (2012) reported the toxic effect of dinotefuran, imidacloprid, fenoxycarb, phenthoate and thiocyclam insecticides against moths and 3rd larval instar of *T. absoluta* under laboratory condition. A botanical extract of Neem (*Azadirachta indica*) and Jatropha (*Jatropha curcus*) were proved to have insectisidal effect against eggs and larvae of tomato leaf miner (Kona et al., 2014). According to these authors, four days treatment of seed extracts of Neem and Jatropha caused around 25% and 18% of egg mortalities while 24 hours seed extracts treatments caused between 33- 46.7% and 23.5 - 48.5% larval mortalities, respectively.

Despite many efforts to develop chemicals to control the pest, tomato leafminer, *Tuta absoluta*, is extremely difficult to control using chemical insecticides because larvae mine within plant tissue and are thus protected at least from contact insecticides, but also because of its ability to develop resistance to insecticides makes its control quite challenging. Each of them could be included in a system of IPM in tomato because they are selective to beneficial insects.

Use of pheromone traps

The word pheromone comes from the Greek pherein, meaning to carry or transfer, and hormon, meaning to excite or stimulate. Pheromones are a class of semiochemicals that insects and other animals release to communicate with other individuals of the same species. The key to all of these behavioral chemicals is that they leave the body of the first organism, pass through the air (or water) and reach the second organism, where they are detected by the receiver. The main methods for utilizing an understanding of pheromones to control pests are monitoring, mating disruption, 'lure and kill' or mass trapping and other manipulations of pest behavior (Mashaly et al., 2012). They have also been used to monitor, forecast and control population of pests. Pheromones are used to control insects by two main techniques; mass annihilation and mating disruption (Witzgall et al., 2010). In an experiment conducted under green house condition, pheromone traps caught as high as 233 males per trap per day (Filho et al., 2000). This number could significantly reduce the male population of *T. absoluta* and the probability of female adult being mated. Similarly, Braham (2014) indicated that large numbers of male individuals caught in pheromone traps as high as 14000 males under green house condition. Even if large numbers of male individuals can be caught by coupling pheromone releasers with use of insect trapping devices, the success of pheromone-based control strategies is usually low.

Conclusion

Tomato leaf miner, *Tuta absoluta,* belongs to the family *Gelechiidae* of the Lepidopterans. *T. absoluta* is an invasive pest native to South America. This pest attacks many crops in the nightshade family, preferably tomato. The larvae damage tomato throughout its growth stages, producing large galleries in their leaves, stem, immature and mature fruits. Tomato leaf miner enters into new areas through tomato fruits from infested areas, containers and packaging equipment and transportation vehicles, plants for planting of tomato and plants for planting of ornamental *Solanaceae*. After its initial detection in eastern Spain in 2006, it has rapidly invaded various other European countries and spread through the Mediterranean basin and Africa. Pheromone traps are usually used to monitor pest incidence and severity. Different control methods have been tried and developed against this pest. These control methods include; chemical insecticides, bio-agents, mass traps using pheromones and botanical extracts.

References

1. Abdul-Rassoul M. S. (2014). A New Host Record for Tomato Leaf Miner *Tuta Absoluta* (Meyrick, 1917) in Baghdad Province, Iraq. *Bull. Iraq Nat. Hist. Mus.* (2014) 13 (1): 15-18
2. Al-Jboory I. J., A. Katbeh-Bader and A. Shakir (2012). First Observation and Identification of Some Natural Enemies Collected from Heavily Infested Tomato by *Tuta absoluta* (Meyrick) (Lepidoptera: Gelechiidae) in Jordan. Middle-East Journal of Scientific Research 11 (6): 787-790
3. Arnó J. and R. Gabarra (2010). Controlling *Tuta absoluta*, a new invasive pest in Europe, Training in Integrated Pest Management – No.5 IRTA Cabrils, Spain.
4. Braham M. and L. Hajji (2012). Management of *Tuta absoluta* (*Lepidoptera*, *Gelechiidae*) with Insecticides on Tomatoes, Insecticides - Pest Engineering, Dr. Farzana Perveen (Ed.), ISBN: 978-953-307- 895-3, InTech, Available from: http://www.intechopen.com/
5. Cabello T., M. Gámez , Z. Varga, J. Garay , R. Carreño , J. R. Gallego , F. J. Fernández and E. Vila (2012). Selection of Trichogramma spp. (Hym.: Trichogrammatidae) for the biological control of Tuta absoluta (Lep.: Gelechiidae) in greenhouses by an entomo-ecological simulation model. Integrated Control in Protected Crops, Mediterranean Climate IOBC-WPRS Bulletin Vol. 80, 2012 pp. 171-176
6. CFIA. 2010. Tomato leafminer- *Tuta absoluta* Pest Fact Sheet. http://www.inspection.gc.ca/english/plaveg/pestrava/tutabs/tech/tutabse.shtml. Accessed, March, 2015.
7. Cherif A., R. Mansour, K. Grissa-Lebdi (2013). 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. Cuthbertson, A.S., J. J. Mathers, L.F. Blackburn, A. Korycinska, W. Luo, R.J. Jacobson and P. Northing (2013). Population Development of *Tuta absoluta* (Meyrick) (Lepidoptera: Gelechiidae) under Simulated UK Glasshouse Conditions. *Insects* 2013, *4*, 185-197; doi:10.3390/insects4020185
9. David D.and A. Catania (2009). *Tuta absoluta* (Povolny, 1994), an important agricultural pest in Malta (Lepidoptera: Gelechiidae). Bulletin of the Entomological Society of Malta (2009) Vol. 2 : 57-60
10. Deleva E. A, and V. B. Harizanova (2014). Efficacy evaluation of insecticides on larvae of the tomato borer T*uta absoluta*, Meyrick (Lepidoptera: Gelechiidae) under laboratory conditions. Journal of International Scientific Publications: Agriculture and Food Volume 2, ISSN 1314-8591 (Online), Published at: http://www.scientific-publications.net
11. Desneux N., E. Wajnberg, G. Wyckhuys, G. Burgio, S. Arpaia, A. Narva´ez-Vasquez, J.Gonza´lez-Cabrera, D. Ruescas, E. Tabone, J. Frandon, J. Pizzol, C. Poncet • T. Cabello, A.Urbaneja (2010). Biological invasion of European tomato crops by Tuta absoluta: ecology, geographic expansion and prospects for biological control. J Pest Sci (2010) 83:197–215
12. FAO (2002). Production year book 2000. Vol. 54. FAO. Italy
13. Filho M. M., E. F. Vilelaa, G. N. Jham, A. Attygalle, A. Svatos and J. Meinwald (2000). Initial Studies of Mating Disruption of the Tomato Moth, *Tuta absoluta* (Lepidoptera: Gelechiidae) Using Synthetic Sex Pheromone. *J. Braz. Chem. Soc.,* Vol. 11, No. 6, 621-628, 2000.
14. Gonza´lez-Cabrera J., O. Molla, H. Monto´n and A. Urbaneja (2011). Efficacy of Bacillus thuringiensis (Berliner) in controlling the tomato borer, Tuta absoluta (Meyrick) (Lepidoptera: Gelechiidae). BioControl (2011) 56:71–80
15. Gorman K., M. Berger, K. Haddi and C. Bass (2011). The current incidence of tomato borer, *Tuta absoluta*, in the UK. EPPO/IOBC/FAO/ NEPPO Joint International Symposium on management of *Tuta absoluta* (tomato borer, Lepidoptera: Gelechiidae) in collaboration with the IRAC and IBMA, Agadir, Morocco, November 16-18, 2011
16. Hanafy E. M. and W. El-Sayed (2013). Efficacy of Bio-And Chemical Insecticides in the Control of *Tuta absoluta* (Meyrick) and *Helicoverpa armigera* (Hubner) Infesting Tomato Plants. Australian Journal of Basic and Applied Sciences, 7(2): 943-948
17. Karadjova O., Z. Ilieva, V. Krumov, E. Petrova and V. Ventsislavov (2013). *Tuta Absoluta* (Meyrick) (Lepidoptera: Gelechiidae): Potential for Entry, Establishment and Spread in Bulgaria. *Bulgarian Journal of Agricultural Science, 19 (No 3) 2013, 563-571 Agricultural Academy*
18. Kaoud H.A., (2014). Alternative methods for the control of *Tuta absoluta.* Glob. J. Mul. App. Sci., 2 (2): 41-46, 2014
19. Kona M., K. Taha and E. Mahmoud (2014). Effects of Botanical Extracts of Neem(*Azadirachta indica*) and Jatropha (*Jatropha curcus*) on Eggs and Larvae of Tomato Leaf Miner, *Tuta absoluta* (Meyrick)

(Lepidoptera: Gelechiidae), Persian Gulf Crop Protection, 3(3): 41-46
20. Harizanova V., A. Stoeva and M. Mohamedova (2009). Tomato leaf miner, Tuta absoluta (Povolny) (Lepidoptera: gelechiidae) – first record in Bulgaria. Agricultural Science and Technology, Vol. 1, No 3, pp 95 - 98
21. Maroo M., (2015). Pest Alert: Tuta absoluta (Tomato Leaf Miner). Media Advisory, Department of Agriculture and fisheries, South Africa. http://www.daff.gov.za/docs/media/Press%20Release%20on%20Tuta%20absoluta%20(Tomato%20Leaf%20Miner).pdf, Accessed April, 2015.
22. Mashaly A., M. Ali and S. Al-Khalifa (2012). Trail Pheromones in Pest Control, New Perspectives in Plant Protection, Prof. Ali R. Bandani (Ed.), ISBN: 978-953-51-0490-2, InTech, Available from: http://www.intechopen.com/
23. Muniappan R. (2013) *Tuta absoluta*: the tomato leafminer. http://www.coraf.org/documents/ateliers/2013-05/tuta-absoluta/Tuta-absoluta-Presentation.pdf, Accessed April, 2015
24. NAPPO (2012). Surveillance Protocol for the Tomato Leaf Miner, *Tuta absoluta*, for NAPPO Member Countries
25. Ögür E., L. Ünlü And M. Karaca (2014). *Chenopodium album* L.: A new host plant of *Tuta absoluta* Povolny (Lepidoptera: Gelechiidae). Türk. Entomol. Bült., 2014, 4 (1): 61-65 ISSN 2146-975X
26. Oliveira C., C. Matos and E. Hatano (2007). Occurrence of *Pyemotes* sp. on *Tuta absoluta* (Meyrick). Brazilian Archives of Biology and Technology, Vol.50, n. 6 : pp.929-932, November 2007 ISSN 1516-8913
27. Öztemiz S. (2013). Population of *Tuta absoluta* and natural enemies after releasing on tomato grown greenhouse in Turkey. African Journal of Biotechnology Vol. 12(15), pp. 1882-1887, 10
28. Potting, R.P.J. , D. J. van der Gaag, A. Loomans, M. van der Straten, H. Anderson, A. MacLeod, J. M. G. Castrillón, and G. V. Cambra. (2013). *Tuta absoluta*, Tomato leaf miner moth or South American tomato moth. Ministry of Agriculture, Nature and Food Quality, Plant Protection Service of the Netherlands.
29. Radwan M. M. and H. S. Taha (2012). Toxic and biochemical effects of different insecticides on the tomato leafminer, *Tuta absoluta* (Meyrick) (Lepidoptera: Gelechiidae). Egypt. Acad. J. Biolog. Sci., 4 (1): 1- 10
30. Roditakis E. and N. Seraphides (2011). The current status of *Tuta absoluta* in Greece and Cyprus. EPPO/IOBC/FAO/ NEPPO Joint International Symposium on management of *Tuta absoluta* (tomato borer, Lepidoptera: Gelechiidae) in collaboration with the IRAC and IBMA, Agadir, Morocco, November 16-18, 2011
31. Salama H., M. Fouda, I. A. Ismail, I. Ebada and I. Shehata (2014). Life Table Parameters and Fluctuations in the Population Density of the Moth *Tuta absoluta* (Meyrick) - (Lepidoptera: Gelechiidae). Current Science International 3(3): 252-259, 2014, ISSN: 2077-4435
32. Srinivasan R. (Ed) (2010). Safer tomato production methods. A field guide for soil fertility and pest management. AVRDC- The world vegetable center Shanhua Taiwan AVRDC Publication No. 10-740. 97 P.
33. Temerak S. A. (2011). The status of *Tuta absoluta* in Egypt. EPPO/IOBC/FAO/ NEPPO Joint International Symposium on management of *Tuta absoluta* (tomato borer, Lepidoptera: Gelechiidae) in collaboration with the IRAC and IBMA, Agadir, Morocco, November 16-18, 2011
34. Taha, A. M., A. F. E. Afsah and F. H., Fargalla (2013). Evaluation of the effect of integrated control of tomato leafminer *Tuta absoluta* with sex pheromone and insecticides. *Nat Sci* 2013;11(7):26-29]. (ISSN: 1545-0740).
35. Toševski I., J. Jović, M. Mitrović, T. Cvrković, O. Krstić and S. Krnjajić (2011). *Tuta absoluta* (Meyrick, 1917) (Lepidoptera, Gelechiidae): a New Pest of Tomato in Serbia. Pestic. Phytomed. (Belgrade), 26(3), 197–204
36. USDA–APHIS. (2011). New Pest Response Guidelines: *Tomato Leafminer* (Tuta absoluta). USDA–APHIS–PPQ–EDP Emergency Management, Riverdale, Maryland.
37. Uchoa Fernandes MA, Della Lucia TMC, Vilela EF (1995), *Mating, oviposition and pupation of Scrobipalpula absoluta (Meyrick) (Lepidoptera: Gelechiidae)*. Anais da Sociedade Entomologicado Brasil 24:159–164,
38. Witzgall P., P. Kirsch and A. Cork (2010). Sex pheromones and their impact on pest management. *J. Chem. Ecol*., 36(1), 80-100.
39. Zouba, A., Chermiti, B., Chraiet, R., and Mahjoubi, K. (2013). Effect of two indigenous *Trichogramma* species on the infestation level by tomato miner, *Tuta absoluta*, in tomato greenhouses in the south-west of Tunisia. Tunisian Journal of Plant Protection 8: 87- 106.