Use of biorational insecticides for the control of *Tuta absoluta* (Meyrick) infestations on open field tomato

P. LO BUE[1], *S. ABBAS*[1], *E. PERI*[1], *S. COLAZZA*[1]

Abstract

Tuta absoluta (Meyrick) (Lepidoptera: Gelechiidae), the tomato leaf miner, is one of the most devastating pests affecting tomato crops in Italy. Management of T. absoluta was assessed in open-field tests using three biorational insecticides, Azadirachtin, Bacillus thuringiensis var. kurstaki, and Beauveria bassiana, and a combination of three synthetic insecticides, Emamectin, Indoxacarb and Metaflumizone, as a control treatment. Our results showed that only the combination of Azadirachtin – B. thuringiensis was able to reduce the impact of tomato leaf miner on the fruit's marketable production similarly to the control treatment. This finding suggests that biorational insecticides are a good alternative to synthetic ones. Possible use of biorational insecticides in the management of tomato leaf miner in organic farming system is discussed.

***Keywords**; Tomato leaf miner, Azadirachtin, Bacillus thuringiensis, Beauveria bassiana.*

Introduction

The tomato leaf miner, *Tuta absoluta* (Meyrick) (Lepidoptera: Gelechiidae), is a key pest of tomato, *Lycopersicon esculentum* Mill., originating from South America (Barrientos et al., 1998). In Europe, *T. absoluta* has been initially detected in eastern Spain in 2006 (Urbaneja et al. 2007), then, a few years later, it was found in most of the countries facing the Mediterranean Sea and in several countries of Europe, where it is causing serious damages to open field and greenhouse tomato (Desneux et al. 2010). Several cultivated and wild species have been reported as host plants, e.g *Solanum melongena* L., S. *tuberosum Nicotiana glauca* Graham, *Datura stramonium* L., *Capsicum annuum* L. *Phaseolus vulgaris* L. (EPPO, 2009); in Italy the pest was also reported on *Lycium* sp. and *Malva* sp. (Caponero, 2009), and on greenhouse plants of Cape gooseberry, *Physalis peruviana* L., cultivated in Sicily (Tropea et al., 2009). To reduce *T. absoluta* infestations, some strategies, currently underway, seem to give encouraging results, as mating disruption technique (Filho et al., 2000), and biological control programs based on indigenous parasitoids and predators (for a review see Desneux et al. 2010). However, to date, applying insecticide treatments is the dominant strategy in *T. absoluta* management. In the present paper we evaluate the efficacy of three biorational insecticides to establish sustainable strategy in controlling the tomato leaf miner in organic tomato plantations.

Materials and Methods

The experiments were carried out in a tomato field located near Santa Ninfa (Trapani), West Sicily, at 410 m above mean sea level (AMSL), from March to August 2011. Tomato plants, cv "Patataro", were cultivated in a 7000 m^2 area, including 12 rows of 36 plants each. Separation between rows and plants was 1.5 m and 1 m, respectively. Plants were cultivated under an organic system, and following typical open-field tomato cultivation techniques applied in Sicily: the plant main stem was trained with plastic rings to a cane structure, secondary shoots and senescent leaves were weekly pruned, and the application of a standard nutrient solution (Guanito, ItalPollina) for tomato was added directly to the soil. The average temperature ranged from 13 °C, on March to 33°C, on August. The average relative humidity ranged from 21%, on March, to 13%, on August. Two delta trap supplied with *T. absoluta* pheromone (Intrachem, Italy) were hung at opposite ends of the field at a height of 1 m. The traps were weekly observed. The sticky plate was changed once a week, and the pheromone capsule once a month. Three biorational insecticides - *Azadirachtin* (Neemazal - Intrachem), *Bacillus thuringiensis* var. *kurstaki* (EG 2348) (Bt Rapax- Intrachem), and *Beauveria bassiana* (Naturalis- Intrachem) – and three synthetic insecticides - Emamectin (Affirm-Syngenta), Indoxacarb (Steward-DuPont), and Metaflumizone (Alverde-Basf) – were selected. The experiment used a randomized block design with four treatments replicated three times (12 plots). Each plot was 12 m long and 3 m wide and contained 3 rows with 12 plants, for a total of 36 plants. The treatments, applied at the dose recommended by the companies, were: 1. *Azadirachtin* (*Az*) with the dose of 300 cc/hl; 2. *Azadirachtin* + *B. thuringiensis* (Az + Bt) with the dose of 300 cc/hl and 150 cc/hl, respectively; 3. *Azadirachtin* + *B. bassiana* (Az + Bb) with the dose of 300 cc/hl and 150 respectively; 4. Emamectin with the dose of 150 g/hl, Indoxacarb with the dose of 12.5 g/hl and Metaflumizone with the dose of 100 ml/hl (Control). The synthetic insecticides were applied in rotation. All the treatments started when

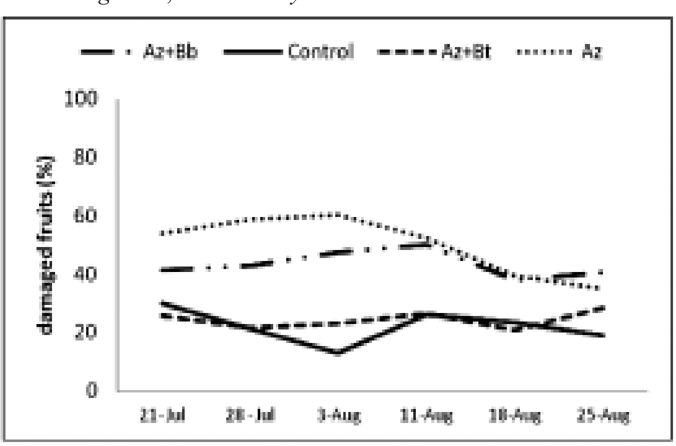
[1] Dipartimento DEMETRA – Università degli Studi di Palermo E-mail: paololobue@hotmail.com; sadekabbass@yahoo.com; ezio.peri@unipa.it; stefano.colazza@unipa.it

more than 3 adults were chaugt in the traps and were weekly repeated. The number of 3 caught adults has been selected to prove the field pest presence without economic threshold correlations. Plants were weekly visually checked from March 28th to August 25th and fruits were weekly harvested and weighted from July 21st to August 25th. Insecticide efficacy was evaluated in terms of marketable production, i.e. weight (g) of no damaged fruits. Data were compared by One-way ANOVA, followed by Fisher's LSD test, using Statistica for Windows 6.0 (Stat Soft Italia, 1997).

Results

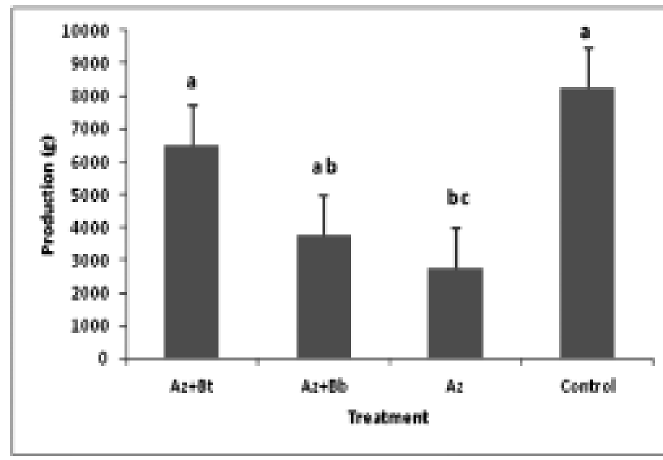
The catches of T. *absoluta* males in the pheromone traps started from June 2nd reaching the fixed threshold (3 adults/trap) to start the treatments on June 16th. In all the plots fruits were damaged by tomato leaf miner (Fig.1). In terms of weight, in the plots treated with *Az + Bt*, damaged fruits never exceed 30% of the total weight of harvested fruits. On the contrary, the weight of the damaged fruits was always upper to 30% in both plots treated with *Az + Bb* and with *Az*. The maximum of damaged fruits was recorded from plots treated with *Az* (60%) on August 3rd, while the minimum was recorded from plots treated with *Az + Bt* (21%) on August 18th. In the control plots the weight of the damaged fruits ranged from a minimum of 13% on August 3rd and a maximum of 30% on July 21st.

Figure 1 - *Percentage of damaged tomato fruits (weight of damaged fruits/total weight of harvested fruits*100) from plants differently treated from July 21st to August 25th 2011.* Az = *Azadirachtin*; Az+Bb = *Azadirachtin + Beauveria bassiana*; Az+Bt = *Azadirachtin + Bacillus thuringiensis*; *Control = synthetic insecticides*.



Considering the mean marketable production, i.e the fruits that were not damaged, for each treatment, (Fig. 2), the maximum and minimum production were obtained from plants treated with *Az + Bt* and with Az (6471 ± 382 g and 2740 ± 280 g, respectively P = 0.015). The production from plants treated with *Az + Bb* (3703 ± 398 g) was not significant different from the plants treated with *Az + Bt* or *Az* (P = 0.064 and P = 0.504, respectively). Compared to the control (8195 ± 420 g), statistic differences were evidenced for *Az + Bb* and *Az* (P=0.004 and P=0.001, respectively). On the contrary no significant differences between control and *Az + Bt* were found.

Figure 2 - *Marketable tomato fruits harvested from plants differently treated from July, 21st to August, 25th 2011. Az = Azadirachtin*; Az+Bb = *Azadirachtin + Beauveria bassiana*; Az+Bt = *Azadirachtin + Bacillus thuringiensis*; *Control = synthetic insecticides.*



Discussion

The results obtained in tomato open-field cultivation reveal that it is possible to reduce the tomato leaf miner impact applying biorational insecticides. In particular, the *Azadirachtin + B. thuringiensis* combination offers promising results in controlling the pest. The potential of Bt formulates in controlling *T. absoluta* was clearly demonstrated in laboratory tests (Giustolin et al., 2001; Lolas and Meza-Basso, 2006; Giulianotti, 2010; Gonzáles-Cabrera et al., 2011; Ladurner et al.; 2011). Moreover, Gonzáles-Cabrera et al. (2011) evidenced that Bt strains are able to reduce the pest's impact to very low levels when tested in greenhouse and open-field. Furthermore, management of *T. absoluta* based on treatments with *Bt* doesn't induce resistance in phytophagous populations, that is a likely cause of field control failures (Silva et al., 2011), and could be associated with the use of parasitoids or predators (de Medeiros et al, 2009; Mollá et al., 2011). *Azadirachtin* has a knock-down power towards larvae of *T. absoluta*, as in laboratory test aqueous neem seeds extracts induced high larval mortality by both systemic and translaminar actions (Gonçalves-Gervásio and Vendramim, 2007). However, our results suggest that in open field cultivation treatment with *Azadirachtin* alone is not enough to reduce successfully tomato leaf miner damages. Moreover, the adding of *B. bassiana* to *Azadirachtin* did not induce a better control of the pest. Previous studies showed that, in laboratory tests, isolates of *B. bassiana* induce high mortality to tomato leaf miner eggs and larvae (Giustolin et al., 2001; Rodríguez et al,, 2006), and the eggs are more susceptible than the first instars larvae (Pires et al., 2010). So that, this entomopathogenic fungus was considered a promising agents for control of *Tuta absoluta* in open tomato fields (Torres Gregorio et al. 2009), however, our data showed that, in open field, the combination *Azadirachtin + B. bassiana* has a lower efficacy than the combination *Azadirachtin* + *B. thuringiensis* in controlling the tomato leaf miner.

Conclusion

Tuta absoluta has become a key pest of tomato in several world regions and its geographic distribution is rapidly expanding. The extensive insecticide use can cause on the one hand several undesired side-effect on human and environment safety, on the other hand resistance development in *T. absoluta*. In this view, is a necessary consequence applying environmentally-friendly strategies. The results obtained in this study demonstrated that treatment based on *Azadirachtin* and *B. thuringiensis* combination can effectively reduce *T. absoluta* damage on tomato open field cultivation. However, the sublethal effects of azadirachtin on tomato leaf miner natural enemies should not be ignored, as it was demonstrated that *Azadirachtin* significantly reduced the offspring of the predator mirid bug *Nesidiocoris tenuis* females (Arnó and Gabarra, 2011). Therefore, further studies should be carried out to integrate this strategy with other integrated or biological control methods in order to reduce the use of chemicals and, consequently, improve food safety and environment quality.

Acknowledgment

We thank Intrachem Italia for providing biorational insecticides.

References

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

Barrientos, Z.R., Apablaza, H.J., Norero, S.A., Estay P.P. (1998): Threshold temperature and thermal constant for development of the South American tomato moth, *Tuta absoluta* (Lepidoptera, Gelechiidae), Ciencia e Investigacion Agraria 25, 133-137

Caponero, A. (2009): Solanacee, rischio in serre. Resta alta l'attenzione alla tignola del pomodoro nelle colture protette, Colture Protette 10: 96-97

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., Urbaneja, A. (2010): Biological invasion of European tomato crops by *Tuta absoluta*: ecology, geographic expansion and prospects for biological control, Journal of Pest Science 83 (3): 197-215.

EPPO (2009): Phytosanitary Alert System Pest Alert www.pestalert.org Prepared on: 08/07/2009 http://www.pestalert.org/viewNewsAlert.cfm?naid=78.

Filho, M.M., Vilela, E.F., Jham, N.G., Attygalle, A., Svatoš, A., Meinwald, J. (2000): Initial studies of mating disruption of the tomato moth, *Tuta absoluta* (Lepidoptera: Gelechiidae) using synthetic sex pheromon.- Journal of the Brazilian Chemical Society, 11 (6): 621-628

Giulianotti, L.G. (2010): Certis IPM programme for the control of *Tuta absoluta*. International Pest Control, 52: 162-165.

Giustolin, T.A., Vendramim, J.D., Alves, S.B., Vieira, S.A. (2001): Associated effect between tomato resistant genotype and *Bacillus thuringiensis var. kurstaki* on the development of *Tuta absoluta* Meyrick (Lep., Gelechiidae), Neotropical Entomology, 30: 461-465.

Gonçalves-Gervásio, R.D.R., Vendramim, D.J. (2007): Bioactivity of aqueous neem seeds extract on the *Tuta absoluta* (Meyrick, 1917) (Lepidoptera: Gelechiidae) in three ways of application, Ciência e Agrotecnologia, 31 (1): 28-34.

González-Cabrera, J., Mollá, O., Montón, H., Urbaneja, A. (2011): Efficacy of *Bacillus thuringiensis* (Berliner) for controlling the tomato borer, *Tuta absoluta* (Meyrick) (Lepidoptera: Gelechiidae), Biocontrol 56:71-80.

Ladurner, E., Benuzzi, M., Franceschini, S. (2011): *Bacillus thuringiensis var. kurstaki* strain EG 2348: effect of formulation on efficacy against tomato leafminer (*Tuta absoluta*), IOBC/wprs Bulletin, 66: 39-42.

Lolas, L.N., Meza-Basso, L. (2006): Evaluation of native strains of *Bacillus thuringiensis* as an alternative of integrated management of the tomato leaf miner (*Tuta absoluta* Meyrick; Lepidoptera: Gelechiidae) in Chile, Agricultura Tecnica, 66: 235-246.

Medeiros, M.A., Villas Bôas, G.L., Vilela, N.J., Carrijo, O.A. (2009): A preliminar survey on the biological control of South American tomato pinworm with the parasitoid T*richogramma pretiosum* in greenhouse models, Horticultura Brasileira 27: 80-85.

Mollá, O., González-Cabrera, J., Urbaneja, A. (2011): The combined use of *Bacillus thuringiensis* and *Nesidiocoris tenuis* against the tomato borer *Tuta absoluta*, BioControl, 56: 883-891.

Pires, L.M., Marques, E.J., de Oliveira, J.V., Alves, S.B. (2010): Selection of isolates of entomopathogenic fungi for controlling *Tuta absoluta* (Meyrick) (Lepidoptera: Gelechiidae) and their compatibility with insecticides used in tomato crop, Neotropical Entomology 39: 977-984.

Rodríguez, M.S., Gerding, M.P., France, A., (2006): Entomopathogenic fungi isolates selection for egg control of tomato moth *Tuta absoluta* Meyrick (Lepidoptera: Gelechiidae), Agricultura Tecnica, 66: 151-158

Silva, G.A., Picanço, M.C., Bacci, L., Crespo, A.L.B., Rosado, J.F., Guedes, R.N.C. (2011): Control failure likelihood and spatial dependence of insecticide resistance in the tomato pinworm, *Tuta absoluta*. Pest Management Science, 67: 913-920

Tropea Garzia, G. (2009): *Physalis peruviana* L. (Solanaceae), a host plant of *Tuta absoluta* in Italy. IOBC/WPRS Bull 49: 231-232.

Torres Gregorio, J, Argente, J, Díaz, M.A., Yuste, A. (2009) Applicación de *Beauveria bassiana* en la lucha biológica contra *Tuta absoluta*. Agrícola Vergel: Fruticultura, Horticultura, Floricultura 326: 129-132

Urbaneja A., Vercher R., Navarro V., Garcıá Marí F., Porcuna J.L. (2007): La polilla del tomate, *Tuta absoluta*, Phytoma España 194: 16-23.