

The complex of natural enemies of invasive species *Tuta absoluta* (Meyrick, 1917) (Lepidoptera: Gelechiidae) on greenhouse-grown tomato crops conditions from southern Romania

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Abstract An obvious consequence of climate change is represented by the rapid spread and establishment of the invasive alien pest worldwide. Soon after its introduction in Romania, the tomato leaf miner *Tuta absoluta* is considered the greatest threat to protected tomato crops in the area from south of the country. Pest control is based mainly on spraying of chemical insecticides but augmentative biological control started to be used more and more by farmers. The indiscriminate use of pesticides against *T. absoluta* may result in undesirable consequences and effects including toxicity to non-target organisms. Gaining knowledge about indigenous natural enemies that adapt to this invasive species is essential for establishing a safer and eco-friendly strategy of control. A complex survey on the *T. absoluta* natural enemies was conducted in 2020 in four localities from the main greenhouse-grown vegetable cultivation areas in southern Romania. The list of *T. absoluta* antagonists includes eleven predators and three parasitoids species. The paper also examines how differences in technology and protection means, currently used by farmers, influence these natural enemies' diversity and dynamics by providing useful information for understanding their role in ecosystem services and a base for further modeling and development of sustainable IPM programs.

Keywords: climate change, ecosystem services, invasive species

1. Introduction

The tomato leaf miner *Tuta absoluta* (Meyrick, 1917) (Lepidoptera: Gelechiidae), a species unknown outside South America continent until the end of 2006 when was first detected in Spain (Urbaneja et al., 2009, 2007; Desneux et al., 2010), has proven an extraordinary capacity of rapidly spreading and establishing in novel areas in the Mediterranean Basin, Europe (Campos et al., 2017), Middle East, Asia (Han et al. 2019, Ishtiaq M. et al., 2020; Zhang et al. 2019) and Africa (Machekano et al., 2018). This phenomenon

depend on various factors, such as favorable temperature and relative humidity conditions, intensive tomato production system, and continuous host plant availability (Desneux et al. 2010, 2011; Cuthbertson et al. 2013; Machekano et al. 2018; Cherif et al. 2019). *T. absoluta* presence was signaled in Romania in 2009 (Cean & Dobrin, 2009; Leota, 2009) and nowadays is considered the most devastating pest of tomato crops in southern area of the country (Iamandei et al., 2020). There are numerous studies documenting *T. absoluta* biology and ecology on new invaded territories, most of them showing the imperative need for efficient and sustainable management methods (Desneux et al., 2010). Giorgini et al. (2019) found that in tomato greenhouses condition the integration of biological control agents (mirid predators and egg parasitoids), microbial insecticides (based on *Bacillus thuringiensis*), selective chemical insecticides, and sex pheromone-based control has proven adequate and successful. The intensive use of pesticides is the preferred method deployed by farmers to control the pest in Romania. One of the key points for establishing safer and eco-friendly strategy of control is to obtain information about indigenous natural enemies that adapt to this invasive species. The aim of this study was to obtain the first data on *T. absoluta* natural enemies from the main greenhouse-grown vegetable cultivation areas conditions in southern Romania.

2. Material and methods

In our survey, carried out during cropping season of 2020, naturally occurring predators and parasitoids of *Tuta absoluta* populations on tomato protected crops were evaluated in five greenhouses from four localities belonging to two of the main tomato growing area in southern Romania. The type of tomatoes pests control strategies used by farmers were as follows: (i) "CC"- chemical control consisted of application of conventional pesticides; (ii) "BC"- Biological control

consisted of inoculative releases of *Macrolophus caliginosus*; (iii) “IPM”-integrated control consisted of the release of the predatory bug in combination with application of the compatible pesticides and (iv) “UT”-without any control measure (Table 1).

Table 1. The basic characteristics of the study greenhouses from southern Romania used for *Tuta absoluta* natural enemies scouting in 2020

Greenhouse code	Locality	County	Type of pest control
Vi	Vidra	Ifov	UT
Var	Varasti	Giurgiu	CC
Iz	Izbiceni	Olt	BC
Ci1	Cilieni	Olt	IPM
Ci2	Cilieni	Olt	CC

Direct observation on 100 tomato plants infested by *Tuta absoluta*, randomly selected in every study site were performed weekly between May to October 2020. All the predators' individuals in adult stage which were easy to be identified were noticed and left in the greenhouse. The other individuals that could not be identified on site, in adult or larval stage, were placed in various recipients for transfer to the laboratory. On each sampling date, 50 leaflets infested by *Tuta absoluta*, were collected in plastic bags sealed and transferred to laboratory for parasitoid surveillance. All the sampled material was kept in laboratory conditions, at a temperature of $24 \pm 1^\circ\text{C}$, $60 \pm 10\%$ relative humidity and 14:10 hour's photoperiod until the individual reached the adult stage for a proper identification to at least genus level.

3. Results

The intensive survey of the natural enemies *Tuta absoluta* in greenhouse-grown vegetable cultivation areas from southern Romania in 2020 revealed a number of three species of Hymenoptera parasitoids that emerged from collected tomato leaves. Also, eleven species of generalist predators were found on tomato plants infested by *T. absoluta* (Table 2).

The site characterized by the biggest species richness of *T. absoluta* antagonists (3 parasitoids and 10 predators) was the greenhouse managed exclusively by the inoculative releases of *Macrolophus caliginosus* (Izbiceni) followed by Vidra greenhouse without any pest control measure (1 parasitoid and 10 predator species) and the IMP managed greenhouse Ci1 (with 1 parasitoid and 8 predators species) while the lower number of natural enemies species was recorded on the greenhouse from Cilieni (Ci2) receiving the intensive schedule of chemical treatments application against tomatoes pest.

The predatory bug were the dominant group of predators encountered in the 2020 study, with *Nabis pseudoferus* present in all study sites.

Our preliminary assessment of the management options currently used in the tomato greenhouse from southern Romania showed that the lack of action to stop the

spread as well as adapted integrated management program has caused the problem generated by *T. absoluta* attack to gradually increase over the past 6 years, in this tomato growing region. Collaborating farmers claimed that they had to apply at least twice as many chemical treatments compared to the situation before the pest entered the area. Despite their efforts, the situation is difficult to control, being worsened by the phenomenon of resistance developed quickly by the pest. On the other hand, the use of biological control means is approached with great caution, very few farmers are willing to exclusively apply predators and/or entomopathogenic based products for pest control in tomato crops. The augmentative release of predators in case of Izbiceni greenhouse and the IPM program applied at Cilieni showed promising results in term of crop protection, but the most important lessons learned during the interaction with the farmers is the need to accelerate the finding of efficient solution, adapted to the actual conditions as well as a good promotion of the results among the final users.

Table 2. Natural enemies associated with *Tuta absoluta* populations in greenhouse-grown vegetable cultivation areas from southern Romania

Order/Family	Species	Place of sampling
Hymenoptera/ Trichogrammatidae	<i>Trichogramma sp.</i>	Ci1, Iz, Vi
Hymenoptera/ Braconidae	<i>Bracon nigricans</i>	Iz
Hymenoptera/ Eulophidae	<i>Necremnus sp.</i>	Iz
Hemiptera/ Anthocoridae	<i>Orius laevigatus</i>	Vi, Iz, Ci1
	<i>O. insidiosus</i>	Vi, Iz, Ci1, Var
Hemiptera/ Miridae	<i>Nesidiocoris tenuis</i>	Vi, Iz, Ci1
	<i>Macrolophus caliginosus</i>	Iz, Ci1, Vi
	<i>M. pygmaeus</i>	Vi
Hemiptera/ Nabidae	<i>Nabis pseudoferus</i>	Vi, Iz, Ci1, Var, Ci2
Hemiptera/ Geocoridae	<i>Geocoris ater</i>	Vi, Iz
Neuroptera/ Chrysopidae	<i>Chrysoperla carnea</i>	Vi, Iz, Ci1, Var
Coleoptera/ Coccinellidae	<i>Adalia bipunctata</i>	Iz, Ci1, Ci2
	<i>Coccinella septempunctata</i>	Vi, Ci1, Var
Diptera/ Syphidae	<i>Episyrphus balteatus</i>	Iz, Vi

Conclusions

The data obtained represent the first report on the natural enemies' complex of the invasive species *Tuta absoluta* since its arrival on the Romanian territory.

The results show the highest presence of natural enemies, in terms of species richness and abundance, on the sites receiving the minimum intervention and control measures but more related aspects are needed to be investigated.

Overall, the results provided useful information and the base for further modeling and development of sustainable IPM programs.

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