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Integrated Pest Management Essay against the Tomato Leafminer *Tuta absoluta* Povolny (Lepidotera: Gelecheiidae) in an Open Field Tomato Crop in the Region of Raggueda, Tunisia

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ABSTRACT

Integrated pest management in open field tomato crops against the tomato leafminer *Tuta absoluta* using mass trapping, predatory bug *Nesitdiocoris tenuis* Reuter (Heteroptera: Miridae) and selective insecticides in the region of Kairouan (Tunisia) was efficient. The infestation rate of apical leaves remained under 14% and the number of leaf mines caused by larvae stayed beneath 5.8 mines per 100 leaves after the release of the predatory bug. Fruit losses were very reduced about 3 tones from a total production of 80 tones, corresponding to 3.75% of loss.

Keywords: Biological control, infestation rate, *Nesidiocoris tenuis*, number of mines per leaf, pheromone traps

INTRODUCTION

The tomato leaf miner *Tuta absoluta* Povolny (1994) is considered as the key pest for fresh market and processing tomato production in South American countries like Argentina and Brazil (Silva *et al*. 1998).This moth Attacks tomato plants in all phenological stages (Griepink *et al.* 1996). On tomato crops *T. absoluta* can infest leaves, buds and stems as well as fruits and can cause up to 100% damage (Filho *et al*. 2000; Mollá *et al*. 2009).

Outbreaks of *T. absoluta* in tomato cropping areas in Mediterranean countries like Spain, Algeria, Morocco and Tunisia have been reported (EPPO 2007; Urbaneja 2007; EPPO 2008; Guenaoui 2008). The aggressiveness of this pest toward tomato and its high biotic potential in addition to its ability to easily develop resistance to most used insecticides (Lietti 2005) can cause severe constraints on the production, commercialization and export of this economically important vegetable. An integrated pest management (IPM) strategy to control populations of this moth seems to be a sustainable solution. This pest management strategy, mainly based on the use of predatory and parasitoid insects, was successful in controlling this pest in its native zones (Mirranda *et al*. 2005; Mollá *et al*. 2009). However, other pest management strategies with irrational use of chemicals tended to decrease the efficiency of most of the used insecticides (Lietti *et al*. 2005) and to reduce natural enemies of the pest (Filho *et al*. 2000).

MATERIALS AND METHODS

The experiment was conducted in 2009 using 'Amel' tomato crop (indeterminate growth variety) of 1.7 ha (4540 m × 38 m) containing 50.000 plants in Raggueda, located 6 km to the west of Kairouan (Tunisia), from the 28th April to the 23rd June. Tomato seedlings were transplanted on the 19th March and trellised on stakes one month later.

The aim of this work was to evaluate the efficiency of IPM against *T. absoluta* in an open field tomato crop using water traps equipped with sexual pheromone dispensers, the massive release of a zoophytophagus mirid *Nesidiocoris tenuis* Reuter (Heteroptera: Miridae) and selective insecticides, compatible with the use of auxiliaries. In order to do that, 22 'Tutasun' water pheromone traps equipped with pheromone dispensers type 'Pherodis', both produced by Kopprt®, Berkel en Rodenrijs, the Netherlands, were installed in two parallel rows in the crop on the 26th March just after transplanting (**Fig. 1**). Nevertheless, from the 28th April, the number of water traps was increased to 38. One week later (3rd May), the owner of the crop allowed to us to count the number of trapped males of *T. absoluta* once a week. Pheromone lures were renewed once throughout the period of the essay, on the 27th May.

On the other hand, one pheromone trap type 'Mc Phail' was set up to monitor the attacks of the tomato fruit borer *Heliothis armigera* Hübner. The pheromone dispenser type 'Agrisens' was renewed every 5 weeks. 19.000 *N. tenuis* ("Nesibug", a Koppert®) were released on the 25th April in the entire crop, 5 weeks after transplantation corresponding to a density of 1.1 insects/m².

To enhance pollination, to guarantee maximum production and to ameliorate the quality of tomato fruits, *Bombus terrestris* (earth bumblebees) was introduced to the crop. Two hives of this pollinator type "Tripol", produced by Koppert®, were introduced in the crop. Each hive contained three colonies of bumblebees with a queen and brood (pupae, larvae and eggs) with a total of 350 to 400 individuals/hive.

The use of pesticides was reduced as maximum as possible with only four applications during all the period of the survey. Three selective insecticides, Avaunt (Indoxacarb), Oberon (Spiromesifen) and Bactospein (*Bacillus thuringiensis*) provided by a local agreed revendor were used in this experiment.

The sampling design was totally randomized. It focused on apical leaves since they are the preferential site of oviposition for *T. absoluta* (Silva *et al*. 1998; Leite *et al*. 1999). 120 representative young leaves from the upper part of 120 tomato plants were sampled weekly to monitor the evolution of the pest and its predator. The number of biological stages of *T. absoluta* and *N. tenuis* as well as the number of leaf mines produced by the moth were counted every week under a binocular microscope type Leica®, model MS 5.

Statistical analysis

Means of counted individuals of *T. absoluta* on young tomato leaves, sex pheromone water traps as well as leaf mines caused by caterpillars of the moth were calculated every week from 24th

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Research Note

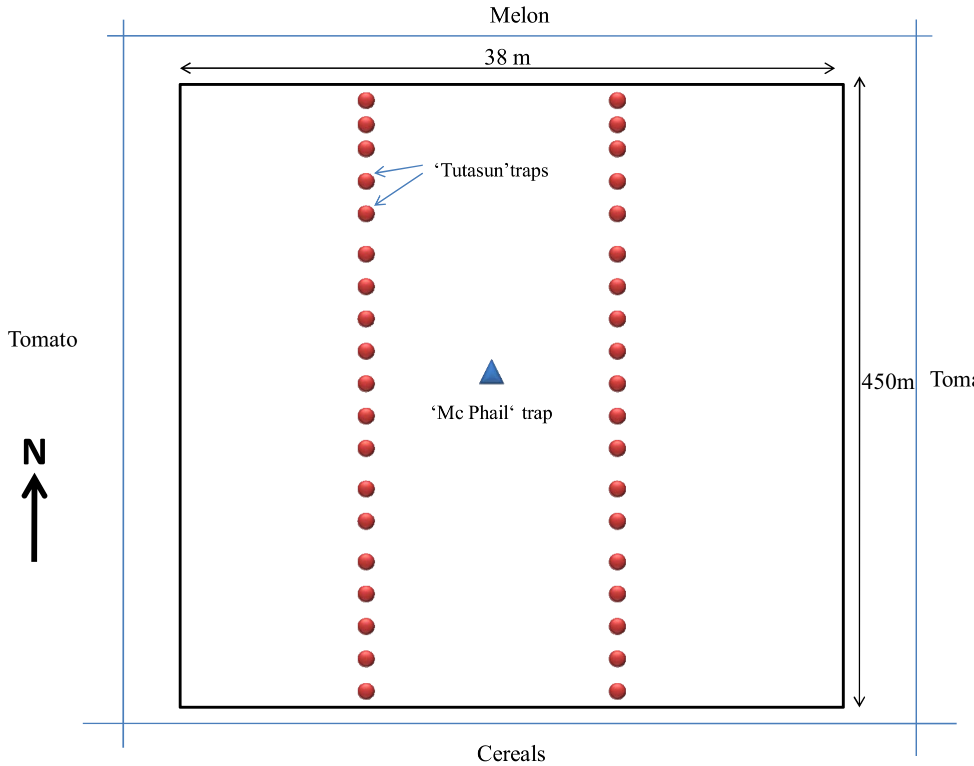

Fig. 1 Plan of the experimental tomato crop in the region of Raggueda.

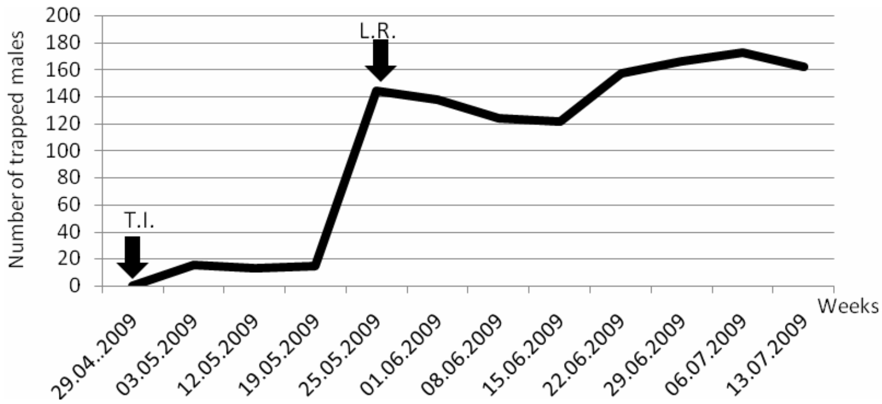

Fig. 2 Evolution of the trapped males of *T. absoltuta* in an open field tomato crop variety 'Amel' in the region of Raggueda in 2009. T.I.: Traps increasing and lures renewal, L.R.: lures renewal..

April to 14th July 2009. The infestation rate (IR) of collected samples is defined as:

IR = IL/TL x100

where IL is the number of leaves containing at least one biological stage of the pest and TL is the total number of sampled leaves (TL= 120). The assessment of the evolution of *N. tenuis* population in the experimental tomato crop was based on the mean number of individuals calculated every week. Sample size was estimated using Yamane (1967) simplified formula where the confidence level is 95% and p= 0.5 (maximum variability):

$n = N/ 1+N (e^2)$

where n is the sample size, N is the size of the population and e is the precision level. In this study the sampling was done with a 10% precision level and the calculated sample size was 100 at least to stay within the chosen level of precision. The sampling method followed that used by Gravena (1991) for leafminers, which consists of the observation of the first completely developed leaf from the upper part of tomato plants.

RESULTS AND DISCUSSION

Mass trapping

The number of trapped *T. absoluta* males was low during the two first weeks of the survey, with a maximum of 16 males/trap/week (**Fig. 2**) due to the low population of the adults of the pest combined with a relatively large number of traps (38 traps) in a cultivated area of 1.7 ha.

The end of the third week of the survey was marked by a sharp rise in the number of trapped males, which increased from 14.7 males/trap/week on the 18th May to 144.5 males/trap/week on the 25th May probably because of the rinsing temperatures in the region of Raggueda at that time of the year making the biological cycle of the insect shorter.

Four weeks after sex pheromone water traps were installed, a slight decrease in the number of trapped males of *T. absoluta* was noticed despite the renewal of the sex pheromone lures on the 27th May. This can be probably explained by the installation of 10 sex pheromone water traps in a nearby tomato crop. The number of trapped males rose again from the 15th June to reach 172 trapped males recorded on the 6th July, one week before the end of culture.

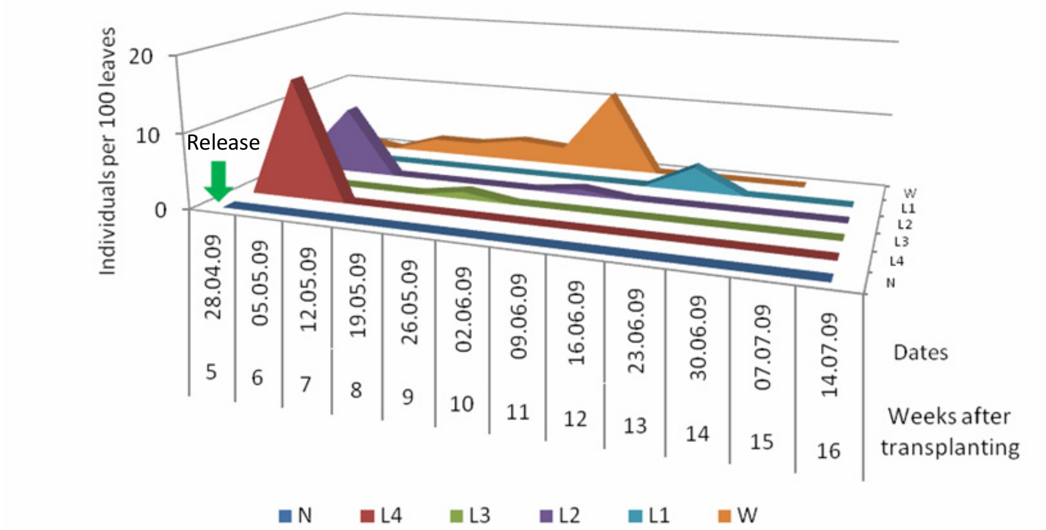

Fig. 3 Population dynamics of *T. absoluta* in an open field tomato crop variety 'Amel' in the region of Raggueda in 2009. w: eggs, L1: first instar larvae, L2: second instar larvae, L3: third instar larvae, L4: fourth instar larvae, N: chrysalids.

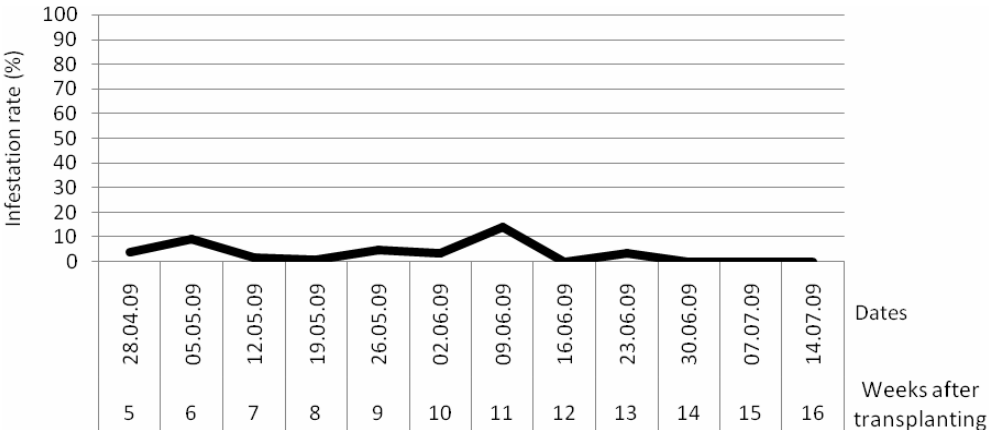

Fig. 4 Evolution of the infestation rate of tomato leaves caused by *T. absoluta* in an open field tomato crop variety 'Amel' in the region of Raggueda in 2009.

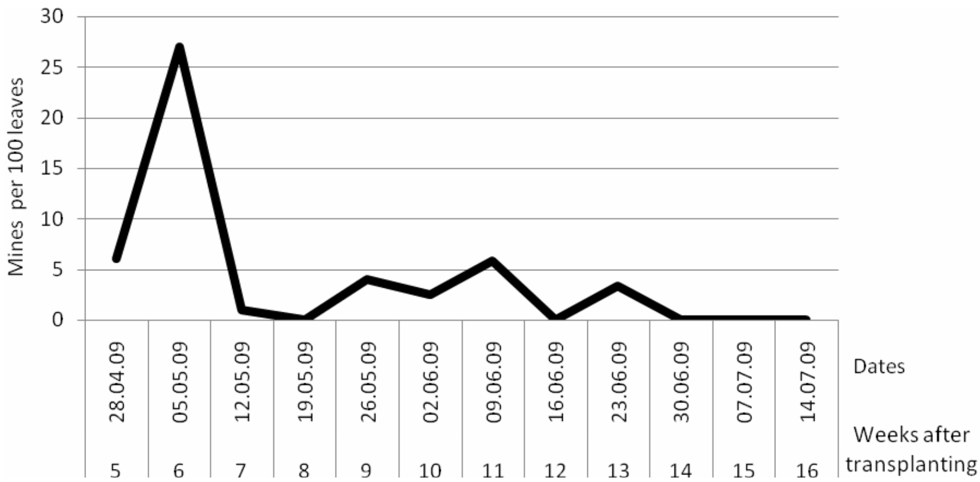

Fig. 5 Evolution of the number of mines caused by *T. absoluta* in an open field tomato crop variety 'Amel' in the region of Raggueda in 2009.

Population dynamics

The analysis of the evolution of the population of *T. absoluta* (**Fig. 3**) reveals the presence of old instars between the 28th April and the 12th May (5th and 7th week after transplanting) which proves the occurrence of the pest on the crop before the beginning of our observations. Indeed, the region had been attacked by *T. absoluta* during the late tomato crops in the previous agricultural season, and these old larvae may have come from an old infestation in the nursery.

The density of eggs was very low since the start of sampling (5 weeks after transplanting) until the end of May (9 weeks after transplanting) without exceeding the level of 3 eggs/100 leaves to increase after that showing a maximum of 10 eggs/100 leaves on the 2nd June.

The low density of all biological stages of the pest on tomato young leaves led to a low infestation rate (**Fig. 4**), under 14%, with two maximum values registered on the 6th May (6 weeks after transplanting) and on the 9th June (11 weeks after the transplanting). The first was generated by

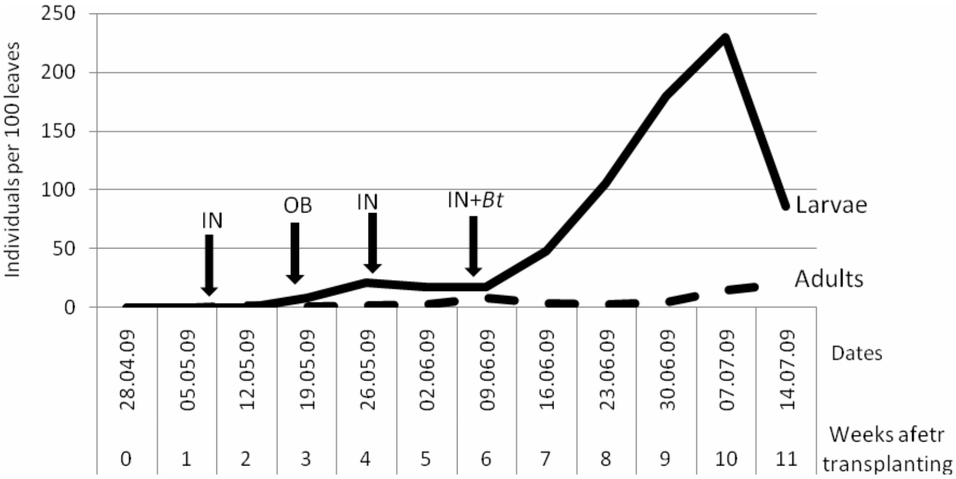

Fig. 6 Evolution of the population of *N. tenuis* in an open field tomato crop variety 'Amel' in the region of Raggueda in 2009. IN: Indoxacarb, OB: Oberon, *Bt*: *Bacillus thuringiensis*.

old larvae and empty mines, while the second resulted from an increase of the density of eggs on apical leaves.

The low population of *T. absoluta* produced a small number of mines/100 leaves (**Fig. 5**) which did not surpass 5.8 mines from the 12th May to the 14th July. As for the small peak of the 5th May, it attests an old attack of the moth without any importance.

Biological control

19.000 *N. tenuis* were released in the experimental crop on the 25th April. 19 days later (12th May) the presence of two individuals/100 leaves of this zoophytophagus mirid was recorded (**Fig. 6**). One week later (18th May), larvae emerged with an average of 8 larvae/100 leaves proving the successful installation of this auxiliary in the crop. The restrictive use of insecticides seems to be a key factor which allowed the right establishment of this predatory bug (Alomar *et al.* 2002; Arnó *et al.* 2006; Sanchez *et al.* 2008). Alomar (2002) suggest that the cyclic colonization of the crops by a predatory mirid like *Macrolophus caliginosus* throughout the year may depend on the availability of unsprayed refuges. According to the same author, the most critical time for this predatory mirid is completing its population cycle in the cold season on ornamental crops grown under glasshouses regularly treated with chemicals and where such natural enemies of pests have little chance to survive. 19 days after the release of *N. tenuis*, the presence of the predator with two individuals/100 leaves was observed (**Fig. 6**). One week later the number of larvae began to rise with an average of 8 larvae/100 leaves attesting the successful installation of the auxiliary in the crop. The population of *N. tenuis* was apparently not affected with the three insecticide treatments with Indoxacarb (two times) and Indoxacarb + *Bt* carried out respectively on the 7th May, the 27th May and the 7th June against caterpillars of the tomato fruit borer *Heliothis armigera* (Hübner) as well as the Oberon treatment to control *Aculops lycopersici* (Massee) carried out on the 18th May. The mirid maintained a density of 20 larvae/100 leaves during the entire period between the 26th May and the 9th June. These insecticides are classified as low toxic toward *N. tenuis* such they can cause the mortality of < 25% present of the population (Anonymous 2009).

From the 9th June, the number of *N. tenuis* larvae increased to over 100 individuals/100 leaves on the 23rd June. The presence of adults has been recorded in the field but not in the samples because they fly when tomato leaves are gathered. At the end of our observations and from the 7th July, 10 weeks after the release of *N. tenuis* a reduction of the density of populations of this zoophytophagus was observed. Indeed, the larval density decreased from an average of 230 larvae to 86 larvae/100 leaves. This reduction in larval population was most likely the result of the rising temperatures in the region of Raggueda at that period of the year with an average of 32.9°C (NIM 2009). The influence of temperature on the development of *N. tenuis* was determined by Sánchez *et al.* (2008), who observed the highest mortality rate between 15 and 35°C.

This essay of IPM using mass trapping with a density of 20 sex pheromone water traps/ha, the release of 19.000 *N. tenuis* for 1.7 ha and only four insecticides treatments, showed that the population of the tomato leaf miner *T. absoluta* was well controlled. This success is confirmed by (i) the abundance of the predatory insect in the crop which reached a density of 230 motile stages/100 leaves on the 7th July, (ii) a low infestation rate of leaves which did not exceed 14%, (iii) a small number of mines/leaf, i.e. < 5 mines/100 leaves.

CONCLUSIONS

Results of mass trapping experiments combined with the biological control and a balanced use of chemicals, showed an undeniable effectiveness in controlling this dangerous pest. Thus, the density of eggs laid on tomato leaves, the infestation rate as well as the number of mines per leaf remained very low. This can be explained by the fact that the massive trapping of males significantly disrupts mating and consequently egg laying. The effectiveness of the mass trapping is therefore demonstrated, it should be confirmed in different tomato cropping systems in different regions of Tunisia. Concerning *N. tenuis*, several parameters still to be clarified such as the threshold of *T. absoluta* requiring biological intervention, the dose and the timing of the release of this auxiliary.

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