Journal of Multidisciplinary Engineering Science and Technology (JMEST)
ISSN: 2458-9403
Vol. 4 Issue 9, September - 2017

Friendly using methods for controlling of *Tuta absoluta* (Meyrick) (Lepidoptera: Gelichiidae)

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***Abstract*—The experiment was carried out in the first culture of the planted tomatoes in the greenhouse. In order to monitor the tomato moth *Tuta absoluta* in experimental area, 4 pheromone traps were installed. In our experiment condition is used pheromone lures coupled with Delta traps (0.5 mg E3Z8Z11-14Ac) Product Code PH-937-1RR. The experimental scheme was divided into 4 variants with an area of 0.5 hectare. The used method was the biotechnical one using 10 water traps with lure per 0.5 hectare as well as monitored with pheromone traps. The traps were placed inside the greenhouse, in the center of it with height less than 1 meter. Traps were checked once per week. In which plot is separate 10 plants and are treated with *Bacillus thuringiensis*, the dosage of *Bacillus thuringiensis* was 100 gram per 100 liter water. The assessment of fruits is done 10 days after second treatments with *Bacillus thuringiensis* variety Kurstaki as were following: first treatment is 4-5 days after the flies` period and second one 8-10 days after the first treatment. Fruits and leaves are analyzed 10 days after the treatments. For that reason the monitoring of population by sex pheromones and using of mass capture are the useful alternative for controlling of *Tuta absoluta*. For an assessment of mass capture techniques 100 fruits and leaves are analyzed just before harvesting.**

Key words—Tuta absoluta, mass capture, pheromones, water traps, Bacillus thuringiensis Kurstaki.

I. INTRODUCTION

Tuta absoluta is a micro lepidopteron moth belonging to the Gelechiidae family and is considered the major pest that attacks tomato in many countries [17]. It is originated from South America. In Europe, *Tuta absoluta* was initially reported from Eastern Spain in late 2006 [18] [12] and has subsequently spread throughout many European countries, including the Balkan and Mediterranean regions [20] [21] [6] [13] [12]. As result of the movements` dynamism of the plants material, *Tuta absoluta* is present all over the Albanian coastal area [23]. In the lack control measures, the percentage of damage caused by this pest on tomato in greenhouses and open-field can achieve very high level [1]. *Tuta absoluta* is easily found on tomato plants because it prefers the apical buds, flowers or new fruits, where the black frass visible. When there is a severe attack it colonizes the leaves on the other parts of the plant. Mines are evident on attacked leaves [10].

Tuta absoluta is a very challenging pest to control. Effectiveness of chemical control is limited due to insect`s nature of damage as well as its rapid capability of development of insecticide resistan trains. The use of biological factors are still largely under development and not ready to combat this pest effectively and in a cost effective way. Sex pheromone trap is using as an early detection tool. Mass trapping and lure and kill application of pheromone has been found to be effective to control *Tuta absoluta.* IPM strategies are being developed to control *Tuta absoluta.* Various active substances can be applied in combination with bio-rational control tactics [29].

Monitoring based on sex pheromones – Sex pheromones are chemical signals released by an organism to attract an individual of the same species of the opposite sex for mating [3]. The most widespread and successful applications of sex pheromones concern their use in detection and population monitoring [19] [3]. They are also used to control insect populations, which is achieved by two main techniques: mass inhalation and mating disruption [19] [3]. By monitoring *Tuta absoluta* males using pheromone traps, it may be possible to determine the correct timing for insecticide applications leading to a reduction and rational use of pesticides; also mass trapping technique can be used with adequacy [2]. Captures in traps baited with synthetic pheromone lures accurately show whether a specific insect species is present, and when its seasonal flight period starts [19] [3]. After pest detection, synthetic sex pheromones are principally used to monitor population levels and trigger applications of chemicals or other control methods [14] [3]. To monitor *Tuta absoluta,* pheromone lures are principally coupled with Delta traps [8] [25] [3].

The Delta traps consist of a sticky insert and a triangle-shaped “house” of long-lasting, water resistant material (Fig.1). In the middle of the ridge of the roof a hanger is attached to hang up the trap. A pheromone dispenser is placed in the center of the sticky insert. Male adults are attracted by the pheromone and enter the Delta trap where they get stuck on the sticky insert.

Each species has a specific pheromone. A minimum distance of 50 meters is recommended so as to avoid pheromone interference [29].

Fig. 1. *Delta traps pheromone for monitoring of Tuta absoluta*

Mass trapping – For mass trapping, a high density of pheromone-baited traps is placed in strategic position within a crop [11]. Large numbers of adult males are trapped, resulting in an imbalance in the sex ratio, which impacts the mating pattern of the pest [26] [3]. The pheromone trap density should be 20 to25 traps per hectare inside greenhouses (30 traps per hectare in greenhouses destined for plant propagation) and 40 to 50 traps per hectare in open fields [24] [3].

The most common pheromone traps used for mass trapping of *Tuta absoluta* are water traps, which are easier to maintain and less sensitive to dust than Delta or light traps and also have a larger trapping capacity than Delta traps [14] [26] [3]. Unfortunately, when mass trapping was used alone for controlling male *Tuta absoluta* populations, it was not effective in reducing leaf and fruit damage [4] [3]. This could be explained by the traps inability to catch all of the male population and by the ability of the females to reproduce parthenogenetically [3].

Water traps – Water traps consist of a plastic container holding water and a pheromone lure (Fig. 2) [26] [3]. The lure is secured above the water to reduce surface tension (and consequently reduce the insect`s capacity to escape from the trap) and limit water population was achieved with a trap density of 32 traps per hectare (or 1 trap per 312 meter square) and was correlated with reductions in the leaf infestation rate and in the number of larvae found on leaves [3].

Fig. 2. *Water traps with pheromone lure for mass capture*

Recently, Russell IPM Ltd (United Kingdom) designed new traps based on combination of a water trap, a sex pheromone and a specific light frequency that is highly attractive to *Tuta absoluta* adults [8] [26] [3]. These traps attract males with the pheromone lure but also females with the specific light frequency, entrapping both effective than standard pheromone traps [8] [25] [3].

Apart of mass capture, *Bacillus thuringiensis* variety Kurstaki is another effective tool for controlling of *Tuta absoluta. Bacillus thuringiensis* is a spore-forming bacterium that produces crystals with insecticidal action, coded by Cry genes [15] [16]. Such proteins are responsible for the pathogenicity of *Bacillus thuringiensis* against some coleopteran, dipteran and lepidopteron insects. *Bacillus thuringiensis* can potentially contribute to control, limiting the widespread use of toxic chemicals, which are hazardous to the environment and human health [16]. The results of various researchers regarding the efficacy of *Bacillus thuringiensis* treatments differ significantly, depending of the formulation used (wet table powder or dust), the application frequency, the insect population density, and the application environment (laboratory or field) [9] [16].

Through a series of laboratory, greenhouse and open-field experiments, evidence that *Bacillus thuringiensis* is highly efficient in controlling *Tuta absoluta* was found. The first instars larvae were the most susceptible, while susceptibility was lower in second and third instars larvae [7]. *Bacillus thuringiensis* toxins are considered to be environmentally friendly by many farmers and may be a potential alternative to broad-spectrum insecticides [23].

The objectives of this study are to identify the friendly environment methods for controlling of *Tuta absoluta* moth as well as manner how to combine different method to increase the effectiveness of control measure for *Tuta absoluta.*

II. Material and Method

A. Monitoring and mass capture as well as Bacillus thuringiensis for controlling of Tuta absoluta

Based on the field conditions, the longevity of pheromone were 4-6 weeks, stable in field temperature up to 45^{o}C. The pheromone was placed in the centre of the trap and do not place lure unprotected in direct sun dispose of the wrapping away from the monitoring area. The pheromone was used before the emergency of the first generation and until the end of the season. Delta traps are most suitable for this insect. Moth catcher trap may be useful if a high dust condition prevails. The traps were positioned near the highest point of the plant using supporting posts approximately 1 meter high. For monitoring the population of *Tuta absoluta* 1 trap was placed in every hectare but no less 2 trap per farm. For mass trapping, number of traps is subject to pest pressure and local control strategy. Trap`s data are collected on weekly basis. During the height of the population more frequent reading may be needed.

Decisions on pesticide application should not be taken solely on the trap catch data. Climatic and biological considerations should be taken in account. The pheromones are replaced every 4-6 weeks or as recommended by the agricultural authorities [27].

The experiment of 2014-2016 was carried out in low coastal area, at the Sukth's greenhouses, with surface of 2 hectare covered with glasses. The experiment was developed in the first culture of the planted tomatoes in the greenhouse. In order to monitor the tomato moth *Tuta absoluta* in experimental area, 4 pheromone traps were installed. In our experiment conditions used pheromone lures coupled with Delta traps (0.5 mg E3Z8Z11-14Ac, 0.024 mg E3Z8-14Ac) Product Code PH-937-1RR [27].

The experimental scheme was divided into 4 variants with an area of 0.5 hectare. The flies counting and their monitoring into pheromone were performed on regular weekly basis intervals. The used method was the biotechnical one using 10 water traps with lure per 0.5 hectare as well as monitored with pheromone traps. The traps were placed inside the greenhouse, in the center of it with height less 1 meter. Traps were checked once per week. The traps delta types were placed in the monitored plots for identifying the evolution of the tomato moth populations. The pheromones were changed after 4 weeks. In this variant with a surface of 0.5 hectare were placed 2 pheromone traps. In each plot separate 10 plants and are treated with *Bacillus thuringiensis*, the dosage of *Bacillus thuriengensis* was 100 gram per 100 liter water. For each generation the treatments with *Bacillus thuringiensis* variety Kurstaki were as following: First treatment is 4-5 days after the flies' period and second one 8-10 days after the first treatment. Fruit and leaves are analyzed 10 days after the treatments [16].

III. Results and Discusion

The monitoring of population by sex pheromones and combination between mass capture and *Bacillus thuringiensis* variety Kurstaki are useful alternative for controlling of *Tuta absoluta*. For an assessment of mass capture techniques 100 fruits and leaves are analyzed just before harvesting. The assessment infected fruit and leaves are calculated based on the following formula (1).

- Based on our experimental results *Tuta absoluta* is the main pest cousin a considerable damage as well as with high population dynamic in low coastal area of Albania.
- In accordance with climatic condition of Albania *Tuta absoluta* gives four generation starting from March till July.
- Mass capture technique gives affectivity from 62%-71% for leaves and fruits. Using of *Bacillus thuringiensis* as an alternative gives 32%-39% control.
- As finally conclusion, mass capture technique does not guaranty a total affectivity used alone but it is necessary to combine with other methods, *Bacillus thuringiensis* variety Kurstaki in first stage of larvae for controlling of *Tuta absoluta*.

$$\text{Attacked fruits and leaves} = \frac{\text{Total fruits and leaves analyze} - \text{Attacked fruits and leaves}}{\text{Total fruits and leaves}} \text{ x } 100 \qquad (1)$$

Table 1. Average of mass capture during the years of the study

Date of analyze	Leaves				Fruits			
	Analyzed	***Attacked***	***Not attacked***	***% of uninfected***	***Analyzed***	***Attacked***	***Not attacked***	***% of uninfected***
14 – Mar	100	29	71	71%	-	-	-	-
21 – Mar	100	31	69	69%	-	-	-	-
28 – Mar	100	40	60	60%	-	-	-	-
4 – Apr	100	43	57	57%	-	-	-	-
11 – Apr	100	46	54	54%	-	-	-	-
18 – Apr	100	48	52	52%	100	48	52	52%
25 – Apr	100	49	51	51%	100	47	53	53%

2 – May	100	50	50	50%	100	44	56	56%
9 – May	100	47	53	53%	100	43	57	57%
16 – May	100	50	50	50%	100	46	54	54%
23 – May	100	44	56	56%	100	45	55	55%
30 – May	100	42	58	58%	100	47	53	53%
6 – Jun	100	43	57	57%	100	36	64	64%
13 – Jun	100	39	52	52%	100	41	59	59%
20 – Jun	100	44	56	56%	100	38	62	62%
27 – Jun	100	45	55	55%	100	31	69	69%
4 – Jun	100	44	54	54%	100	29	71	71%
11 – Jun	100	47	53	53%	100	37	63	63%
18 – Jul	100	49	51	51%	100	34	66	66%
25 – Jul	100	36	64	64%	100	28	72	72%
31 – Jul	100	38	62	62%	100	36	64	64%

TABLE 2. AVERAGE DATA TREAT WITH *BT*. KURSTAKI DURING THE YEARS OF THE STUDY

***Bacillus Thuringiensis* variety Kurstaki**	**Date of analyze**	**Leaves**				**Fruits**			
		Analyzed	***Attacked***	***Not attacked***	***% of uninfected***	***Analyzed***	***Attacked***	***Not attacked***	***% of uninfected***
Generation I	20 - Mar	100	65	35	35%	-	-	-	-
Generation II	25 - May	100	66	34	34%	100	68	32	32%
Generation III	15 - Jun	100	62	38	38%	100	64	36	36%
Generation IV	21 - Jul	100	59	41	41%	100	61	39	39%

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