COMPARISON OF PHEROMONE LURES USED IN MASS TRAPPING TO CONTROL THE TOMATO LEAFMINER *TUTA ABSOLUTA* (MEYRICK, 1917) IN INDUSTRIAL TOMATO CROPS IN PLOVDIV (BULGARIA)

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Abstract

Trials were conducted in the summer growing season of 2012-2014 in tomato fields in the region of Plovdiv (Bulgaria). The sex pheromone, produced by the females of *T. absoluta* – a mixture of (3E,8Z, 11Z)-3,8,1 l-*tetradecatrienyl acetate* and (3E,8Z)-3,8-*tetradecadienyl acetate* in ratio 90:10 was used in several comercially available pheromone lures. A comparison was made between three lures of *Russel IPM* (*Tuta absoluta - 500* loaded with 0,5 mg synthetic sex pheromone, *Tuta absoluta-Optima* – with 0,8 mg and *TUA-100N* – with 3 mg), *Pherodis Tuta absoluta* – with 0,8 mg (*Koppert*) and *Tuta absoluta pheromone* (*BioBest*) – with 0,5 mg. The lures were mounted on delta traps, spaced at relatively equal distance between each other at 60 cm height in open-field tomato crops. The trap density was 1 per 0.05-0.1 ha. No correlation was found between the number of trapped moths and the damage on leaves and fruits. Even with catches of more than 400 moths per week/trap the level of damage on leaves and fruits did not reach 8%. All the tested lure formulations adequately represented the dynamics of the population density of the males but exhibited different attractiveness to the moths. Overall for the years of the trials, the most attractive was the formulation of *Tuta absoluta-Optima*, followed by *Pherodis Tuta absoluta*, but during the cooler summer of 2014, the lures of *Pherodis Tuta absoluta* (*Koppert*) and *Tuta absoluta pheromone* (*BioBest*) were more attractive.

Key words: mass trapping, sex pheromones, tomato, degree of damage.

INTRODUCTION

The tomato leafminer, *Tuta absoluta* (Meyrick) (Lepidoptera: Gelechiidae), is a major pest of processed and fresh tomatoes, both in greenhouses and open field crops (Desneux et al., 2010). This pest has spread rapidly since its introduction to Europe in 2006, and within just a few years its global status has changed completely, from a South American tomato pest into a major threat to world tomato production (Roditakis et al., 2010; Desneux et al., 2011). *Tuta absoluta* is a very challenging pest to control (Korycinska et al., 2009) since the efficiency of chemical control has been poor because of the endophytic habit of its larvae, which are protected in the leaf mesophyll or inside fruits (Cocco et al., 2013), and pest resistance against a number of applied insecticides (Siqueira et al., 2000a; Siqueira et al., 2000b; Siqueira et al., 2001; Lietti et al., 2005; Silva et al., 2011; Reyes et al., 2012). In order to reduce the use of insecticides in tomato fields, environmentally sound control strategies have been developed, including methods, based on the use of the insect's sex pheromones.

Sex pheromone-based strategies (*i.e.* mass trapping and mating disruption) are promising techniques to control this invading pest. Mass trapping may effectively remove sufficient males to lower overall *T. absoluta* population levels and reduce pest pressure (Witzgall et al., 2008; 2010). However, mass trapping would likely be most effective when used in combination with recommended insecticides. The decision scheme of using insecticides for management of *T. absoluta* is largely based on adult captures in sexual pheromone traps (Benvenga et al., 2007), as adult catches are correlated with larval damages and yield losses (Faccioli, 1993; Benvenga et al., 2007). In Brazil, Benvenga et al. (2007) reported an action level of 45 ± 19.50 *T. absoluta* catched daily using pheromone traps, while in Chile extension specialists report an economic threshold of 100 males per pheromone trap per day. Action threshold could also be based on occurrence of the pest in the tomato crop with 2 females/plant or 26 larvae per plant (Bajonero et al., 2008) or 8% defoliation (BayerCropScience, Colombia) recommended in Colombia.

The majority of female sex pheromones identified in Lepidoptera consist of a mixture of two or more compounds, which not only evoke long-range male attraction but also elicit courtship behavior (Linn et al., 1987). The female sex pheromone of *T. absoluta* consists of two components. The major component, which represents about 90% of the volatile material found in the sex gland of calling females, is (3*E*, 8*Z*, 11Z)-3,8,11-tetradecatrien-l-yl acetate or TDTA (Attygalle et al., 1996; Griepink et al., 1996; Svatoš et al., 1996). The minor constituent (10%) was identified as (3*E*, 8*Z*)-3,8- tetradecadien-l-yl acetate or TDDA (Svatoš et al., 1996).

Mass trapping consists of the use of a lure (semiochemicals or a light source) combined with a physical device to “entrap” insects, like an adhesive surface or water bath (Jones, 1998). The mate-finding communication system of *T. absoluta* is guided by a female-produced sex pheromone, so only males are caught in traps, which decreases their efficiency (Jones, 1998; Witzgall et al., 2010). Since tomato leafminer males are polygynic and mate on average 6.5 times (Silva, 2008), a very high proportion of males must be removed before the number of eggs oviposited in a population starts to be affected (Jones, 1998; Witzgall et al., 2010). Moreover, Caparros Megido et al. (2012) have demonstrated that females are able to lay eggs without male fertilization, which could increase the difficulty in affecting the pest population density.

However, it has been observed in laboratory experiments that *T. absoluta* males were far less sensitive to the absence of the minor component than most other lepidopterans, which are characteristically highly sensitive to small qualitative or even quantitative changes in the composition of pheromone blends (Svatoš et al., 1996). Actually, different loadings of pheromone are suggested for monitoring *T. absoluta* populations: 0.5 mg in greenhouses for 4–6 weeks of longevity, 0.8 mg in open fields for 4–6 weeks of longevity and 3.0 mg in open fields in hot desert climates for a long lasting lure (Hassan et al., 2010a).

The aim of the study was to compare the attractiveness of lures with different loadings of synthetic pheromone at field conditions and evaluate their role in reducing population density of the tomato leafminer and resulting degree of damage.

MATERIALS AND METHODS

The trial, designed with a density of about 10 traps per hectare, was conducted in a 1,3 ha (in 2013) and in a 1,8 ha (2014) open-field tomato crop in the region of Plovdiv – v.Trilistnik. In 2013 a tomato cultivar for processing 1H5 (HeinzSeed) was planted on 5-10 June and in 2014 – cultivars for fresh consumption - Torbay F1 (BEJO ZADEN); Bobcat F1 (Syngenta); Terra Kota F1 (Syngenta), planted on 6 June.

During the trial, the attactiveness of five brands of sex pheromone dispensers commercialized in Bulgaria was tested - TUA-500® (Russell IPM) with 0,5 mg synthetic pheromone, TUA-Optima® (Russell IPM) with 0,8 mg, TUA -100N ® (Russell IPM) with 3 mg (Russell IPM), Pherodis® (Koppert) with 0,8 mg and Tuta absoluta pheromone (BioBest) with 0,5 mg.

The different pheromone dispensers were mounted on red Delta traps (Fig.1), spaced minimum 20 m apart from each other. The traps were mounted on bamboo sticks at a height of 60 cm.

Catches of male moths were counted every week, and the removable sticky inserts were replaced (Fig. 2). On the same date degree of damage on the leaves and fruits was recorded as % of all inspected plant parts.

Fig. 1. *Red Delta type constuction was used for all brands of sex pheromone dispensers*

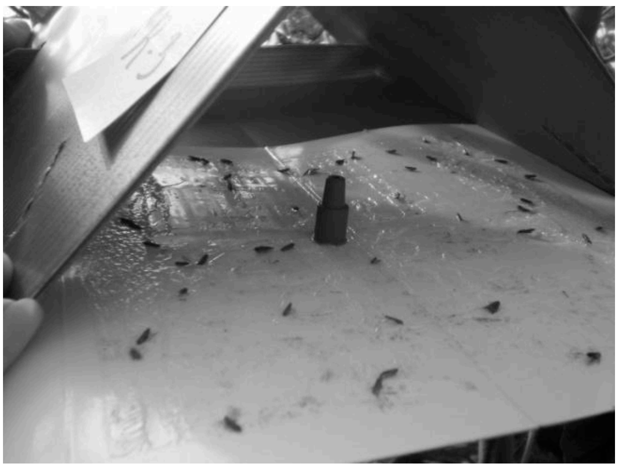

Fig. 2. *The removable sticky inserts were replaced after counting the male moths catched*

The traps were placed on 7 August (2013) and on 8 August (2014). Three replicates were used for each brand (Fig. 3). The experiment was conducted in August-September in both years at fruiting stage of tomato. No insecticides were used.

The level of damage was calculated as percent of mined leaves and fruits from all inspected leaves and fruits. Weekely the upper fully expanded leaves on at least 100 plants and at least 100 fruits randomly chosen were inspected in the plot.

The results were analyzed using a package for statistical analysis SPSS 13.0 for Windows.

RESULTS AND DISCUSSION

At a rate of 12 sex pheromone dispensers per 1,3 ha in 2013 (Table 1) the average number of males caught per week per trap varied from 200,3±41,6 on 31 August to 323,5±16,8 on 7 September (Table 1). For the period of the experiment the different dispensers had attracted an average of 238,3±92,4 for Pherodis to 334,9±51,2 for TUA-Optima. The numbers of attacted males was significantly higher in the traps with dispensers TUA-Optima. For the other three tested (TUA-500, Tuta BioBest, and Pherodis) the difference in the catches was insignificant.

North

△	▲	○	●
▲	○	●	△
○	●	△	▲

South

2013: △TUA 500; ▲TUA-Optima; ○ Pherodis; ● Tuta absoluta pheromone BioBest

North

◆	●	▲	△	○	●	◆	
○	△	◆	●	▲	△	○	▲

South

2014: △TUA-500; ▲TUA-Optima; ○ Pherodis; ●Tuta aboluta pheromone BioBest; ◆TUA- 100N

***Fig. 3**. Situation scheme of the pheromone traps with different brands of sex pheromone dispensers in 2013 and 2014 in Trilistnik village, Plovdiv's region*

Table 1. Male *Tuta absoluta* catches per trap/week using different brands of synthetic sex pheromones in field tomato crop in 2013 in the region of Plovdiv, Trilistnik village

Pheromone dispensers	Number of males/trap				Mean number of males/trap
	15.8.2013	23.8.2013	31.08.2013	07.09.2013	
TUA-500	311,7±63,3	250,3±22,4	138,0±95,2	313,0±41,8	253,3±88,4a
TUA-Optima	340,0±15,2	349,7±27,3	280,7±69,3	369,0±16,5	334,9±51,2b
Tuta BioBest	286,3±57,9	201,7±77,8	221,3±52,1	364,3±20,2	268,4±44,7a
Pherodis	318,3±87,8	226,0±34,1	161,3±102,4	247,7±76,2	238,3±92,4a
Mean number of males/trap/observation	313,9±12,1a	256,9±27,6ab	200,3±41,6b	323,5±16,8b	

**a, b – Duncan's multiple test, P = 0,05*

The dynamics of the population density of the males recorded in August-September 2013 using the four different brands of dispensers was quite similar with one exception on only one date for the dispensers of Tuta BioBest (Fig. 4). Based on numbers of all the catches the dispenser TUA-Optima have attracted 31% of the male population at the field (Fig. 5).

In 2014 at a rate of 15 sex pheromone dispensers per 1,8 ha the average number of males caught for a week by a trap varried between 277,3±66,0 on 20 August to 386,0±123,7 on 2 September (Table 2).The dispensers of each brand had attracted an average of 177,3±134,7 males for TUA-500 to 341,9±78,5 for Pherodis. There was no significant difference in the numbers of the attracted males by the dispensers of TUA-Optima, TUA-100N and Tuta BioBest (Table 2).

Regarding the population dynamics of the moth in August-September 2014 recorded by the aid of different pheromone dispensers, there were two exceptions of the trends – on 20 August the traps with dispensers TUA-Optima and on 2 September – with dispensers of Pherodis caught more males compared to the previous weeks in contrast to the rest of the traps (Fig. 6). In 2014 Based on numbers of all the catches the dispenser Pherodis attracted 26% of the male population at the field, followed by Tuta BioBest (22%), TUA-Optima (20%), TUA-100N (19%) and TUA-500 (13%) (Fig. 5).

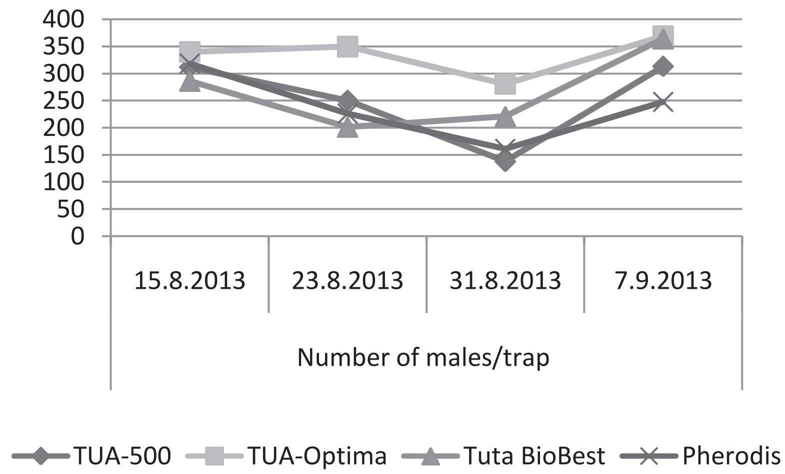

Fig. 4. Population dynamics of T. absoluta recorded using different brands of synthetic sex pheromones in field tomato crop in 2013

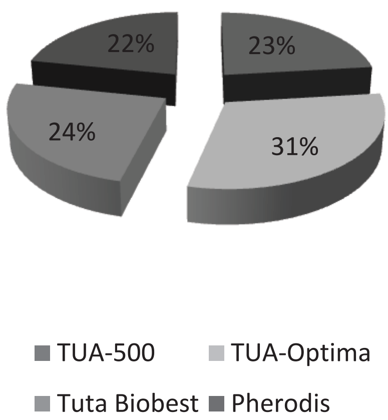

Fig. 5. Percentage of attracted males by different brands of synthetic sex pheromones in field tomato crop in 2013

Table 2. Male catches per trap/week using different brand of synthetic sex pheromones in field tomato crop in 2014 in the region of Plovdiv, Trilistnik village

Pheromone dispensers	Number of males/trap by date				Mean number of males/trap
	13.08.2014	20.08.2014	27.08.2014	02.09.2014	
TUA-500	213,7±43,4	164,7±17,5	225,7±53,8	85,0±28,9	177,3±134,7a
TUA-Optima	234,3±27,8	260,0±84,4	279,7±121,4	251,7±111,4	256,4±22,9 b
TUA-100N	366,3±97,2	223,0±23,2	274,3±42,7	145,3±65,1	252,2±44,39b
Tuta Biobest	376,7±76,4	274,6±12,5	384,7±56,4	370,3±60,3	289,8±18,1b
Pherodis	368,7±104,9	277,3±66,0	335,7±78,9	386,0±123,7	341,9±78,5c
Mean number of males/trap/observation	319,9±85,2a	210,2±30,9b	300,0±99,3a	247,7±66,8ab	

**a, b – Duncan's multiple test, P = 0,05*

The climatic conditions in 2014, especially during the summer were not typical, the average sum of rainfall being far above the normal (Fig. 8), and the average daily temperature – lower (Fig. 9). Under these climatic conditions the pheromone dispensers of Russell IPM (TUA-500, TUA-Optima ans TUA–100N), designed for hot climate, proved to be less attractive to the males of the moth.

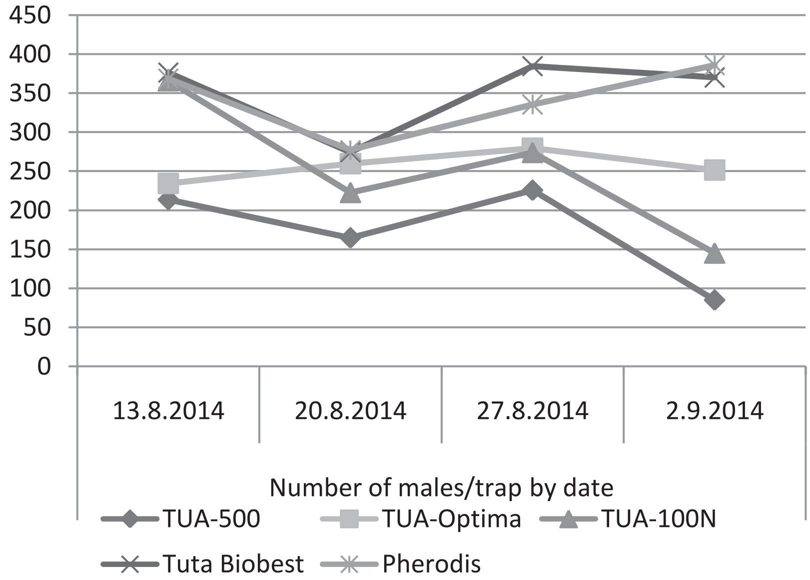

Fig. 6. *Population dynamics of T. absoluta recorded using different brands of synthetic sex pheromones in field tomato crop in 2013*

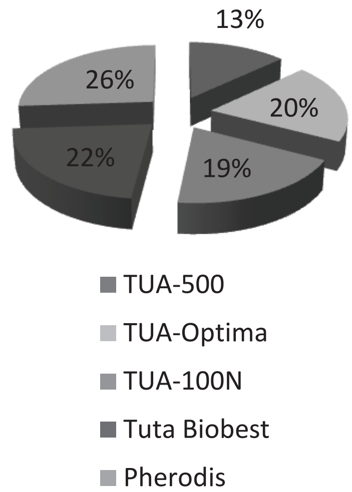

Fig. 7. *Percentage of attracted males by different brands of synthetic sex pheromones in field tomato crop in 2013*

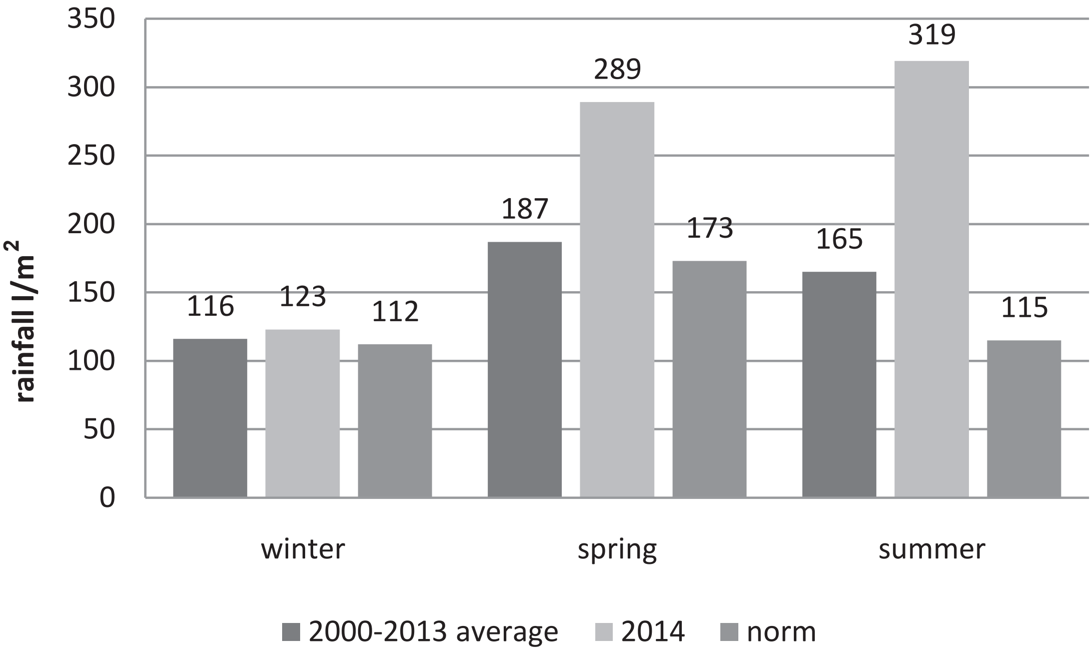

Fig. 8. *Average rainfall in the region of Plovdiv in 2014*

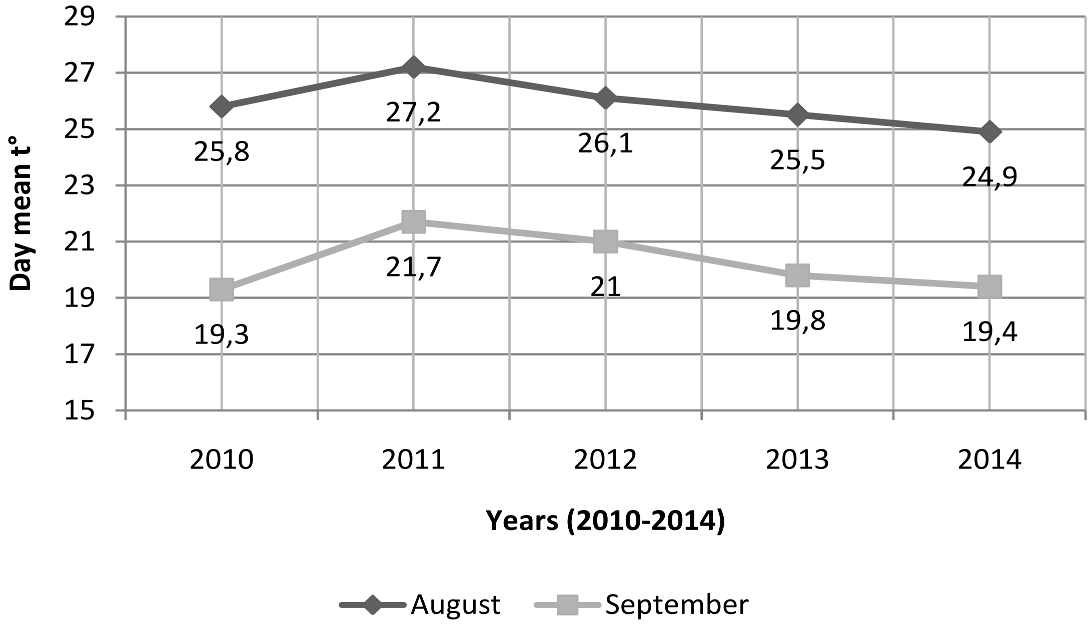

Fig. 9. *Average daily temperature in August and September in the region of Plovdiv in 2014*

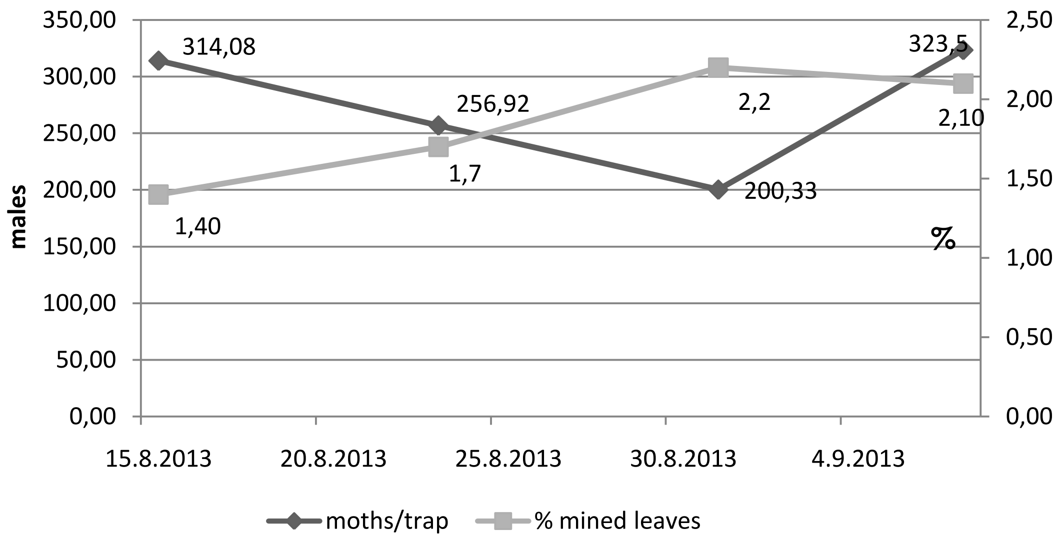

Fig. 10. *Level of damage and average population density of Tuta absoluta males in the region of Plovdiv in August-September 2013*

Since the adult male population caught in pheromone traps should also reflect any increase in the larval population, it seems easier to use this method to evaluate the infestation level. Unfortunately, results of some researchers indicate that mass trapping used alone for controlling male *T. absoluta* populations was not effective in reducing leaf and fruit damage (Cocco et al., 2012; Taha et al. 2013). As we had previous observations on the level of damage on leaves and fruits of tomato varieties for processing, we recorded the percentage of damaged leaves and fruits on each date of counting males in the traps. In both years, inspite the fact that tomatos were grown with no insecticide applications, the level of damage was less than 2,2% mined leaves in 2013 (Fig. 10) and 2,6% in 2014 (Fig. 11). There were no damaged fruits. According to the economic treshold of 5% of stems with infested fruits, suggested by Gravena (1984), the level of damage was insignificant and control measures were not applied.

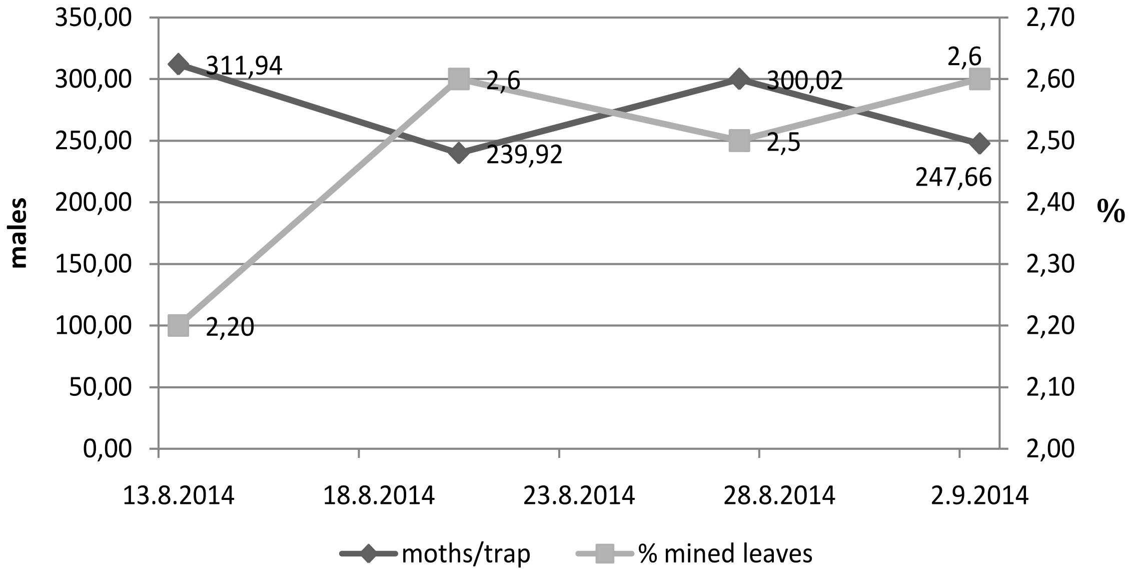

Fig. 11. *Level of damage and average population density of Tuta absoluta males in the region of Plovdiv in August-September 2014*

CONCLUSIONS

1. All the tested lure formulations adequately represented the dynamics of the population density of the males but exhibited different attractiveness to the moths. Overall for the years of trials, the most attractive was the formulation of Tuta absoluta-Optima, followed by Pherodis Tuta absoluta, but during the cooler summer of 2014, the lures of Pherodis (Koppert) and Tuta absoluta pheromone (BioBest) were more attractive.

2. The concentration of the synthetic sex pheromone in the dispensers does not ultimately influence the attractiveness to the male moths.

3. Based on our observations one sex pheromone dispenser of any of the tested brands per 0,05–0,1 ha is sufficient to maintain the population density of *Tuta absoluta* and the degree of damage on tomato bellow the economic treshold.

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