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CORRELATION BETWEEN POPULATION DYNAMICS OF *TUTA ABSOLUTA* (LEPIDOPTERA: GELECHIDAE) AND CLIMATE, AT TOMATO IN PROTECTED AREA

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Abstract

This research confirmed the occurrence and presence of tomato leaf miner *Tuta absoluta* (Meyrick 1917) (Lepidoptera: Gelechidae) on tomato, in a protected area, in Southeast Macedonia, in the period of 2015 - 2016. Pheromones traps, as a secure method for monitoring and detecting the presence of *T. absoluta*, were used for collecting insects. The presence of *T. absoluta* was proved by morphological analysis of the male genital structure. The main objective of our research was to determine the correlation between the dynamics of populations of *T. absoluta* and climate factors in two production systems – integral and conventional, over two season spring /autumn, at tomatoes in a protected area. The correlation is displayed through statistical analysis of the results, by applying a software package for statistical processing of the results, SPSS 19.

Key words: *tomato leaf miner, pheromone traps, monitoring, integral production, conventional production*

INTRODUCTION

The South American tomato leafminer, *T. absoluta* (Meyrick 1917), is a micro lepidopteran moth belonging to the Gelechiidae family and is considered as one of the most devastating tomato pests (Arnó et al. 2010). It originates from South America and was detected for the first time in Europe in Spain in 2006 (Karadjova et al. 2013). This newly introduced pest has spread very quickly along the Mediterranean Basin and to other Central and Northern European countries, including the Balkan (Tosevski et al. 2011). Since the 1960s, this moth has become one of the key pests of tomato crops in South America (Garcia and Espul 1982). In Europe, the presence of *T. absoluta* was initially reported in Eastern Spain, at the end of 2006 (Urbaneja et al. 2007), then in Morocco (EPPO 2008) and in Tunisia (EPPO 2009d), as well as, in several European countries (Tosevski et al. 2011). It is now a devastating pest in tomato crops in South America, Europe, Africa and Asia (Tropea et al. 2012, Zappalà et al. 2013). In most countries where *T. absoluta* occurs, the main control strategy consists of frequent sprays with chemical insecticides (Öztemiz et al. 2013). Without control *T. absoluta* causes the yield loss to increase up to 100%, which leads to dramatic decrease of the fruit quality in both field and greenhouse tomato crops (Gilardón et al. 2002, Tropea et al. 2012). *T. absoluta* is a small moth, with a body length of around 7 mm and wing span of 10-14 mm. The ground colour of the adult moths is a greenish-brown or silvery gray, with darker patches on the fore wings. Wing apex is fringed with speckled brown scales. The eggs are oval-cylindrical, cream white coloured, 0.2x0.4 mm in size. The larvae of young insects are whitish-gray in early instars (L1- L3) with a black head. In later developmental stages (L4-L5), larvae become pinkish-green to green in colour with brown head (Goftishu et al. 2014). Temperature between 19 and 23 °C is most favourable for moth development (Pervin et al. 2014). Temperatures of 10 °C and below proved to be fatal for moth development. Temperatures above 23 °C appear to have a detrimental effect on the development of *T. absoluta* and their longevity (Silva et al. 2015).

MATERIAL AND METHODS

The experiment was set in July 2015, at the village Josifovo, Gevgelisko-Valandovski region of tomato in protected area. Gevgelisko-Valandovski region is located in the South-eastern part of Republic of Macedonia characterized by sub-Mediterranean climate which influence is mostly felt. The survey was conducted over two season, spring / fall. The first season started from July to October 2015, and the second season from April to July 2016. During these two seasons two climate factors were monitored and measured: temperature and precipitation. At first, the area in the greenhouse was split in two parts, using the dripping films-agril, therefore two production systems of tomato, were obtained, an integrated and conventional. Total 120 plants are placed in integral production, as well as in the conventional, in an area of 120 m^2. Because it was a commercial production, the plant protection was performed with pesticides with different active ingredients for conventional and integrated type of production, during the two seasons. The pesticides used in the conventional production were: methomyl, flubendiamide, chlorpyrifos and in integral production: abamectin, pymetrozine, as well as, zeofit forte (Ca 35% and Mg 7%, and includes iron, potassium, zeolite, etc.), 100% natural ecological product, in form of powder, used for plant nutrition and soil improving. After planting, water traps with pheromones were set up to attract males of *T. absoluta* (PHERODIS, *Tuta absoluta*, Biobest). The insects from the traps were collected in every 10 days and placed in 96% ethanol, for further morphological studies. Morphological characters of the trapped adults which, according to morphological characters, correspond to *T. absoluta* were examined under stereo microscope Leica DM 2500.

For all collected specimens the abdomen was carefully removed and macerated in 10% KOH for about 15 minutes. After maceration the male genitalia were extracted and analyzed. The shape of the valvae and vinculum, as most relevant characters for *T. absoluta* were studied according to the description provided by the Cooperative Agricultural Pests Surveys (CAPS) https://caps.ceris.purdue.edu/dmm/542.

The correlation between the dynamics of populations of *T. absoluta* and climate in both integrated and conventional production systems, over two seasons, spring/autumn, was performed by using the software package SPPS 19. Comparing the Pearson's coefficient of correlation we can see which parameters have higher correlation. If $\rho = 1$, it means that there is a perfect linear correlation, i.e. the growth of the one variable means growth of other variables. If $\rho = 0.5 - 0.9$, there is close correlation. If $\rho = 0.2 - 0.5$, then the correlation is weak, but there is still correlation between variables. Of course, negative values, $\rho = -1$ means inversely proportional connection.

RESULTS AND DISCUSSION

During the first season (July to October / 2015), total of 115 in integral production, and 179 males of *T. absoluta* in conventional production, were collected with pheromone traps. In the second season (April to July / 2016) total of 408 in integral production, and 272 males of *T. absoluta* in conventional production were collected. The analysis of the male genital structure proves the presence of *T. absoluta* in tomato crops in Gevgelisko-Valandovski region. The most informative character is morphology of valvae, which are digitate and setose apically, with inner margin prominent convex medially (Tosevski et al., 2011), which is also confirmed for the species that we have collected. The results obtained in this work were statistically processed, using the SPSS statistical software package 19. The analysis of the results was calculated with Pearson's correlation coefficient. Dependent critical variables in this research are the number of insects *T. absoluta* and climate factors: average monthly temperature (°C) and sum of monthly rainfalls (l/m^2).

Table 1, shows the main climate parameters measured in a period from July to October, 2015, in the locality Josifovo, the monthly average temperature (°C) and sum of monthly rainfalls (l/m^2), as well as the number of *T. absoluta* for each month separately, in both integral and conventional production. From the results we observed, there is a difference between the number of *T. absoluta* in the integrated

and conventional production in 2015. In the integrated production lower numbers of insects is noticed, apart the conventional type of production. In the integrated production the lowest number is in July (10), and highest in September (48), as well as in conventional, July (16) and in September (74). In view of climate parameters (Tab. 1), July is with the highest monthly average temperature (28.3°C) and sum of monthly rainfall (628 l/m^2), while in October the lowest monthly average temperature (15.5°C) is measured, and in August minimum sum of monthly precipitation is (23.5 l/m^2). In September, when there are optimal climatic conditions for insect development, the highest numbers of *T. absoluta*, in both integral and conventional production (48/74 respectfully) is noticed.

Table 1. The number of *T. absoluta* and climate parameters: monthly average temperature (°C) and sum of monthly rainfalls (l/m^2) in the period from July/October 2015, in conventional and integrated production of tomato.

Month	No. of *T. absoluta* in integrated production	No. of *T. absoluta* in conventional production	Average monthly temperature (°C)	Sum of monthly rainfalls (l/m^2)
July	10	16	28.3	628
August	24	47	27	23.5
September	48	74	22.5	183.8
October	33	42	15.5	167.7
July/October	28.75	44.75	23.32	250.75

From the results shown in Table 2 we can see the difference between the number of *T. absoluta* in integrated and conventional production in 2016. The integrated production shows a highest number of insects, compared to the previous season (April/July 2016). The lowest number of insects is noticed in April in both integral and conventional production (32/21), and the highest is in June (239/173). In view of climate parameters (Tab. 2) July is with the highest monthly average temperature (28.4°C) and the lowest sum of monthly precipitation (25 l/m^2), while in May the highest sum of monthly rainfall (342 l/m^2) is measured. In June, when there are optimal climate conditions for insect development, the highest number of *T. absoluta* in integrated and conventional production are shown respectfully (239/173).

Table 2. The number of *T. absoluta* and climate parameters: monthly average temperature (°C) and sum of monthly rainfalls (l/m^2) at the period from April/July 2016, in conventional and integrated production of tomato.

Month	No. of *T. absoluta* in integrated production	No. of *T. absoluta* in conventional production	Average monthly temperature (°C)	Sum of monthly rainfalls (l/m^2)
April	32	21	16.4	34.6
May	46	32	18.5	342
June	239	173	20.5	244
July	91	46	28.4	25
April/July	102	68	20.95	203.6

Using the software package SPPS 19, tabular display (Tab. 3) of correlation between the insect number and climate conditions, in two different production systems, over two season spring/autumn, in the period 2015/2016, was made. The influence of climate factors and system of production of tomato, to the dynamics of populations of *T. absoluta*, is represented by correlation in Table 3.

Table 3. Pearson's correlation coefficient (ρ) obtained from the correlation between insect *T. absoluta* and climate conditions, for two different production systems-integrated and conventional, in two season spring / autumn in the period of 2015 / 2016.

Pearson's coefficient of correlation (ρ)							
2015				2016			
Conventional production		Integrated production		Conventional production		Integrated production	
T. absoluta - Average monthly T	*T. absoluta* - Sum of monthly rainfalls	*T. absoluta* -Average monthly T	*T. absoluta*- Sum of monthly rainfalls	*T. absoluta* -Monthly average T	*T. absoluta* - Sum of monthly rainfalls	*T. absoluta* - Monthly average T	*T. absoluta* - Sum of monthly rainfalls
-0.333	-0.702	-0.578	-0.610	0.082	0.334	0.210	0.259

Much higher correlation between the number of *T.absoluta* and climate conditions, is noticed in 2015. Although this correlation has a negative value, however, there is a high correlation between variables and are inversely proportional. Unlike 2015, 2016 shows lower correlation value between variables, but it is positive. The analysis shows that there is a different correlation value between the number of insects and climate conditions, in two different production systems, integrated and conventional, over two seasons spring / autumn, in the period 2015/2016. The lowest correlation exists in conventional production in 2016, between the number of *T.absoluta* and average monthly temperature ρ = 0.082, while the highest negative value is in conventional production in 2015, between the number of insects and the amount of monthly precipitation, ρ = -0.702.

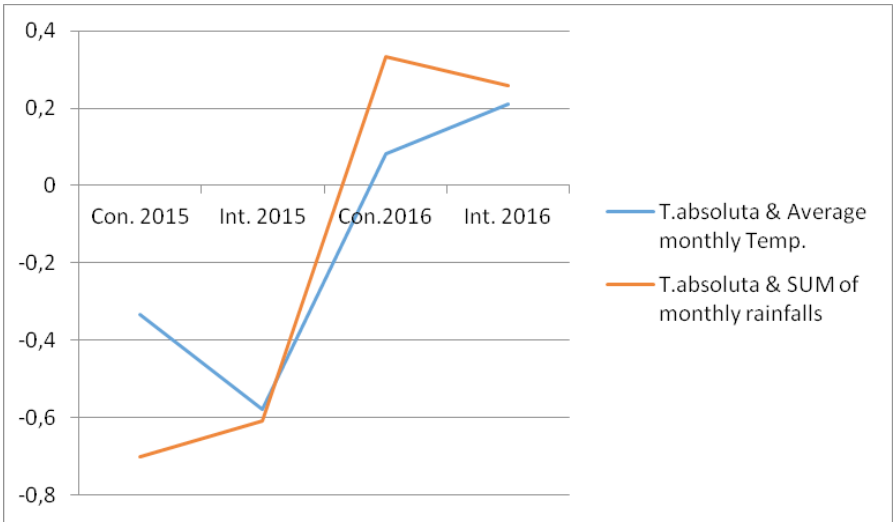

Figure 1. Correlation between *T. absoluta* and climate conditions, for two different production systems-integrated and conventional, in the period of 2015/2016

Figure 1 shows the highest correlation connectivity between *T.absoluta* and average monthly temperature, in integrated production, 2015 (-0.578), while this correlation in conventional production, 2015 was significantly lower (-0.333). It means that these two variables are inversely related. In 2016, higher correlation exists between *T. absoluta* and average monthly temperature in integrated production (0.210) while in the conventional production the correlation is significantly lower (0.082). It means that these two variables are directly proportional.

In both integrated and conventional production, in 2015 could be seen high negative correlation between *T. absoluta* and the sum of monthly precipitation (-0.610 / -0.702), while in 2016 this correlation is positive and lower (0.259 / 0.334).

CONCLUDING REMARKS

This research confirmed the occurrence and presence of tomato leaf miner *T. absoluta* (Meyrick 1917) (Lepidoptera: Gelechidae) on tomato, in a protected area, in Southeast Macedonia, in the period of 2015 - 2016. Pheromone traps as a secure method for monitoring and detecting the presence of *T. absoluta* were used for collecting insects. The presence of *T. absoluta* is proved by morphological analysis of the genital apparatus of males. The population dynamics, which depends on the climate conditions and the system of production, is displayed with statistical analysis of the received results by applying the software package for statistical analysis of the results SPSS 19. The results of the analysis showed that there is a different correlation value between the number of insects and climate conditions, in two different production systems, integrated and conventional, over two seasons spring / autumn, in the period 2015/2016. In the first season (2015), there is an inverse correlation between *T. absoluta* and average monthly temperature and the sum of monthly precipitation. In the second season, in 2016, there is a proportional relationship between the variables. The presence of *T. absoluta* in the South-eastern region of Republic of Macedonia confirms that there are optimal conditions for growth and development of the pest, because there reigns Mediterranean and sub-Mediterranean climate, which is completely suitable for the emergence of this type of insect.

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КОРЕЛАЦИЈА МЕЃУ ДИНАМИКАТА НА ПОПУЛАЦИЈА НА *TUTA ABSOLUTA* (LEPIDOPTERA: GELECHIDAE) И КЛИМАТА, КАЈ ДОМАТОТ ВВО ЗАШТИТЕН ПРОСТОР

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Ова истражување ги потврдува појавата и присуството на лисниот минер *Tuta absoluta* (Meyrick 1917) (Lepidoptera: Gelechidae) кај доматот во заштитен простор во југоисточна Македонија, во периодот од 2015 до 2016 година. За собирање на инсектите беа поставени феромонски мамки, кои се еден од најдобриот метод за мониторинг и детекција на *T. absoluta*. Присуството на *T. absoluta* е докажано со морфолошка анализа на машкиот генитален апарат. Главната цел на нашето истражување беше да се одреди корелацијата меѓу динамиката на популација на *T. absoluta* и климатските фактори во два производни системи – интегрален и конвенционален во текот на две сезони, пролет и есен, кај доматите во заштитен простор. Корелацијата е прикажана со статистичка анализа на резултатите, со примена на софтверски пакет за статистичка обработка на податоците, SPSS 19.

Клучни зборови: *лисен минер на доматот, феромонски мамки, мониторинг, интегрално производство, конвенционално производство.*