Control of *Tuta absoluta* using Pheromone Traps on Tomato Crops under Greenhouse in Algeria

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ABSTRACT

Bellatreche, M., Messgo-Moumene, S., Guendouz-Benrima, A., and Chaieb, I. 2021. Control of *Tuta absoluta* using pheromone traps on tomato crops under greenhouse in Algeria. Tunisian Journal of Plant Protection 16 (1): 1-10.

The present study aimed to assess the effectiveness of pheromone traps of adults of *Tuta absoluta* in 4 potential tomato production areas in Algeria: Tipaza (Center), Mostaganem (West), Jijel (East) and Biskra (South), during the 2012-2014 campaigns. Two tomato greenhouses were considered for each zone in which, one was protected by the setup of pheromone traps and the other as an insecticide sprayed control. Tomato leaf samples were taken from each greenhouse, each month of each year according to the areas of studies to calculate the rates of infestation. Higher infestation rates were recorded in the greenhouses with local agricultural practices (control) compared with those protected by pheromone traps. With the use of the pheromone traps, a remarkable reduction affected the infestation of the greenhouses in the 4 studied areas during the years 2012 to 2014. The southern area seemed to be the most infested and at a least degree the areas of the West, the Center and the East, respectively. The temporal evolution of infestation rates showed an increase since January until July with June and July showing the higher infestation rates. These results showed the efficacy of trapping of *T. absoluta* males and the importance of their sustainable use in the integrated control system against this devastating insect in Algeria.

Keywords: Control, greenhouse cropping, pheromone traps, tomato, *Tuta absoluta*

Tuta absoluta (Lepidoptera: Gelechiidae) is a microlepidoptera leaf miner causing significant damage on the crop of the tomato (Badaoui 2018). The larvae can cause damage ranging from 80 to 100% (Desneux et al. 2010). In 2007, numerous foci of infestation were observed along the Mediterranean coast (Urbaneja et al. 2007). The insect was reported from Algeria in 2008, in Mostganem in the west initially, then spread in the center and to the east (Badaoui et al. 2011).

The control of *T. absoluta* is based mainly on chemicals sprays. However, this method is known to have serious consequences on the man and his environment (Al-Sayeda 2007). Moreover, this species showed in several countries insecticide resistance (Leite et al. 2004; Haddi 2011).

Facing this situation, the researchers focused on finding alternative means in particular the biological control. Many studies were undertaken in Algeria to develop the biological alternative control methods. We can cite the use of indigenous predatory and parasitoids (Mahdi 2014; Dehliz 2016; Badaoui 2018), entomo-pathogenic fungi and biopesticides which were adopted to control the insect (Badaoui et al. 2011). Some work concerned the use of the extracts of plants such as *Inula viscosa*, *Salvia officinalis* and *Urtica urens* (Bellatreche 2012).

In addition, many research tasks have also reported the importance the semiochemical control by using pheromone traps as a good method to reduce insect populations by reduction

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of the number of male adults (Collavino and Gimenez 2008; Germain et al. 2009). For this goal, agricultural local authorities have setup a massive surveillance and trapping system in Algeria, since September 2008. Thus, a total of 1,128,030 of pheromones traps were purchased and used during two campaigns to cover the total area allocated to tomato which is annually around of 3.000 ha of greenhouse cropping tomato, 13.000 ha of industrial tomato and 20.000 ha of consumption tomato grown in open field (MADRP 2014).

The monitoring and study of this trapping system is essential for their application as a strategy to control this devastating insect. Hence, this study aimed to appropriately assess the effectiveness of pheromone trapping of *T. absoluta* adults in the potential cropping areas of tomato in Algeria.

MATERIALS AND METHODS

Study area.

The experimentation was carried out on tomato crops grown under greenhouse in four potential areas of tomato production in Algeria: in Douaouda (Governorate of Tipaza), Emir Abdelkader (Governorate of Jijel), Khadra (Governorate of Mostaganem) and Ain Naga (Governorate of Biskra). For this purpose, 8 tunnel greenhouses of 400 m^2 surface area (600 plants) were used; two greenhouses per region, one with pheromone traps and the other not (control) (Fig. 1).

Search and insect identification.

From collected samples, a montage of the male genitalia was carried out at the Entomology Laboratory of the National Plant Protection Institute (lNPV, Algiers), in order to confirm the identification of *T. absoluta* (Gonzales et al. 2011).

Installation of pheromone traps and sampling.

The "Delta" pheromone sex traps were used to capture adult males. This type of trap has a sticky plate at floor level and a capsule with female pheromone. The capsule diffuses pheromones that attract males (Fig. 1).

Fig. 1. Delta trap for *Tuta absoluta* adult males in tomato greenhouse

Two traps were placed in the greenhouse at 1m height (Fig. 2). A renewal of pheromone capsules was made every month, from January to late July during 2012 to 2014.

Leaf samples were taken each month, starting at one week after the installation of each new pheromone, according to the method of transects of Frontier (1983). Three blocks of plants were chosen, two at each end of the greenhouse and the other in the middle (Fig. 2). The sampling was of the systematic: 150 leaves taken from each greenhouse, and 50 leaves per block. In each block, the 50 leaves are taken from three levels of the plants, (F1: high, F2: middle, F3: low), then put in plastic boxes where were mentioned the harvest date, the tomato variety name and the place of sample.

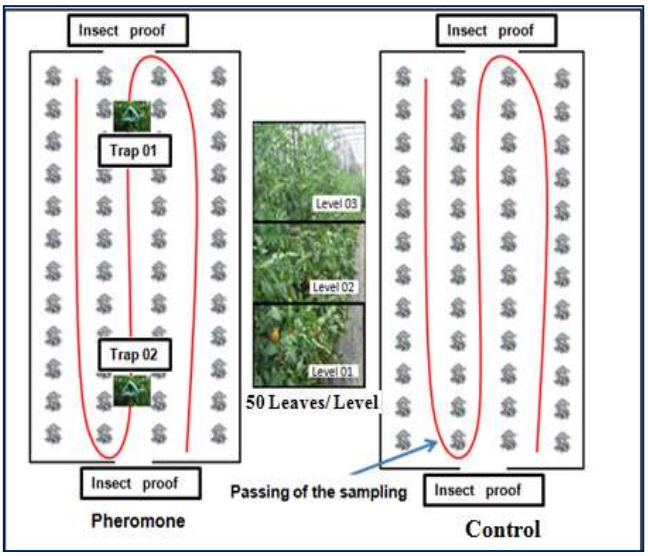

Fig.2. Diagram of the experimental plan for pheromone traps used of the control of *Tuta absoluta*.

Infestation assessment.

The various leaves collected were regularly examined in the laboratory under a binocular microscope after each sampling. The infestation symptoms were identified as typical galleries in leaves containing live larvae of the insect.

Infestation rates have been calculated using the following formula: I (%) = Ni / Nt× 100, with I: Infestation rate; Ni: Number of infested leaves; Nt: Number of the total observed leaves.

The threshold levels have been established using the rating scale summarized in Table 1 (Monserrat 2009).

Table 1. Scoring scale of risk levels of *Tuta absoluta* in greenhouse tomato crop

Phytosanitary risk threshold	Infestation rate
Threshold 0	0%
Threshold 1(Very low level)	5% of leaves with an active gallery
Threshold 2 (Low level)	5 to 25% of leaves with an active gallery
Threshold 3 (Moderate level)	25 to 50% of leaves with an active gallery
Threshold 4 (High level)	More than 50% of leaves with an active gallery
Threshold 5(Very high level)	More than 50% of leaves with more than one active gallery

Treatments of the greenhouse tomato crops.

In tomato crop greenhouses in the four studied regions (Biskra, Tipaza, Mostaganem and Jijel), no insecticide sprays against *T. absoluta* were applied, unlike positive control greenhouses where farmers applied several insecticides, according to the local area practices. Seven insecticides are generally used including Chlorpyriphos-Ethyl, Abamectin, Lambda-Cyhalothrin, Spinetoram, Cyromazine, Chlorantranlprole and Thiamethoxam (Fig.3).

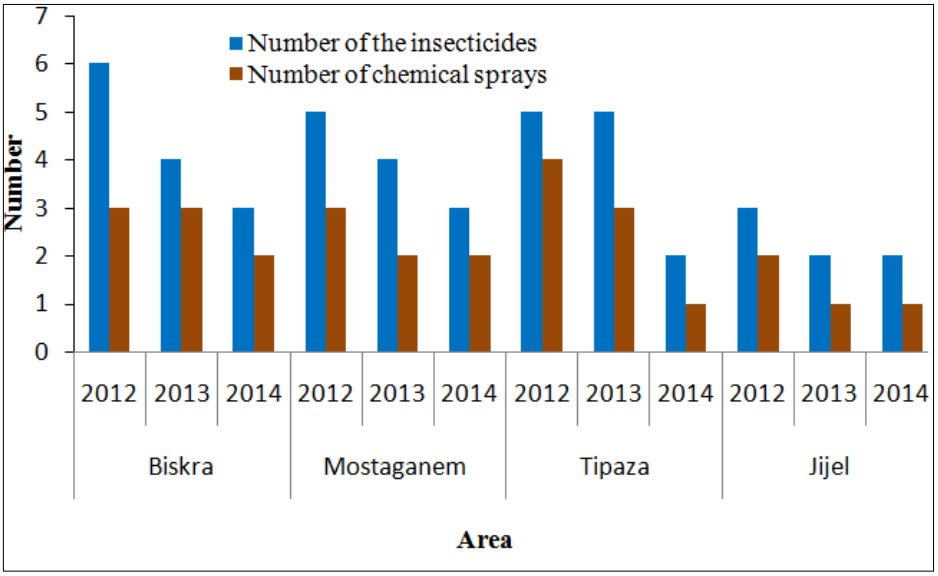

Fig. 3. Effect of the number of the insecticides and the chemical sprays applied on the *Tuta absoluta* infestation in the control greenhouses.

Statistical analysis.

The analysis of variance was used to explain the meaning of the variability of a quantitative mean according to the factors involved (campaign, region, month and treatment). The general linear model (GLM) was used to know explicitly the effect of an independent factor. Our study was based on the variation of infestation rates depending on the factors studied, in particular the years, regions, months of sampling and treatments. Their comparison focused also on the greenhouses protected by pheromone traps and the control greenhouses performing local area practices. They were analyzed by statistical tests (ANOVA) carried out using the SYSTAT V7 software (Hammer et al. 2001).

The correlation analysis of the evolution of infestation rates as a function of maximum and minimum temperatures was performed by PAST software (Hammer; v 12). The comparison of the averages between the infestation rates according to regions was

Carried out by XLSTAT (version 2014). The graphical representation of the results was made by histograms with calculations of standard errors for each parameter studied (year, region, month of sampling and treatment).

RESULTS

Effect of the applied mode of crop protection.

The infestation rates recorded on tomato plants grown under greenhouses confirmed the presence of larvae recovered from leaves and adults found in traps confirmed the presence of *Tuta absoluta* in tomato greenhouses in all regions (Fig.4).

A highly significant variability was detected on the infestation according to the years of study, the mode of protection (pheromone traps and local practice (Fig.4a, b) and the sampling

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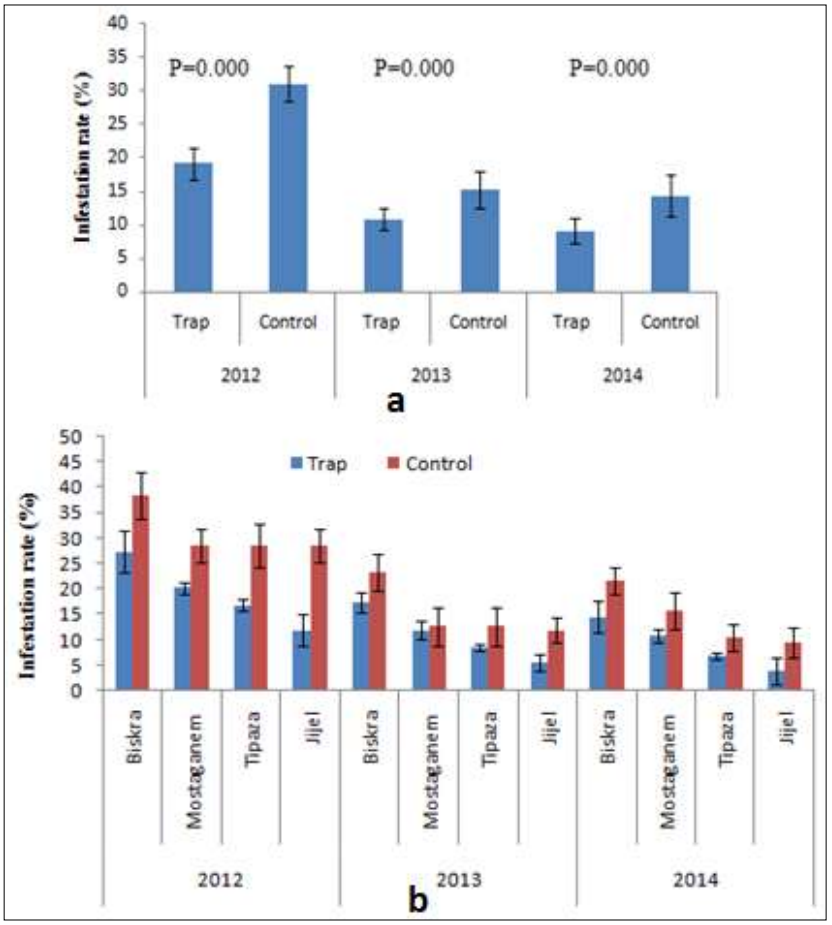

Fig.4. Infestation of tomato leaves by *Tuta absoluta* according to the mode of protection during the period 2012-2014, a: results of the total of all regions, b: results by region.

A low infestation was recorded on the leaves of the tomato at the level of the two greenhouses (less than 35%) (Fig.4). In fact, the infestation rates recorded were decreasing in greenhouses with pheromone traps and in control greenhouses during the years of study respectively; they went from around 19 and 31% in 2012, to around 11 and15% in 2013, to around 9 and 14% in 2014 (Fig. 4).

Infestation rates according to the studied areas.

Furthermore, the analysis of the variance in the infestation rates of plants during the three successive years: 2012, 2013 and 2014 showed a highly significant difference.

The comparison analysis of the averages showed the presence of 2 groups (a) and (b) and an intermediate group (ab) (Fig. 5).

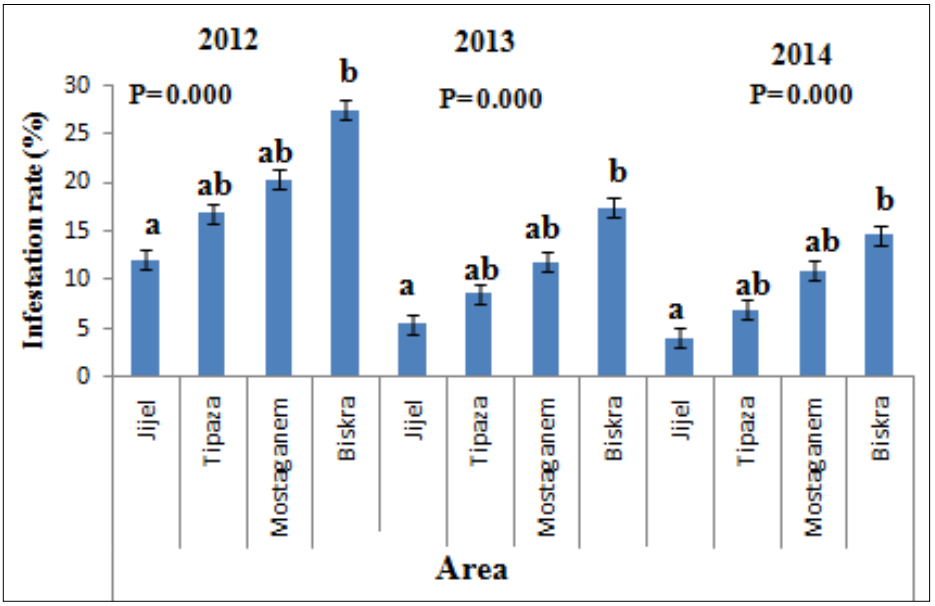

Fig.5. Variability of the infestation rate of tomato leaves by *Tuta absoluta* according to the studiedareas, during the period 2012 -2014. The bars surmounted by the same letter are not significantly different.

Variability was revealed on the number of infested tomato leaves, according to the years and according to the studied areas. The infestation was important in 2012 but showed a remarkable reduction in the following years (2013-2014). The southern area (Biskra) seemed to be the most infested with recorded rates of around 27, 17 and 15% respectively during the three years, unlike the eastern area (Jijel) whose infestation rates remained lower at around 12, 5 and 4%, respectively (Fig.5)

Effect of the temperature on the infestation rate.

Analysis of the correlation between the infestation rate and the maximum and minimum temperatures showed highly significant differences (P=0.000; P<0.001) and a positive correlation with determination coefficients of 0.49 and 0.48, respectively (Fig.6).

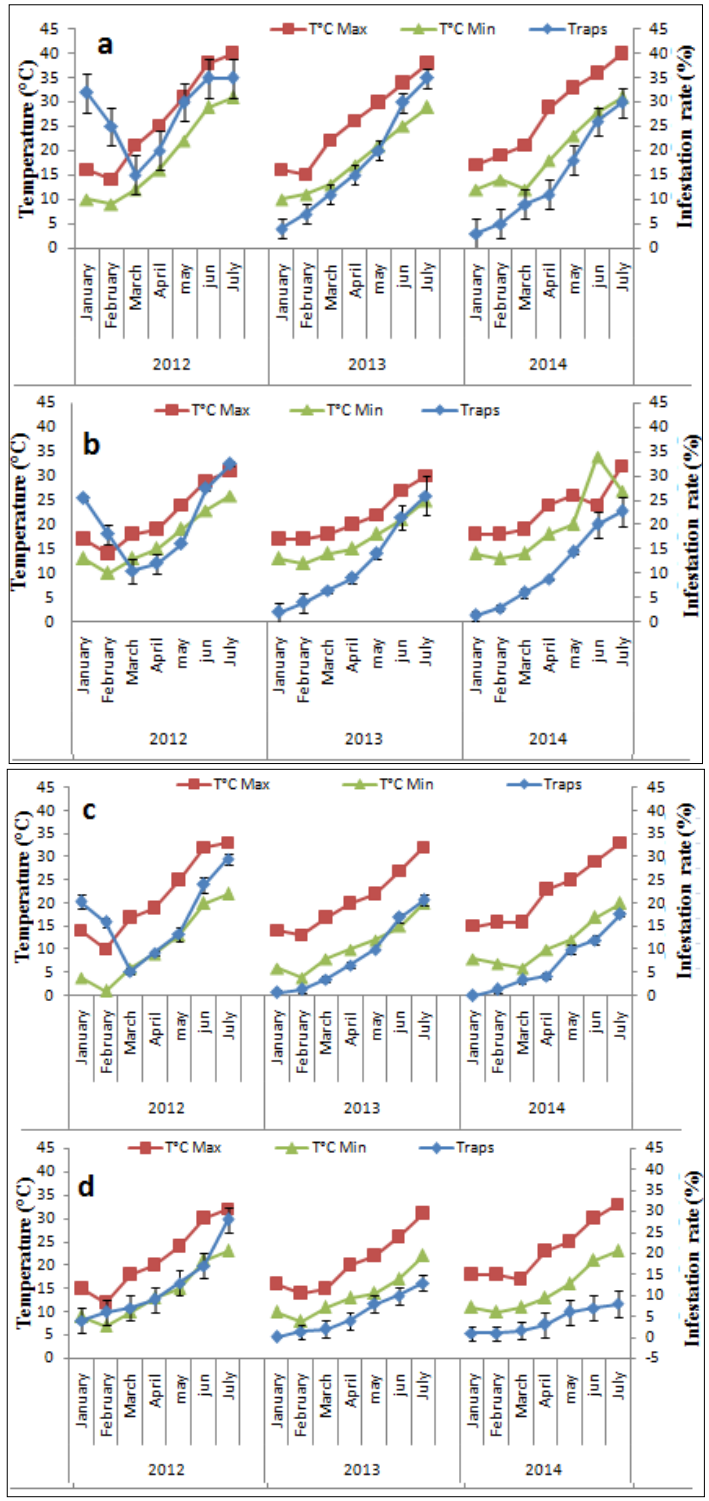

Fig. 6. Monthly variability in infestation rates of tomato plants under greenhouses by *T. absoluta* during the period 2012_2014 depending on ambient temperatures. a: Biskra region, b: Mostaganem region, c: Tipaza region, d: Jijel region.

The infestation of tomato plants by *T. absoluta* showed variability according to the studied areas and according to the sampling periods (months) during the three years of study. It was irregular in 2012 for the regions of Tipaza, Mostaganem and Biskra but appears to be regular in the same year in the region of Jijel and in the following two years for all regions (Fig.6).

DISCUSSION

The infestation of tomato leaves by *T. absoluta* showed variability in the greenhouses of the studied Algerian areas. The values recorded during the studied years converge to those noted by Filho et al. (2000) on leaves of tomatoes grown in greenhouses in Brazil.

Furthermore, our results explain a remarkable reduction of infestation of tomato leaves in protected greenhouses by pheromone traps compared to control greenhouses with local practices. In this sense, Ababsia et al. (2011) confirmed that fruit infestation does not depend only on the installation of sex pheromone traps, but also on the isolation of the greenhouse from the outside. Cherif (2018) reported some dose of two sex pheromone traps per greenhouse were the most effective compared to other tested doses. In contrast, Braham (2014) showed that there was no significant difference between mass trapping technique and chemical control strategy.

Our results also highlighted a major infestation during the three years of study in the greenhouses of the Biskra, Mostaganem and Tipaza areas, unlike that recorded in the Jijel region. This explains the influence of weather conditions on the degree of infestation, mainly the temperature. Gonzalez et al. (2011) showed the importance of the temperature on the activity and the intensity of trapping during the season. Guenaoui (2008) also recorded that the populations of *T. absoluta* are regulated by climatic factors, in particular temperature and humidity. Daoudi-Haciniet al. (2011) reported that temperature is an important factor in the bio-ecology of this insect. The same findings were recorded in the work of Mahdi (2014). In contrast, the results recorded by Elouissi in (2016) showed that temperatures and humidity rates do not affect directly the number of adult males trapped over the months of study.

The temporal evolution of infestation rates showed an increase since January to July, with the months of June and July recording the higher infestations. Our results agree with several works such as those of Leite et al. (2004) who also noted a severe intensity of attack towards the end of the crop cycle, hence the importance of eliminating the previous crop.

In the Biskra area, Drouai in 2011 noted a low infestation during the fall-winter period, but it increased significantly during the spring period. Ababsia (2012) also mentioned that the tomato crops grown in west and southern Algeria were more infested.

Bellatreche (2012) recorded values greater than 50% in the coastal region on the crops of three varieties of tomatoes: Zahra, Doucen and Kartier, particularly from May. Benzara et al. (2014) mentioned that the leaf miner activity begins in March and accelerates with the increase in temperature as spring runs. It results in an increase in numbers of eggs and larvae during April, then much more from May, June until mid-July.

In conclusion, the use of pheromone trapping against the tomato leaf miner *T. absoluta*, in for (04) different areas of tomato cropping, showed higher infestation rates in greenhouses with local agricultural practices compared to those protected by pheromone traps. The southern region seemed the most infested and, to a lesser degree, the western, the central and the eastern respectively. The temporal evolution of infestation rates recorded an infestation increase from January to July but.

RESUME

Bellatreche M., Messgo-Moumene S., Guendouz-Benrima A. et Chaieb I. 2021.Contrôle de *Tuta absoluta* à l'aide de pièges à phéromone sur des cultures de tomates sous-serre en Algérie. Tunisian Journal of Plant Protection 16 (1): 1-10.

La présente étude vise l'évaluation de l'efficacité des pièges à phéromone sur les adultes de *Tuta absoluta* dans 4 zones potentielles de production de tomates en Algérie: Tipaza (Centre), Mostaganem (Ouest), Jijel (Est) et Biskra (Sud), durant la période 2012-2014. Deux serres de tomates ont été considérées pour chaque zone dans laquelle, l'une était protégée par la mise en place de pièges à phéromone et l'autre par la lutte

insecticide. Des échantillons de feuilles de tomate ont été prélevés de chaque serre, chaque mois de chaque année selon les zones d'études pour évaluer l'infestation. Les taux d'infestation les plus élevés ont été enregistrés dans les serres avec des pratiques agricoles locales (témoin) comparées à celles protégées par des pièges à phéromone. Dans le cas d'utilisation des pièges à phéromone, une réduction remarquable a affecté l'infestation des serres dans les 4 zones étudiées au cours des années 2012 à 2014. La zone sud semblait être la plus infestée et par degré moindre les zones de l'Ouest, du Centre et de l'Est, respectivement. L'évolution temporelle des taux d'infestation a montré une augmentation depuis le mois Janvier jusqu'au mois de Juillet où, Juin et Juillet ont montré les taux d'infestation les plus élevés. Ces résultats ont confirmé donc l'efficacité du piégeage des mâles de *T. absoluta* et l'importance de leur utilisation durable dans le système de lutte intégrée contre cet insecte dévastateur en Algérie.

Mots clés: contrôle, pièges à phéromone, serre plastique, tomate, *Tuta absoluta*

ملخص

بلطرش، محمد وسعيدة مسغوـمومن وعتيقة قندوزـبن ريمة وإقبال الشايب. 2021. مكافحة حافرة الطماطم (*Tuta absoluta*) باستخدام مصائد فيرومونية على زراعة الطماطم تحت البيوت البلاستيكية في الجزائر.

Tunisian Journal of Plant Protection 16 (1): 1-10.

تهدف هذه الدراسة إلى تقييم فعالية استعمال مصائد الفيرمون وذلك للتخلص من الحشرات البالغة لحافرة الطماطم (*Tuta absoluta*) في أربع مناطق لإنتاج الطماطم في الجزائر وهي تيبازة (وسط) ومستغانم (غرب) وجيجل (شرق) وبسكرة (جنوب)، خلال المواسم 2012 إلي 2014. تم اختيار بيتين بلاستيكيين في كل منطقة وتمت حماية إحداهما باستعمال مصائد الفيرمون ومعالجة الأخرى بمبيدات حشرية. تم أخذ عينات من أوراق الطماطم من كل بيت بلاستيكي كل شهر من كل عام، على حسب منطقة الدراسة وذلك لحساب نسبة الإصابة. تم تسجيل نسب إصابة عالية في البيوت البلاستيكية ذات الأعمال الزراعية المحلية (الشاهد) مقارنة بتلك المحمية بواسطة مصائد الفيرمون. مع استعمال المصائد الفيرومونية، لوحظ انخفاض في نسبة الإصابة في البيوت البلاستيكية في المناطق الأربع التي تمت دراستها بشكل خاص من 2012 إلى 2014. كانت المنطقة الجنوبية الأعلى إصابة، وبدرجة أقل، المناطق الغربية ثم الوسطى ثم الشرقية، على التوالي. وأظهرت المتابعة الزمنية لنسب الإصابة زيادة متواصلة في الفترة من يناير/جانفي إلى يوليو/جويلية، حيث بلغت نسبة الإصابة ذروتها خلال شهريْ يونيو/جوان ويوليو/جويلية من كل سنه. كما أكدت هذه النتائج فعالية اصطياد ذكور حفارة الطماطم وأهمية استخدامها الدائم في نظام المكافحة المتكاملة ضد هذه الحشرة المدمرة في الجزائر.

كلمات مفتاحية: بيوت بلاستيكية، طماطم، مصائد فيرومونية، مكافحة، *Tuta absoluta*

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