Control of the Cotton Bollworm *Helicoverpa armigera* in Tunisian Tomato Open Field Plot by the Application of Some Insecticides

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ABSTRACT

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The cotton bollworm, *Helicoverpa armigera* is considered a serious pest that attacks tomato in Tunisia and in other countries around the world. Thus, it is a necessity to control this pest and to establish a management program. The monitoring of the insect flight activity using sex pheromone traps, under Takelsa open field plot, revealed that this insect developed up to three generations. The study of its population dynamics showed that on leaves, eggs and larvae are able to achieve two peaks. However, on fruits, only larvae were present in an important number and produced two generations. Pupae are almost absent in leaves and fruits. In this study, the management of this pest was performed through the chemical treatment by testing the efficacy of some insecticides. Two trials were tested on June, 2011. All tested insecticides were proved to be efficient in controlling *H. armigera* under field conditions.

Keywords: Chemical treatments, *Helicoverpa armigera*, population dynamics, tomato open field

Tomato is a strategic crop in Tunisia. It is considered as a major source of income for many Tunisian families by providing seasonal job on picking tomatoes and its transformation (9). Production can be limited by different factors, such as fertilizers, water and crop genetic potential, as well as attacks by pests (fungi, virus, bacteria, insects,…) that feed on plants (6). Among pests which attack tomato and can give heavy losses, we noted the cotton bollworm *Helicoverpa armigera* (Lepidoptera: Noctuidae) (7). Several control strategies were undertaken in order to limit damages caused by this pest. However, chemical control is still the control method the most used by Tunisian farmers which is less acceptable now because of the development of insecticide resistance (4). In Pakistan, due to the excessive use of insecticides on tomato and other crops, *H. armigera* has developed varying levels of resistance to many insecticides such as endosulfan, chlorpyrifos, and thiodicarb (3). For these reasons, and in order to manage this pest, this study was carried out.

The present work was proposed firstly to study the male flight activity and population dynamics of *H. armigera* and secondly to test the efficacy of some insecticides in reducing damage caused by this pest under tomato open field plot in Takelsa region (North East of Tunisia).

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MATERIALS AND METHODS

Experimental site.

During this study, one open-field plot was considered in 2011, covering an area of 0.75 ha, located in Takelsa, and planted with the tomato (cv. Chams) on April 1st, 2011.

Insect monitoring was realized using sex pheromone delta trap (PheroNorm®, Andermatt Biocontrol) at a density of 2 traps per 0.75 ha and started when plants were at the fruit setup beginning stage. Delta traps were put on June 16th, 2011 and pheromone capsules were removed and replaced by new ones 4 weeks after their setup. Insect presence on tomato plants (eggs, larvae and pupae) was assessed weekly by sampling at random 30 leaves and 15 fruits.

Insecticides tested.

The efficacy of eight insecticides was tested during this study. The first trial was conducted on June 23th, 2011 by using two active ingredients (chlorfenapyr and a combination of abamectin + chlorantranliprol) (Table 1). The second trial was made on June 27th, 2011 using the remaining 6 active ingredients (Table 1). Insecticides were sprayed when the captures in monitoring traps reached 5 moths/day/trap (8). The experimental plan was a randomized complete block design with two replicates. Each block, containing 374 plants, received one of the following insecticides described in Table 1 along the control which is left unsprayed. For insecticide application, a hydraulic knapsack hand sprayer of 10 liters was used.

The insecticide efficacy against *H. armigera* was evaluated on a sample from each 187 tomato plants in each experimental unit, which consisted of taking 15 tomato fruits. Counting of *H. armigera* larvae was performed in the laboratory with a binocular microscope. Populations were recorded 3, 7, 14 and 21 days after spraying. Percentage mortality was calculated using the Abbott's formula (1):

Efficacy Rate = (T0 - Tt / T0) × 100,

with T0: number of larvae on control tomato plants; Tt: number of larvae on treated tomato plants.

Table 1. Insecticides tested against *Helicoverpa armigera* larvae on tomato plants under field conditions

Active ingredient	Trade name	Concentration of active ingredient	Dose (g/hl or ml/hl)
Chlorfenapyr	Challenger	240 g/l	50 ml/hl
Abamectin + Chlorantranliprol	Voliam Targo 063 SC	chlorantranliprol 45 g/l + abamectin 18 g/l	60 ml/hl
Cyromazin 750	Clave	75%	30 g/hl
Indoxacarb	Amiral	150 g/hl	50 ml/hl
Verticillium lecanii	Biocatch	109 cfu/ml	100 ml/hl
Bacillus thuringiensis* var. *kurstaki	Bt 32000	32000 UI/mg	250 g/hl
Azadirachtin	Fortune aza	32 g/l	150 ml/hl
Sodium tetraborohydrate	Prevam	9.9 g/l	400 ml/hl

Climatic data.

The climatic data were given by the Tunisian Meteorological Institute. In Takelsa, the temperatures and relative humidity averages ranged from 17.4 to 29°C and from 71 to 87.3%, respectively (Table 2).

Table 2. Climatic conditions in Takelsa (average year 2011)

Month	April	May	June	July	August
Temperature (°C)	17.4	20.7	29	30	29
Relative humidity (%)	87.3	88	71	70	71

Statistical analysis.

Data related to the effect of different insecticides tested on reducing pest population in tomato plants were evaluated by analysis of variance using one-way ANOVA. Means of treatments were separated using Duncan's multiple range test at $P = 0.05$. All statistical analyses were performed using the software SPSS 17 (13).

RESULTS

Male flight activity and population dynamics of *H. armigera*.

The male flight activity of *H. armigera* began on June and completely declined on August, 19th. Catches were high (= 40 males/trap/week) but progressively decreased from the month of July to August to reach a number of 1 male/trap/week. In Takelsa tomato open field plot, *H. armigera* developed three peaks recorded on June, 23rd, July, 07th and from July 21rd to the end of the experiment (19/08/2011) (Fig. 1).

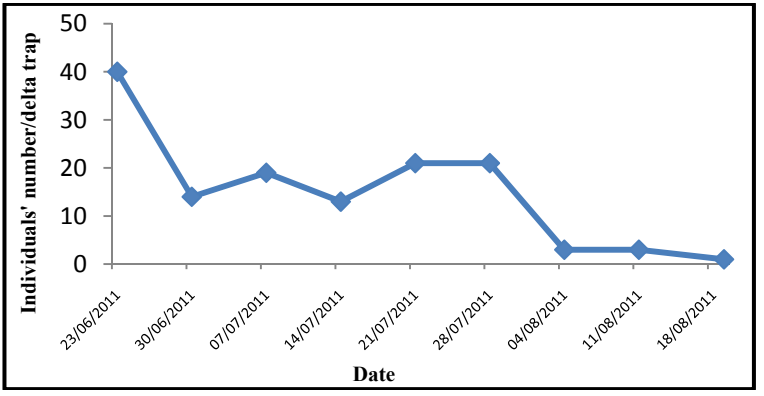

Fig. 1. Male flight activity of *Helicoverpa armigera* in Takelsa open field plot (June-August, 2011).

Population dynamics of *H. armigera* on tomato leaves revealed the presence of two generations of eggs and larvae recorded on June and July. Eggs were more frequent on leaves than larvae. In fact, in the 1st and the 2nd peaks, the number of eggs recorded was 13 and 3 per 30 leaves, respectively. However, the number of larvae in the 1st and 2nd peaks was 4 and 1, respectively (Fig. 2a).

On fruits, eggs were present in a very little number (≤ 1 egg/15 fruits). However, larvae were present in fruits with an important number with 9 and 3 larvae/15 fruits respectively in the 1st and 2nd peak (Fig. 2b).

Pupae, which had a brown color and a 16 to 18 mm in length were absent in both leaves and fruits (Fig. 2).

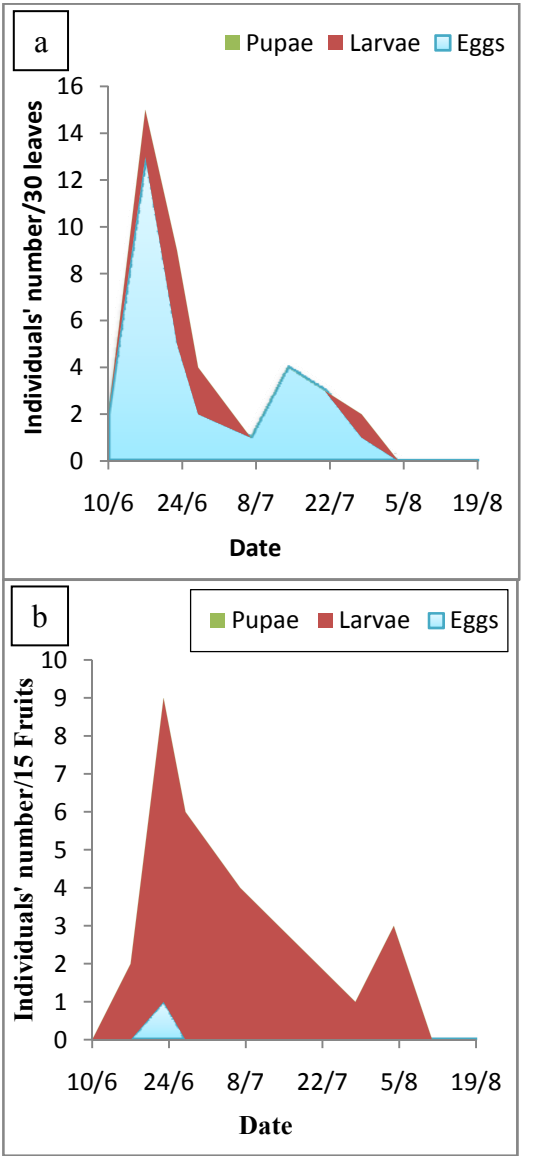

Fig. 2. Population dynamics of *Helicoverpa armigera* on leaves (a) and fruits (b) in Takelsa open field plot (June-August, 2011).

Efficacy of the insecticides against *H. armigera*.

For the first trial, the two tested insecticides decreased significantly *H. armigera* population ($F_{2,14}$ = 4.43, P = 0.036) (Fig. 3a, Table 4a). The abamectin associated with the chlorantranliprol showed an excellent effect on reducing the pest population. Its efficacy was 100% at 3, 7, 14, and 21 days after treatment (DAT) (Table 3a). Also, the chlorfenapyr was shown to be effective against *H. armigera*; its efficacy ranged from 42.85 to 75% following treatment (Table 3 a).

For the second trial, all tested insecticides were effective in reducing *H. armigera* larvae in tomato fruits ($F_{6,34}$ = 5.97, P = 0.000) (Fig. 3b, Table 4b). Three days after spraying, an important percentage of efficacies was observed in the experimental units treated by cyromazin (83.33%), indoxacarb (66.66%), *V. lecanii* (66.66%) and *B. thuringiensis* or Bt (50%) (Table 3b). However, the azadirachtin was proved to be the least effective (16.66%) at 3 DAT, but its efficacy increased progressively to reach 71.42 and 85.71% at 7 and 14 DAT, respectively (Table 3b). Table 3b showed that the sodium tetraborohydrate was not effective on *H. armigera* larvae 3 DAT, but its efficacy increased progressively to reach 57.14, 57.14, and 50%, respectively, at 7, 14 and 21 DAT.

A highest and statistically similar efficacy was observed at 7, 14 and 21 DAT of cyromazin and Bt (Table 3b). The indoxacarb was proved also to be efficient throughout the experiment. The percentage of its efficacy was 100, 85.71, and 75%, respectively, at 7, 14 and 21 DAT (Table 3b).

DISCUSSION

In the present study, results concerning *H. armigera* male flight activity and population dynamics in Takelsa tomato open field plot are almost similar to those obtained in other work (4). These authors suggested that *H. armigera* are active from late May to early November with a maximum trap catches and greatest number of eggs and larvae reported on July. In another study realized in the south of France (5), it was showed that *H. armigera* accomplished three flight peaks on tomato plants recorded respectively on mid May, mid June, July-August, September-October. Also, these authors suggested that the infestations occur from August to early October.

In this study, only eggs and larvae were present with different number in leaves and fruits. This result led us to conclude that pupation occurred in the soil. In fact, when growth is achieved, larvae leave the plant and pupate in the soil (3-15 cm depth) (11). Also, the same authors suggested that, in Zimbabwe, pupae can take place at the end of formation of the corn cob.

Concerning the effect of the tested insecticides on *H. armigera* larvae population, the present study suggests that all insecticides are efficient in reducing damages caused by this pest. These findings are in agreement with another work showing that both *B. thuringiensis* and *Melia azedarach* suspension reduced significantly pest populations and were comparable to methomyl (4).

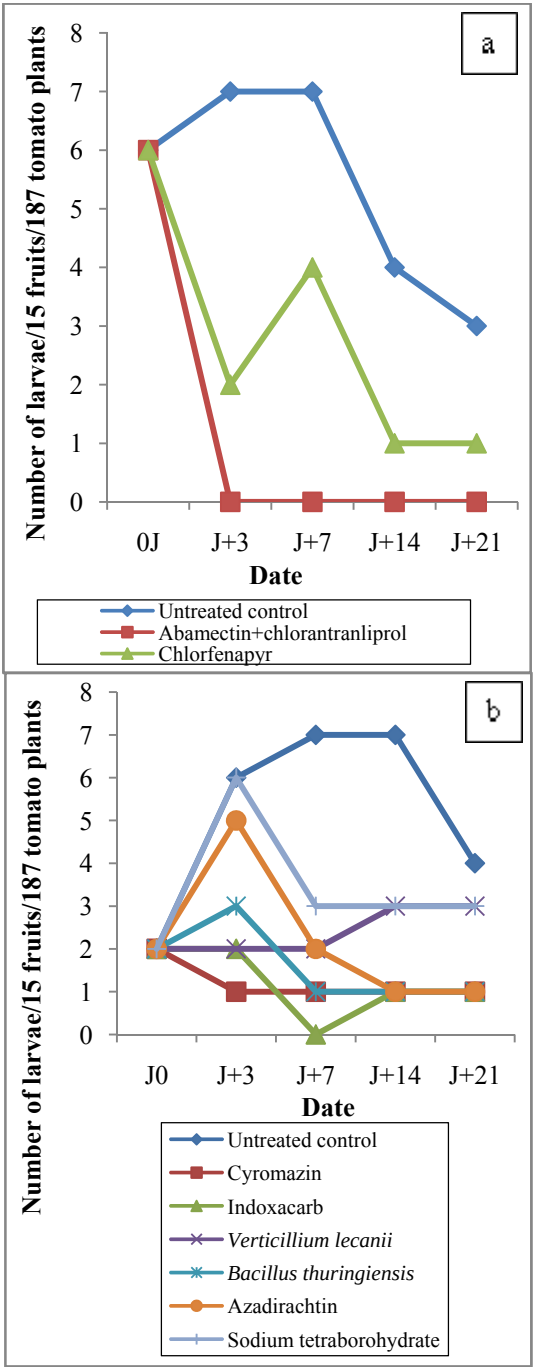

Fig. 3. Evolution of *Helicoverpa armigera* larvae after treatment in Takelsa open field plot in 2011 noted at the first (a) and the second trial (b).

Table 3. Efficacy rate of the tested insecticides on *Helicoverpa armigera* at larvae 3, 7, 14 and 21 days after treatment recorded in the two trials

Treatment (1st trial)	Efficacy rate (%)			
	DAT			
	3	7	14	21
Untreated control	-	-	-	-
Chlorfenapyr	71.42	42.85	75.00	66.66
Abamectin + chlorantranliprol	100	100	100	100

Treatment (2nd trial)	Efficacy rate (%)			
	DAT			
	3	7	14	21
Untreated control	-	-	-	-
Cyromazin	83.33	85.71	85.71	75
Indoxacarb	66.66	100	85.71	75
Verticillium lecanii	66.66	71.42	57.14	0
Bacillus thuringiensis	50	85.71	85.71	75
Azadirachtin	16.66	71.42	85.71	50
Sodium tetraborohydrate	0	57.14	57.14	50

*DAT: Days after treatments

Table 4. Effect of insecticide treatment of the two trials on *Helicoverpa armigera* larvae

Treatment (1st trial)	Mean number of larvae/15 Fruits/187 tomato plants
Untreated control	5.4 a
Chlorfenapyr	2.8 ab
Abamectin+chlorantranliprol	1.2 b

Treatments (2nd trial)	Mean number of larvae/15 Fruits/187 tomato plants
Untreated control	5.2 a
Cyromazin	1.2 c
Indoxacarb	1.2 c
Verticillium lecanii	2.4 cb
Bacillus thuringiensis	1.6 cb
Azadirachtin	2.4 cb
Sodium tetraborohydrate	3.2 b

* Means followed by the same letter are not significantly different at $P \leq 0.05$ within each column.

In a previous study, the efficacy of new insecticides against *H. armigera* on cotton crop at Multan (Pakistan) in 2002 and 2003 was compared (12). The authors suggested that the emamaectin benzoate and the indoxacarb showed a highest larval mortality five days after insecticide application during the two years. In fact, in plots treated with the emamaectin benzoate, the percentage of larval mortality was 73.5 and 73.2%, respectively, after the 1st and the 2nd year of insecticides' applications. In the same period, the indoxacarb had an efficiency of about 71.2 and 69.5%, respectively (12).

The effect of pesticides applications based on an IPM program on cotton bollworm, *H. armigera*, cotton mirids and cotton leafhoppers was tested (10). The authors demonstrated that in 1999 and 2000, bollworm populations on non-transgenic cotton were larger than those on transgenic cotton. Also in Bt-cotton fields, the numbers of fourth generation bollworms were greater than those in the second and the third generations over all three years of study (10).

In another study, two botanical pesticides, Neem Azal-T/S (NA) and *Quassia amara*, one biopesticide, *Bacillus thuringiensis* subsp. *aizawai* (Bta) and one combination of Bta + NA against 2nd and 4th instar larvae of the noctuids *H. armigera* and *Spodoptera exigua* on field beans under both laboratory and greenhouse conditions were tested (2). The authors demonstrated that the maximum mortality of 58 and 27% was obtained in Bta + NA treatments in case of 2nd and 4th instar larvae of *H. armigera* under laboratory conditions followed by Bta (50 and 14%) and NA (34 and 7%) alone treatments. Under greenhouse conditions, a mortality of 69 and 26% was observed in case of Bta + NA treatments in 2nd and 4th instar larvae of *H. armigera* followed by Bta (67 and 20%) and NA (56 and 10%) alone (2).

In conclusion, all these results related to male flight activity, population dynamics and management of *H. armigera* using insecticides represent preliminary information about this pest. Further study should be performed to acquire a better knowledge of this pest. During this study, the tested insecticides gave a good and an important effect by reducing damage caused by *H. armigera*. These insecticides could play an important role in managing this pest and could solve, in part, the problem of resistance developed by this pest to many insecticides. Other alternatives such as biopesticides based on nucleopolyhedrovirus should be also tested. These insecticides are shown by not only their efficiency but also their harmless to beneficial organisms.

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RESUME

Cherif A. et Grissa-Lebdi K. 2015. Contrôle de la chenille du coton *Helicoverpa armigera* sur culture de tomate de plein champ en Tunisie par l'application de certains insecticides. Tunisian Journal of Plant Protection 10: 45-54.

Helicoverpa armigera est un ravageur dangereux qui attaque la culture de tomate en Tunisie et dans d'autres pays à travers le monde. Ainsi, il est nécessaire de contrôler cet insecte et établir un programme de lutte. L'étude de son activité de vol moyennant l'utilisation des pièges à phéromones sexuelles installés au niveau d'une parcelle de tomate de plein champ à Takelsa, a révélé que ce

ravageur peut réaliser jusqu'à trois générations. L'étude de sa dynamique des populations a montré que sur feuilles, les œufs et les larves peuvent effectuer jusqu'à deux pics. Cependant, sur fruits, seules les larves sont présentes et réalisent deux générations. Les chrysalides sont absentes au niveau des feuilles et des fruits. Durant cette étude, le contrôle de ce ravageur a été réalisé moyennant des traitements chimiques en testant l'efficacité de certains insecticides. Les deux essais sont menés en Juin 2011. Tous les insecticides testés sur terrain ont montré une efficacité en contrôlant *H. armigera*.

Mots clés: Dynamique des populations, *Helicoverpa armigera*, tomate de plein champ, traitements chimiques

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ملخص

شريف، أسماء وكوثر غريسة-لبدي .مقاومة يرقة القطن *Helicoverpa armigera* في حقول الطماطم بتونس من خلال تطبيق بعض المبيدات الحشرية.

Tunisian Journal of Plant Protection 10: 45-54.

تُعتبر حشرة *Helicoverpa armigera* من أهم الآفات في تونس وفي بقية أنحاء العالم لذلك يجب مراقبة هذه الآفة ووضع برنامج مكافحة. أثبتت دراسة نشاط طيران الذكور (بواسطة المصائد الفيرومونية) على الطماطم الحقلية بمنطقة تاكلسة تعاقب 3 أجيال. بالنسبة إلى ديناميكية مجموعات الحشرة، أظهرت الدراسة أن مرحلة البيض واليرقات يمكن أن تصل إلى قمتين على أوراق الطماطم. أما على الثمار، فاليرقات موجودة وحدها وتنتج جيلين. وكانت الشرانق غائبة تماما على أوراق وثمار الطماطم. خلال هذه الدراسة، تمت السيطرة على هذه الآفة من خلال المعاملة الكيميائية عن طريق اختبار نجاعة بعض المواد الفعالة وأجريت الاختبارات في جوان/يونيو 2011. وقد أظهرت جميع المبيدات الحشرية من خلال اختبارها ميدانيا كفاءة كبيرة في مكافحة *H. armigera*.

كلمات مفتاحية: ديناميكية المجموعات، طماطم حقلية، معاملة كيميائية، *Helicoverpa armigera*.

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