

I.P.M Strategy for *Tuta absoluta* on Tomatoes and Potatoes

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ABSTRACT

Complementary strategies of pest management aiming to reduce the use of insecticides on *Tuta absoluta* infested tomatoes and potatoes carried out at Abo hommus during 2017 and 2018 seasons.

Ten of generations of *Tuta absoluta* were recorded per year. The longest generation period was on January while the shortest generation was on May.

On the other hand the percent infestation by *Tuta absoluta* was highest on tomatoes than potatoes. The pesticide consequence model indicated that (Emamectin benzoate – Chlorantraniliprole – Flubendiamide - Chlorfenapyr) gave the highest percent reduction of *Tuta absoluta* on the fourth model in the first season of 2017. While, (Chlorantraniliprole - Emamectin benzoate – Chlorfenapyr – Flubendiamide) gave the highest pest mean reduction on the third model in the second season of 2018. Flubendiamide followed by Chlorfenapyr gave the highest percent reduction of *Tuta absoluta*.

Using pheromone traps (E3Z8Z11-14Ac[®]) to monitoring and capturing of *Tuta absoluta* males in the cultivated field of tomato and potato during 2017 and 2018 seasons, which show that infestation was fluctuated due to the different parameters at field condition.

Key Words: Tomato leafminer, *Tuta absoluta*, pheromone traps, pesticide consequence model

INTRODUCTION

The tomato borer, *Tuta absoluta* (Meyrick) (Lepidoptera: Gelechiidae) has been recognized in South America, then spreading quickly to the major tomato-producing countries. Although the cultural control methods were attempted against *T. absoluta*, using of resistant tomato varieties and the use of pheromones and natural enemies, and insecticides which are still the main control method used, (Guedes and Picanco, 2012).

Nowadays, *T. absoluta* is present in many countries (Europe, Africa, Middle East and Asia) and affecting nearly 60% of all cultivated tomato worldwide (Campos *et al.* 2017, Sylla *et al.* 2017 and Biondi *et al.* 2018). The caterpillar feeds on several parts of tomato plants, such as leaves, stems and fruits, causing direct and indirect damage that could result in 100% yield loss if no control measures are implemented (Desneux *et al.* 2010 and Tropea Garzia *et al.* 2012).

Egypt is one of the world's developing countries that suffer from population increase, tomato, (*Solanum lycopersicum* L.) is considered as the most economically important feeding crop. More than one million fedan are yearly cultivated with tomato varieties for local consumption and export affairs.

T. absoluta attack green plant foliage causing blotch mines between both leaf surfaces, flowers and tend to infest fruits which lead to partial and complete tuber rotting by subsequent insect pest infestations. In this case, the infested fruits become completely unmarketable and not suitable for human feeding. Tomato of Autumn plantation is harvested during end of August to early September demonstrating were harbor the highest levels of infestation expressed as number of larvae/plant foliage reliable yield figures (Saad, 2014).

Therefore, the aim of the present study focused on this insect pest *Tuta absoluta* that attacking tomato and potato in the field at different time of cultivation concerning. In addition using sex pheromone (E3Z8Z11-14Ac[®]) as a trail to calculate number of infestation during cultivation period of tomato and potato plants. Also, put an IPM trail to control infestation by using different way of control.

MATERIALS AND METHODS

Field experiments were carried out during 2017 and 2018 growing seasons at El-Berka village, Abou Hommos city, Behaira province, Egypt. The first field trial was conducted using different sequence of application as a model to control *Tuta absoluta* without producing resistance strain after application. The second field trial was carried out to estimate the effect of temperature and relative humidity on infestation of the tomato leafminer in tomato and potato. The third field trial was conducted to determine the generations' number of *Tuta absoluta* per year under normal conditions.

The experiment was excited in randomized complete blocks design within three replications. The tomato variety namely; Malika F1 was cultivated in both seasons. The plot size was 21 m² (1/200 fed-1), with 6 m in length and 3.5 m width i.e.; six ridges. All other agricultural practices were applied at the

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recommendations of the Egyptian Ministry of Agriculture.

Sampling technique and inspection of the *Tuta absoluta*

The infestation rate was recorded after 1, 5 and 10 days post- spraying taking into account the mean number of larvae / 10 sampled plants /replicate in each treatment compared the check untreated. Percent reductions of infestation were also calculated. The estimated infestation rate in treatments was determined pre- and after 1, 5 and 10 days from insecticidal applications and the percent of infestation reduction were calculated using Henderson and Tilton (1955) equation.

Sex pheromone traps for monitoring and capturing the males of the tomato leafminer, *Tuta absoluta*

Three yellow aquatic pheromone traps (E3Z8Z11-14Ac®) were replaced within a cultivated area of Feddan during 2017 and 2018 seasons. The used pheromone traps (1 lure) is specific for *T. absoluta*. Monitoring was started when the plants were 40 days old. Examination was done weekly till the end of the season but the replace every month with another phenomenon. The captured males were counted (Attygalle *et al.*, 1996).

Calculation of generation

Number of *T. absoluta* per a year calculated according to Richmond *et al.* (1983) by using lower threshold temperature (T_0) 8 °C with 460-degree day's unit (D.D.U) for estimating the possible number of generation per year in the field according to the following two formulas:

$$\text{First if } T_{\min} \text{ is lower than } (T_0) 8 \text{ }^\circ\text{C}$$

$$\text{DDU} = \frac{(T_{\max} - T_0)^2}{2 (T_{\max} - T_{\min})}$$

Second T_{\min} is higher than (T_0) 8 °C using the following equation

$$\text{DDU} = \frac{(T_{\max} + T_{\min})}{2} - T_0$$

Data analysis:

Pheromone data were analyzed by using a standard analysis method established by SAS institute by (Anonymous, 2003).

Statistical analysis

All collected data were subjected to the statistical analysis following the procedure described by Gomez and Gomez (1984). The least significantly differenced test (L.S.D) at 0.05 was used to compare between means of the different treatments.

RESULTS AND DISCUSSION

Agrochemical performance of different adopted models tested chemical insecticides against the tomato leafminer, *Tuta absoluta* infesting tomato plants on 2017 season

The data in Table 1 shows the efficiency of the tested insecticides through the different adopted models against the insect-pest compared to the untreated check.

The presented data of 1st model proved statistically that there were significant differences regarding the general mean for reduction percent among the tested treatments. In this context, the highest general mean of reduction resulted from Chlorantraniliprole 70.70% and Flubendiamide 60.94%. Meanwhile both of Chlorfenapyr and Emamectin benzoate gave reduced values of reduction comprised 54.43 and 53.12% in respects.

In general, 2nd model showed that both Chlorfenapyr and Flubendiamide recorded the highest general means of 88.16 and 80.97 of reduction percent, respectively. The less effective one was Chlorantraniliprole and Emamectin benzoate with a reduction percent of (74.63%), for each.

On the third model of 2017, the same trend were revealed that highest general means of reduction percent (89.73%) obtained by Flubendiamide, followed by (88.26%) for Emamectin benzoate and Chlorfenapyr with (84.59%) a reduction, in respect, but Chlorantraniliprole gave less effective with 82.61% reduction percent.

The fourth model on 2017, the data indicated that Flubendiamide was the most effective treatment causing 98.42% reduction, followed by Chlorfenapyr with reduction percent 96.32%, while Emamectin benzoate and Chlorantraniliprole gave less effective with 88.66% and 86.57% reduction percent against the tomato leafminer, *Tuta absoluta* infesting tomato plants, successfully.

Agrochemical performance for different adopted models against the tomato leafminer, *Tuta absoluta* infesting tomato plants on 2018 season

The tested treatments for the first model gave the general means reduction percent of 77.14% for both Chlorantraniliprole and Chlorfenapyr. While both treatment of Emamectin benzoate and Flubendiamide gave reduction values comprised to 67.34% and 65.04% in respects.

Table 1. Agrochemicals performance means for the pesticides model on tomato leafminer, *Tuta absoluta* infesting tomato plants in 2017 season

1 st season (2017)											
1 st model	A	B	2 nd model	A	B	3 rd model	A	B	4 th model	A	B
Flubendiamide	4.66	60.94	Chlorfenapyr	2.33	88.16	Chlorantraniliprole	3.66	82.61	Emamectin benzoate	2.11	88.66
Chlorfenapyr	3.50	54.43	Flubendiamide	2.00	80.97	Emamectin benzoate	1.33	88.26	Chlorantraniliprole	2.66	86.57
Emamectin benzoate	2.00	53.12	Chlorantraniliprole	1.66	74.63	Chlorfenapyr	1.00	84.59	Flubendiamide	0.33	98.42
Chlorantraniliprole	1.00	70.70	Emamectin benzoate	1.33	74.63	Flubendiamide	0.33	89.73	Chlorfenapyr	0.77	96.32
Untreated check	21.33	-	Untreated check	22.33	-	Untreated check	24.33	-	Untreated check	22.33	-

A= Average number of larvae /10 plants

B =Reduction percent (%)

The second model showed that Chlorfenapyr was the most effective treatment causing 87.98% reduction, followed by Flubendiamide with reduction percent 84.38%, while Chlorantraniliprole and Emamectin benzoate gave less effective with reduction percent 84.14 and 74.63% for each, successfully.

The data presented in the third model on Table (2) indicated that Emamectin benzoate and Flubendiamide were the most effective treatments causing 91.78% a reduction, for each, but Chlorfenapyr and Chlorantraniliprole gave less effective with reduction percent 89.43% and 84.93% reduction, in respectively.

The fourth model indicated that Flubendiamide was the most effective treatment causing 90.50% reduction, followed by Chlorantraniliprole with reduction percent 86.36%, while Emamectin benzoate and Chlorfenapyr

gave less effective reduction percent 85.33% and 83.11%, in respectively.

The above demonstrated results were in agreement with those mentioned earlier investigators for example, Bassi *et al.* (2012) when reported that Chlorantraniliprole (Rynaxypyr®, Coragen® and Altacor®) gave outstanding performance against *Tuta absoluta* with extremely low mammalian toxicity profile. This compound was tested on *T. absoluta* since 2002 in Brasil and the early results indicated a new standard of *T. absoluta* control, even on insecticide-resistant populations. Nannini *et al.* (2012) reported that the most insecticides used in Sardinian tomato greenhouses by growers against *T. absoluta* management were initially abamectin, azadirachtin and spinosad.

Table 2. Agrochemicals performance means for the pesticides models on tomato leafminer, *Tuta absoluta* infesting tomato plants in 2018 season

1 st season (2017)											
1 st model	A	B	2 nd model	A	B	3 rd model	A	B	4 th model	A	B
Flubendiamide	4.33	65.04	Chlorfenapyr	3.00	87.98	Chlorantraniliprole	3.67	84.93	Emamectin benzoate	3.66	85.33
Chlorfenapyr	2.00	77.14	Flubendiamide	2.67	84.38	Emamectin benzoate	1.33	91.78	Chlorantraniliprole	2.33	86.36
Emamectin benzoate	1.66	67.34	Chlorantraniliprole	1.67	84.14	Chlorfenapyr	1.00	89.43	Flubendiamide	1.00	90.50
Chlorantraniliprole	0.66	77.14	Emamectin benzoate	1.33	74.63	Flubendiamide	0.33	91.78	Chlorfenapyr	0.66	83.11
Untreated check	11.66	-	Untreated check	22.33	-	Untreated check	24.33	-	Untreated check	25.00	-

A= Average number of larvae /10 plants

B =Reduction percent (%)

Sex pheromone traps for capturing the tomato leafminer

Virgin female tomato leafminer releases a sex pheromone that strongly attracts males (Quiroz, 1978). This pheromone was identified by Attygalle *et al.*, (1996) as (3E, 8Z, 11Z)-3,8,11-tetradecatrien-1-yl acetate. By monitoring *T. absoluta* males using pheromone traps, it may be possible to determine the correct timing for insecticide applications leading to a reduction and proper rational use of pesticides. Therefore the complementary strategies for pest management aiming to reduce the use of insecticides through an efficient monitoring of pest population to fix a correct time for pesticide application need to be tested including the use of pheromone. Taha *et al.* (2014) reported that *T. absoluta* sex pheromone appears to be a valuable component in the integrated management of *T. absoluta*.

The date of male captures by pheromone traps that have been set inside the tomato and potato fields were weekly monitored to evaluate their efficiency in capturing the tomato insect-pest *Tuta absoluta*.

Pheromone traps were set to assess the population of *Tuta absoluta* during either the spring season of tomato plantation but the winter and Neely seasons of potato plantation. Examination of the traps was carried out at intervals of 7 days and therefore, the number of adults caught by pheromone traps every week was recorded and identified.

The date showed the seasonal fluctuations of *Tuta absoluta* on tomato plants during the first season of 2017, began to occur during the period elapsed from transplanting until early harvest on tomato plants.

The first appearance was 56.52 male / 3 traps on the 1st week. One peak was noticed on the 5th week, 2017 with a mean number of 103.44 male / 3 traps, where it was the lowest peak. The second peak occurred on the 12th week with a mean number of 155.38 male / 3 traps. This means that in the first season, *Tuta absoluta* had two population peaks. (Fig. 1).

The data showed the seasonal fluctuations of *Tuta absoluta* on tomato plants during the second season of 2018; in the sense that the *Tuta absoluta* male began to occur during the period elapsed from transplanting until early harvest on tomato plants. The first appearance was 9.95 male / 3 traps on the 1st week. One peak was noticed on the 10th week, 2018 with a mean number of 103.94 male / 3 traps, where it was the highest peak. The second peak occurred on the 17th week with a highest number of 88.71 male / 3 traps. This demonstration that in the second season, *Tuta absoluta* had two population peaks. (Fig. 2).

The date showed the seasonal fluctuations of *Tuta absoluta* on potato plants during the first season of 2017; in the sense, which *Tuta absoluta* larvae began to occur during the period elapsed from transplanting until early harvest on potato plants. The first appearance was 16.86 male / 3 traps on the 1st week. One peak was noticed on the 9th week, 2017 with a mean number of 110.68 male / 3 traps, where it was the lowest peak. The second peak occurred on the 14th week with a mean number of 105.03 male / 3 traps. This means that in the first season, *Tuta absoluta* had two population peaks. (and Fig. 3).

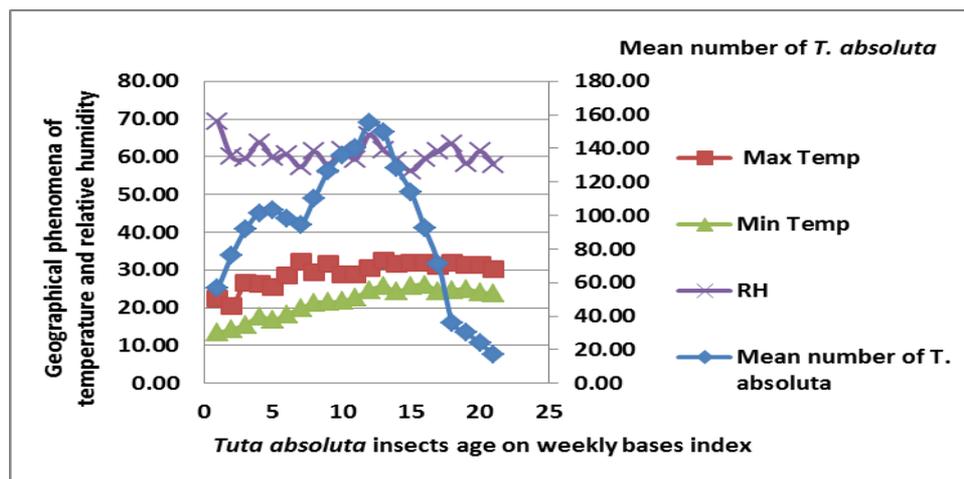


Fig. 1. Relationship between the different weather factors (Temperature and Humidity) and *Tuta absoluta* infestation level though plant age on tomato traps during 2017 season

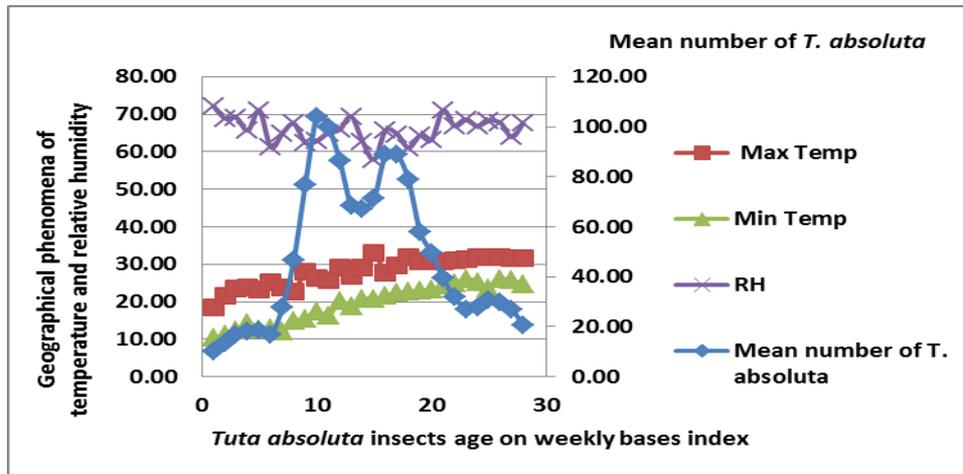


Fig. 2. Relationship between the different weather factors (Temperature and Humidity) and *Tuta absoluta* infestation level though plant age on tomato traps during 2018 season

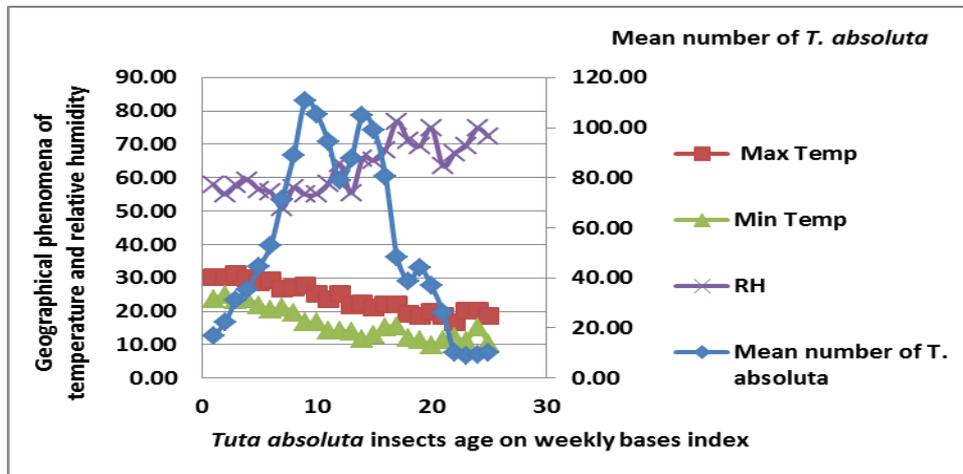


Fig. 3. Relationship between the different weather factors (Temperature and Humidity) and *Tuta absoluta* infestation level though plant age on potato traps during 2017 season

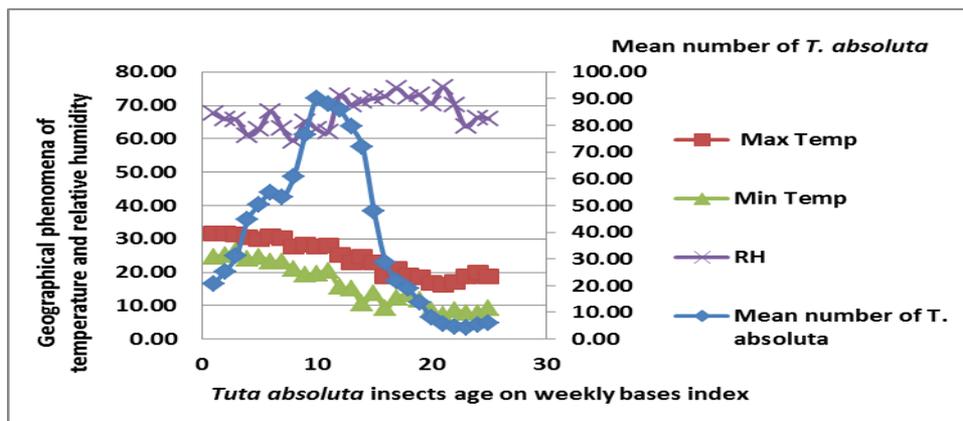


Fig. 4. Relationship between the different weather factors (Temperature and Humidity) and *Tuta absoluta* infestation level though plant age on potato traps during 2018season

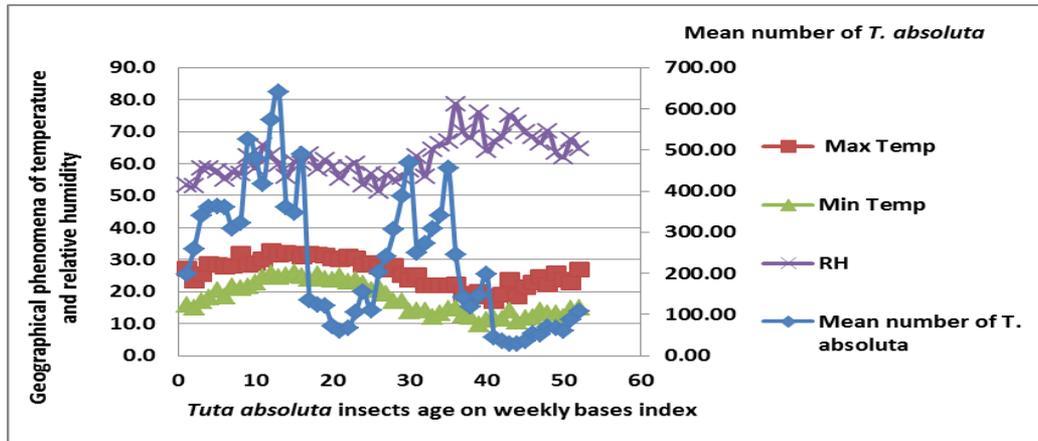


Fig. 5. Correlation of infestation by *Tuta absoluta* for tomatoes and potatoes during the year 2017

The data showed the seasonal fluctuations of *Tuta absoluta* on potato plants during the second season of 2018; in the sense, which *Tuta absoluta* larvae began to occur during the period elapsed from transplanting until early harvest on tomato plants. The first appearance was 20.67 male / 3 traps on the 1st week. One peak was noticed on the 6th week, 2018 with a mean number of 55.03 male / 3 traps, where it was the lowest peak. The second peak occurred on the 10th week with a highest number of 90.13 male / 3 traps. This means that in the second season, *Tuta absoluta* had two population peaks. (Fig. 4)

The above demonstrated results were in agreement with those mentioned by earlier investigators for example; Nunez *et al.* (2009) used sex pheromones successfully to control *T. absoluta*. The goal of his study was to evaluate the effect of sex pheromones on male behavior in greenhouse conditions. The first step was to determine the durability of male attraction to rubber septa dispensers loaded with 0.2 mg of the pheromone, which according to our results can be estimated to last for at least 105 days. Then, the effect of sex pheromones on male behavior was evaluated. Male captures in traps baited either with pheromone septa or virgin females were used as indicators for the efficacy of the treatments. Two dispenser densities (16.000 and 32.000 per hectare), with and without a sticky surface as a mortality factor, were evaluated. The sticky surface did not improved effectively. Finally, 3.200 dispensers were located in a 1000 m² commercial greenhouse, resulting in a strong reduction of male captures with respect to an untreated greenhouse that served as control and reduction of trap captures were more than 96% for the first 78 days after dispenser

installation, falling to 92% at 106 days. These results showed that sex pheromone of *T. absoluta* affects male behavior and could be an important tool to control this pest. Hrnčić and Radonjic (2011) detected the arrival *T. absoluta* by setting up pheromone traps in greenhouses, at four locations. The first captured moths were found in the middle of July in one locality at the coast. In the period from the last week of July to the first week of August, large galleries in tomato leaves, green and ripe fruits were detected at all four monitored locations, as well as at some other sites. The same symptoms as those on tomato were detected on leaves of *Solanum nigrum*, which as a weed, is usually present around and inside greenhouses. In Egypt Mahmoud *et al.*, (2015) found that, *T. absoluta* had four peaks during winter season; the first peak occurred in the 4th week of Jan., the second occurred in the 3rd week of February, the third was in 3rd week of March, while the fourth occurred in the 1st week of April. In summer plantations, four peaks of *T. absoluta* were recorded the first peak was in 2nd week of July, the second was in 1st week of August, the third and fourth were in the 1st and the 4th week of Sept., respectively.

Generation number of the tomato leafminer, *Tuta absoluta* Meyrick on tomato and potato

The tomato leafminer, *Tuta absoluta* Meyrick had 10 generations in both season of 2017 and 2018, and the longest period for a generation occurred in the first generation in January while the shortest generation was the fifth generation during May 2017 and sixth, seventh and eighth generations during June, July and August 2018. (Tables, 3 and 4)

Table 3. Generation number of *Tuta absoluta* Meyrick during 2017 season

Generation	Start	End	Duration in days	Accumulated heat units
1 st	1/1/2017	3/17/2017	75	461.95
2 nd	3/18/2017	4/29/2017	42	461.88
3 rd	4/30/2017	5/30/2017	30	469.22
4 th	5/31/2017	6/27/2017	27	475.67
5 th	6/28/2017	7/19/2017	21	472.39
6 th	7/20/2017	8/11/2017	22	464.61
7 th	8/12/2017	9/4/2017	23	473.56
8 th	9/5/2017	9/29/2017	24	470.83
9 th	9/30/2017	10/28/2017	28	460.22
10 th	10/29/2017	12/11/2017	43	464.11
11 th	12/12/2017	not completed		

Table 4. Generation number of *Tuta absoluta* Meyrick during 2018 season

Generation	Start	End	Duration in days	Accumulated heat units
1 st	1/1/2018	3/2/2018	60	467.30
2 nd	3/3/2018	4/13/2018	41	460.39
3 rd	4/14/2018	5/15/2018	31	465.94
4 th	5/16/2018	6/10/2018	25	463.11
5 th	6/11/2018	7/5/2018	24	471.39
6 th	7/6/2018	7/28/2018	22	469.89
7 th	7/29/2018	8/20/2018	22	474.06
8 th	8/21/2018	9/12/2018	22	469.06
9 th	9/13/2018	10/7/2018	24	471.94
10 th	10/8/2018	11/5/2018	28	465.50
11 th	11/6/2018	not completed		

CONCLUSIONS

It could be concluded that application of using sex pheromone traps to find out the population fluctuations for *Tuta absoluta* on tomato and potato plants to find out the appropriate time to use chemical control. Also, using the recommended pesticides from time of begin transplants up to time of begin harvest against *Tuta absoluta* on tomato and potato plants to give on optimizing tomato and potato yield and decrease costs and environmental pollution.

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الملخص العربي

إستراتيجية مكافحة المتكاملة للآفات لصانعة أنفاق أوراق الطماطم على البطاطس

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كما تم تسجيل عدد 10 أجيال في السنة وأطول مدة جيل كانت في شهر يناير خلال العامين وأقصر مدة جيل كانت في مايو خلال عام 2017 بينما الأجيال السادس والسابع والثامن أقصر الأجيال خلال عام 2018. كما أعطى نموذج مبيدات الآفات الرابع والمكون من Emamectin benzoate ثم Chlorantraniliprole ثم Flubendiamide ثم Chlorfenapyr أعلى نسبة إنخفاض للتوتا في الموسم الأول 2017 بينما أعطى نموذج مبيدات الآفات الثالث والمكون من Emamectin benzoate ثم Chlorantraniliprole ثم Flubendiamide أعلى نسبة إنخفاض للتوتا في الموسم الثاني 2018.

تهدف الإدارة المتكاملة لمكافحة الآفات إلى الحد من استخدام المبيدات الحشرية لصانعة أنفاق أوراق الطماطم التي تصيب الطماطم والبطاطاس في منطقة أبو حمص خلال الموسمين 2017 و2018. تم وضع 3 مصائد فرمونية لجذب الذكور. بدأ الرصد عندما كان عمر النبات 40 يوم وتم إجراء الفحص أسبوعياً حتى نهاية الموسم وتسجيل عدد الذكور الذين تم اصطيادهم وتم دراسة العلاقة بين الظواهر الجوية (درجة الحرارة - الرطوبة النسبية) ونسبة الإصابة بالتوتا أبسليوتا.

أوضحت النتائج أنه كلما زاد عمر النبات كلما زاد تواجد الحشرة وازداد عدد الذكور المنجذبة في المصائد الجنسية ومن ناحية أخرى كانت النسبة المئوية للإصابة بصانعة الأنفاق عالية في الطماطم مقارنة بالبطاطس.