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Heat accumulations and sex pheromone traps as a tools for predicting the cotton leaf worm *Spodoptera littoralis* (Boisd.) (Lepidoptera: Noctuidae) field generations at Assiut Governorate

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Abstract

This study was conducted at the open field in, Abnob, Assiut Governorate - Upper Egypt under field conditions during the two cotton seasons of 2017and 2018.The results indicated that the population of the cotton leafworm *Spodoptera littoralis* (Boisd.) moths in cotton plant by observing and recording moths in sex pheromone traps every three days. *Spodopteralittoralis*had seven peaks starting from the 1stweek of May until the 3rdweek of October during the two studied seasons. The highest number of average moths was recorded insex pheromone traps during the end of July which being 66.0 and 63.0moth /trap/ 3 night in both seasons, respectively. It was noted the predicted peaks of generations could be detected when the accumulated thermal units recorded 525.42 DD's.As recorded the peaks for the detected seven generations varied from -3 to +3 days from the observed peaks. For better prediction of the *S. littoralis* the period between the observed and expected peaks should be positive at least one or two days when early preparation of control materials are of great important, consequently, it is necessary to design an program for controlling this pest renewed annually depends on climate changes an addition to the use of insecticide program for better prediction and controlling of the cotton leafworm *Spodoptera littoralis.*

Keywords

Spodoptera littoralis, cotton leaf worm

INTRODUCTION

The Egyptian cotton leafworm *Spodoptera littoralis* (Boisd.) is a polyphagous insect. Approximately112 plant species belonging to 44 families are reported as hosts of this pest in tropical and temperate zones of the old world (Magd El-din and El-Gengaihi, 2000) or 73 species recorded from Egypt. In Egypt, this destructive phytophagouslepidopterous pest attacks cotton and various vegetable and field crops all over the year. When large numbers of the pest are present complete crop loss is possible (Basiouny*et al.*, 2016).Sex pheromone traps were found to be more effective than the high- pressure mercury lamp (Rizk, *et al*, 1990). Climate change is a major concern for agriculture globally. Dynamic climatic parameters including increased temperature and carbon dioxide have greatly affected crop production. As a consequence of climatic uncertainties, new insect pests have emerged, the crop cultivation practices have changed, and drought and floods have created havoc around the globe. Besides, plant and insecticidal resistance against insects and diseases has got compromised, the diversity and abundance of arthropods has changed, geographical ranges of insect pests have extended far beyond their existing limits and new biotypes have evolved. All these have led to the reduced efficacy of crop protection technologies, huge crop losses, thereby, food insecurity. Although concerted efforts have been made and simulation models have been developed to mitigate the climate change effects on plants, still, most simulation models fail to account for losses due to pests, weeds and diseases. In addition, the monitoring data of insect pests are not available in most of the developing countries and the software models developed for prediction analysis are not effective against insect- pests. This review highlights the possible impacts of climate change on phytophagous insects, chemical ecology, and plant pest interactions leading to food insecurity and the strategies (Abdul Rashid, *et al*., 2016). The fourth assessment report of Inter India Governmental panel on climate change (IPCC 2007) observed that the annual average temperature of the earth is likely to increase by 1°C by 2025 and by 3°C towards the end of the century (Srinivasa, *et al*., 2014). In Egypt, it is necessary to design an program for controlling this pest renewed annually depends on climate changes an addition to the use of insecticide program for better prediction and controlling of the cotton leafworm is considered the most effective method to control such this pest, so, it is becoming very important to find out and develop a program associated to the use of insecticides for human health safety and / or better agro ecosystem. This approach makes possible the aid in the development of powerful tools for analyzing eruptive insect population Behavior and response to changing climatic conditions integrated pest management program involves (J Régnière *et al*., 2012). The system to suppress the pest population which depends on predicting the seasonal population cycles insects; this led to the formulation of many mathematical methods (Richmond, *et al*., 1983), which described the developmental rates as function of temperature (Wagner *et al.*, 1984). Predicting and monitoring population systems for lepidopterist insect pests by using light or pheromone traps based on heat-requirements were reported by Potter *et al*., 1981, Sing *et a*l., 2004, Dahi, 2007, Amer *et al*., 2009, El-Sayed *et al*., 2009 and El-Mezayyen and Ragab, 2014.The aim of this investigation is study the seasonal fluctuations of *S. littoralis* moths by using sex pheromone traps and predicting possibility of *S. littoralis* generations in cotton fields in relation to calculated accumulated heat units.

MATERIALS AND METHODS

This study conducted during two successive cotton growing seasons, 2017 and 2018 at the Abnob district, Assiut Governorate - Upper Egypt region. The sex pheromone traps were fixed in the cotton fields (three feddans of cotton at the rate of one trap per feddan) on wooden stands. The wooden stand designed with four sides, height of 2 meters, width of 25 cm, and length of 40 cm, divided into ladders, each 20 cm long, with a movable wooden shelf on which the pheromone trap is placed, to ensure the stability of the trap against air currents. And placed above the cotton canopy with a distance of about 20 cm high and was kept in the level till the end of the season (Flint and Merkle, 1983 and Dhawan andSidhu, 1988).

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The synthetic sex pheromone capsules were obtained by cotton leaf worm Research Department, Plant Protection Research Institute, Dokki, Giza, Egypt for used for computing the degree- days (DD's) and fluctuation temperatures. The results were calculated by formula according to Richmond *et al*. (1983).

$$H=\Sigma Hj$$

Where:

H = Number of heat units to emergence

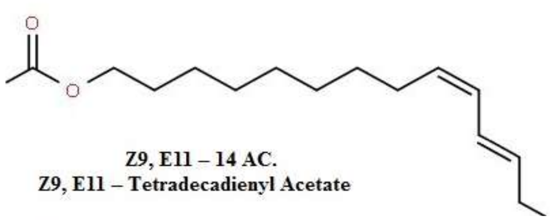
Hj = (max. +min.)/2-C,.&min.>C.

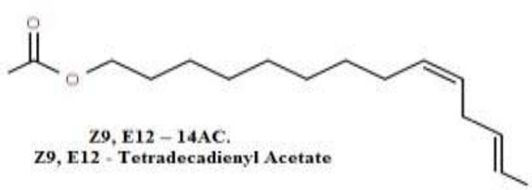
Hj = (max-C)/2(max. - min.), if max.>C & min. <C.

Hj = 0, if max. <C & min. <C.

C = Temperature threshold (t0).

The traps were baited with a vial loading 1 gm. A.I. of specific pheromone for each trap. The chemical structure of cotton leaf worm pheromone according to (Nesbitt *et al*., 1973) as follows:





Cotton leafworm stretcher pheromone according to (Nesbitt *et al*., 1973)

The sex pheromone vial was hooked in trapcap above the surface with about 5 -7 cm. soaped water (catching solution) (Sokar, 1988). The cotton plants area was 3 feddans in the first and second seasons, the daily catch of the cotton leafworm males were collected, counted, identified and recorded. The number of the captured moths was accumulated for three days during both seasons and was presented graphically to determine the population peaks in the successive generations in relation to the accumulated thermal units in degree days.

To study the prediction possibility in relation to heat accumulations, the temperature was could be transformed into heat units and serves as a tool for measuring insect population dynamics and predicting the appearance of the cotton leafworm in the field during the aforementioned two successive seasons. Each season extended from early May to the third week of October.

Daily Maximum and minimum temperatures were obtained and recorded by www.timeanddate.com

Degree –days (DD's) were calculated from the daily maximum and minimum temperature (ºC) with developmental threshold (t_0) which has been estimated in the laboratory under constant conditions, where the zero development (t_0) value was 10.14 ºC with 523.27 DD's for *S. littoralis* generation development used after (Dahi, 1997).

RESULTS AND DISCUSSION

1- Seasonal fluctuations (flight activity) of *Spodoptera littoralis* moths on cotton plants.

The results presented in Figures (1 and 2) indicate that *S. littoralis* moths during the two studied seasons showed seven peaks for each. These peaks occurred from the 1st week of May until the 3rd week of October. The first peak was occurred on 7th and 4th May for 2017 and 2018, respectively. The corresponding moths were 27.0 and 36.0as average moth /trap/ three days during 2017 and 2018 cotton season, respectively, then population fluctuated and increased to reach the second peak on 6th and 3rd June where the captured moths were recorded 42.0 and 51.0as average moth /trap/ three days during the first and second season 2017 and 2018, respectively. The 3th peak was occurred on 30th June for both 2017 and 2018, where the trapped moth's average was 51.0

and 57.0 moth /trap/ three days in the two tested seasons, respectively. The 4th peak occurred on July 27th for both 2017 and 2018 cotton seasons, while, the trapped moths were recorded 66.0and 63.0moth / trap/ three days during the two tested seasons, respectively. The 5th peak was recorded on August23th and 20th for two tested seasons, wherethetrappedmothsaverage54.0and57.0moth /trap/ three days in the two tested seasons 2017 and 2018, respectively. The 6th peak was occurred on 22th and 13th of September at the two tested seasons, where the trapped moths were 45.0and 42.0 average moth /trap/ three days for both seasons2017 and 2018, respectively. The 7th peak recorded on 22nd and 16th October, while the captured moths reached to 24.0 and 33.0 moth /trap/ three days during the two seasons of 2017 and 2018, respectively.

It could be noticed that the 3th peak during the two seasons of 2017 and 2018 had highest number of moths (66.0 and 63.0 average month /trap) than the other six peaks in the first and second seasons, respectively, during the season of 2017 and 2018.

These results are in agreement with those obtained by Abdel – Fattah *et al*. (1987) who indicated that form other broods of *S. littoralis* of variable sizes could be detected with their peaks that occurred late in May and June, in mid – August and late in September. In Kafr El- Sheikh, Egypt, El-Mezayyen *et al*. (1997) recorded three adult population peaks of *S. littoralis* in May, August and November in the first season and it occurred in April, July and November in the second one. In addition, Dahi (1997) recorded seven main peaks of *S. littoralis* from May until September with only four minor peaks in Menofia Region at the same trend; Robert *et al*. (2019) indicated that pheromone trap is an important tool for monitoring *Spodoptera frugiperda* in the USA.

2- The Prediction of *S. littoralis* field generations and in relation to accumulated heat units.

Data in Table (1) and figures (1 and 2) showed that the observed peak of overwintering generation was occurred on 7th and 4th May in 2017 and 2018 seasons, respectively. On the other hand, the expected peak for the same generation was observed on 7th and 4nd May at 521.82 and 523.66 DD's during the two seasons of 2017 and 2018, respectively with deviation interval 0.0 than there a l peak for both 2017 and 2018 seasons.

There a l peak of the second generation was occurred on the 6th and 3rd June in the first and second season (2017 and 2018), while the expected dates of this generation were observed on the 4th and 1st June with an average of 523.58 and 526.72 DD's during 2017 and 2018, seasons respectively. The deviations between the observed and expected peaks were +2 and +2 days earlier for the two seasons, respectively.

The observed and expected peaks of the third generation were occurred on30th June during the two seasons of 2017 and 2018, respectively, when the accumulated heat requirements completed 530.36 Occurred on 2 July and 533 DD's during both seasons, respectively. The deviation between the observed and expected peaks was -2 later and +2 days earlier for 2017 and 2018, respectively. The actual observed peak of the fourth generation appeared on 27th July for both seasons. The expected dates of this generation occurred on the 26th and 25th July in the first and second seasons with deviation intervals of +1 and +2 dayswhentheaccumulateddegreedayswere527.14and 527.5 DD's in 2017 and 2018, respectively. The observed 5th generation was occurred on 23th and 20th August in 2017 and 2018 seasons, respectively. On the other hand, the expected peak for the same generation was observed on 21th and 22th August at 541.5 and 528.86 DD's during the two seasons of 2017 and 2018, respectively, with deviation interval +2 earlier and -2 later than the real peak for both 2017and2018seasons. There real peak of the 6th generation was occurred on the 22th and 13th September in the first and second season while the expected dates of this generation were observed on the 20th and 16th September with an 526.58 and 525.72 DD's during 2017 and 2018, seasons respectively. The deviations between the observed and expected peaks were +2 earlier and -3 later days for the two seasons, respectively. The observed and expected peaks of the 7th generation were occurred on 22nd and 16th October during the two seasons of 2017 and 2018, respectively when the accumulated heat requirements completed 529.38 and 523 DD's Occurred on 25th and 13th October during both seasons, respectively with a deviation intervals of -3 and +3 days.

Fig.(1): Predicted dates of annual generation of *S. littoralis* attributed to accumulating degree-days and sex pheromone trap catches during 2017 .

Fig. (2): Predicted dates of annual generation of *S.littoralis* attributed to accumulating degree-days and sex pheromone trap catches during 2018.

Table (1): observed and predicted dates of *S.littoralis* field generations depending on sex pheromone catches and accumulated degree-days during 2017 and 2018 cotton seasons at Assiut Governorate.

Seasons	Generation	Generation dates		Deviation (days)	Accumulated degree-days
		Observed	Expected		
2017	1st	7/5	7/5	0	521.80
	2nd	6/6	4/6	+2	523.68
	3rd	30/6	2/7	-2	530.36
	4th	27/7	26/7	+1	527.64
	5th	23/8	21/8	+2	514.50
	6th	22/9	20/9	+2	526.68
	7th	22/10	25/10	-3	529.38
	Average			+2	524.86
2018	1st	4/5	4/5	0	523.66
	2nd	3/6	1/6	+2	526.72
	3rd	30/6	28/6	+2	533.00
	4th	27/7	25/7	+2	527.50
	5th	20/8	22/8	-2	528.86
	6th	13/9	16/9	-3	525.72
	7th	16/10	13/10	+3	523.72
	Average			+4	527.02

Can be concluded that the highest number of moths was appeared on 27thJuly (66 average moth/trap) during the season of 2017while during the season of 2018, the highest peak was occurred on 21thJune (366.3 moth/trap) during the first generation. In addition, it could be noticed that the strength of the *S. littoralis* population appeared during the two studied seasons depended mainly on the number of male moths occurred during May and early June where the males occurred during that period emerged from the brood reared on clovers and other host plants during winter. If the occurrence of the male moths was high during May, the insect population should be high during the main successive occurrence and viceversa. These results are in agreement with those obtained by Taman (1990) mentioned that the maximum and minimum daily temperatures were responsible for 23% and 30% of the *S. littoralis* population density. Dahi (1997) recorded overwintering generation during May on clovers and there main overlapping generations during June, July and August during the three tested seasons in cotton fields. The same author found that the average of thermal units of these generations was 523.27. DD's. At the same trend, temperature is an influencing factor affecting the insect life and activity. This factor may be utilized to gain some insight into the size and behavior of field population and consequently into the history and ultimately prediction of future generation (Ragab, 2009; Amer *et al*., 2009; Dahi, 2007 and El-Mezayyen and Ragab, 2014). Similarly,Duraimrugan and Alivelu (2018)used pheromone trap for determining action threshold of *S. litura*based on number of moths catches. They concluded that pheromone trap based on action threshold identified can be used to forecast the seasonal status of *S. litura*. These results agree with those obtained by Abdel-Badie (1977) and Mohamed (1977) on *S.littoralis*: Clement *et al.*, 1979 on *A.ipsilon*; Potter *et al.*, 1981 on *H. virescens*and Moftah *et al.*, 1988 on *P. gossypiells*.

Also, El-Shafei (1980) by using the light trap, stated that *S. littoralis* had seven annual overlapping generations started by mid-March to the early of November in addition to the 7 generation which started by the second half of January of next year.

Last but not least, it could be concluded that the prediction of the cotton leafworm *S.littoralis* field activities is based on to, thermal units under constant temperature, T_{max}, T_{min}. And catched moths by traps.

CONCLUSION

We conclude from the presented study that in order to better predict the cotton leaf worm population, must to be flowing the climate changes , especially the daily temperature, where we can calculated accumulated heat units ,where it should be the difference between the observed and expected peaks positive at least one or two days when the early preparation of control materials of great importance, therefore, it is necessary to design a program to combat this pest that is renewed annually and depends on climate change in addition to using the insecticide program to better predict the controlling of the cotton leaf worm.

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الملخص العربى

التركم الحراري والمصائد الجاذبة الجنسية كأدوات للتنبؤ بالاجيال الحقلية لدودة ورق القطن بمحافظة اسيوط

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أجريت هذه الدراسة تحت الظروف الحقلية لمركز أبنوب بمحافظة أسيوط -فى صعيد مصر وذالك خلال موسمي 2017 و 2018 ، واستهدفت الدراسة تعداد ذكور دودة ورق القطن على نبات القطن حيث تم تسجيل النتائج من المصائد الجنسية الفرمونية كل ثلاث أيام وأوضحت النتائج وجود سبع قمم لدودة ورق القطن تبدأ من الأسبوع الأول من مايو حتى الأسبوع الثالث من أكتوبر وذالك خلال الموسمين محل الدراسة. أظهرت النتائج أن أعلى متوسط للذكور في المصائد الجنسية الفرمونية خلال نهاية شهر يوليو حيث بلغ 66 و 63 ذكرلكل ثلاث ليالى في الموسمين ، على التوالي . كما لوحظ أن القمم المتوقعة للاجيال عندما سجلت الوحدات الحرارية المتراكمة اليومية واللتى بلغت 525.42 وحدة حرارية يومية .كما تم تسجيل قمم لسبعة أجيال واللتى تراوحت من -3 إلى +3 أيام من القمم المرصودة. وجائت التوقعات أيجابية بالنسبة للقمم المتوقعة على الاقل فى يوم واحد أو يومين مما يتيح فترة مبكرة مناسبة لتحضير ادوات ومواد المكافحة . من الضرورى تصميم برنامج لمكافحة دودة ورق القطن يجدد سنويا يعتمد على التغيرات المناخية بالاضافة الى استخدام برنامج المبيدات الحشرية للتنبؤ بشكل أفضل ومكافحة دودة ورق القطن.