REMOTE SENSING TECHNOLOGIES AS A TOOL FOR COTTON LEAFWORM, *SPODOPTERA LITTORALIS* (BOISD.): PREDICTION OF ANNUAL GENERATIONS

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The study was carried out at Menia Governorate during 2014/2015 sugar beet season under field conditions. The temperature is an important environmental factor that has an effect on the rate of development, survival and in any other biological and ecological aspects for the cotton leafworm, *Spodoptera littoralis* (Boisd.). Seasonal abundance of the insect population and prediction of field generation throw a light on the temperature influence on insect development in the field. The data obtained in this work showed that the cotton leafworm, *S. littoralis* had four generations on sugar beet during the period from September 1st to March 1st. The predicted peaks of generations could be detected when the accumulated thermal units reach 524.27 degree days (dd's). The predicted peaks for the four generations detected earlier or later +3 to -2 days than the observed peaks. The expected peaks and the corresponding expected generations for cotton leafworm could be helpful to design the IPM control program.

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INTRODUCTION

Sugar beet, *Beta vulgaris* L. is considered as one of the two main sugar crops in Egypt. Under Egyptian ecosystem, sugar beet is affected by numerous insect pests during its different growth stages.[1]

The crop damage caused by the pest is well known. The major advantages of remote sensing are timely estimates of agriculture crop yield and prediction of pest infestation. In this study, an attempt has been made to investigate the utilization and potential application of microwave remote sensing for detection of annual generation of the pest within sugar beet field.

Various techniques are being used to study ecological parameters and gathering data for agricultural benefits. Reduction in losses caused by pests by timely and effective control measures will considerably add to economic growth in the country. The incidence of pests and diseases and there intensities are dependent on certain predisposing weather conditions. The meteorological data are being used in some countries for forecasting the outbreaks of pests and diseases.[2] The correlation between environmental factors and the rate of development of pests form the basis of such forecast.

Early detection of pest infestation via remote sensing will (i) reduce cost of foot scouting, (ii) limit environmental hazards, and (iii) improve precision farming techniques by allowing local pest control before the problem spreads. Remote sensing technologies can provide quicker responses than customary manual scouting methods for determining the presence of pests.[3,4]

During cotton-growing season, chemical control still one of the major tool to control bollworms but it is becoming increasingly important to design and develop an alternative program to assure man and/ or environment safety.

Pest management system depends on predicting the seasonal population cycles of insects. This has led to the formulation of many mathematical methods[5,6] that described developmental rates as a function of temperature.[7] Taman[8] reported pheromone traps as useful ecological tool for monitoring cotton insect pests and early prediction of their successive generations.

Many studies have been carried out for forecasting and monitoring population systems on the basis of the seasonal fluctuations and annual generations of the pink bollworm according to the number of males attracted and captured by the pheromone baited traps and the heat units required completing each generation.[9-16]

MATERIAL AND METHODS

As the first process to observe the prediction possibility in relation to heat units accumulations, the temperature data was transformed into heat units and was used as a tool for studying insect population dynamics and predicting the appearance of cotton leafworm in the field during season 2014-2015 at Menia Governorate. Each season extended from early March (after emergence from its diapause) to early December (before next diapause).

As a previous work indicated that, there was no significant difference between degree days obtained from daily maximum and minimum air temperatures derived from satellite images and thermograph and daily maximum and minimum air temperature that derived from satellite images appeared to be the best way for predicting and calculation of the average of thermal units in degree-days (dd's) required for the completion of development of *S. littoralis* generations.[17] So, the numerical weather results (daily maximum and minimum air temperatures derived from satellite images) were obtained and recorded from the Mesoscale model which was processed at NARSS Modelling Simulation and Visualization Lab and corporate data from NOAA satellite images.[18-20] Degree-days (dd's) were calculated from the daily maximum and minimum temperatures (°C) with developmental threshold (t_0), which has been estimated in the laboratory under constant conditions, [16] where the zero development (t_0) was 9.89°C with 524.27 dd's for generation development. The following formula[6] was used for computing the degree-days (dd's) according to under fluctuation temperatures.

$$H = \Sigma HJ \qquad (1)$$

where

H = number of heat units to emergence;

C= threshold temperature

$HJ = [(\text{max.} + \text{min.})/2]-C$, if max.>$C$ and min.>C.

$HJ = (\text{max.}- C)2/(\text{max.}-\text{min.})$, if max.>C and min<$C$.

HJ= 0 if max.< C and min.< C;

The present study was conducted at the study was conducted at Abou Korkas, Menia Governorate, Egypt. The monitoring by pheromone trap was carried out using the reported sex pheromone traps (sticky trap).[21] The traps were baited with the synthetic pheromone formulation in polyethylene vials. Every vial is containing one of the active ingredients of the specific pheromone for pink bollworm.

The traps were fixed in the fields on a steel stands and placed above the cotton plants canopy with a distance of about 20 cm high and were kept in the same level till the end of the season.[22,23]

The card boards of the Delta traps were changed weekly and replaced by new ones. The pheromone vials were replaced by new ones for both traps every two weeks. The catch of the captured males of *S. littoralis* were collected, counted, recorded identified and removed out of the sticky board every 3 days. Daily mean number of male moth of pink bollworm per trap was accumulated for three days for the season (2014 and 2015) was represented graphically to determine the population peaks (the real peaks were considered in case of a significant correlation between the accumulated degree days and moth activity) in the successive generations in relation to the accumulated degree-days.

RESULTS AND DISCUSSION

As shown in Table 1 and Figure 1, the observed and expected peaks of generation occurred at 21st and 15th of May when the average of male moths/trap/3 days reached 17.8 and 2.8 moths for 2014 and 2015, respectively.

For the first generation, the observed peak occurred on 1st of October when the average male moths reached to 12.6 male moths/trap/3days for 2014/2015 season. On the other hand, the expected peaks for the same generation were September 28th at 530.3 dd's with deviation intervals +3 days earlier than the real peak.

For the second generation, the real peak occurred on October 28th when the average male moths reach 12.3 male/trap/3 nights for 2014/2015 season. The expected date of this generation was October 29th with an average 516.3 dd's. The deviations between observed and expected peaks were -1 day later for this season.

Table 1. Observed and expected *S. littoralis* generations by monitoring sex pheromone traps and accumulated degree-days (dd's) derived from satellite images at Menia during sugar beet season 2014 and 2015.

Generation	Generation dates		Deviation (days)	Accumula-ted degree-days (dd's)
	Obsd.	Expd.		
1st	1/10	28/9	+ 3	530.3
2nd	28/10	29/10	- 1	516.3
3rd	12/12	14/12	- 2	523.1
4th	25/2	22/2	+ 3	525.9
Average			+ 3	523.9

Generation; Obsd. = Observed; Expd. = Expected

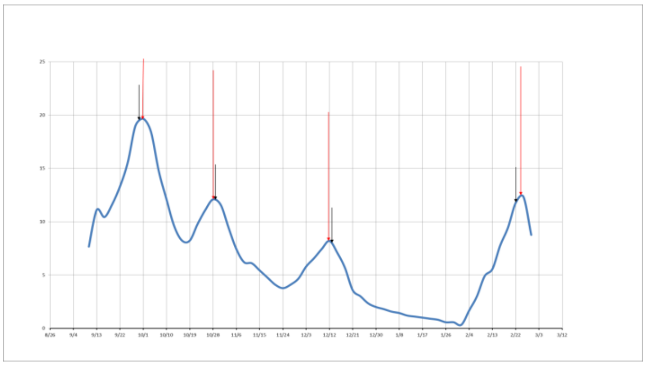

Figure 1. The annual generations of the cotton leafworm *S. littoralis* at Menia during 2014/2015 season.

For the third generation**,** the observed and expected peaks of this generation occurred on December 12th and December 14th respectively, when the accumulated heat requirements completed 523.1 dd's during this seasons, respectively, When the average male moths reach 5.6 male/trap/3 nights. The deviation between observed and expected peaks was -2 day later.

For the fourth generation, the actual observed peak which represented the average number of captured male moths, appeared on February 25th where the average reached 5.1 male/trap/3 nights. The expected date of this generation occurred on February 22th with deviation intervals +3 days earlier than the real peak when the accumulated degree days completed 525.9 dd's.

Generally, it will be better for good prediction to have a positive periods between predicted and actual observed and to be as short as possible to obtain good accuracy of prediction according to dd's population patterns of *S. littoralis* particularly in hot spots of infestation where early preparation of pest control materials are of great importance. This leads to good and perfect control and minimized the costs of control. Also, when both accumulated and calculated (dd's) above threshold of development for generation were confirmed, however, this technique could be considered as one of the most important factor of pest management program.

These results agree with those obtained earlier[24] on *Pectinophora gossypiella*[8] where is mentioned that the maximum and minimum daily temperature were responsible for 23 % and 30 % of the *S .littoralis* population density.

The expected peaks and the corresponding expected generations for pink bollworm could be helpful when IPM control tactics are considered. Finally, it could be concluded that the prediction of the cotton leafworm field activities is based on lower threshold of development (t_0), thermal units (dd's) for complete generation, T_{max}, T_{min}. and catch moths.

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