Using Remote Sensing Technologies and Sex Pheromone Traps for Prediction of the Pink Bollworm, *Pectinophora gossypiella* (Saund.), Annual Field Generations.

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Abstract: The present study was carried out at Qaha Research Station (Plant Protection Research Institute), Qaluobya Governorate, during 2009 and 2010 cotton seasons. Under field condition the number of generations, their peaks and durations were computed through baited sex pheromone traps and accumulated temperature degree days derived from satellite images. The obtained data obtained in this work showed that the pink bollworm, *Pectinophora gossypiella,* had four generations on cotton plants during the period from May 1st to September 30th, in addition to overwintering generation, when the moths emerged during May from diapaused larvae. The predicted peaks of generations could be detected when the accumulated thermal units reached 499.71 degree days (dd's). The males of the suicidal generation reached the real and predicted peaks at the same time (during May for the two investigated seasons). The predicted peaks for the other four generations were detected earlier or later +4 to -3 days than the observed peaks. The expected peaks and the corresponding expected generations for the pink bollworm could be helpful to design the IPM control program.

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1. Introduction

Cotton is one of the major economic crops in Egypt. Most of the losses in yield and quality are caused by insect pests, specially the pink bollworm, *Pectinophora gossypiella,* as it attacks the fruiting part (squares, flowers and green bolls).

The major advantages of remote sensing are timely estimates of agriculture crop yield and prediction of pests. Therefore, in the present study, an attempt has been made to investigate the utilization and potential application of microwave remote sensing for detection of pest annual generation in cotton fields.

In today's world of advanced technology 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 (**Ray, 2001**). The correlation between the 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 food scouting, (ii) limit environmental hazards, and (iii) improve precision farming techniques by allowing local pest control before the problem spreads **(Singh, 2007)**.

Remote-sensing technologies can provide quicker responses than customary manual scouting methods for determining the presence of pests. (**Yang and Anderson, 1996** and **Moran *et al.,* 1997).**

During the cotton-growing season, chemical control is 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.

Integrated pest management program involves a total system to suppression of pest population, which depends on predicting the seasonal population cycles of insects, which has led to the formulation of many mathematical methods (**Clement *et al.*, 1979; Richmond *et al.*, 1983**), which described the developmental rates as a function of temperature **(Wagner *et al.*, 1984).** Also, **Taman (1990)** stated that pheromone traps provide as useful ecological tool for monitoring cotton insect pests and early prediction of their successive generations.

Several workers have reported about sex

pheromone traps and heat requirements for lepidopterous insect pests (**Davidson, 1944; Bierl *et al.*, 1974; Sevacherian *et al.*, 1977; Abdel Meguid and Amin, 1994**; **Khidr *et al.*, 1995; Dahi, 1997**; **Dahi, 2003; Sing *et al.*, 2004, Ismail *et al.*, 2005 and Dahi, 2007).**

In the present study an attempt was 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 for completing each generation**.**

2. Material and Methods

To study the prediction possibility in relation to heat units accumulations, the temperature data was transformed into heat units and served as a tool for studying insect population dynamics and predicting the appearance of pink bollworm in the field during two successive seasons (2009 and 2010) at Qaluobya Governorate. Each season extended from early March (after emergence from its diapause) to early December (before next diapause).

Statistical analysis 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 found that daily max. and min. 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 (**Yones, 2008**).

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 Modeling Simulation and Visualization Lab and corporate data from NOAA satellite images (**Sherif *et al.*, 2005 a, b, c**). 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 (**Yones *et al.*, 2011)**, where the zero development (t_0) was 12.03°C with 499.71 dd's for generation development. The following formula was used for computing the Degree-days (dd's) according to **Richmond *et al.*, (1983)** under fluctuating temperatures:

H = ∑ HJ
Where:
H = number of heat units to emergence;
HJ = [(max. + min.) / 2]-C, if max.>C & min.>C.
= (max. - C) 2 / (max. - min. if max.>C & min<C.
= 0if max. <C & min. <C.
C = threshold temperature.

Monitoring by pheromone traps was carried out using the sex pheromone traps (sticky traps) described by **Romella (1991)**. The traps were baited with the synthetic pheromone formulation in polyethylene vials.

The traps were fixed in the field 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 **(Flint and Merkle, 1983 and Dhawan and Sidhu, 1988)**.

As a frequent routine, the sticky card boards of the traps were changed weekly and replaced by new ones. The pheromone vials were replaced by new ones every two weeks. The daily catch of the captured males of *P. gossypiella* were collected, counted, recorded identified and removed out of the sticky board every 3 days. Daily mean number of male moths of pink bollworm per trap was accumulated for three days for the two seasons (2009 and 2010). This was represented graphically to determine the population peaks in the successive generations in relation to the accumulated degree-days (the real peaks were considered in case of a significant correlation between the accumulated degree days and moth activity).

3. Results and Discussion

As shown in Table (1) and Figs. (1, 2), the observed and expected peaks of suicidal generation occurred on 21st and 15th of May when the average of male moths/trap/3days reached 17.8 and 2.8 moths for 2009 and 2010, respectively.

The first generation: the observed peak occurred on 21st and 14th of June when the average male moths reached 1.5 and 6.1 male moths/trap/3days for 2009 and 2010 seasons, respectively. On the other hand, the expected peaks for the same generation were Jun 17th and 16th at 482.3 and 496.1dd's for 2009 and 2010, respectively with deviation intervals +4 days earlier than the real peak for 2009 season, and -2 days later for 2010 season.

The second generation: the real peak occurred on Jul. 9th and 14th when the average male moths reached 2.9 and 5.7 males/trap/3nights for 2009 and 2010, respectively. The expected dates of this generation were Jul. 12th and 14th with an average of 491.9 and 496.9 dd's for 2009 and 2010, respectively. The deviation between observed and expected peaks was -3 days later for 2009 season but no deviation in 2010 season.

The third generation: the observed and expected peaks of this generation occurred at (Aug.

2nd and Aug. 4th) & (Aug. 13th and Aug. 9th) for 2009 and 2010, respectively, when the accumulated heat requirements completed 597.0 and 503.8 dd's during the two seasons, respectively, When the average male moths reached 4.8 and 7.5 males/trap/3nights for 2009 and 2010. The deviation between observed and expected peaks were -1 day later and +4 days earlier for 2009 and 2010, respectively.

The fourth generation: the actual observed peak which represented the average number of captured male moths, appeared on Aug. 29th and Sep. 3rd, when the average reached 15.5 and 3.0 male/trap/3nights for 2009 and 2010, respectively. The expected dates of this generation occurred on Aug. 27th and Sep 4th with deviation intervals +2 days earlier than the real peak for 2009 season, and -1 day later for 2010 season, when the accumulated degree days completed 487.7 and 502.2 dd's for 2009 and 2010, respectively.

Generally, it will be better for good prediction to have 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 *P. gossypiella* 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 minimize 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 programs.

The expected peaks and the corresponding expected generations of pink bollworm could be helpful when IPM control tactics are considered. Finally, it could be concluded that the prediction of the pink bollworm 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.

Table (1): Comparison of observed and expected *P. gossypiella* generations by monitoring sex pheromone traps and accumulated degree-days (dd's) derived from satellite images at Qaha farm during cotton seasons 2009 and 2010.

Seasons	Generations	Generation dates		Deviation (days)	Accumulated degree-days (dd's)
		Observed	Expected		
2009	Suicidal emergence	21/5	21/5	0	501.7
	1st	21/6	17/6	+ 4	482.3
	2nd	9/7	12/7	- 3	491.9
	3rd	2/8	4/8	- 2	497
	4th	29/8	27/8	+ 2	487.7
	Average			+ 1.0	**492.1**
2010	Suicidal emergence	15/5	15/5	0	498.8
	1st	14/6	16/6	- 2	496.1
	2nd	14/7	14/7	0	496.9
	3rd	13/8	9/8	+ 4	503.8
	4th	3/9	4/9	- 1	502.2
	Average			+ 1.0	**499.6**

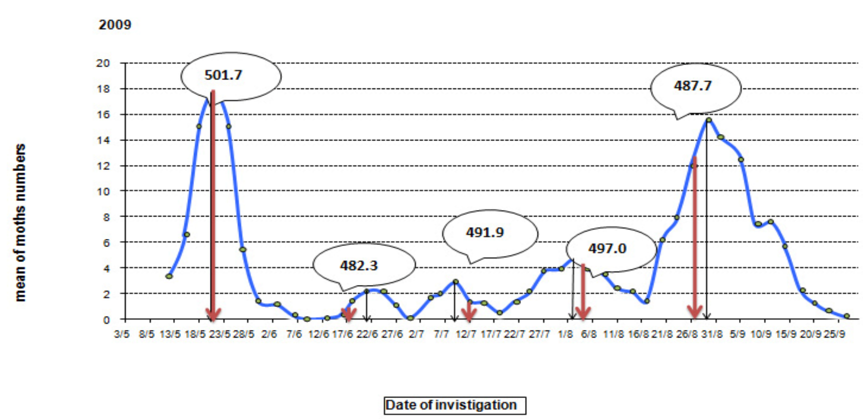

Fig.(1): The annual generations of the pink bollworm *P. gossypiella,* at Qaha farm during 2009 cotton season.

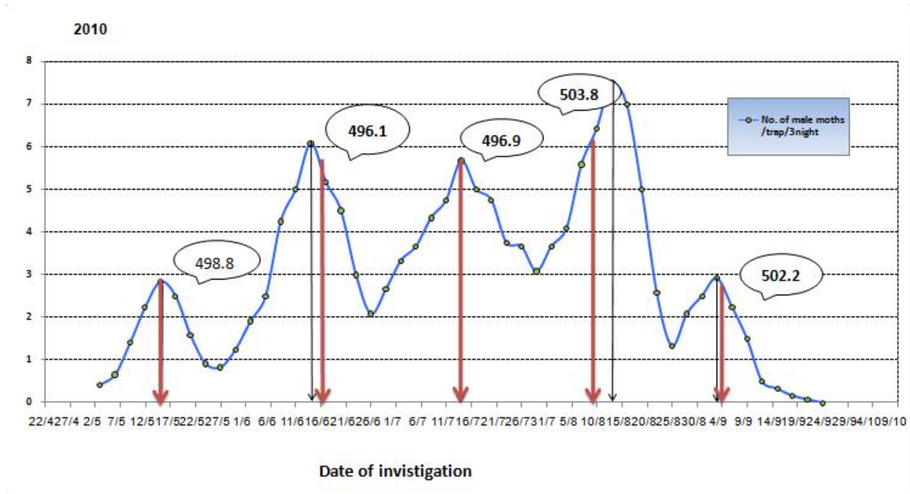

Fig.(2): The annual generations of the pink bollworm *P. gossypiella,* at Qaha farm during 2010 cotton season.

Discussing the foregoing results, it could be seen from the results recorded herein a harmony with those obtained by various authors on different insects e.g. **Tamaki 1980; potter *et al.*, 1981** on *H. virescens*; **Richmond *et al.,* 1983** and **Moftah *et al.,* 1988** on *P. gossypiella*, who stated that the negligible values of the difference between actual and predicted values of thermal units and the corresponding developmental times of this insect generation, which indicate the accurate simulation of the relationship between temperature and development under field conditions. Also, several authors studied the role of environmental factors and the thermal units accumulations (dd's) as a mean for forecasting moth population peaks **(Chu and hennebrry (1992)** on *P. gossypiella***,** **Abdel-Maguid and Amin (1994)** on *P. gossypiella***,** **Korat and Lingappa (1995)** on some bollworm moths (*P. gossypiella, Earias insulana and H. armegira*)**; Al Beltagy (1999)** on *E. insulana*; **Dahi, (2003)** on *E. insulana* and **Dahi, 2007** on the American bollworm *Heliocoverpa armigera*.

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