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Predict Peaks of Emergence and Generation Numbers of the Pink Bollworm, *Pectinophora gossypiella* Using the Interaction of Accumulation Heat Units with Plant Phenology

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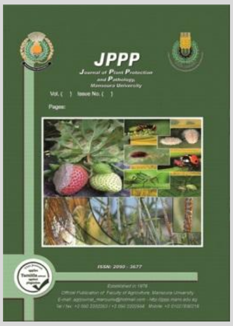

ABSTRACT

This work was carried out to conduct studies using degree days and plant phenological interaction to predict peaks of the emergence and generations of the pink bollworm, *Pectinophora gossypiella* (Saunders), during cotton growing seasons of 2021, 2022, 2023, and 2024. The coefficient of variation values ranged between 3.17, 4.4%, and 0.9, 4.3%, respectively. The lowest value was from April 18th, 3.1%, and from January 1st, 0.9%, respectively. The abundance of receptors, which is the presence of sufficient numbers of sensitive squares for pink bollworm larvae, which is related to the peak of male F_1 moths captured. This occurs when the plant has fruiting branches with an average number of 9.9±1.0 and 17.2±2.7 squares per plant. The average heat units and days for the four seasons from sowing date were calculated at 1140.3±7.9 units and 88.8±5.6 days with a coefficient of variation of 0.7 and 6.3%, respectively. The thermal units ranged between 523.8±4.5, 527.5±0.6 units, and 0.6, 1.8%, respectively. For days, they ranged between 33.3±1.9, 35.8±4.3 days, and 5.7, 11.9%, respectively, for the four seasons. These results indicate that thermal units, days, and the interaction with plant phenology can help detect periods of high risk for the pink bollworm moth's activity and can be used to manage this pest throughout the cotton crop season.

Keywords: Pink bollworm; Phenological interaction; Heat units; cotton crop

INTRODUCTION

In order to forecast growth events in plants, insects, and other cold-blooded creatures, physiological models that rely on thermal units are now employed (Arnold, 1959; Higley *et al.*, 1986). Time scales are usually less precise than temperature scales when predicting events. Developing a model involves identifying an event of interest, such as the appearance of the first bud, flower and fruit on a plant or eggs, larvae, and adult of an insect. Furthermore, during the duration of the event, it is necessary to establish lower and upper temperature thresholds as well as the total number of degree days that fall between them (Campbell *et al.*, 1974; Stinner *et al.*, 1974). *Pectinophora gossypiella* (Saunders), often known as the pink bollworm is a severe pest of cotton, *Gossypium hirsutum*, and *G. barbadense* that results in significant financial losses. Researchers have not tried to agree upon a low growth threshold value; instead, a number of mathematical models of daily temperature units have been put out to explain the development of this pest. According to (Watson *et al.*, 1973), in growth chamber experiments, 13.9°C was found to be below the threshold, whereas 15.6°C was determined to be appropriate for larval development under wet conditions but not under dry conditions. Pink bollworm development was modeled by (Gutierrez *et al.*, 1977) using a sine wave with a low threshold of 10°C and no upper threshold. The triangle approach was applied with a minimum temperature of 15°C and no higher limit by (Sevacherian and El Zik, 1983; Sevacherian *et al.*, 1977). Applying Sevacherian techniques, (Dhaliwal *et al.*, 1991) determined that a greater temperature threshold was required in order to more precisely anticipate moth emergence peaks. The cumulative percentage of the ascent curve is visually described in terms of degrees of cumulative days, calculated using 13.0/30.0°C lower/higher, respectively, based on the pink bollworm emergence data of (Huber *et al.*, 1979; Wene *et al.*, 1965). Lower/upper thresholds of 13.0/30.0°C were found to be beneficial in characterizing the physiological time of the pink bollworm generations based on the laboratory data obtained by (Butler and Henneberry, 1976) for eggs, larvae, and pupa. The lower and higher temperature limits were determined to be 12.0 and 32°C by (Hutchison *et al.*, 1986). The optimal conditions for egg and larval development, as well as adult stage, identified within the temperature range of 30 to 35°C. Variations from this range led to reduced egg hatchability and increased larval mortality. Thermal stress had a persistent effect on the F_1 generation, significantly affecting immature stages egg and larvae. These findings offer valuable insights for predicting the population dynamics of *P. gossypiella* at the field level and developing climate-resilient management strategies in cotton (Iqbal et al., 2024; Nagaraju *et al.*, 2024). Variation in weather due to current climatic conditions with decreases of temperature increase *P. gossypiella* infestation on cotton crop. In this investigation, the effects of a severe outbreak of pink bollworm infections (Hussain *et al.*, 2023). Therefore, exploring the relationship between insects, pests and climate variables is important for producing environmentally based forecasting models and may lead to improved long-term pest forecasting (Peddu *et al.*, 2020; Xiao *et al.*, 2019). Studies conducted in laboratories at constant temperature were used to identify each of these criteria. Determining the start and end times of occurrences under study in the field is sometimes more difficult than in controlled laboratory research. The buildup of degrees starts on January1, and the moth appearance in spring, which usually starts in late March, lasts for three months, from April through June. Moth traps were employed to chart the link between moth populations and time in order to ascertain the dates of the pink bollworm field generations and peak spring emergence (Beasley and Adams, 1996; Toscano *et al.*, 1979). Plant phenology, such as flowering time, can be monitored to track daily degree build-up and predict insect activity, since temperature affects plant development as well. A biological calendar that predicts the order and timing of pests reaching vulnerable phases can be

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created using the readily observable phenological sequence, provided that it can be demonstrated that a sequence of plant phenological events correlates with the emergence of insect pests. It explains when plant phenology and grade days can be utilized to accurately anticipate insect emergence and schedule pest management procedures (Fraisse *et al.*, 2010; Sevacherian and El Zik, 1983). However, graphical selection of juvenile dates is often difficult due to weather-induced fluctuations in the numbers of moths captured and the overlap of early spring and waves of subsequent generations. The aim of the study is using thermal units, days and plant phenological interaction to predict the peaks of male moths emerging from overwintering larvae and subsequent generations of pink bollworm. (Lepidoptera: Gelechiidae) in cotton crops.

MATERIALS AND METHODS

Methods

The studies were conducted in Sharkia Governorate, Egypt (30.7°N; 31.63°E), during the cotton growing seasons of 2021, 2022, 2023, and 2024. The selected experimental areas were represented by four plots per season. Each plot was chosen with an area of not less than five feddans, and they were close in terms of planting dates. Cotton seeds variety of Giza 94 were planted during the period from March 20 to 31 through the four growing seasons according to traditional agricultural practices. It has also received a chemical control program approved by the Ministry of Agriculture and Land Reclamation (MALR), Egypt. A delta sticky gossyplure-baited trap was installed in the area of each experimental plot from January 1st, and moved to each experimental plot after planting until the end of December for each year to monitor male pink bollworm (PBW) moths. The numbers of male moths capture were counted every three days. The pheromone capsules were replaced with new ones every 15 days during the year. Moth emergence dates are the date of the appearance of male moths in traps, with a rate of catching one or more males in one trap every 3 nights during the four seasons. Dates of the peak numbers of male pink bollworm moths that were caught, which is the date on which their peak numbers occur during the four study seasons. Twenty-five cotton plants were randomly selected, from each experimental plot, every six days. Cotton fruiting structures, fruit branches, squares, and flowers numbers were counted on each plant. The obtained data were used to show the relationship between PBW activity and the fruiting structures of cotton plants. Heat units were calculated from different bio-fixed dates, the 1st of January, February, March, 19st of March, April, and the date of emergence of male pink bollworm moths, which overwinter in diapause larvae to the other events. The daily maximum and minimum temperatures for four years were obtained from the Central Laboratory for Agricultural Climate (CLAC), Giza, Egypt; which are converted into daily degree units according to (Seaver *et al.*, 1990) with a base of 30/12.78°C, upper/lower temperature, respectively.

RESULTS AND DISCUSSION

Emergence peak

The average cumulative heat units from the different bio-fixed dates until the peaks of emergence ranged from 442 to 1115 units, calculated on the start dates of April 18th and January 1st, respectively. The standard deviation varied for the same bio-fixed dates, ranging from 13.6 to 39.5 units, respectively, and the coefficient of variance ratio was between 3.1% and 5.3%. In cumulative days, the average ranged from 35.3 days from the April 18th start date to 142.5 days from January 1st, respectively. The standard deviation of the different bio-fixed dates varied from 1.3 to 1.5 days for the same biologically fixed dates, respectively, and the coefficient of variation between for the same dates was 0.9 and 4.3 (Table 1, Fig 1).

Table 1. Change in average, standard deviation, and coefficient of variation ratios for cumulative units of heat and days required for peaks of male pink bollworm moths emerging from winter diapause larvae for the seasons of 2021-2024 on various bio-fixed dates.

Bio-fixed	Cumulative heat units			Cumulative days		
dates	Average	SD	CV	Average	SD	CV
January 1st	1115	± 38.4	3.4	142.5	±1.3	0.9
February 1st	970	± 39.5	4.1	111.5	±1.3	1.2
March 1st	829	± 35.2	4.3	83.5	±1.3	1.5
March 19th	721.3	±32.0	4.4	65.3	±1.5	2.3
April 1st	614	± 32.6	5.3	52.3	±1.5	2.9
April 18th	442	± 13.6	3.1	35.3	±1.5	4.3

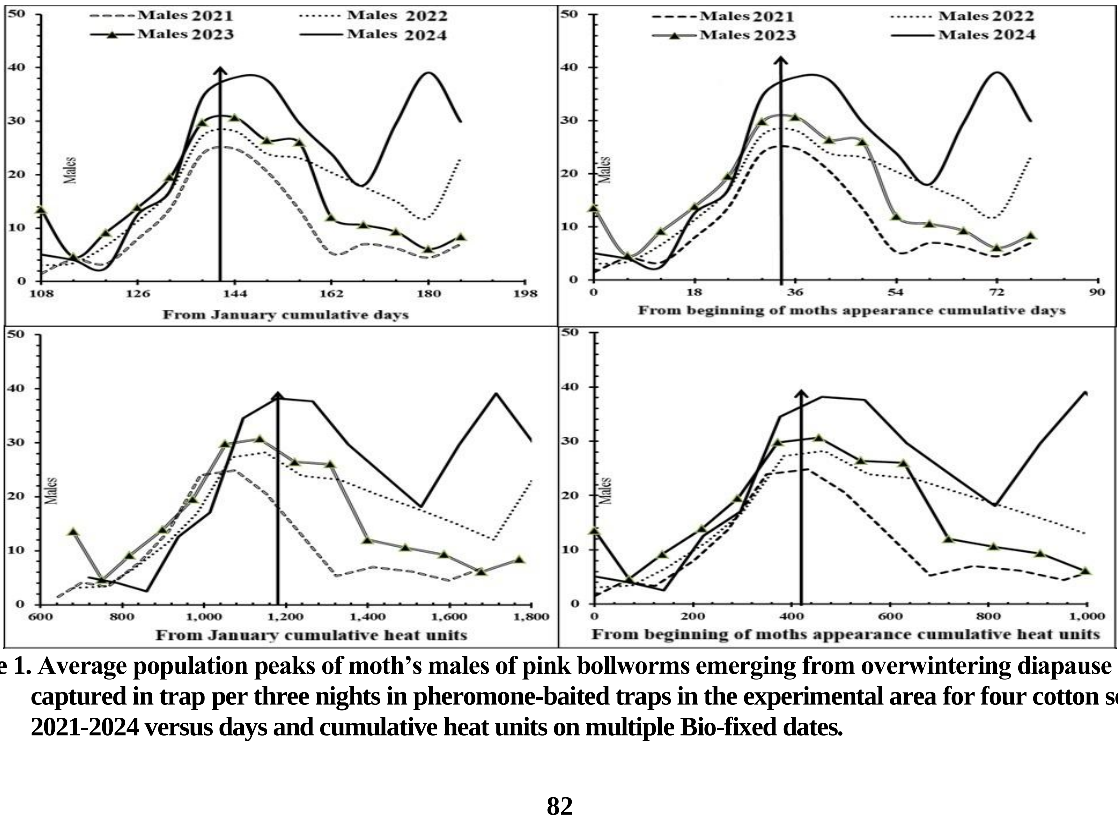

Figure 1. Average population peaks of moth's males of pink bollworms emerging from overwintering diapause larvae captured in trap per three nights in pheromone-baited traps in the experimental area for four cotton seasons 2021-2024 versus days and cumulative heat units on multiple Bio-fixed dates.

The coefficients of variation ratios for degree days for peak spring onset were 3.4, 4.1, 4.3, 4.4, 5.3, and 3.1% for accumulation of degree days beginning on January until April 18th bio-fixed dates, respectively, and for days were 0.9, 1.2, 1.5, 2.3, 2.9, and 4.3%, respectively. The coefficient of variation ratios, for cumulative heat units was lowest on the start date of April 18th, at 3.1%. As for the cumulative days, the lowest was on January 1st, at 0.9% (Table, 1; Fig., 1).

Estimated thresholds and thermal requirements may help understand the seasonal dynamics of the pink bollworm in relation to the timing of developmental events such as the onset and peak of moth emergence, egg laying, and egg hatching. The temperature range of 30 to 35 °C was found to provide the best conditions for the development of eggs, larvae, and adults. Increased larval mortality and decreased egg hatchability were the results of deviations from this range. In the F1 generation, thermal stress had a long-lasting impact that greatly impacted the egg and larval stages of immaturity. According to (Iqbal *et al.*, 2024; Nagaraju *et al.*, 2024), these results provide important information for forecasting *P. gossypiella* population dynamics at the field level and creating climate-resilient cotton management plans.

Pink bollworm-cotton plant interaction

The date used to initialize the days and units of heat accumulation for the F_1 generation was determined from a pink bollworm-cotton plant interaction. Emerging moths, from the overwintering diapause larvae, mate and lay their eggs on the various structures of young cotton plants. However, newly hatched larvae require susceptible squares to complete their development. The squares are susceptible to infection within 10-12 days of their first appearance, and if infected before that, they shed (personal observations), the time required for the larvae to grow in the squares that tolerate their growth ranges from 11-14 days. The number of days from first visible square to opening as a flower is 24-30 days (Butler Jr and Henneberry, 1976). The data presented in Table 2 showed that the history of having an average number of 9.9±1.0 and 17.2±2.7 fruit branches and squares per cotton plant, respectively, is the number of maximum incidence of infection in squares (receptor abundance). This number occurred in the time period of June 24-26, calculated from the March 20-31 planting date, for the four seasons 2021-2024. The average heat units and days were 1140.3±7.9 units and 88.8±5.6 days, with a coefficient of variation of 0.7 and 6.3%, respectively. This correlates with the subsequent peak of male F_1 pink bollworm moths captured. Moth emergence of the first peak, overwintered as diapause larvae, depended on accumulated heat units from fixed date, Jan 1st; occurred over the last third of May. The other three peaks depended on sowing dates (Nada *et al.*, 2018).

Generations, delta pheromone traps installed in field trial replicates were used to record the population of male pink bollworm moths from 2021 to 2024, to identify the peaks of generations. The date used to start calculating the cumulative days and daily heat units for the F_1 generation of the pink bollworm plant interaction was determined in Table 2 by receptor abundance for the four seasons, June 24-26. The presence of fruiting branches, with an average of 9.0±1.0 branches, was used as the event of maximum infection in the squares, and this date is related to the peak of the population in the subsequent generation of F_1 male moths in the field.

Table 2. Average, standard deviation, and coefficient of variation ratios for cumulative units of heat, days, number of cotton fruit branches and number of squares per plant from sowing dates March 20-31 to different receptors abundance dates, during the four cotton seasons 2021-2024.

From	To the range dates of receptor abundance	The measurements	CuHU*	CuDays**	Fruit branches	Squares
Planting date	12-14 Jun	Average	959.3	76.8	6.1	10.1
		SD	±10.9	±5.6	±1.2	±2.4
		CV	1.1	7.3	19.7	23.8
	18-20Jun	Average	1050	79.8	7.8	13.8
		SD	±9.3	±8.3	±1.2	±2.9
		CV	0.9	10.4	15.4	21.0
	24-26Jun	Average	1140.3	88.8	9.9	17.2
		SD	±7.9	±5.6	±1.0	±2.7
		CV	0.7	6.3	10.1	15.7

Planting date: 20th to 31st March through the four growing seasons; *: Cumulative units of heat; **: Cumulative days.

For the 2021 cotton season, the data in Table 3 and Fig. 2 shows the cumulative days and heat units for the generations, calculated from the abundance of receptors on June 26 until the peak of the first generation on July 29, with duration of 33 days and 526 heat units. The peak of the first generation F_1, on July 29, is considered the starting date for calculating the peak date of the second generation F_2, which occurred on August 31, with duration of 33 days and 532 heat units.

Table 3. Cumulative days and heat units for generations calculated from the abundance of receptors to the peaks of the different generations for the 2021 cotton season.

The phenomenon	From	To	Dayes	Achu
F1	26-06-2021*	29-Jul-2021	33.0	526.0
F2	29-Jul-2021	31-Aug-2021	33.0	532.0
F3	31-Aug-2021	04-Oct-2021	34.0	526.0
F4	04-Oct-2021	12-Nov-2021	39.0	526.0
Average			34.8	527.5
SD			2.9	3.0
C.V.			8.3	0.6

*** From receptor abundance to Peak F_1, and From Peak to peak**

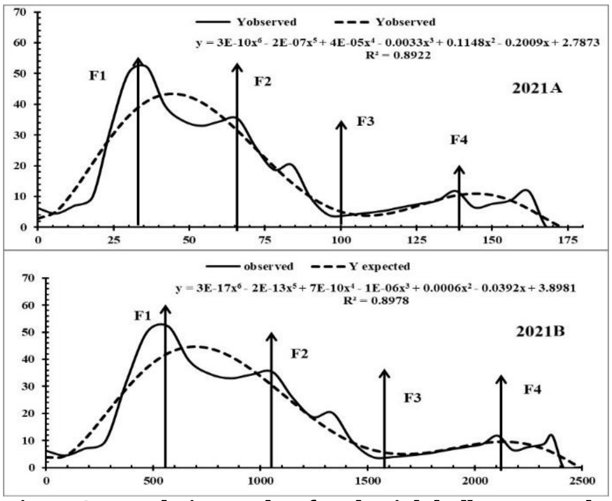

Figure 2. Population peaks of male pink bollworm moths captured in a delta pheromone baited trap versus cumulative days A and heat units B calculated from receptor abundance as a Bio-fixed date and Polynomial regression equation degree 6 in the 2021 cotton season.

The peak of F_2, which is considered the beginning of F_3, the F_3 peak on October 4, with duration of 34 days and 526 heat units, is the primary F_4. The F_4 peak was on November 4, with duration of 39 days and 526 heat units. The average number of days and heat units required for generation to complete its development from adult to adult is 34±2.9 days and 527.5±0.6 heat units, and the coefficient of variation ratios are 8.6 and 0.6%, respectively.For the 2022 cotton season, the data in Table 4 and Fig. 3 shows the cumulative days and heat units for the generations, calculated from the abundance of receptors on June 24 until the peak of the first generation on July 26, with duration of 32 days and 522 heat units. The peak of the first generation F_1 on July 26, is considered the starting date for calculating the peak date of the second generation F_2 which occurred on August 27, with duration of 32 days and 532 heat units. The peak of F_2, which is considered the beginning of F_3, the F_3 peak on September 29, with duration of 33 days and 528 heat units, is the primary F_4. The F_4 peak was on November 4, with duration of 36 days and 523 heat units. The average number of days and heat units required for generation to complete its development from adult to adult is 33.3±1.9 days and 526.3±4.6 heat units and the coefficient of variation ratios are 5.7 and 0.9%, respectively.

Table 4. Cumulative days and heat units for generations calculated from the abundance of receptors to the peaks of the different generations for the 2022 cotton season.

The phenomenon	From	To	Days	Achu
F1	24-06-2022*	26-Jul-2022	32.0	522.0
F2	26-Jul-2022	27-Aug-2022	32.0	532.0
F3	27-Aug-2022	29-Sep-2022	33.0	528.0
F4	29-Sep-2022	04-Nov-2022	36.0	523.0
Average			33.3	526.3
SD			1.9	4.6
C.V.			5.7	0.9

*** From receptor abundance to Peak F_1, and From Peak to peak**

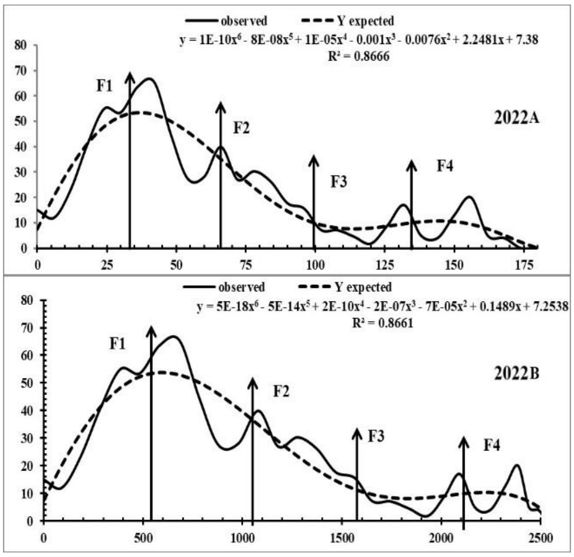

Figure 3. Population peaks of male pink bollworm moths captured in a delta pheromone baited trap versus cumulative days A and heat units B calculated from receptor abundance as a Bio-fixed date and Polynomial regression equation degree 6 in the 2022 cotton season.

For the 2023 cotton season, the data in Table 5 and Fig. 4 shows the cumulative days and heat units for the generations, calculated from the abundance of receptors on June 26 until the peak of the first generation on July 28, with duration of 32 days and 514 heat units. The peak of the first generation, F_1, on July 26, is considered the starting date for calculating the peak date of the second generation, F_2, which occurred on August 30, with duration of 33 days and 537 heat units. The peak of F_2, which is considered the beginning of F_3, the F_3 peak on October 3, with duration of 34 days and 527 heat units, is the primary F_4. The F_4 peak was on November 11, with duration of 39 days and 528 heat units. The average number of days and heat units required for generation to complete its development from adult to adult is 34.5±3.1 days and 526.5±9.5 heat units and the coefficient of variation ratios are 9.0 and 1.8%, respectively.

Table 5. Cumulative days and heat units for generations calculated from the abundance of receptors to the peaks of the different generations for the 2023 cotton season.

The phenomenon	From	To	Dayes	Achu
F1	26-06-2023*	28-Jul-2023	32	514
F2	28-Jul-2023	30-Aug-2023	33	537
F3	30-Aug-2023	3-Oct-2023	34	527
F4	3-Oct-2023	11-Nov-2023	39	528
Average			34.5	526.5
SD			3.1	9.5
C.V.			9.0	1.8

*** From receptor abundance to Peak F_1, and From Peak to peak**

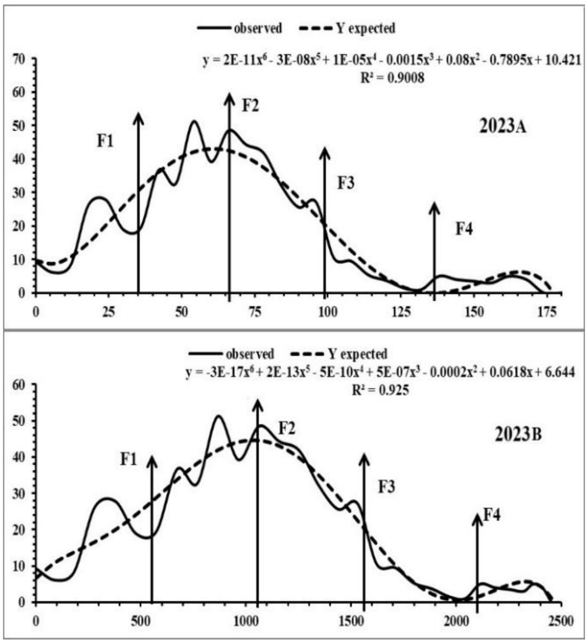

Figure 4. Population peaks of male pink bollworm moths captured in a delta pheromone baited trap versus cumulative days A and heat units B calculated from receptor abundance as a Bio-fixed date and Polynomial regression equation degree 6 in the 2023 cotton season.

For the 2024 cotton season, the data in Table 6 and Fig. 5 shows the cumulative days and heat units for the generations, calculated from the abundance of receptors on June 25 until the peak of the first generation on July 28, with duration of 33 days and 520 heat units. The peak of the first generation, F_1, is considered the starting date for calculating the peak date of the second generation, F_2, which occurred on August 30, with duration of 33 days and 526 heat units. The peak of F_2, which is considered the beginning of F_3, the F_3 peak on October 4, with duration of 35 days and 529 heat units, is the primary F_4. The F_4 peak was on November 15, with duration of 42 days and 520 heat units. The average number of days and heat units required for generation to complete its development from adult to adult is 35.8±4.3 days and 523.8±4.5 heat units and the coefficient of variation ratios are 11.9 and 0.9 %, respectively.

Table 6. Cumulative days and heat units for generations calculated from the abundance of receptors to the peaks of the different generations for the 2024 cotton season.

The phenomenon	From	To	Days	Achu
F1	25-06-2024*	28-Jul-2024	33	520
F2	28-Jul-2024	30-Aug-2024	33	526
F3	30-Aug-2024	4-Oct-2024	35	529
F4	4-Oct-2024	15-Nov-2024	42	520
Average			35.8	523.8
SD			4.3	4.5
C.V.			11.9	0.9

*** From receptor abundance to Peak F_1, and From Peak to peak**

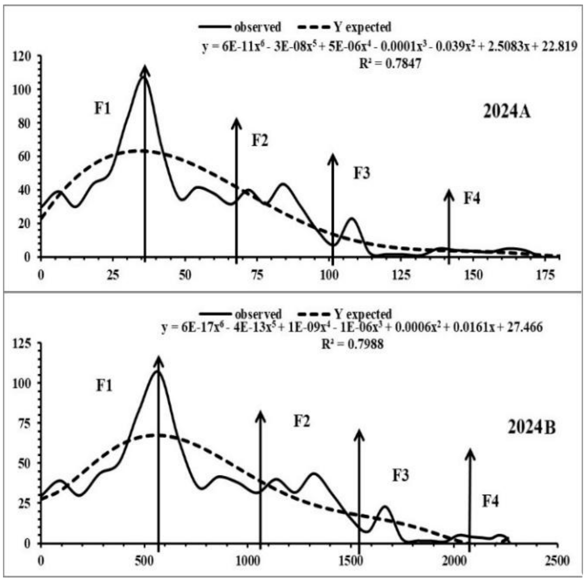

Figure 5. Population peaks of male pink bollworm moths captured in a delta pheromone baited trap versus cumulative days A and heat units B calculated from receptor abundance as a Bio-fixed date and Polynomial regression equation degree 6 in the 2024 cotton season.

The four years of study (2021-2024) in the experiment conducted in cotton fields showed the dates of emergence and peak numbers of male pink bollworm moths. Cumulative units of heat and days were calculated from different bio-fixed dates. It is from the beginning of the months from January to April. In addition to March 20, which are the date for planting cotton, and April 18, the date for the appearance of male moths. Until the population reach its peak during the four study seasons. Values of the coefficient of variation ratios for the accumulation of thermal units and the days required for the beginning and peak of spring. For cumulative heat units it was 3.4, 4.1, 4.3, 4.4, 5.3, 3.1%, and for days, it was 0.9, 1.2, 1.5, 2.3, 2.9, and 4.3%, which calculated from different biological constants starting dates, respectively. (Toscano *et al.,* 1979) reported that moth traps were used to plot the relationship between moth populations and time to determine dates of peak spring emergence and field generations of pink bollworm. The lowest coefficient of variation of cumulative temperature units calculated from April 18, with a rate of 3.1%, while the lowest for cumulative days calculated from January 1, with a rate of 0.9%. Receptor abundance is the presence of sufficient numbers of susceptible squares of pink bollworm larvae to provide a peak in the first generation on cotton. This abundance is present when the plant has fruitful branches with an average number of 9.9±1.0 and 17.2±2.7 squares per cotton plant, Table 2. This number was present in the time June 24-26, calculated from the planting date March 20-31 for the four seasons 2021-2024. The average heat units and days were 1140.3±7.9 units and 88.8±5.6 days, with a coefficient of variation of 0.7 and 6.3%, respectively. This is the number that gives the maximum incidence of injury in squares. This correlates with the subsequent peak of male F_1 pink bollworm moths captured (Fraisse *et al.*, 2010). (Beasley and Adams, 1996) mentioned that the date used to initialize degree day accumulation for the F_1 generation was determined by interact the pink bollworm plant with the date 2 weeks before peak rosette flowers as the date of maximum squared infection. This point must relate to a later peak in the capture of F_1 male moths in the field.

For the 2021 season, the average number of days and heat units needed for the population to complete its development from receptor abundance to reach peak F_1 generation and the following three peaks of generations with 34±2.9 days and 527.5±0.6 heat units, and the coefficient of variation ratios are 8.6 and 0.6%, respectively. As for the 2022 season, it reached 33.3±1.9 days and 526.3±4.6 thermal units, and the coefficient of variation ratios reached 5.7 and 0.9%, respectively. For 2023, the season was 34.5±3.1 days, 526.5±9.5 HU and coefficient of variation ratios 9.0 and 1.8%, respectively. As for the 2024 season, it reached 35.8±4.3 days and 523.8±4.5 thermal units, and the coefficient of variation ratios reached 11.9 and 0.9%, respectively. (Wene *et al.,* 1965) they concluded that the lower/upper thresholds of 13.0/30.0˚C were useful in describing the physiological time of pink bollworm generations. The average number, standard deviation, and coefficient of variation ratios were calculated for the days and heat units required for the pink bollworm to complete its development from receptor abundance to the peak of the first generation and then the peaks of the subsequent three generations every year and over all the four years. For days, they ranged between 33.3±1.9 and 35.8±4.3 days and 5.7 and 11.9%, respectively. The thermal units ranged between 523.8±4.5 and 527.5±0.6 thermal units, and 0.6 and 1.8%, respectively, for the four seasons 2021-2024.

CONCLUSION

The study discovered that between April 18 and January 1, the average cumulative heat units and cumulative days fluctuated, with a standard deviation ranging from 13.6 to 39.5 units and a coefficient of variance ratio between 3.1% and 5.3%. The timing of developmental processes such as moth emergence, egg laying, and hatching affects the seasonal dynamics of the pink bollworm, according to the study. Also, the generation's days and heat accumulation units were determined from a pink bollworm-cotton plant interaction. The maximum incidence of infection in squares occurred in June 24-26 during the four seasons 2021-2024. This coincided with the peak of male F_1 pink bollworm moths, which overwintered as diapause larvae. Furthermore, the study used delta pheromone traps to record the population of male pink bollworm moths from 2021 to 2024. The cumulative days and heat units for the F_1 generation were calculated depending on receptor abundance for the four seasons. These results show that heat units, days, and the interaction with plant phenology can help detect periods of high risk for the pink bollworm moth's activity and can be used to manage this pest throughout the cotton crop season.

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التنبؤ بقمم وفرة وأعداد أجيال دودة اللوز القرنفلية، بيكتينوفورا جوسيبيلا باستخدام تفاعل الوحدات الحرارة التراكمية مع الظواهر النباتية

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الملخص

تم هذا العمل لإجراء دراسات باستخدام درجات الحرارة التراكمية والتفاعل الفينولوجي للنباتات للتنبؤ بقمم ظهور وأجيال دودة اللوز القرنفلية،بيكتينوفورا جوسيبيلا (ساوندرز) ، خلال أربع مواسم زراعة القطن ، ٢٠٢١, ٢٠٢٢, ٢٠٢٣ و 2024. تراوحت قيم معامل الاختلاف بين ٣,١٧، ٤,٤٪، و٠,٩، ٤,٣٪، على التوالي. أدنى قيمة كانت في ١٨ أبريل، ٣,١٪، وفي ١ يناير، ٠,٩٪، على التوالي. وفرة المستقبلات، وهي وجود أعداد كافية من الوسواس القابل للإصابة بيرقات دودة اللوز القرنفلية ، والتي ترتبط بذروة تعداد ذكور الفراشات من الجيل الأول. يحدث هذا عندما تحتوي النباتات على فروع ثمرية بمتوسط عدد من ٩,٩±١,٠ و١٧,٢±٢,٧ وسواسة لكل نبات. تم حساب متوسط وحدات الحرارة والأيام للأربعة مواسم من تاريخ الزراعة عند ١١٤٠,٣±٧,٩ وحدة و٨٨,٨±٥,٦ يومًا مع معامل تباين قدره ٠,٧ و٦,٣٪ على التوالي. تراوحت الوحدات الحرارية بين ٥٢٣,٨±٤,٥ و٥٢٧,٥±٠,٦ وحدة، وبنسب تباين بلغت ٠,٦ و١,٨٪ على التوالي. بالنسبة للأيام، تراوحت بين ٣٣,٣±١,٩، ٣٥,٨±٤,٣ يومًا، و٥,٧، ١١,٩٪، على التوالي، للمواسم الأربعة. تشير هذه النتائج إلى أن الوحدات الحرارية، والأيام، والتفاعل مع علم الظواهر النباتية يمكن أن يساعد في اكتشاف فترات الإصابة العالية لنشاط دودة اللوز القرنفلية ويمكن استخدامها لإدارة هذا الآفة طوال موسم محصول القطن.