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PREDICTION OF AMERICAN BOLLWORM, *Helicoverpa armigera* (HÜB.), DEPENDED ON THE ACCUMULATED HEAT UNITS IN COTTON FIELDS

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ABSTRACT

The present study was carried out at Mahala, Basion and Tanta districts in Gharbia Governorate during 2006 &2007 cotton seasons to study prediction of ♀♀♀♀♀♀american bollworm, *Helicoverpa armigera* (Hüb.), depended on accumulated heat units in cotton fields with enough period for the pest control. The host plants of *H. armigera* surveyed in investigation areas during the wintry, summery and niley seasons. Results indicated that, seasonal abundance appeared in four main peaks of the capture that occurred during the two investigation seasons, at the three districts. The monthly average number of catches ranged between 2.86 to 11.16 male /Trap/month at three districts during the tested seasons. Tanta had the largest significant mean number of the capture for months followed by Mahala and Bason. Fit polynomial regression equation between the two variables that was represented in coefficient of determination R^2 values indicated that the equation degree14 for the three districts. The R^2 values ranged at three districts between 0.64731 and 0.94397. Sum of deviations square for the expected from observed population ranged between 12.31 and 45.08 at Mahala, 15.99 and 98.99 at Basion and at Tanta the population take the same trend for the two seasons. Therefore, accumulated heat units can be used to forecast *H. armigera* population before appearance with a month using equation $Y=a+b_1x+\ldots\ldots b_{14}x^{14}$ under the same field condition of host plants at the three different districts in Gharbia Governorate.

INTRODUCTION

Helicoverpa armigera (Hüb.) is a highly polyphagous pest of many economically significant crops in the most world countries (new and old) (King 1994). These plants include over 180 cultivated and wild species in at least 45 families (Kant *et al.*, 1999 and Sidde Gowda *et al.*, 2002). *H. armigera* have in Egypt a wide range of alternative host plants either cotton such as Maize, various legumes , Tomato and Okra , or wild host plants as well as other solanaceae. In each case, the main period of infestation is usually associated with flowering period. Cotton plants were liable to be attacked by a number of serious pests, but the majority of annual production loss is caused by a few key pests as *H. armigera*. The most critical period of cotton crop development takes place during a period of about ten weeks after the first flower buds have formed. During this period of growth, there are an increasing number of buds and then bolls, which attacked by the pest. In some agro – ecosystem the severity infestation on cotton is often associated with the extent of maize acreage rather than other host plants. An initial population will increase on maize before it moves to cotton (Willcocks and Bahgat, 1937; Adkisson *et al.*, 1964; Ismail and Swailem,1975; Shaheen, 1976; Zalucki *et al.,*1986 and Wallch *et al*.,1988). The population of american bollworms (ABW) is greatly important in the programs of integrated pest management in cotton crops. Clement *et al.* (1979) mentioned that the pheromone traps appeared to be more sensitive than light traps in monitoring early season occurrence of *Agrotis ipsilon* (Hufn.) males. Pheromone traps had been used to monitor the activity of the ABW to determine the seasonal dynamics of spatial distribution by Ridgwaye and Lingren (1972) and Slosser *et al.*(1987). On the other hand, temperature is the ever present factor influencing insect life and relationship between the insect activity and this factor may utilized to gain some insight into the size and behavior of field population and consequently into life history and ultimately prediction of future generation (Riedle *et al*.,1976 and Sevacherian *et al.,*1977). Fitt (1989) suggested that temperature, host plants sequence and host suitability play an important role in population dynamic of ABW male moths. In addition, the knowledge on the role of temperature summations is one of the best and new approaches toward eventual economical control. It is providing early warning system for the insect abundance and the population fluctuation of ABW during the last three decades. The ABW became a serious cotton pest in different districts in Egypt

The aim of this work is to clarify the influence of temperature as accumulated heat units on number of male moths captured by pheromone traps in determining the emergence of *H. armigera* population and using the heat units summation method to predict their population peaks with enough periods to begin pest control in cotton fields.

MATERIALS AND METHODS

The present study was carried out at three districts, Mahala, Basion and Tanta, in Gharbia Governorate, where cotton variety Giza 89,86 and 89 were cultivated in three districts, respectively. Five delta pheromone traps were conducted per district in cotton fields at the rate of one trap/ five feddans throughout a period extended from the first of June to the end of September during the two successive cotton seasons, 2006 &2007. Each trap was baited with a capsule loading 2 mg a. i. of specific sex attractant and replaced with fresh one every two weeks. Traps were fixed and situated 20 cm above the cotton plants canopy height. The experimental area subjected to normal agricultural processes. Cotton pest control procedures were applied according assignee by Governmental authorities. The number of male moths of ABW / district was recorded every three days. The whole data / district of the two seasons were graphically represented to determine the population peaks in successive generations in relation to accumulated heat units (calculated according Seaver *et al*., 1990 and Amer, *et al*. 2009). Daily maximum and minimum temperatures for the two seasons were obtained from Agricultural Research Center (ARC) for Gahrbia Governorate. The two seasons 2006 & 2007 of moths counts and the corresponding daily degrees (DD`s) were statistically analyzed to determine the main periods of activity, subsequently the real peaks on the basis of the periods and fit equation (Thomas and Hills ,1975and SAS Institute,1999).

RESULTS AND DISCUSSION

Seasonal abundance of Helicoverpa armigera.

The actual of the number of male moths/trap for the experimental areas at the three districts are graphically that illustrated in Fig (1) through the aforementioned two seasons of 2006 and 2007. At Mahala district, data in Fig (1) demonstrated that the population of *H. armigera* captured male moths recorded during a period extended from the 1^{st} of June to the 28^{th} of September2006 and 2007 cotton seasons. Four main peaks of the capture occurred during the two investigated seasons, with few minor peaks. Meanwhile data in Table (2) showed that accumulated days from January, that facing the four peaks which were 160, 196, 229 & 263 and160, 195, 229 & 267days at Mahala district for the two seasons, respectively. Also accumulated heat units from the same arbitrary date that facing the same four peaks were 813, 1233, 1638 &2051 and 743, 1161, 1584 &2004 unit for the four peaks and the two seasons, respectively. Data in Fig (1) demonstrated that the captured male moths were recoded during the same period from the 1^{st} of June to the 28^{th} of September of 2006 and 2007 cotton seasons. Four main peaks of the capture occurred during the two investigated seasons. Whereas, data in Table (2) showed that accumulated days from January that facing the four peaks take the same trend as at Mahala district for the four peaks and the two seasons, respectively. Accumulated heat units from the previous fixed date that facing the same four peaks take the same trend. Investigator Bekheit (1992) and Ragab (1999) recorded number of peaks of *H. armigera* in Sharkiya and Gharbia Governorates, respectively.

Table (1): Fit polynomial regression equation between acumulated heat units before moth, independent factor, and *Helicoverba armegra* captured male moths after month as mean,dependant factor in Gharbia Governorate during 2006-2007 cotton seasons

Degree of equation	Equation	R^2
2	$Y=a+ bx+bx^2$	0.2152768
6	$Y=a+ bx+bx^2 +\ldots+bx^6$	0.5837782
10	$Y=a+ bx+bx^2 +\ldots+bx^{10}$	0.6009349
12	$Y=a+ bx+bx^2 +\ldots+bx^{12}$	0.7787153
13	$Y=a+ bx+bx^2 +\ldots+bx^{13}$	0.7787153
14	$Y=a+ bx+bx^2 +\ldots+bx^{14}$	0.8842638
15	$Y=a+ bx+bx^2 +\ldots+bx^{15}$	0.8842638
16	$Y=a+ bx+bx^2 +\ldots+bx^{16}$	0.8842638
17	$Y=a+ bx+bx^2 +\ldots+bx^{17}$	0.8842638

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Table (2): Peak occurance, accumulated days, heat units facing peaks and from peak to peak seasonal abundance of *Helicoverpa armigera* at three districts in Ghsrbia Governorate during and 2006 and 2007 cotton seasons

District	Season	Peaks	Dates	Ac. Days from Jun	Ac. From Jan.		from peak to peak	
					Days	H. units	Days	H. units
Mahla	2006	First	6-12/6(9/6)	9	160	813		
		Second	12-18/7(15/7)	45	196	1233	36	420
		Third	11-17/8(17/8)	78	229	1638	33	405
		Fourth	16-22/9(20/9)	112	263	2051	34	414
	2007	First	6-12/6(9/6)	9	160	743		
		Second	12-18/7(14/7)	44	195	1161	35	418
		Third	11-17/8(17/8)	78	229	1584	34	423
		Fourth	22-28/9(24/9)	116	267	2004	38	420
Basion	2006	First	6-12/6(9/6)	9	160	813		
		Second	12-18/7(15/7)	45	196	1233	36	420
		Third	11-17/8(17/8)	78	229	1638	33	405
		Fourth	16-22/9(20/9)	112	263	2051	34	414
	2007	First	6-12/6(9/6)	9	160	743		
		Second	12-18/7(14/7)	44	195	1161	35	418
		Third	11-17/8(17/8)	78	229	1584	34	423
		Fourth	22-28/9(24/9)	116	267	2004	38	420
Tanta	2006	First	6-12/6(9/6)	9	160	813		
		Second	12-18/7(15/7)	45	196	1233	36	420
		Third	11-17/8(17/8)	78	229	1638	33	405
		Fourth	16-22/9(20/9)	112	263	2051	34	414
	2007	First	6-12/6(9/6)	9	160	743		
		Second	12-18/7(14/7)	44	195	1161	35	418
		Third	11-17/8(17/8)	78	229	1584	34	423
		Fourth	22-28/9(24/9)	116	267	2004	38	420
Mean							35	416.5
SD							1.7	6.2

Ac. = Accumulated, H. = Heat

Statistical analysis

The monthly average number of catches fluctuated at the three districts during each of tested seasons within the months as shown in Tables (3, 4 and 5). At Mahala district, the average of male moths per month fluctuated from 3.58 to 7.00 and 3.3 to 5.3 males during June to Sept. for the two seasons, respectively. Statistical analysis revealed that significant deferent between the total catch of *H. armigera* male moths captured during July than the other months except Aug. and Aug. significantly deferred with Sep. and insignificant with Jun. Jun and Sept had insignificant deferent during 2006 cotton season. While, insignificant deferent was between the four months during 2007 cotton season. Also, the difference between the average catches for the two seasons was insignificant except Sept. At Basion district, the average of male moths per month fluctuated from 2.86 to 7.38 and 2.2 to 6.88 males during June to Sept. for the two seasons, respectively. Statistical analysis revealed that significant deferent between the total catch of *H. armigera* male moths captured during June than the other months and insignificant deferent July, Aug. and Sept during 2006 season. But during 2007 season, Sept. had the lowest significant capture and insignificant deferent at the other tested months. Whereas, average 2006-2007 cotton seasons, June and Sept. had than other months and July and Aug. had insignificant deferent between them. At Tanta district, the average of male moths per month fluctuated from 8.06 to 9.00 and 8.32 to 11.16 males during June to Sept. for the two seasons, respectively. Statistical analysis revealed that insignificant deferent between the total catch of *H. armigera* male moths captured during the four tested months during 2006 season. But during 2007 season, June had the lowest significant capture and insignificant deferent with Sept. At the other tested months had insignificant deferent. . Whereas, average 2006-2007 cotton seasons showed that the tested months had insignificant deferent between them. The captured moths in the months at the three districts Mahala, Basion and Tanta were during 2006, June had the largest capture at Tanta(9.00 male moths/Trap)) but Sept. had lowest one at Basion (2.86 male moths/Trap). During 2007 cotton season, July at Tanta had largest number also Sept. at Basion the lowest one.

Table (3): Mean number *of H. armigera* male moths / trap /month caught at Mahla, Basion and Tanta districts in Gharbia Governorate during 2006 cotton season

Months	Mahla	Basion	Tanta
Jun	bc4.92b	a7.38a	a9.00a
Jul	a7.00a	b3.64b	a8.58a
Aug.	ab6.22ab	b3.98b	a8.46a
Sep	c3.58b	b2.86b	a8.06a
Mean	5.43b	4.465b	8.53a

Insignificant different between the values that have the same letters perpendicularly or horizontal

Table (4): Mean number *of H. armigera* male moths / trap /month caught at Mahla, Basion and Tanta districts in Gharbia Governorate during 2007 cotton season

Months	Mahla	Basion	Tanta
Jun	a5.3a	a5.4a	b6.5a
Jul	a5.48b	a6.88b	a11.16a
Au	a4.54b	a5.7b	a9.84a
Sep	a3.3b	b2.2b	ab8.32a
Mean	4.55b	5.045b	8.955a

Insignificant different between the values that have the same letters perpendicularly or horizontal

Table (5): Mean number *of H. armigera* male moths / trap /month caught at Mahla, Basion and Tanta districts in Gharbia Governorate during 2006-2007 cotton seasons

Months	Mahla	Basion	Tanta
Jun	a5.11b	s6.39ab	a7.75a
Jul	a6.24b	b5.26b	a9.87a
Au	a5.38b	b4.84b	a9.15a
Sep	b3.44b	c2.53b	a8.19a
Mean	5.0425b	4.755b	8.74a

Insignificant different between the values that have the same letters perpendicularly or horizontal

The average of 2006 and 2007 capture in moths take the same trend in the previous season 2007. Mean of the capture for months at the three districts, Tanta had largest significant number followed by the two others.

Host plants of the pest in the investigated area

The pest develops in the crops wintry and follows up their development in the crops at summary and niely. Data in Table (6) illustrate that percent area (Feddan) of crops cultivated in wintry season in three districts Gharbia Governorates during 2006 and 2007. These crops are wheat (Triticum aestivum), broad bean, flax/linseed (Linum usitatissimum), clover (Trifolium alexandrinum), beet, vegetables wintry, onion (Allium cepa) and others. Table (7) shows that percent of area (Feddan) of crops that cultivated in the summery season in the same districts and seasons. These crops are cotton (*Gossypium barbadense*), white (*Zea maize*) summery, sorghum (*Sorghum* sp.) summery, watermelon summery, vegetables summery and others. Also, the niley crops are white (*Zea maize*) niley, sorghum (Sorghum sp.) Niley and yellow (*Zea maize*) Niley (Table 8).

Table (6): Percent area(Feddan) of crops cultivated in wintry season in three districts Gharbia Governorates during 2006 and 2007

	2006			2007		
Crops	**Mahla**	**Basion**	**Tanta**	**Mahla**	**Basion**	**Tanta**
Wheat (*Triticum aestivum*)	37.1	40.9	42.4	47.0	37.3	39.8
Broad bean	1.4	14.7	1.0	0.7	13.8	1.1
flax/linseed (*Linum usitatissimum),*	1.9	0.2	0.2	2.1	0.2	0.3
clover (*Trifolium alexandrinum*),	42.8	18.6	28.3	33.6	20.2	31.6
Beet	9.5	0.4	0.2	8.4	0.7	0.4
vegetables wintry	2.1	7.4	3.7	2.6	7.4	3.1
onion (*Allium cepa*,	3.3	13.8	13.8	3.9	16.5	14.3
Others	1.9	3.9	10.4	1.8	3.9	9.5
District area	83713	31280	52190	83713	31280	52190

Table(7): Percent area(Feddan) of common crops cultivated in summery season in three districts Gharbia Governorates during 2006 and 2007

	2006			2007		
Crops	**Mahla**	**Basion**	**Tanta**	**Mahla**	**Basion**	**Tanta**
Rice (Oryza sativa)	64.4	40.5	51.8	57.8	37.5	51.3
Cotton, *Gossypium barbadense*	13.9	23.5	4.2	16.8	26.4	5.5
White (*Zea maize*) summery	2.8	16.0	20.0	5.3	15.3	12.6
sorghum(Sorghum sp.) summery	0.5	4.3	2.7	0.4	3.8	2.7
watermelon summery	4.0	1.5	0.0	3.5	2.7	0.0
vegetables summery	2.3	7.0	6.2	1.9	9.0	6.8
Others	12.1	7.1	15.1	14.2	5.3	21.1
District area	83713	31280	52190	83713	31280	52190

Table (8): Percent area (feddan) of common crops cultivated in niley season in three districts Gharbia Governorates during 2006 and 2007

	2006			2007		
Crops	**Mahla**	**Basion**	**Tanta**	**Mahla**	**Basion**	**Tanta**
White (*Zea maize*) Niley	12.0	3.9	11.9	12.4	3.2	17.4
sorghum(Sorghum sp.) Niley	0.0	3.2	3.2	0.0	2.1	3.6
yellow (*Zea maize*) Niley	0.1	0.0	0.0	1.8	0.0	0.0

(Ismail and Swailem,1975; Shaheen, 1976; King,1994) and Kant *et al*., 1999). Fitt (1989) reported that host plants sequence and host suitability play an important role in population density of ABW male moths.

Relationship between Accumulated Heat units and captured male moths

The relationship between accumulated heat units before month as independent factor and captured male moths after month as dependent factors were cleared in Table (1). Fit polynomial regression equation between the two variables represented in r^2 values indicated that the polynomial regression equation degree14 is the best equation for the three districts where the r^2 value was 0.8842637515.

Coefficient of determination R^2

Data in Table (9) illustrated that coefficient of determination R^2 values of polynomial regression equation degree14 at three districts in Gharbia Governorate during 2006 and 2007 cotton seasons and average. At Mahala, R^2 values were 0.94397, 0.832175 and 0.88053846 for the two seasons and average, respectively. At Basion, R^2 values were 0.91658, 0.9760892 and 0.91515259 for the two seasons and average, respectively. At Tanta, R^2 values were 0.64731, 0.81528 and 69492 for the two seasons and average, respectively. And mean of the three districts, R^2 values were 0.88426, 0.8717586 and 0.85719792 for the two seasons and average, respectively. The coefficient of determination R^2 values at Tanta less than other two districts Mahala and Basion Nada, *et al.* 2004 and El-Sayed, *et al*. 2009).

Sum of deviations square for the expected from observed population

Table (9): R^2 values of polynomial regression equation degree14 between acumulated heat units before month and *Helicoverba armegra* captured male moths after month at three districts in Gharbia Governorate during 2006 and 2007 cotton seasons

District	R^2		
	2006	**2007**	**Average**
Mahla	0.94396918	0.832174985	0.880538456
Basion	0.916583254	0.976089237	0.915152588
Tanta	0.647309747	0.81527964	0.694917073
Mean	0.884263752	0.87175855	0.857197922

Figures (2-3) illustrate that the application of polynomial regression equation degree14 which show observed and expected population of male moth /trap of *H. armigera* at the three districts. At Mahala, the sum of deviations square for the expected from observed population were 34.82, 12.31 and 45.08 for the two seasons and average, respectively (Table 10). The expected population coincides with the observed one at three peaks from first to third peak. While in the fourth peak, it was differed during 2006 cotton season. But during 2007season and average, the expected population was more coincides in the fourth peak. At Basion, the sum of deviations square for the expected from observed population were 68.27, 15.99 and 98.99 for the two seasons and average, respectively.

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The sum of deviations square for the expected population at 2007 cotton season was less than 2006 and average. At Tanta, the sum of deviations square for the expected and observed population take the same trend (Table 10). Fitt (1989) suggested, the knowledge on the role of temperature summations is one of the best and new approaches toward eventual economical control. It is providing early warning system for the insect abundance and the population fluctuation of ABW during the last three decades. Temperature is the ever present factor influencing insect life and relationship between the insect activity and this factor may utilized to gain some insight into the size and behavior of field population and consequently into life history and ultimately prediction of future generation (Riedle *et al*.,1976 & Sevacherian *et al.,*1977 and Nada, *et al.* (2009).

Table (10): Sum square deviations of the expected from observation values at three districects in Gharbia Governorate during 2006 and 2007 cotton seasons

District	2006	2007	Average
Mahla	34.82	12.31	45.08
Basion	68.27	15.99	98.99
Tanta	33.29	24.66	18.11
Mean	57.95	11.31	111.24

Therefore, accumulated heat units can be used to forecast ABW population before appear of its peaks with a month under the same condition of host plants at the three districts in Gharbia Governorate.

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التنبؤ بدودة اللوز الأمريكية، هليكوفيربا أرميجرا (هوبنر)، إعتماداً على الوحدات الحرارية المتراكمة فى حقول القطن

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أجريت الدراسة فى ثلاثة مراكز بمحافظة الغربية وهى المحلة ، بسيون وطنطا، موسمى 2006 و2007 لدراسة التنبؤبظهور تعداد دودة اللوز الأمريكية ، الأمريكية، هليكوفيربا أرميجرا (هوبنر)، إعتماداً على الوحدات الحرارية المتراكمة في حقول القطن بفترة كافية لإجراء مكافحة الآفة،أشارت النتائج إلى أن العوائل المحيطة في مواسم الشتوى والصيفى والنيلى قد سجلت فى مناطق الدراسة،وتحت هذه الظروف أظهرت الوفرة الموسمية أربع قمم رئيسية خلال موسمي الدراسة ، مع وجود قمم صغيرة في المراكز الثلاثة، تذبذب المتوسط الشهري للفراشات فى المصيدة من 2.86 إلى 11.16 ذكر لكل مصيدة لكل شهر في المناطق الثلاث خلال كل موسم من المواسم التي أجريت فيها التجربة، متوسط التعداد الشهرى الذى تم إصطياده ، كان فى مركز طنطا أكبر عدداً بفارق معنوي مقارنة بالمركزين ألآخرين المحلة وبسيون، أفضل درجة لمعادلة الإنحدار متعدد الحدود بين المتغيرين ممثلة في معامل التحديد R^2 كانت 14 درحة للمراكز الثلاثة وقيم معامل R^2 للمعادلة فى المراكز الثلاثة تراوحت بين 0.64731و0.94397 ، مجموع مربع انحرافات التعداد المتوقع عن المشاهد تراوح في المحلة الكبرى بين 12.31 و 45.08 ، في بسيون بين 15.99 و 98.99 و في طنطا كان فى نفس الاتجاه ، ولذلك يمكن استخدام الوحدات الحرارية المتراكمة للتنبؤ بظهور تعداد دودة اللوز الأمريكية قبل شهرمن التوقيت المطلوب باستخدام المعادلة $Y= a +b_1x +....+b_{14}x^{14}$ تحت نفس الظروف الحقلية من العوائل النباتية في المراكز الثلاثة بمحافظة الغربية.

قام بتحكيم البحث

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