

## EFFECT OF TEMPERATURE DEGREES ON SOME BIOLOGICAL ASPECTS OF *HELCOVERPA ARMIGERA* IN RELATION TO BIOCHEMICAL CONTENTS

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Received: Sep. 11, 2017

Accepted: Oct. 3, 2017

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**ABSTRACT:** The temperature effect on some biological aspects and biochemical of *Helicoverpa armigera* reared on bell pepper were conducted under laboratory conditions in Plant Protection Research Institute Sharkia branch, ARC to study the effect of three temperatures (21, 24 and 27 ± 1°C). The results showed that the incubation period of *H. armigera* eggs were 4.10, 3.70 and 2.50 days at 21, 24 and 27 °C, respectively. Larval and pupal duration were decreased as temperature increased. Generation period lasted 52.50, 42.01 and 31.67 days, respectively. The thresholds of development ( $T_o$ ) were 12.30, 11.50, 11.85, 11.90 and 12.50 °C for eggs, larvae, pupae, pre- oviposition and generation period, respectively. While, the average of thermal units required to complete the developmental stages were 38.57, 275.44, 149.93, 32.58 and 462.86 unit, respectively, when reared on bell pepper. The total eggs laid by female high significantly affected by all temperatures. Decreased at temperature from 24 to 21 °C caused decreased in total lipid, protein and carbohydrate but the increase from 24 to 27 °C caused decreased in all parameters except carbohydrate caused increased.

**Key words:** Cotton bollworm, temperature, *Capsicum annuum*, life cycle, biochemical

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### INTRODUCTION

The cotton bollworm, *Helicoverpa armigera* (Hüb.) (Lepidoptera: Noctuidae), is an extremely polyphagous species and a common insect pest of many crops in Egypt Nada *et al.*, (2004) and many parts of the world Reddy *et al.*, (2004). The larvae of this *H. armigera* also attack tomato, corn, tobacco, chick pea, pepper, okra, carnation, and gladiolus in Greece Pelekassis (1962). *H. armigera* was reared on six host plants: cotton, corn, tomato, hot pepper, tobacco and common bean. They found that the larvae were successfully survived on all six host plants, although mortality was very high. The developmental time of immature stages reared on hot pepper and tomato were 32.91 and 27.96 days, respectively Zhudong Liu *et al.*, (2004). The effect of temperature were studied on the rate of development for *H. armigera* reared on tomato. The duration of different life history stages decreased as temperature increased from 13.3 to 32.5 °C. A development

threshold of 10.5, 11.3 and 13.8 °C was estimated for the eggs, larvae and pupal stages, respectively Jallow and Matsura (2001). The lowest developmental thresholds of the immature stages of *Helicoverpa armigera* was reared on an artificial diet and it were estimated by a linear model and ranged from 10.17 (pupal stage) to 11.95 °C (egg stage) at constant temperature regimes. Mean adult longevity fluctuated from 34.4 d at 15 °C to 7.6 d at 35 °C Mironidis and Savopoulou (2008). Stated that the temperature increasing led to an increase in the developmental rate and reduces the development periods of the different stages. The generation period of *H. armigera* reared on lettuce was shorter (32.23 days) than that reared on pea (34.70 days). The lower developmental temperatures were 11.60 and 11.39 °C for the generation and the thermal units required were 467.13 and 511.26 DD's, respectively Amer and El-sayed (2015). The thermal requirements (degree-days) of

development was often used for estimating developmental times because temperature has a major effect in determining the rate which *H. armigera* develop Zaslavski, (1988). Developmental processes are controlled by temperature dependent on biochemical reactions, which are restricted by lower and upper thresholds Domos and Soutani, (2008). Tested temperatures 16 and 37 °C caused high reduction in soluble protein and total lipid in larvae compared to the larvae reared at 26 °C., Glucose activity greatly reduced in *E. insulana* larvae reared on okra at 16, 32 and 37 °C. Kandil Mervat (2013).

The objectives of the current study were to investigate the effect of constant temperatures and fed on bell pepper, *Capsicum annuum* on some biological aspects and biochemical of *H. armigera* in order to determine the lower threshold temperature.

## **MATERIALS AND METHODS**

### **1- Host plant:**

The host plant used in this study was: bell pepper, *Capsicum annuum*

### **2- Insect rearing:**

The American bollworm, *H. armigera*, (ABW) larvae were collected from bell pepper fields of Zagazig district and placed individual in glass tubes in November 2016 and incubated under laboratory at a temperature of  $27 \pm 1^\circ\text{C}$  and  $70 \pm 5\%$  RH and light period 14 light :10 dark. The larvae were feed daily on bell pepper fruits washed with water until pupation. Pupae were transferred to clean glass tubes and incubated until moth emergence. When adults emerged, moths were sexed and (five pairs) in each cage and it left till egg laying. Moths were provided with 10% sugar solution on a cotton swab. The laid eggs were separated daily and placed in glass jars. The eggs incubated on the previous laboratory conditions until hatching.

### **3- Effect of temperature and host plant on the American bollworm:**

The newly hatched larvae were transferred individually to glass tubes (3.5 x 7 cm) containing bell pepper and changed daily with fresh one until pupation. 450 glass tubs were prepared as three treatments: 21, 24 and 27 °C. Each treatment was divided into three replicates 50 larvae in each replicate. Tubes were examined daily until larval pupation to record larval duration and larval mortality percentages. Pupae were transferred to clean glass tubs and examined until moth emergence to record pupal duration, pupal mortality and pupal weight. When adults emerged, moths were sexed and caged to egg laying. Five replicates of two pairs/each treatment. Moths were provided with 10 % sugar solution. The cages was inspected daily until moth death. The pre-oviposition, oviposition and post- oviposition periods and longevity of adult females and males were calculated. Eggs laid on the same day in each temperature was placed in glass jar and incubated under the same temperatures. Three replicates of 100 eggs/each treatment. Incubation periods were calculated.

### **4-Statistical analysis:**

The effect of host plant, and temperatures degrees on developmental time of *H. armigera* was determined by one way analysis of variance (ANOVA) and Duncan's multiple range tests of means were used (Duncan's, (1957). The relationship between temperature and mean developmental rate of each stage and generation under tested temperature was determined using liner regression. For tested temperature degree in each treatment, developmental rate (DR) was calculated as reciprocals of development time (D) for each stage ( $DR = 1/D$ ). The relation between developmental rate and temperature (T) was determined using liner regression equation:  $DR = a + bT$ , whereas: a and b parameters of the liner regression.

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The lower developmental threshold ( $t_0$ ) was determined:  $t_0 = -a/b$ . Thermal units (degree days= $DD^{\circ}$ ) required for complete development of larvae were calculated according to Arnold (1959).  $DD\text{'s} = d*(T-t_0)$  whereas  $d$ = duration,  $T$ = temperature and  $t_0$  = lower developmental temperature.

### **5- Biochemical analysis:**

To study the effect of temperature on some biochemical parameters. The samples of ABW larvae were collected after 14 days at 21, 24 and 27 °C and kept in clean tubes in a refrigerator at 4 °C for chemical analysis. Total protein, lipids and carbohydrate were determined colorimetrically according to Koller (1984).

## **RESULTS AND DISCUSSION**

### **Duration of different stages:**

Data in Table (1) showed the durations of ABW different stages reared on bell pepper at three constant temperatures 21, 24 and 27°C was decreased as temperature increased. The incubation periods of ABW reared on Bell pepper were 4.10, 3.70 and 2.50 days at 21, 24 and 27°C, respectively. The average of incubation periods was 3.43 days.

The larval durations were 28.00, 23.66 and 17.07 days when the larvae reared on bell pepper at 21, 24 and 27°C, respectively. The average of larval duration was 22.91 days. The pupal duration of the ABW were 17.00, 11.75 and 10.00 days, respectively. The average of pupal duration was 12.91 days. The pre-oviposition periods were 3.40, 2.90 and 2.10 days, respectively whereas the average was 2.80 days. The oviposition periods were 11.10, 10.00 and 7.33 days, respectively. The post-oviposition periods were 4.10, 3.00 and 2.00 days, respectively. The adult females longevity were 18.60, 15.90 and 11.43 days, respectively. Regarding generation period, (egg to egg), data indicated that ABW, generation on Bell pepper were 52.50, 42.01 and 31.67 days at 21, 24 and 27°C., respectively whereas the

average was 42.06 days. Jallow and Matsura (2001) studied that the effect of temperature was studied on the rate of development for *H. armigera* reared on tomato. The duration of different life history stages decreased as temperature increased from 13.3 to 32.5 °C. A development threshold of 10.5, 11.3 and 13.8 °C was estimated for the eggs, larvae and pupal stages, respectively. Zhudong Liu *et al.*, (2004) they stated that *H. armigera* was reared on six host plants: cotton, corn, tomato, hot pepper, tobacco and common bean. They found that the larvae were successfully survived on all six host plants, although mortality was very high on hot pepper and tomato. The developmental time of immature stages reared on hot pepper and tomato were 32.91 and 27.96 days, respectively. Al-Shannaf and El-Sayed (2010) found that increasing the temperature from 20 to 30 °C caused decreased in the duration of the different stages of *Spodoptera littoralis*. Larval and pupal developmental periods were influenced by the host plants. Zero developmental temperature ( $t_0$ ) differed according to the host plant fed.

### **Rate of development:**

Data in Table (2) showed that the average of developmental rate for the ABW different stages increased as temperature increased it were 0.29, 0.04, 0.07, 0.35 and 0.02 for eggs, larvae, pupae, pre oviposition period and generation at 21, 24 and 27°C., respectively. Amer and El-sayed (2015) they found that temperatures ( 23, 27 and 30 °C ) tested were increased led to an increase in the developmental rate and reduces the development periods of the different stages of ABW. The generation period of *H. armigera* reared on lettuce was shorter (32.23 days) than that reared on pea (34.70 days). The lower developmental temperatures were 11.60 and 11.39 °C for the generation and the thermal units required were 467.13 and 511.26 DD's, respectively when feed on lettuce.

**Table (1): Duration of different stages of the *H. armigera* reared on *Capsicum annuum* at constant temperatures**

Stages	Temperature degrees			
	21°C	24°C	27°C	Average
Egg	4.10	3.70	2.50	3.43
Larva	28.00	23.66	17.07	22.91
Pupa	17.00	11.75	10.00	12.91
Pre-oviposition period	3.40	2.90	2.10	2.80
Ovi- oviposition period	11.10	10.00	7.33	9.47
Post oviposition period	4.10	3.00	2.00	3.03
Adult	18.60	15.90	11.43	15.31
Generation	52.50	42.01	31.67	42.06

**Table (2): Development rate of different stages of the *H. armigera* reared on bell pepper, *C. annuum* at constant temperatures**

Stage	Temperature degrees °C			
	21 °C	24 °C	27 °C	Average
Egg	0.24	0.27	0.40	0.29
Larva	0.03	0.04	0.05	0.04
Pupa	0.05	0.08	0.10	0.07
Pre-oviposition period	0.29	0.34	0.47	0.35
Generation	0.01	0.02	0.03	0.02

**Lower developmental threshold:**

The lower developmental threshold for ABW different stages reared on Bell pepper were 12.30, 11.50, 11.85, 11.90 and

12.50°C for egg, larvae, pupae, pre oviposition and generation, respectively Table (3).

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**Table (3): Lower threshold temperature for different stages of the *H. armigera* reared on *C. annuum***

Stage	Regression equation		Lower threshold temperature (°C)
	a	b	
Egg	-0.32	0.026	12.30
Larva	-0.046	0.004	11.50
Pupa	-0.083	0.007	11.85
Pre-oviposition period	-0.357	0.03	11.90
Generation	-0.025	0.002	12.50

Mironidis and Savopoulou (2008) stated that the lowest developmental thresholds of the immature stages of *H. armigera* was reared on an artificial diet and it were estimated by a linear model and ranged from 10.17 (pupal stage) to 11.95 °C (egg stage) at constant temperature regimes. Mean adult longevity fluctuated from 34.4 day at 15 °C to 7.6 day at 35 °C.

**Thermal units requirement:**

The average thermal units (degree-days) required for egg development till hatched was 38.57 DD's. The average of the thermal units required for larval complete development was 275.45 DD's. The average of the thermal units required for pupal development until moths emergence was 149.94 DD's. While, for pre-oviposition period the average of the thermal units required was 32.58 DD's. The average of thermal units required to complete generation period was 462.86 DD's Table (4). Zaslavski, (1988) found that the thermal requirements of development were often used for estimating developmental times because temperature has a major effect in determining the rate which *H. armigera* develop.

**Biological aspects of American bollworm reared on bell pepper at constant temperature:**

**Larval stage:**

The mean larval weights were decreased significantly as temperature increased. The average mortality percentage of larval stage was 38.98 days.

**Pupal stage:**

Data given Table (5) showed that the pupal weights were decreased significantly as temperature increased when female fed on Bell pepper. The pupation percentages were 46.00, 66.00, and 77.00 %. The pupal mortality was increased significant as 18.12 %. Increase the temperature from 21 to 27 degrees caused shorten the duration of the larvae, pupae, weight and pupation percentage while larval mortality percentage was decreased.

**Adult emergence percentage:**

Data given in Table (6) showed that temperature was effect significantly on adult emergence percentage were 75.00, 81.74 and 88.89 %, respectively.

**Adult female longevity:**

The pre-oviposition and oviposition periods were significantly increased as temperature increased while the average of post-oviposition was 3.03 day. The female and male longevity of the ABW moths was high significantly effect under different

temperatures and it were 15.31 and 13.05 days, respectively.

**Eggs laying:**

Data given in Table (6) showed that the average number of eggs deposited per female were high significant affect with temperature.

**Hatchability percentage:**

The hatchability percentages of ABW eggs were 76.00, 80.00 and 83.00 % at 21, 24 and 27 °C, receptively (Table, 6). The hatchability percentages were increased as temperature increased. Greenberg *et al.*,

(2001) found that development times and life table parameters of *Spodoptera exigua*, were determined on five host plants: cabbage, *Brassica oleracea capitata*; cotton, *Gossypium hirsutum*; bell pepper, *Capsicum annuum*; pigweed, *Amaranthus retroflexus*; and sunflower, *Helianthus annuus*. Significant relationships were found between pupal weight and subsequent adult fecundity on all host plants. Duration of the larval stage was shortest on pigweed (12.4 d) and longest on pepper (18.0 d). Larval survival was highest on pigweed (94.4%) and lowest on cabbage (67.1%).

**Table (4): Thermal unit for different stages of the *H. armigera* reared on *C. annuum***

Stage	Temperature degrees°C			
	21 °C	24 °C	27 °C	Average
Egg	35.67	43.29	36.75	38.57
Larva	266.00	295.75	264.59	275.44
Pupa	155.55	142.76	151.50	149.93
Pre-oviposition period	30.94	35.09	31.71	32.58
Generation	446.25	483.11	459.21	462.86

**Table (5): Biological aspects of immature stages of *H. armigera* reared on *C. annuum***

Temperatures	Larval stage			Pupal stage			
	duration days	weight g	Mortality %	duration days	weight g	Pupation %	Mortality %
21°C	28.00a	0.31a	54.00a	17.00a	0.28	46.00c	25.00a
24°C	23.66b	0.30a	34.00b	11.75b	0.25	66.00b	18.26b
27°C	17.07c	0.26b	28.94b	10.00b	0.23	71.06a	11.11c
Average	22.91	0.29	38.98	12.91	0.25	61.02	18.12
P	0.0008**	0.0104*	0.0001**	0.0015**	Ns	0.0001**	0.0032**
LSD <sub>0.05</sub>	3.48	0.03	5.88	2.61	-	6.24	5.78

NS : Non-significant    \*:Significant    \*\*:Highly significant

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**Table (6): Adult longevity and reproductive potential of *H. armigera* reared on *C. annuum***

Temperatures °C	Adult emergency%	Ovipositional period/ days			Longevity (days)		No. of eggs/female	Hatchability %
		Pre-oviposition	Oviposition	Post-oviposition	Female	Male		
21°C	75.00c	3.40a	11.10a	4.10a	18.60a	15.90a	250.0c	76.00
24°C	81.74b	2.90b	10.00a	3.00b	15.90a	12.75b	371.0a	80.00
27°C	88.89a	2.10c	7.33b	2.00c	11.43b	10.50b	297.0b	83.00
Average	81.87	2.80	9.47	3.03	15.31	13.05	306.0	79.66
P	0.0002**	0.0003**	0.0131*	0.000**	0.0032**	0.0078**	0.0001**	ns
LSD <sub>0.05</sub>	3.46	0.35	2.15	0.13	3.01	2.69	28.02	-

NS : Non-significant    \*:Significant    \*\*:Highly significant

**Biochemical analysis:**

**Total soluble protein:**

The total soluble protein were 8.78, 37.43 and 29.98 mg/ml, respectively. From these data can be concluded that the high level of total soluble protein 37.43 at 24 °C while the lowest values was 8.78 at 21 °C Table (7).

**Total lipid:**

Data in Table (7) indicated that the total lipid contents were 229.68, 280.82 and 173.96 mg/ml, when larvae reared at 21, 24 and 27 °C, respectively. From these data can be concluded that the high level of total lipid 280.82 mg/ml at 24 °C while the lowest values was 173.96 mg/ml at 27 °C.

**Total carbohydrates:**

Data in Table (7) show that the total carbohydrates in *H. armigera* larvae reared on Bell pepper at 21,24 and 27 °C were 15.61, 23.71 and 28.41 mg/ml. From these data can be concluded that the high level of total carbohydrates 28.41 at 27 °C while the lowest values was 15.61 mg/ml at 21 °C.

Keeley (1985) recorded that in insect adult females, the major function of the fat

body is the synthesis and release of vitellogenic proteins and lipids for yolk formation during oocyte maturation. Also, decreased the total lipid caused decreased on the mean number of eggs and hatchability percentage for *Spodoptera exigua* adult. Kandil Mervat (2013) tested temperatures 16, 21, 32 and 37 °C caused high reduction in total soluble protein in larvae compared to the larvae reared at 26 °C. indicated that the high reduction in total lipid contents were 2.15, 4.89, 2.88 and 1.69 mg/ml, when larvae reared at 16, 21, 32 and 37 °C, respectively, compared with 26 °C, which recorded the high level of total lipid (8.07 glucose activity greatly reduced in *E. insulana* larvae reared on okra at 16, 32 and 37 °C.

In conclusion, the decreased as temperature from 24 to 21 °C caused decreased in total lipid, total protein and total carbohydrate but 24 to 27 °C caused decreased except carbohydrate caused increased. The reduction in total lipid, total protein and total carbohydrate caused reduction in the number of deposited eggs of *H. armigera* adult female.

Table (7): Effect of temperatures on some biochemical analyzed of *H. armigera*

Temperatures °C	Total Protein mg/ml	Total Lipid mg/ml	Total Carbohydrate mg/ml
21 °C	8.78	229.68	15.61
24 °C	37.43	280.82	23.71
27 °C	29.98	173.96	28.41

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## **تأثير درجات الحرارة على بعض الخصائص البيولوجية لدودة اللوز الأمريكية في علاقة المحتوى البيوكيميائي**

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### **الملخص العربي**

أجريت هذه التجربة تحت الظروف المعملية فى معهد بحوث وقاية النباتات - قسم بحوث ديدان اللوز بهدف دراسة تأثير درجات الحرارة 24، 21 ، 27 درجة مئوية على بعض الخصائص البيولوجية والكيميائية لدودة اللوز الأمريكية المرباه على ثمار الفلفل الرومى .

أظهرت النتائج ان فترة الحضانه لبيض دودة اللوز الامريكية كانت 4.01 ، 3.70 ، 2.50 يوم عند درجات الحرارة 21، 24 ، 27 درجة مئوية، على التوالي. طالبت مدة الطور اليرقى والعذارى بزيادة درجة الحرارة المرباه عليها وسجل مدة الجيل 52.50 يوم عند درجة الحرارة 21 مئوية ، وقصرت مدة الجيل الى 31.67 يوم عند درجة حرارة 27 مئوية. أوضحت النتائج ان صفر النمو كان 12.30، 11.50، 11.85، 11.90 ، 12.50 درجة مئوية لكل من طور البيض والطور اليرقى والعذارى وفترة ما قبل وضع البيض ومدة الجيل ، على التوالي. كان متوسط الوحدات الحراريه 38.57، 275.44، 149.93، 32.58 ، 462.86 وحده ، على التوالي . كما أوضحت النتائج تأثير مجموع البيض الموضوع معنويا بدرجة الحرارة . كما أوضحت النتائج أنه بانخفاض درجة الحرارة من 24 الى 21 درجة مئوية سبب خفض فى الدهون والبروتين والكربوهيدرات ، ولكن عند زيادة درجة الحرارة من 24 الى 27 درجة مئوية حدث خفض فى الدهون والبروتين وزيادة فى الكربوهيدرات .