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ECOLOGICAL AND BIOLOGICAL INVESTIGATIONS ON *HELIOTHES ARMIGERA* INFESTING EGGPLANT CROP

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ABSTRACT: Field experiments were conducted at Shbeen EL-Kom ; Menoufia Governorate during winter and Nil plantation of Eggplant, (*Solanum melongena L.*), Pepper (*Capsicun annuun L.*) belong to (family: *solanacae*) during (2019-2020 and 2020-2021) of growing seasons. the survey and population dynamic (seasonal fluctuation) of *Heliothes amigera* on eggplant and pepper vegetable crops were the main aimed for field studies. and rearing American bollworm, *Heliothes armigera* (Hubner) larvae with feeding on the eggplant and pepper vegetable fruit

In laboratory showed that there was negative correlation between temperature and all studied aspects under four constant temperatures of 18, 25, 30 and 34 ^{o}C each ± 1 ^{o}C A The time required for embryogenesis, larval duration and pupal duration decreased as the temperatures increased from 18 to 34 ^{o}C

Key words: Eggplant, *Heliothes armigera*, seasonal fluctuation, temperature, biological effects.

INTRODUCTION

Eggplant, (*Solanum melongena L.*) and Pepper (*Capsicun annuun L.*) belong to (family: *solanacae*) are a Vegetable food with a good sources of vitamins, minerals and carbohydrates, Neha and Ravi (2018). In Egypt, vegetables are subjected to be attacked by several pests. The piercing- sucking pests, cotton bollworm and cotton leaf worm which are the key economical important pests affecting vegetables. The eggplant (*Solanum melongena L.)* and Pepper (*Capsicun annuun L.*) plants vegetables that are affected by several pests such as.

Cotton bollworms (*Heliothes armigera*) is a polyphagia species, that attacks been effecting on over 180 cultivated hosts and 45 families of wild plant species of crops. This insect attacks vegetable in the field. The moth develops two generations a year of winter as a pupa in the soil. The larvae eat the epidermis of the leaves, and after that penetrates the fruit to consumed the pulp and the seeds. The fruits cannot be consumed due to excrement s from the inside. A larva can destroy even 10 fruits.

MATERIALS AND METHOD

Field studies

Field studies were carried out during the two successive seasons (2019- 2020 and 2020-2021). One site was the experimental for eggplant and anther one for pepper; each area was 360 m^2 located at the Experimental field chosen for this study, i.e. Menoufia, Governorate. The chosen areas at eggplant and pepper received all agricultural practices. the chosen areas were kept free of any insecticidal application.

-Population dynamics of H. armigera

Samples of 20 (flowers and fruit) were collected randomly from the two diagonals of the field and from the experimental area weekly intervals throughout the two seasons of the study. Samples of vegetable plants were kept in muslin bags and brought to the laboratory to be examined by naked eyes. Samples were collected around 1st week of October the number and percentages of infestation were recorded. Also, the pests were estimated in fields samples 1st week of August to 2nd week of November, during the two seasons of the study.

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Laboratory studies

1- Effect of different constant temperaturs on some biological aspects of *H. armigera*

Insect Rearing

H. armigera; different stages were originally collected as larvae and pupae from the eggplant field in Menoufia Government Egypt and maintained for over one generation under controlled conditions at 26 ± 1 °C and 55–65 % relative humidity. Larvae were fed and Pupae were sexed and placed in cages separately. After mergence, male and female adults mated in nylon cages. 3-day-old, mated females were kept at cages test. To verify the mating status, tested females were dissected and provided with a 10 % honey solution.

RESULTS AND DISCUSSION

Seasonal abundance of *H. armigera* and their relationship to temperature and relative humidity

H. armigera

Data recorded in Tables (1& 2) and (Figs 1 & 2) show that the occurrence of *H. armigera* started from the 1st standard week November and reached peak level in the 2nd week and end week of December with a larval population of 25 and 15 larvae per 20 plants when the temperature ranges from 20.0°C) insect on the pepper plant during the 2019-2020. While 2020-2021 seasons at winter and Nile loop of agriculture, recorded two peeks the first one in 2nd week of December 21 larvae/20 plant and the 2nd peek recorded by 17 larvae on 2nd week of October.

2. Biological studies

2-1- Effect of four temperatures on some biological aspects of *Heliothes armigera* (Hübner)

Heliothes armeigera

All the *H. armigera* stages were kept under four constant temperatures at 18, 25, 30 and 35 °C to determine the rate of development. Temperature has a clear significant effect on the biology of the American bollworm insect, and this was demonstrated by studying the effect of four fixed degrees on the different stages of the insect.

Table (1): Seasonal abundance of *H. armigera* on eggplant plants during (2019 -2020) and (2020-2021) seasons in winter planting season.

Date of survey	*Heliothes*		Temperature (°C)		Humidity (%)	
	2019-2020	2020-2021	2019-2020	2020-2021	2019-2020	2020-2021
1/11	0.0	3	25	26	46.9	65.1
10/11	4	9	23	24	64.7	66
20/11	10	11	23	21	77.4	56.5
30/11	2	8	23	22	36	68.8
12/12	22	2	20	20	70.1	53.4
20/12	8	1	19	17	50.3	45.4
30/12	1	1	17	16	59.6	79.3
10/1	0.0	3	17	14	47.8	83.1
20/1	18	3	18	17	72.7	89.5
30/1	9	17	18	15	59.8	61.6
10/2	9	5	19	16	56.2	46.4
20/2	7	4	19	17	54	63.7
1/3	5	13	20	18	14.4	62.2

Table (2): Seasonal abundance of major insect pests on eggplant plants during (2019 -2020) and (2020-2021) seasons in Nile planting season.

Date of survey	*Heliothes*		Temperature (°C)		Humidity (%)	
	2019-2020	2020-2021	2019-2020	2020-2021	2019-2020	2020-2021
20/7	2	6	34	34	46.9	65.1
30/7	2	3	34	35	64.7	66
10/8	3	7	36	37	77.4	56.5
20/8	4	11	37	37	36	68.8
30/8	4	21	37	38	70.1	53.4
10/9	8	8	33	34	50.3	45.4
20/9	15	10	34	34	59.6	79.3
30/9	17	7	33	34	47.8	83.1
10/10	7	5	32	30	72.7	89.5
2010	5	1	27	26	59.8	61.6
30/10	7	2	27	26	56.2	46.4

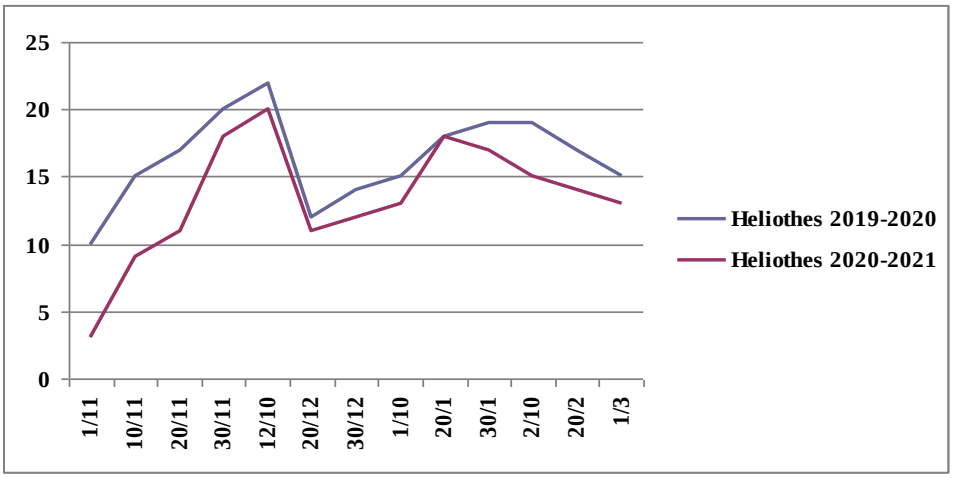

Fig. (1): Seasonal abundance of *H. armeigera* on eggplant in winter planting season.

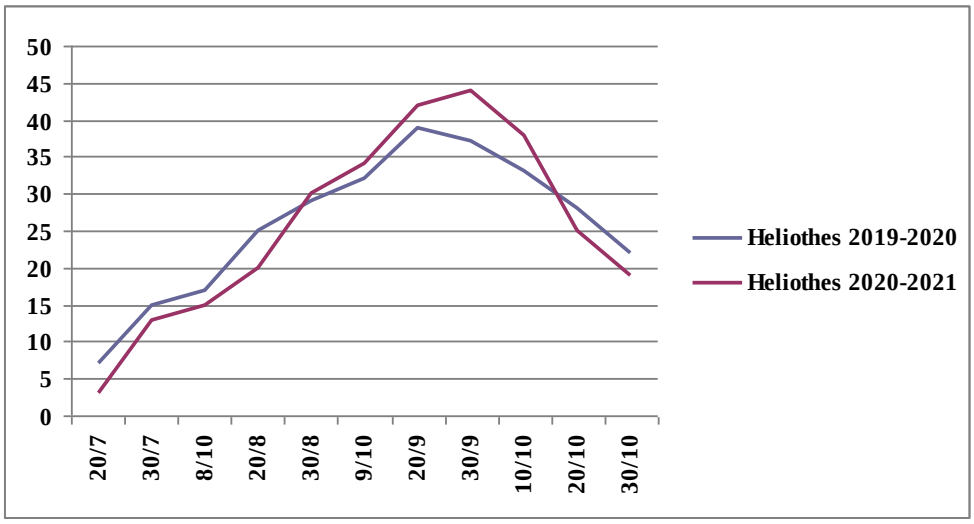

Fig (2): Seasonal abundance of *H. armeigera* on eggplant in Nile planting season.

2-1-1 Egg stage

Incubation period

Data showed that the required time for completion of *H. armigera. The* embryogenesis decreased gradually as the temperature increased from 18 to 34 °C. The mean of incubation 18.00±1.15, 20.67±1.20, 29.33±0.67 and 12.67± 0.88, respectively. Statistically analysis revealed that highly significantly difference between, between all incubation period resulted at the different temperatures, were recorded.

Egg hatchability

Data represented in Table (3) stated that the averages hatchability of *H. armigera* were as follows; 60.00, 87.87, 97.77 and 42.21 at 18, 25, 30 and 34, respectively. Statistically, there were significant differences between the hatchability percentages recorded at 18, 25, 30 and 34 °C. It is clearly noticed that the constant temperature in the range of 25 to 30 °C is the favorable zone for the hatching of *H. armigera.*

The results in the previous table indicated the effect of temperature on the hatching rate and the incubation period of the eggs. The results indicated that the high or low temperature from the appropriate temperature led to a decrease in the hatching rate. Also, the increasing in temperature led to a significant shorted the incubation period of eggs, as well as when the temperature decreased, it led to a prolongation of the incubation period of eggs. Figs. (3 and 4) Showed a positive correlation between the hatching rate and temperature.

2-1-2- Larval stage

Data in Table (4), Showed the expected larval *H. armigera* duration values at four constant temperatures; 18, 25, 30 and 34 °C were 22.67, 18.67, 14.33 and 9.00 days / larva, respectively, there were obvious significant differences between the mean larval duration at the four constant temperatures. Generally, the developmental rates of the *H. armigera* larvae decrease with the increasing of the constant temperature from 18 to 34 °C.

Table (3): Hatchability% and incubation time of the American bollworm eggs under three constant laboratory conditions

Temp. °C	**Egg stage**		
	No. of Hatchability	**Hatchability%**	**Reduction**
18	18.00±1.15^{b}	60.00±3.85^{b}	40.00±3.85^{b}
25	20.67±1.20^{b}	87.87±4.01^{b}	31.13±4.01^{b}
30	29.33±0.67^{a}	97.77±2.23^{a}	2.23±2.23^{c}
34	12.67±0.88^{c}	42.21±2.94^{c}	57.67±2.96^{a}
Variance analysis			
Mean Square	145.22	1613.68	1607.69
F	48.41	48.32	47.99
Sig.	0.000	0.000	0.000
probability	**	**	**
L.S.D. 0.5	3.26	10.88	10.90

a, b, c, Differences between values having the same high script in each column are not significant. ** Significant differences at P≤ 0.01. * Significant differences at P ≤ 0.05 N.S. non-significant differences

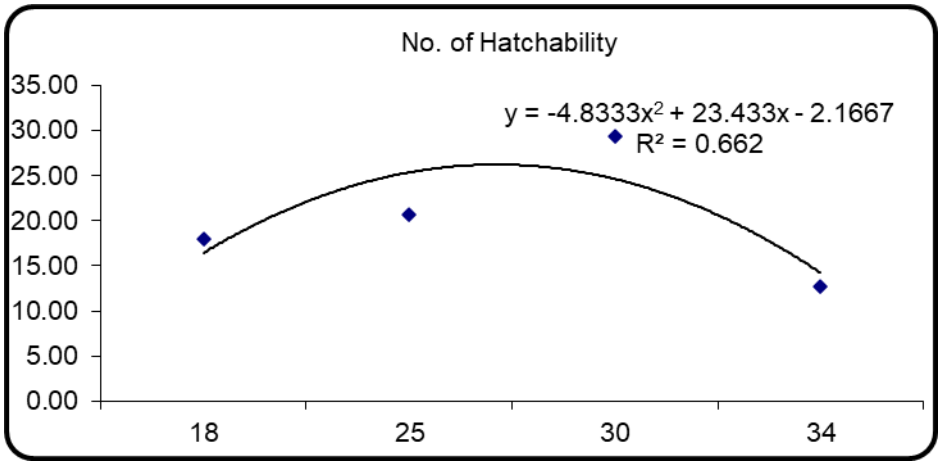

Fig (3): Recreation line and positive correlation relationship between No. of hatchability ***H. armigera*** **and temperature.**

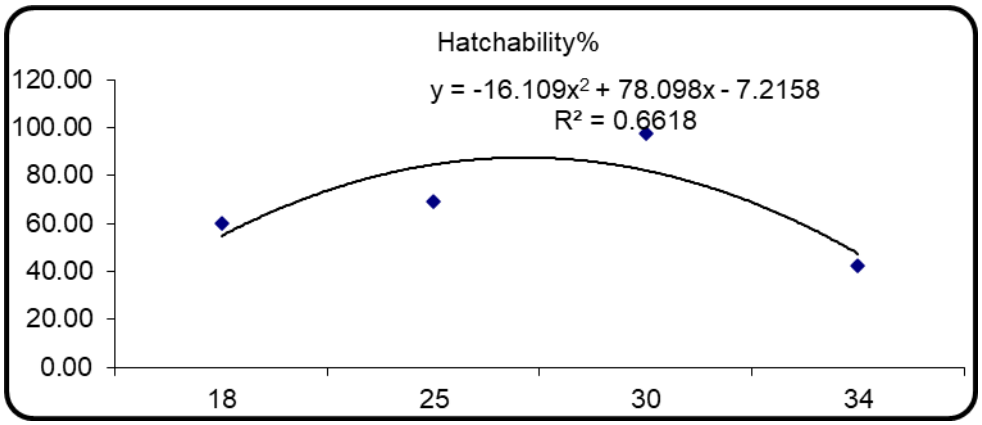

Fig (4): Recreation line and positive correlation relationship between % of hatchability ***H. armigera*** **and temperature**

Table (4): Rearing of American bollworm larvae under four constant laboratory conditions.

Temp. °C	**Larval stage**			
	No. of mortality	**Duration in days**	**Malformed%**	**Reduction**
18	9.33±0.88[a]	22.67±0.88[a]	3.33±0.67	13.33±1.86[a]
25	2.67±0.33[c]	18.67±1.20[b]	3.33±0.88	6.00±1.00[b]
30	5.33±0.88[b]	14.33±0.88[c]	1.67±0.88	7.67±1.76[b]
34	10.67±0.67[a]	9.00±0.58[d]	4.33±0.67	15.00±1.15[a]
Variance analysis				
Mean Square	40.44	103.22	3.67	56.56
F	25.54	41.29	2.00	8.48
Sig.	0.000	0.000	0.193	0.007
Probability	**	**	N.S.	**
L.S.D. 0.5	2.37	2.98	2.55	4.86

(a, b, c,) Differences between values having the same high script in each column are not significant; ** significant differences at P≤ 0.01; * significant differences at P ≤ 0.05.; N.S. non-significant differences

Also in Table (4) showed the larval mortality and malformation larvae of *H. armigera*. The mortality rates were 9.33, 2.67, 5.33 and 10.67 at 18, 25, 30 and 34 C, respectively.

From the previous table, it is clear that temperature has an effect on the larval stage, as high temperatures led to a shortening of the larval lifespan, and the opposite happened when temperatures decreased, which led to a lengthening of the larval duration. Therefore, the difference in temperature had a significant effect on the larval duration and it led to a significant increase in the percentage of deformities mortality (Fig. 5-7).

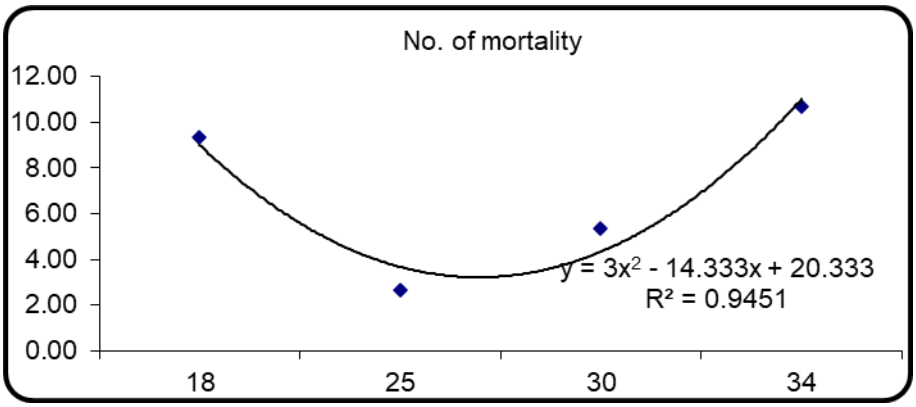

Fig (5): Recreation line and positive correlation relationship between mortality and temperature.

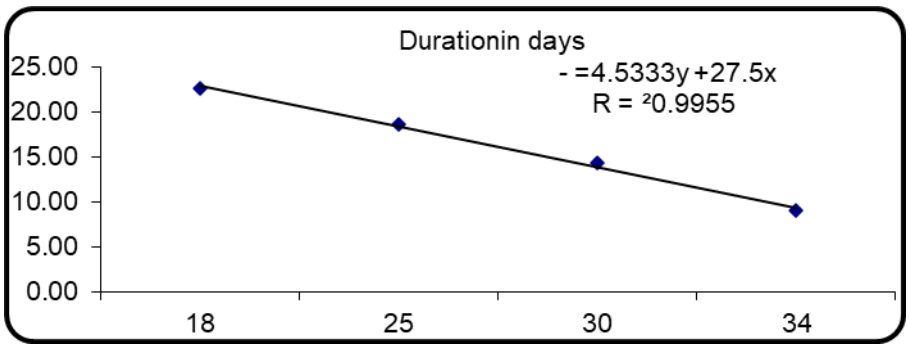

Fig (6): Recreation line and positive correlation relationship between mortality and temperature.

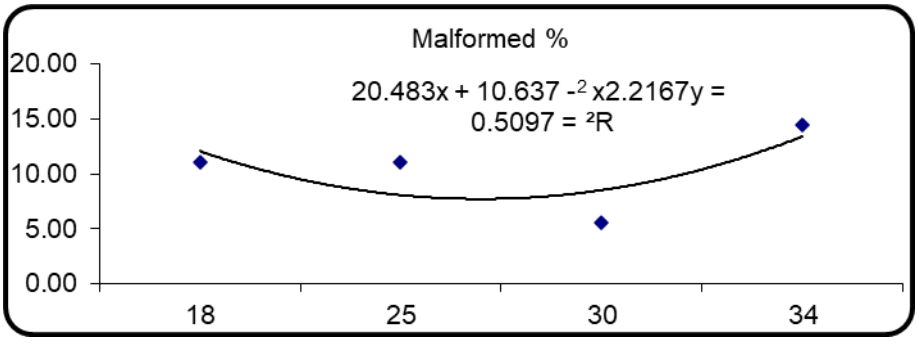

Fig (7): Recreation line and positive correlation relationship between mortality and temperature.

2-1-3 Pupal stage

Data given in Table (5) indicated that the time required for pupae of *H. armigera* completed the development pupation, was 12.33±1.20 days at 18 °C followed by 7.33±0.33 days at 25 °C, 5.67±0.67 days at 30 °C and 3.33±0.33 days at 34 °C. Whereas an extremely high reduction of this rate of pupal former or non-completed the development was occurred at 18 °C, (13.33±1.86%) and at 34 °C (15.00±1.15%) (Fig. 8). Also, it is clear that the constant temperatures in the range of 25 °C was the effective temperature zone for *H. armigera* development and the optimum degree of temperature may be around 25 °C. There are significant differences between the value of pupation rates at the four different constant temperatures; i.e. 18, 25, 30 and 34 °C. Also pupal stage were significantly affected.

Table (5): Rearing of American bollworm pupal stage results from larvae under four constant laboratory conditions.

Temp. °C	Pupal stage		
	No. of mortality	Duration	Reduction%
18	20.00±1.15^{ab}	12.33±1.20^{a}	13.33±1.86^{a}
25	0.67±0.33^{b}	7.33±0.33^{b}	6.00±1.00^{b}
30	2.67±0.88^{ab}	5.67±0.67^{cd}	7.67±1.76^{b}
34	40.00±0.58^{a}	3.33±0.33^{d}	15.00±1.15^{a}
Mean Square	5.78	43.67	46.33
F	3.01	27.58	26.21
Sig.	0.094	0.000	0.000
Probability	N.S.	**	**
L.S.D. 0.5	2.61	2.37	0.641

(a, b, c,) Differences between values having the same high script in each column are not significant ---** significant differences at P≤ 0.01; * significant differences at P ≤ 0.05. N.S. non-significant differences

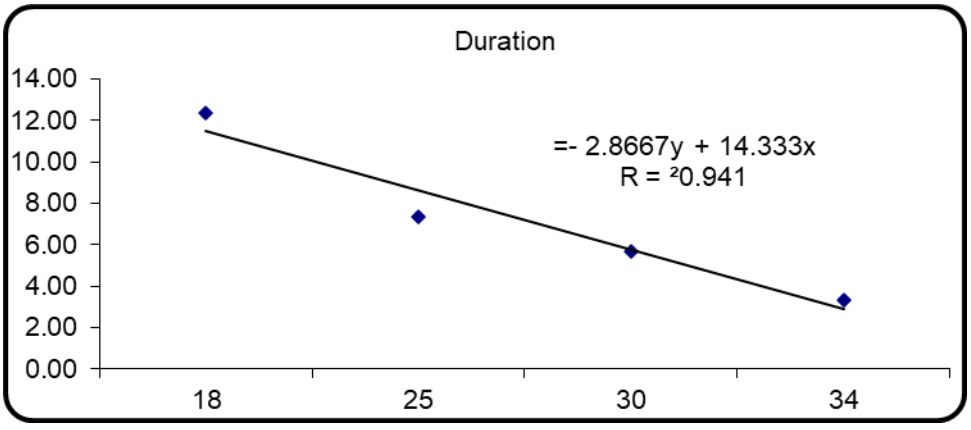

Fig (8): Recreation line and positive correlation relationship between duration pupal stage and temperature.

From our previous results recorded in Table (5) it clear that that likewise, high temperature led to a shortening of the pupal period, and prolongation occurred when the temperature decreased, with an increase in the rate of death and deformities. The results indicated that the pupae different in produced from the larvae of the previous treatment were under four constant temperatures in the laboratory. The increase in temperature led to a shortening duration of the pupal stage and a decrease in deformities, but the opposite occurred when the temperatures decreased, as the pupal period was prolonged and the deformities increased in the resulting pupae.

2-1-4 Adult emergence

Data recorded in Table (6), showed that the temperatures has a clear high significant effect on percent of the American bollworm adults emergence, when reared at 4 fixed degrees of different temperatures. The data recorded that 88.0% at 25 °C, while it decreased gradually to 45.0 and 20.0% at 30 and 18 °C until reached in decreased to (0.0%emargence) no adult emergence at 34 °C.

Adults' lifespan (longevity)

The effect of 4 fixed degrees of different temperatures on producing adults is illustrated in Table (6). Results indicated that the lifespan (longvity) of the *H. armigera* adult stages reared was prolonged to 9.26 and 7.66 days for female and male at 25 °C compared to that previously reared at 30, which recorded 5.6 and 4.66 days for femal and male at 30. °C. oviposition time of *H. armigera* adult females that emerged from reared at both tested temperatures was considerably shorter (3.0 days at 30. °C) compared to 4.66 days at 25 °C. (Table 6). On the other hand, the pre - oviposition estimated value of *H. armigera* female significantly in time estimated it decreased from 2.3 days at 25 °C. to 1.3 days at 30 °C.

Fecundity

The total number of laid eggs per *H. armigera* female were 787.3 eggs/ female with an average of 17.30 eggs/ day when reared on the laboratory at 25 °C., but, the numbers decreased significantly to 253.33 eggs/ female (with an average number daily 12.97 eggs/ day) at 30 °C. (Table 7).

Hatchability percentage

As shown in Table (7), the mean hatchability percentage of *H. armigera* deposited eggs were (66.43%) when previously reared at 25 °C., however, reduced to 36.81 % when reared at 30 °C.

Table (6): Rearing of American bollworm adult stage results from pupae formed at four constant temperatures.

Temp. °C	Adult stage					
	% of emergence	Pre-ovi	Oviposition	Post-ovi	Longevity	
					Female	Male
18	20[a]	2.0±0.20[b]	0.0	0.0	2.0±0.10[a]	0.0
25	88.0[c]	2.3±0.10b	4.66 ±0.30[b]	2.3±1.20[b]	9.26±0.60[a]	7.66±0.30[b]
30	45.0[b]	1.3±0.10[a]	3.0±0.20[a]	1.3±1.20[a]	5.6±0.3	4.66±010a
34	0.0					
Mean Square	2.8	1.87		13.33	4.35	1.71
F	13.01	11.58	5.14	3.21	2.11	1.65
Sig.	0.0104	0.000	0.001	0.000	0.000	0.0001
Probability	S***	**	**	**	**	***
L.S.D. 0.5	7.794	0.537	0.213	0.641	1.35	0.839

(a, b, c,) Differences between values having the same high script in each column are not significant ---** significant differences at $P \leq 0.01$; * significant differences at $P \leq 0.05$. N.S. non-significant differences

Table (7): Reproductive and fecundity of American bollworm at four constant temperatures.

Temp. °C	Fecundity		
	No. of egg laid/	% hatchability	Reduction%
25	787.3±10.6[6]	66.34±5.3b	33.76±1.6a
30	253.33±8. 8[.ab]	36.81±1.76[a]	63.91±4.13[b]
Mean Square	13.28	24.17	26.83
F	11.01	20.58	16.31
Sig.	0.001	0.000	0.000
Probability	S***	***	***
L.S.D. 0.5	10.21	6.34	4.261

(a, b, c,) Differences between values having the same high script in each column are not significant ---** significant differences at P ≤ 0.01; * significant differences at P ≤ 0.05. N.S. non-significant differences

From the priors results George (2014) evaluated laboratory studies were conducted to assess the effect of temperature on the survival, development, longevity and fecundity of *Heliothes armigera* (Lepidoptera: Noctuidae) at eight different fluctuating temperatures with an amplitude ±9 °C under constant photoperiodic conditions of 16:8 h (L: D).

Said (2020) studied the threshold of development and thermal units' requirements for laboratory strain of Earias insulana Boisd. (Lepidoptera: Noctuidae) evaluated experiments at five constant temperatures of (12, 18, 23, 27, and 33 ± 2ºC) and relative humidity 65±5 % R.H. all stages were reared on an artificial diet without agar. Results of the total developmental period, percentages of adults' emergence, and longevity of females are significantly affected when reared at different temperatures. The total developmental period of the immature stages was shorter at high temperatures than that reared at low temperatures. also, the incubation period of egg significantly affected by different temperatures. (Jaleel, *et al.,* 2019). Studied conducted to explore the effect of different temperature on some biological parameters of *E. insulana*. Generally, Insect pests affected by abiotic factors in nature especially by temperature, and their biology, behavior, and fitness are greatly affected. There were various studies showing the effect of temperature on the development of different insects such as (Garrad, *et al.,* 2016 and Jaleel, *et al.,* 2018).

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دراسات بيولوجية وايكولوجية علي دودة اللوز الأمريكية التي تصيب بعض نباتات العائلة الباذنجانية

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الملخص العربي

الدراسات الحقلية :-

أجريت الدراسات الحقلية لدراسة الديناميكية السكانية (التقلب الموسمي) للدودة اللوز الأمريكية *Heliothes armigera* خلال عروتين الشتوى و النيلي على محاصيل الباذنجان *(solanum mologena L)* والفلفل *(Capsicun annuun L)* وتنتمي هذه المحاصيل الي عائله *(solanacae)* وذلك خلال (٢٠١٩-٢٠٢٠ و ٢٠٢٠-٢٠٢١) من مواسم الزراعة.

الدراسات المعملية:

دراسة تاثير أربع درجات الحرارة علي دودة اللوز الامريكية *(H. armigera)*

تم جمع اطوار مختلفة من دودة اللوز الامريكية *(H. armigera)* (يرقات وعذارى) من حقلى الباذنجان و الفلفل في المنوفية وتم تربية لمدة جيل واحد تحت الظروف المعملية علي درجة حرارة ٢٦ ± ١ درجة مئوية ورطوبة نسبية ٥٥-٦٥٪.تم تغذية اليرقات على قطع من الباذنجان و الفلفل .تم فصل العذاري في أأنابيب سعة (٣x١٢سم٢) و ملاحظاتها حتى خروج الاحشرات الكاملة. ثم عمل تجنيس للحشرات الكاملة (ذكور+ اناث) داخل كيدجات التربية وتم تغذية بمحلول سكرى بنسبة ١٠ ٪. و ذالك لدراسة تاثير درجات الاحرارة على نمو و تطور االاطوارالمختلفة لدودة اللوز الامريكية:

تم وضع البيض في نفس اليوم (أقل من ٢٤ ساعة) في برطمان زجاجي وحضنت تحت أربع درجات حرارة ثابتة (١٨ ، ٢٥، ٣٠و ٣٤ ± ١ درجة مئوية) و ٦٥-٧٠٪ رطوبة نسبية. تم استخدام ثلاث مكررات وتم ملاحظة و تسجيل فترات حضانة البيض و مدة طور اليرقات ومدة طور العذارة و كذالك نسب الموت و التشوة.

قد أوضحت النتائج ان هناك تاثير لدرجات الحرارة ١٨و ٢٥ و٣٠ و ٣٤ درجة مئوية علي مدة حضانة البيض و كذالك الاطوار المختلفة من يرقات او عذاري فكلما زادت درجات الحرارة ذات المدة الازمة لنمو كل طور من أطوار دودة اللوز الامريكية. و قد أدت درجات الحرارة العالية و المنخفضة الي خفض في نسب فقس البيض الى ٢.٩٤ ± ٤٢.٢١ علي درجة حرارة ٣٠ و كذالك زيادة في نسيب التشوة الى ٠.٦٧ ± ٤.٣٣ و زيادة نسب الموت في اليرقات الى ٠.٦٧ ± ١٠.٦٧علي درجة حرارة ٣٤ وزيادة نسبة الموت في العذارء ٠.٥٨± ٤.٠٠ علي درجة حرارة ٣٤ .