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Biology and life table of fall armyworm *Spodoptera frugiperda* (J.E. Smith) reared on turnip leaves in Egypt

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Abstract
Development of the Fall Armyworm *Spodoptera frugiperda* (J.E. Smith) was studied on constant temperatures (15, 20, 25, 30 and 35℃ ±1 ˚C), carried out in laboratory of Department Research Vegetable Pests at the Plant Protection Research Institute, Giza Governorate, during years 2021 and 2022. Development of immature stages was accelerated on tested temperatures. Total averaged of immature stages was 69.53±2.72, 52.93±1.43, 30.93±0.91, 23.20±0.69 and 15.96±0.36 days at 15, 20, 25, 30 and 35˚C, respectively. Generation period ranged between 78.53±2.65 and 18.03±0.37 days at 15 and 35˚C, respectively. Additionally, adult female survived slightly longer than male and fecundity was decrease at temperature (15˚C) than higher (30˚C). Estimated the threshold of development (t_o) to be 11.14, 10.50, 10.90 and 10.81 ˚C for egg, larval, pupal, and all immature stages, respectively. Thermal requirements (D.D′s) were 55.76, 225.50, 133.31, 414.05 and 472.21 heat units are required for completion the development of egg, larval, pupal, all immature and generation stages. Recorded the highest average numbers of eggs laid /female (Fecundity) and Hatching% (fertility) was 713.33±30.60 and Hatching% 98.13% at 30˚C. whereas, the mortality% were 17.90 & 1.61 and 16.00 & 2.79 % for larval and pupal, respectively. Also, highest the percentage of emergence was 98.33 % at 30 ˚C, and lower the percentage of emergence was 77.78 % at 15 ˚C. The life table analysis indicted that doubling generation time (DT) was 15.06, 10.19, 5.09, 3.74 and 3.01 days at 15, 20, 25, 30 and 35˚C, respectively. Also, the percentage of survival was 2.08, 2.66, 6.70, 8.30 and 2.98 at 15, 20, 25, 30 and 35˚C, respectively.

Keywords: fall armyworm, *Spodoptera frugiperda*, biology, life table, degree days

Introduction
During 1987 in America armyworm spread on a forage crop and caused great large Bermudagrass, *Cynodon dactylon* (L.) is widely used as a forage crop in the southern United States during this timing autumn army worm (FAW), *Spodoptera frugiperda* (J. E. smith) (Lepidoptera: Noctuidae) is a serious insect pest that infest Bermudagrass yield. During this year of the fall armyworm outbreak on the Bermudagrass yield, it affected the quality of the forage and stopped its growth, reducing the amount of forage and increasing its prices during this period. Chemical control was performed to control the activity of the insect [1], the present time the population of the armyworm has increased with second outbreak in America, from which it spread to the countries of the world, and the infestation caused great damage to the corn crop, estimated at about 17%. The fall armyworm (FAW) *S. frugiperda* feeds in large numbers on leaves and stems of more than 80 plant species, causing major damage to economically cultivated grasses such as maize, rice, cotton, sorghum, sugarcane but also other vegetable crop [2]. First time the current *S. frugiperda* has been identified and reported from Africa in 2016 and spread in many countries in a very short period of time. The infestation of the pest has been reported from various countries, including Africa, India, China, Korea, Thailand, Japan, Australia, Indonesia, Egypt and Philippines [3, 4].
The recent years in Egypt, Armyworm has been found on maize crop in early and late plantation, but late plantation are more infestation which proves the wide thermal range of the army worm. This biological study determines the range of thermal temperatures and stages of biological development that were reared on leaves of turnip plant. The life cycle is important because an insect's habitat, habits, change dramatically during the life cycle, depending on the life cycle and the feeding host. The results used to emergence of generations of Armyworm, they are useful in determining the early dates of infestation in the field and preparing for control.

Material and Methods
The experiment was carried out in laboratory of Department Research Vegetable Pests at the Plant Protection Research Institute, Giza Governorate, during years 2021 and 2022. Larvae of fall armyworm *Spodoptera frugiperda* (J. E. Smith) were collected from maize fields from Qaha city, Qalyubia governorate, then transferred at room temperature in the laboratory and divided into several plastic containers (40 x 20 x 15 cm) closed tight with gassy cap muslin

Fig 1: Plastic containers

As Fig. (1), Larvae were reared until pupal on fresh green turnip leaves (Family: Cruciferae, *Brassica campestris*). After the adult emergen and lays eggs transferred to the incubators experimental. From the beginning, each incubator contained 15 replicates in plastic container for the tested temperatures of 15, 20, 25, 30 and 35 ˚C and the relative humidity ranged between 55 - 75 ± 5 R.H % (Use hygrometer to measure R.H%) under photoperiod of 12L:12D until adult and the investigation was daily for all tested constant temperature.

The eggs incubation period

During the egg-laying period added are white papers sheet (10L x 15w, cm) as Fig. (2) to the female lay eggs and record number of eggs, the white paper change daily until the end of period. The piece of white leaves are removed with the laid eggs and distributed to the replicates and divided into several plastic containers with gassy cap muslin then transferred to the incubators on tested temperature, provided fresh turnip leaves Fig. (2) and changing daily until eggs hatching and start of larval duration, calculated the numbers of eggs laid (fecundity), hatchability percentage (fertility %) for each tested temperature.

Fig 2: White paper sheet

The larval duration

Newly hatched larvae feed daily on fresh turnip leaves show Fig.(5), remove faeces daily and washing of plastic containers with disinfect alcohol, larva instars six ages differentiate by molting skin and metamorphosis appearance [2], when increasing the larvae in replicate divide to the numbers to obviate cannibalism the larvae transferred when pupation to glass tube with saw dust and covered with fine muslin cloth secured with rubber band, record daily observation to calculate the number of larvae duration, mortality %.

The pupal duration

pupal duration provide layer fine saw dust in the glass tube (10 L x 6 w, cm) covering with fine muslin cloth secured with rubber band, as Fig.(3). The pupae were collected daily on the same day from replication on the tested temperature Fig. (3) and relative humidity and were observed daily until the emergence of adult insects, calculate the pupae period, pupal weight, mortality%.

Fig 3: Pupal in glass tube

The Adult

Insects emerging from the pupa add piece of white paper to lay the eggs and feed on concentrated sugar with water solution. Twenty adult female with males (1♂ + 1♀) were transferred on day of emergence and divded ten replicates into large glass container (16L x 10w cm) as Fig.(4), on the tested temperature and relative humidity. Calculated the number of eggs laid, emergence%, malformed %, pre-oviposition, oviposition, and post-oviposition periods, Adult longevity, life span, sex ratio, life table parameters, [5].

Fig 4: large glass container

Statistical analysis

The relationship between temperature and rate of development for each stage under temperatures was determined using the formula (1/Y), the points obtained when the reciprocal for time (1/y) in days are plotted against temperature (T ˚C) [6]. Determine the heat units required for the complete development of each phase according to the thermal aggregation equation [7]: also from the straight regression line for equation y= a±bx and we can determine the two constants t_o= -a/b (˚C) and K=1/b or K= y (t- t_o) in D.D′s. Also, Life table parameters were done according to Birch (1948) using the Life 48, BASIC, Computer Program, [8].

Where: a: constant term it is the y intercept, the place the line crosses y axis.

b: the developmental rate line slope. X: constant temperature (˚C).

t_o: temperature threshold of development in degrees centigrade.
K: The developmental heat constant in degree-days (D. D.′s).
y: developmental duration of a given stage.
t : temperature in degrees centigrade.

To study the prediction possibility for relation between heat unit accumulations (K) and the temperature data is transformed into heat units and served as a tool for studying insect population dynamics and predicting fall armyworm in the field. The developmental threshold value that has been estimated after constant temperature experiment carried out before. The following formula was used for computing the heat units (D.D′s) according to [9]:

$H = \Sigma HJ$
$HJ = (Max. + Min.)/ 2-C,$ if max.>C & min.>C.
$= (max.- C)^2 /2 (max.- min.)$ if max >C & min.<C
$= 0$ if max. <C & min.<C.
H = Number of accumulated heat units to emergence.
C = Threshold temperature.

Results and Discussion
Data obtained in Table (1), showed the results of rearing of fall armyworm *Spodoptera frugiperda* (J. E. Smith) on different temperatures, and they were as follows:

A. The Egg Stage
The results in Table (1) showed that difference in the periods of egg development, the period increased with decreasing temperature and decreased with increasing temperature, the average number of eggs layed (fecundity) for females during the oviposition period were 607.00±24.96, 613.15±23.59, 667.18±25.03, 713.33±30.60 and 693.31±26.62 eggs/female at 15, 20, 25, 30 and 35˚C, respectively. The eggs are laid in groups of one or two rows on top of each other on the added on white papers sheet, record hatching percentage (fertility) were 75.80, 80.43, 93.41, 98.13 and 97.60 % at 15, 20, 25, 30 and 35˚C, respectively. The newly laid eggs are pale green in color by the female, turns black to hatching. The egg mass appeared blurry due to the scales of the female body, some egg masses were also seen without scales, as Fig.(7). The average incubation period was recorded 13.13±0.84, 8.53±0.34, 3.53±0.13, 2.73±0.12 and 2.50±0.16 days at 15, 20, 25, 30 and 35˚C, respectively. Also, the different rate of development temperatures recorded 0.076, 0.117, 0.283, 0.366 and 0.400 at 15, 20, 25, 30 and 35℃, respectively. The estimated threshold of egg development (t_0) was 11.14 ˚C, the thermal units was (K) 55.76 D.D.′s, and gave R^2= 0.946.

B. The larval duration
At the beginning of the larval duration in the first instar the newly hatched larvae feed on the lower layer of fresh turnip leaves and feed on complete leaf in the last instar show Fig.(6), changing the leaves daily. The larval instar record are six instar old cannibalistic behavior when rearing larvae density in one plastic container, Cannibalism was higher among larvae in the fourth, fifth and sixth instar than the previous instar, Fig.(8). Data in Table (1) show that the average of larval duration was 33.67±1.62, 27.27±1.15, 17.40±0.55, 12.87±0.66 and 8.33 ±0.16 days at 15, 20, 25, 30 and 35˚C, respectively. Rate of development were 0.030, 0.037, 0.057, 0.078 and 0.120 at 15, 20, 25, 30 and 35℃, respectively. While, the estimated threshold of larval development (t_0) was 10.50℃, whereas the thermal units was (K) 225.50 D.D.'s, gave R^2= 0.929. In addition, the percentage of mortality for the duration of the larva reached 17.90, 13.37, 5.26, 1.61 and 4.77% at 15, 20, 25, 30 and 35℃, respectively.

C. The Pupal duration
The pupa of *S. frugiperda* is of the pupa obtect type and large and movement, the newly pupa greenish color in the pre-pupal period, depending on temperature the color of pupa is to reddish-brown in the pupa period, as shown in Fig.(9). Data in table (1), indicated that the average of pupal duration were 22.73±2.07, 17.13±0.17, 10.00±0.65, 7.60±0.23 and 5.13±0.14 days at 15, 20, 25, 30 and 35 ˚C, respectively. The rate of development recorded 0.044, 0.058, 0.100, 0.132 and 0.195 at15, 20, 25, 30 and 35℃, respectively. The estimated threshold of pupal development (t_0) was 10.90 ˚C, where the thermal units was (K) 133.31 D.D.'s, gave R^2= 0.956. Additionally, the pupae move when transported to glass tube with sawdust and weight reached 0.3041±0.0032, 0.3135±0.0017, 0.3149±0.0089, 0.3335±0.0002 and 0.3396±0.0013 days at 15, 20, 25, 30 and 35˚C, respectively. While, the percentage of mortality for the duration of the pupae were 16.00, 8.97, 6.90, 2.79 and 3.57 % at 15, 20, 25, 30 and 35 ˚C, respectively.

D. The total immature
Showed the average of the total stages of development different eggs, larvae and pupae, which decreased in total with the degrees 30 and 35 and increased when the temperature was reduced, this was confirmed by the rate of development. Hence, the average total of the immature stages record 69.53±2.72, 52.93±1.43, 30.93±0.91, 23.20±0.69 and 15.96±0.36 days at 15, 20, 25, 30 and 35˚C, respectively. Also, rate of development recorded 0.014, 0.019, 0.032, 0.043 and 0.063 at 15, 20, 25, 30 and 35 ˚C, respectively. The estimated threshold of egg development (t_0) was 10.81 ˚C, the thermal units was (K) 414.05 D.D.'s, and gave R^2= 0.960.

E. The adult stages
- **Emergence% & Malformed%**

The moths emerging from pupae different according to the temperature were 77.78, 81.82, 92.31, 98.33 and 96.77 % at 15, 20, 25, 30 and 35˚C, respectively. Also, adult malformed varied according to temperature as recorded 22.22, 18.18, 7.69, 1.67 and 3.23 % at 15, 20, 25, 30 and 35˚C, respectively.

1. Pre-oviposition Period
The Pre- oviposition period decreased with increasing temperatures and developmental rates increased with increasing of tested temperatures, the estimated threshold of Pre- oviposition (t_0) 11.60˚C. The average of pre-oviposition period was 9.00±0.19, 7.27±0.30, 5.87±0.23, 3.80 ±0.17 and 2.07±0.18 days at 15, 20, 25, 30 and 35˚C, respectively. The rate of development where were 0.111, 0.138, 0.170, 0.263 and 0.483 at 15, 20, 25, 30 and 35 ˚C**,** respectively. Recording the thermal units lasted to (K) 57.50 D.D.'s, gave R^2= 0.828, shown Table (1).

Table 1: Biological aspects and estimation of the required thermal units of *S. frugiperda* reared on turnip leaves at different temperatures.

Variable	Temperatures (°C)	The Egg stage			Total Larval duration		Total Pupal duration			Average general total of immature stages	Adult			Generation (days)
		Average numbers of eggs laid /female (Fecundity)	Hatching% (fertility)	Period (days)	Total average larval duration Period	Mortality %	Period (days)	Pupal weight average (gm)	Mortality %		Emergence%	Malformed%	Pre-oviposition Period(days)	
Duration	15	607.00 ±24.96	75.80	13.13± 0.84	33.67± 1.62	17.90	22.73± 2.07	0.3041± 0.0032	16.00	69.53± 2.72	77.78	22.22	9.00± 0.19	78.53± 2.65
	20	613.15 ±23.59	80.43	8.53± 0.34	27.27± 1.15	13.37	17.13± 0.71	0.3135 ± 0.0017	8.97	52.93± 1.43	81.82	18.18	7.27± 0.30	60.20± 1.36
	25	667.18 ±25.03	93.41	3.53± 0.13	17.40± 0.55	5.26	10.00± 0.65	0.3149± 0.0089	6.90	30.93± 0.91	92.31	7.69	5.87± 0.23	36.80± 1.01
	30	713.33 ±30.60	98.13	2.73± 0.12	12.87± 0.66	1.61	7.60± 0.23	0.3335± 0.0002	2.79	23.20± 0.69	98.33	1.67	3.80± 0.17	27.00± 0.65
	35	693.31 ±26.62	97.60	2.50± 0.16	8.33± 0.16	4.77	5.13± 0.14	0.3396 ± 0.0013	3.57	15.96± 0.36	96.77	3.23	2.07± 0.18	18.03± 0.37
Rate of development	15			0.076	0.030		0.044			0.014			0.111	0.013
	20			0.117	0.037		0.058			0.019			0.138	0.017
	25			0.283	0.057		0.100			0.032			0.170	0.027
	30			0.366	0.078		0.132			0.043			0.263	0.037
	35			0.400	0.120		0.195			0.063			0.483	0.055
Regression values	Intercept			-0.200	-0.047		-0.082			-0.026			-0.20	-0.02
	Slope			0.018	0.004		0.008			0.002			0.02	0.00
	t_o (°C)			11.14	10.50		10.90			10.81			11.60	10.93
	K (D. D.s)			55.76	225.50		133.31			414.05			57.50	472.21
	R^2			0.946	0.929		0.956			0.960			0.828	0.864

Average ± S. E.

Table 2: Biological aspects and estimation of the required thermal units of *S. frugiperda* reared on turnip leaves at different temperatures.

Variable	Temperatures (ºC)	Adult (days)		Longevity (days)		Life span (days)		Sex ratio %	
		Oviposition	Post-oviposition	Female duration	Male duration	Female duration	Male duration	Female	Male
Duration	15	23.60±1.99	6.00±0.74	38.60±1.89	33.73±1.61	117.13±3.44	112.26±3.09	51.72	48.28
	20	18.67±0.86	3.90±0.30	29.84±1.56	20.33±0.63	90.04±2.38	80.53±1.56	52.05	47.95
	25	15.53±0.47	2.80±0.20	24.20±0.63	20.00±0.54	61.00±1.46	56.80±1.41	56.52	43.48
	30	11.20±0.74	1.07±0.07	16.07±0.80	10.00±1.28	43.07±1.13	37.00±1.54	58.86	41.14
	35	5.93±0.45	1.47±0.16	9.47±0.58	8.20±0.60	27.50±0.67	26.23±0.66	51.79	48.21
Rate of development	15	0.042	0.167	0.026	0.030	0.009	0.009		
	20	0.054	0.256	0.034	0.049	0.011	0.012		
	25	0.064	0.357	0.041	0.050	0.016	0.018		
	30	0.089	0.935	0.062	0.100	0.023	0.027		
	35	0.169	0.680	0.106	0.122	0.036	0.038		
Regression values	Intercept	-0.060	-0.374	-0.040	-0.048	-0.015	-0.016		
	Slope	0.006	0.034	0.004	0.005	0.001	0.001		
	to (ºC)	10.49	10.96	10.72	10.10	10.89	10.75		
	K (D. D.s)	173.46	29.32	265.82	212.38	737.85	684.53		
	R^2	0.812	0.413	0.501	0.905	0.921	0.991		

F. The Generations duration (Life cycle)

Data in table (1) indicated that the generation period decreased with temperature increase, Hence the average of generation were 78.53±2.65, 60.20±1.36, 36.80±1.01, 27.00±0.65 and 18.03±0.37 days at 15, 20, 25, 30 and 35˚C, respectively. Showed the rate of development recorded 0.013, 0.017, 0.027, 0.037 and 0.055 at 15, 20, 25, 30 and 35 ˚C, respectively. Whereas, the estimated threshold of generation (t_0) was 10.93 ˚C. and recorded thermal units (K) 472.21 D.D.'s, gave R^2= 0.864. From the previous results calculate the number of expected generations in the field according to [9], with the identify of threshold temperatures (t_o) and thermal units (K) for generation calculated ten expected generations in the field they: two generations in spring, four generations in summer, three generations in autumn, one generations in winter.

2. Oviposition and post-oviposition period

Data in Table (2) show that oviposition and post-oviposition period of *S. frugiperda* was short with increase temperature and length with decrease in temperature which affected the number of eggs, (data in Table (1)). The average of oviposition period was 23.60±1.99, 18.67±0.86, 15.53±0.47, 11.20±0.74 and 5.93±0.45 days at 15, 20, 25, 30 and 35˚C, respectively. Also, the rate of development where were 0.042, 0.054, 0.064, 0.089 and 0.169 at 15, 20, 25, 30 and 35 ˚C**,** respectively. The estimated threshold (t_0) was 10.49 ˚C. The average of thermal units was (K) 173.46 D.D.'s, gave R^2= 0.812. The average of the post- oviposition period was 6.00±0.74, 3.90±0.30, 2.80±0.20, 1.07±0.07 & 1.47±0.16 days at 15, 20, 25, 30 and 35˚C, respectively. The rate of development was (0.167, 0.256, 0.357, 0.935 and 0.680) at 15, 20, 25, 30 and 35˚C, respectively. Additionally, the estimated threshold recorded (t_0) 10.96 C. The thermal units (K) 29.32 D.D.'s, and gave R^2= 0.413.

G. The longevity Adult

Data in table (2) showed that the average of *S. frugiperda* longevity for female duration recorded 38.60±1.89, 29.84±1.56, 24.20±0.63, 16.07±0.80 and 9.47±0.58 days, and male period were 33.73±1.61, 20.33±0.63, 20.00±0.54, 10.00±1.28 and 8.20±0.60 days at 15, 20, 25,30 and 35˚C, respectively. The rate development of longevity reached (0.026, 0.034, 0.041, 0.062 and 0.106 and 0.030, 0.049, 0.050, 0.100 and 0.122) at 15, 20, 25, 30 and 35 ˚C for female & male**,** respectively. The estimated threshold for both female and male were (t_0) 10.72 & 10.10˚C, respectively. Hence, the average of thermal units for female and male was (K) 265.82 & 212.38 D.D.'s, respectively. showed (R^2) for female and male recording 0.501 & 0.905, respectively.

H. The Life span and Sex ratio

The results in Table (2) showed that the average life span was 117.13±3.44, 90.04±2.38, 61.00±1.46, 43.07±1.13 & 27.50±0.67 days and 112.26±3.09, 80.53±1.56, 56.80±1.41, 37.00±1.54 & 26.23±0.66 days at 15, 20, 25, 30 and 35 ˚C for females & males, respectively. The rate of development life span was (0.009, 0.011, 0.016, 0.023 and 0.036) & (0.009, 0.012, 0.018, 0.027 and 0.038) at 15, 20, 25, 30 and 35 ˚C for females and males respectively.

Fig 5: Fresh turnip leaves

Fig 6: larvae feed on fresh turnip leaves

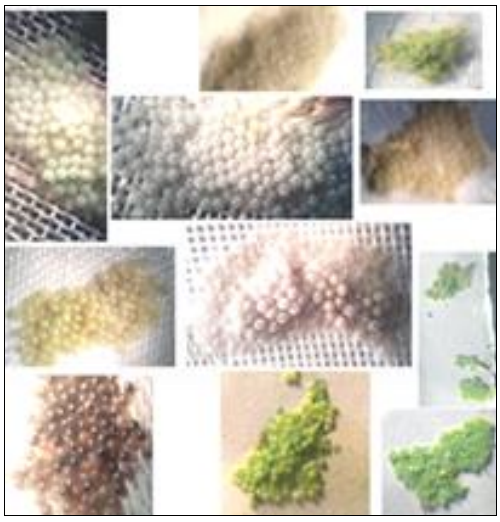

Fig.7: The eggs

Fig 8: The larva

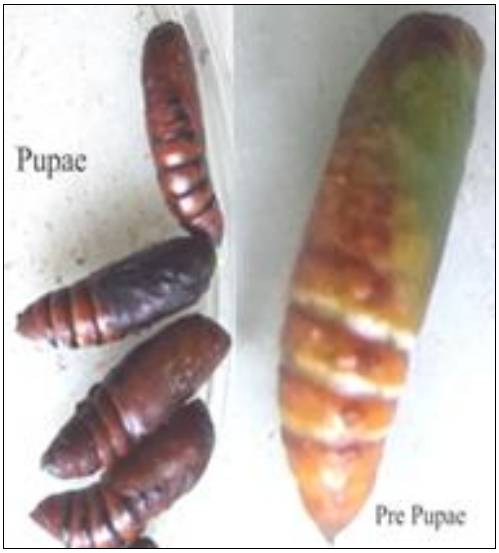

Fig 9: The pupa.

Fig 10: The adult

The estimated threshold of life span for both female and male were (t_0) 10.89 & 10.75°C, respectively. The thermal units both female and male were (K) 737.85 & 684.53 D.D.'s, respectively. Gave (R^2) for both female and male recording 0.921 & 0.991, respectively.

While, the sex ratio female percentage recorded 51.72, 52.05, 56.52, 58.86 & 51.79 % and male 48.28, 47.95, 43.48, 41.14 & 48.21 % at 15, 20, 25, 30 and 35°C, respectively, show Fig.(10).

It's clear that the number of eggs layed does not different from degree to another but the effect temperature on growth, development, life cycle, emergence percentage of moth, mortality percentage, high when decrease for temperature. This explains the decrease in the population of armyworm insects in the winter to the high mortality rates and lack of adaptation to weather conditions and versa when the temperature increases.

Life table parameters of *S. frugiperda*.

Data obtained in table (3), life table parameters of *S. frugiperda* reared on turnip leaves and illustrated in Figure (11). Life table parameters were estimated at tested temperatures as: mean generation times (T) were 79.93, 60.59, 36.75, 28.29 and 17.85 days at 15, 20, 25, 30 and 35°C, respectively. Reached net reproductive rate (Ro) were 41.41, 63.21, 152.75, 190.94 and 61.61 female per generation at 15, 20, 25, 30 and 35°C, respectively. The intrinsic rate of natural increase (rm) was 0.046, 0.068, 0.136, 0.185 and 0.23 individuals/female/day at 15, 20, 25, 30 and 35°C, respectively.

Table 3: Life-table parameters of *S. frugiperda* reared on turnip leaves at different temperatures.

Parameter	15	20	25	30	35
Mean generation time (TG) [a]	79.93	60.59	36.75	28.29	17.85
Net reproductive rate (Ro)[b]	41.41	63.21	152.75	190.94	61.61
Intrinsic rate of increase (rm)[c]	0.046	0.068	0.136	0.185	0.230
Survival rate %	0.155	0.220	0.540	0.827	0.649
Mortality 50%	80.20	66.00	41.50	33.50	19.50
Sex ratio (females/total)	0.51	0.52	0.56	0.58	0.54
Finite rate of increase (λ)	1.04	1.07	1.14	1.20	1.25
Doubling generation (DT)[a]	15.06	10.19	5.09	3.74	3.01

[a] Day, [b] per generation, [c] individuals/female/day

(Ro= Σ(l*x* × m*x*); TG= Σ(x × lx × m*x*) / Σ(l*x* × m*x*); rm= ln (Ro)/T; DT= ln (2)/ rm and λ= exp (rm))

Additionally finite rate of increase (λ) 1.04, 1.07, 1.14, 1.20 and 1.25 progeny/individual/day at 15, 20, 25, 30 and 35°C, respectively. Showed doubling generation time (DT) was 15.06, 10.19, 5.09, 3.74 and 3.01 days at 15, 20, 25, 30 and 35°C, respectively. Also, the percentage of survival rate was 0.155, 0.220, 0.540, 0.827 and 0.649% at 15, 20, 25, 30 and 35°C, respectively. The mortality 50% was 80.20, 66.00, 41.50, 33.50 and 19.50 % at 15, 20, 25, 30 and 35°C, respectively. Gave the sex ratio different on temperature was 0.51, 0.52, 0.56, 0.58 and 0.54 female/total at 15, 20, 25, 30 and 35°C, respectively.

The analysis of the life table indicated that the low temperatures (15, 20 °C) gave different results than the other degrees (30, 35 °C), where the generation period was shortened to (30, 35 °C), was (28.29, 17.85 days), respectively. Also, the results of the doubling generation (DT) indicate that the temperature 30 and 35 °C double the generation increasing was (3.74 & 3.01days), respectively, while, decreased the doubling generation shortest period the temperature (15 °C) was (15.06 day). The intrinsic rate of increase (rm) was negative on population at 15°C, whereas results highly and positive on population at 30 and 35°C.

During the experiment test the temperature 13°C and over 36°C on armyworm but it not complete the life cycle. This indicated that the maximum temperature is 37°C, after which the development reaches the lethal temperature zone.

Discussion

Data in table (1) these findings are in general agreement with those obtained by many authors such as [10] and similar to Jason & James (2001) they found similar results for eggs incubation period and larvae duration. Also, the results agree with [11], Development of

eggs at a constant temperature of 18 ˚C was, however, slow and the percentage of eggs that survived very low. Continuous low temperatures, although above the lower thermal limit, will therefore slow development down and may reduce population dynamics as a result of high mortality at five different temperature regimes, namely 18, 22, 26, 30 and 32±1˚C, at 65±5% RH. The development period of the egg-to-adult stage decreased from 71.35 days at 18 ˚C to 20.27 days at 32 ˚C. Based on linear regression analysis of development rate at all temperatures, a minimum temperature threshold of 13.01˚C was calculated for egg development and 12.12 ˚C for larvae, 13.24˚C for pupae and 12.57 ˚C for egg-to-adult development. Degree-day requirements for *S. frugiperda* egg and larval development was determined at 35.72±1.30 and 202.67 ±4.45˚D D s, respectively when larvae were reared on sweet corn kernels. Pupae needed 147.06 ˚ D D s for development and development of the life cycle (egg-to-adult) 391.01±1.22˚ D D s and other results in the study, also, the results agree with [12], Where in Brazil show that the reared of armyworm at 25 ˚C on hosts plant under controlled laboratory conditions (25 ± 2 °C, 70 ± 10 % RH) the hosts evaluated were soybean, cotton, maize , oat and wheat , which represent the most important crops used in the soybean production system during the summer and winter seasons production system during the summer and winter seasons grain in brazil. FAO (2020) report agrees with the findings of the study, [13].

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Conclusion
The Fall Armyworm (FAW) *Spodoptera frugiperda* (J. E. Smith) (Lepidoptera: Noctuidae) was reared on turnip leaves to study biology at 15, 20, 25, 30 and 35 ˚C on biological aspects. The incubation period was decrees on lower constant temperature and shortest when increased, also, larval duration and pupal duration. The differences between the tested temperatures on incubation periods and adult longevity were significant. calculated ten expected generations in the field they: two generations in spring, four generations in summer, three generations in autumn, one generations in winter.

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