EFFICACY OF TEMPERATURE FLUCTUATION ON THE DEVELOPMENT OF STALK BORER, SESAMIA CRITICA (LEPIDOPTERA: NOCTUIDAE)

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Abstract - Pink stem borer, *Sesamia cretica* Led. (Lepidoptera: Noctuidae) is an important destructive agent responsible for enormous losses of corn plant in Egypt. The LC_{50} value of Silica nano-particles/Challenger 36% SC formulation was tested against *S. cretica* immature stages. We evaluated the development of treated Pink stem borer within range of temperatures between 10 and 40°C under laboratory condition. The duration and thermal requirements of *Sesamia* development at four constant temperatures (10, 20, 30 and 40°C) were significantly different between the treated and the check individuals. The developmental time directly proportional with temperature within the tested range for silica treated and untreated stages. The life table indices for treated and untreated populations were estimated.

Keywords - Pink stem borer, *Sesamia cretica*, duration, thermal requirements, constant temperature, silica nano-particles, life table indices.

I. INTRODUCTION

The Pink stem borer is the main pest of maize in the fields allover the world that damaged Sugarcane and maize fields (Ranjbar Aghdam 1999, Ramadan, 2000). Silicon (Si) was considered a helpful mineral nutrients that reduce the damage of some pests by making abrade in their digestive tract leading to the eradication of agricultural pests and reducing crop susceptibility to infection (Ma and Takahashi, 2002, Meyer and Keeping, 2005). The development, geographical distribution and population density of Pink stem borer are strongly influenced by temperature fluctuation (Ebeid *et al*., 2017). The biological development depends directly on chemical reactions, which affected by amount of heat units (Degree-Days) received to develop from one life stage to another and complete one generation depending on the lower threshold temperature for each insect (Roy *et al.*, 2003). These values may be used in predicting insect activity during the growing season (Ebeid, (2008) on *Sesamia critica* and Ebeid *et al.* (2015)) on *Spodoptera litoralis*). Life table parameters are essential in Integrated Pest Management (IPM) program to describe the growth dynamic of an insect under different temperature, to improve mass-rearing performance of biological agents on different host plants (Sedighi, 2016). The goal of this paper is to compare between the treated larvae of *S. cretica* with silica nano-particles/Challenger formulation and untreated one with respect to their development, life table, and to determinate the temperature threshold for the development of *Sesamia* stages in order to expect the annual pattern of adult emergence due to the effect of insecticide and different temperature.

II. MATERIAL AND METHODS

A. Tested conditions Four constant temperatures (10, 20, 30 and 40°C & 75±5% RH) were used to select the most suitable temperature, the duration of each insect stage, thermal requirement as minimal temperature threshold (T_0), thermal constant unit (DD) and life table indices by the effect of silica nano-particles treatment, that being helpful in IPM program to control stalk borers larvae, *S. critica*.

B. Experimental insect

S. cretica larvae were obtained from NRC rearing culture. Two groups of egg masses, one of them was treated with Silica Nano-particles/Challenger formulation at LC_{50} concentration (1.091 %) according to Gesraha *et al.* (2017) and the other was used as control, were placed in cups (10cm diameter), that lined with moist filter paper. Egg development was monitored at four tested constant temperatures. Three replicates each has 30 individuals were set at each tested temperature. The numbers of survived and lifeless larvae were recorded every day along all experimental time. The developmental progress of each instar was monitored. Developmental time was calculated for all instars of both groups (treated and untreated individuals) until adult emergence. Campbell *et al.* (1974) equations were used to estimate the relationship between developmental rate and tested temperatures, zero of development (t_0) and Day Degree (DD). The indices of life table are the intrinsic rate (r), The net reproductive rate (R_0), The doubling time (T) and the finite rate of increase (Lambda (λ)) used to make comparisons among different temperatures on the population growth of *S. cretica* for either Silica nano-particles/Challenger treated or untreated stages were analyzed according to (Chi, 2015).

C. Statistical analysis

Analysis of variance (ANOVA) F-test was carried out through the SPSS Computer program to discriminate differences between silica-treated and untreated *Sesamia* stages. Differences between means were compared using Duncan's Multiple Range test (Duncan, 1955). TWOSEX-MSChart a computer

program was used to construct the life table parameters (Chi, 2015).

III.RESULTS AND DISCUSSION

Development and survival of treated *Sesamia cretica* at different constant temperatures

Development of both Silica/Challenger-formulation treated and untreated *S. critica* at 4 constant temperatures revealed an increase in developmental time from egg to adult emergence with increases in temperature (Table 1 a&b) but the duration inversely proportional with the temperature.

The influence of different temperatures on the development of *S. criteca*

At the low temperature (10^{o}C), the larval development decreased due to the influence of this low temperature, so the prolongation of time necessary to completing different life stages prevent our experiment to be completed at this temperature probably because it was acclimatized to live at high temperature (Table 1 a&b); this finding agreed with Ebeid (2008) on *S.cretica.* At 20 and 30^{o}C the duration of all developmental stages except prepupal stage of untreated individuals were statistically higher than that of treated one (Table 1b). On the other hand, the higher temperature (40^{o}C) affect significantly the duration of both larval and total immature stages of treated individuals lower than that of the untreated one (Table 1 b).

Rate of development and thermal requirement

The knowledge of thermal constants and lower development thresholds provides creative prediction model to determine the developmental rate of a particular species as mentioned by Jarošík *et al*. (2011) and timing pests' control in different environments. Although the rate of development of egg stage for treated insect was higher than that of untreated one, its zero of development (10.3^{o}C) was lower than that of untreated stage (11.7^{o}C). Our results exhibit the decrease of incubation period with increasing temperature resulted in high rate of the development from 20 to 40°C, being matched with that mentioned by Orang *et al*. (2014). An opposite trend was reported in case of other pyralid (Rahman & Khalequzzaman, 2004). Average thermal constants for egg stage of *S. critica* were 67.473 DD & 77.546 DD for treated and untreated stage, respectively (Table 1a).The same trend was observed in case of the larval stage, where the lower threshold temperatures (T_0) and thermal constants for larval stages of *S. critica* treated stage were 9.2ºC and 447.067 DD, as compared with that of the untreated stage (10.76ºC and 584.873 DD) (Table 3). The insignificant differences between the prepupal stage of the *S. cretica* of two tested groups inverse the previous trend where the threshold temperatures (T_0) and thermal constants for tested prepupal stages of untreated (8.39^{o}C) become slightly lower than that of treated one (8.90^{o}C), where there recorded thermal units were 87.387 and 44.343 DD for untreated and treated stage, respectively (Table1 a). The duration of the pupal stage behaved the same trend, *i.e.*, decreased with increasing the temperature. This decrease leading to the increase of the rate of development that affects the average thermal unit of treated stage to reach 111.607 DD, while untreated stage recorded 126.982 DD (Table 1 a). The lower threshold temperature (T_0) for pupal stage of *S. critica* was 9.38^{o}C for the treated one, being lower than untreated that recorded 11.76 ºC. Our findings regarding larval and pupal durations were longer than that estimated by Ebeid (2008) and Orang *et al*. (2014) for same pest. Under these circumstances, it was observed that amount of day degree required by total immature of *S. cretica* insect to complete its development belong to untreated stage (794.346 DD) above threshold temperature 11.40^{o}C was higher than that of treated one (656.216 DD) above a lower developmental threshold of 9.8°C (Table 2).

In our result, untreated stage showed higher zero of development than treated one, this finding was agreed with that of Allan *et al*. (2010) and Taveras *et al*. (2004) on *S. cretica.* The developmental rates of the immature stages of *S. cretica* between the treated and untreated stage varied due to the difference in temperature. This findings accordance with that for Ebeid (2008) and Rahman & Khalequzzaman (2004) on stem borer, and contradict with that obtained by Calvin *et al*. (1991) on *Ostrinia nubilais.*

Life table parameters

Table (2 a) showed significant decrease of the (r), (R_0), (λ), (T), relative growth rate and fecundity values for untreated stage with the increasing of the temperature from 20 to 30^{o}C.

In treated group, all life table parameters in case of 20^{o}C treatment being significantly higher than the other temperatures followed by 40^{o}C, while 30^{o}C treatment showed lower values; being significantly different with the others. Data in table (2 b) for comparing values of treated and untreated stages could be explained as follows: (r) and (λ) of treated stages being significantly lower than the treated one at 20 and 30ºC, while at 40ºC the opposite is being occurred. While (R_0) for the two groups showed insignificant differences with respect to 20&40ºC, but at 30^{o}C the treated stage was significantly lower than untreated one, where the doubling time at 20&40^{o}C of the treated group showed significant increase while at 30^{o}C it showed significant decreased value.

On the other hand, the relative growth rate (GRR) of treated stage at 20& 30ºC was significantly different than untreated one, the opposite trend was observed at 40^{o}C as mentioned by some authors (Naseri *et al*. (2014) and Tazerouni *et al.* (2016)). The same trend was observed in case of and fecundity. With respect to the longevity, the lower and higher temperatures insignificantly affected for both treated and untreated stages, but at 30ºC the treated stage showed highly

significant decrease. The previous data were matched with that reported by Sedighi *et al.* (2016) on *S. cretica.*

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Table (1a): Duration of different stages of treated and untreated *S.critica*, threshold of temperature and thermal requirements of temperature

Duration at	Eggs		Larvae		Prepupae		Pupae		Total immature	
	Treated	Untreated	Treated	Untreated	Treated	Untreated	Treated	Untreated	Treated	Untreated
10°C	--	--	--	--	--	--	--	--	--	--
20°C	6.80 ±0.37a	8.20 ±0.37a	34.40 ±1.29a	51.60 ±1.25a	3.60 ±0.40a	3.00 ±0.40a	7.40 ±0.40a	12.00 ±0.56a	53.40 ±0.93a	74.80 ±1.96a
30°C	3.61 ±0.37b	5.60 ±0.24b	25.00 ±2.05b	40.20 ±2.22b	2.20 ±0.37b	1.75 ±0.37b	7.60 ±0.24a	10.20 ±1.24a	40.20 ±2.08b	59.20 ±1.07b
40°C	2.20 ±0.20c	2.20 ±0.20c	14.60 ±0.24c	17.25 ±0.48c	1.50 ±0.24b	1.25 ±0.25b	3.25 ±0.48b	3.40 ±0.24b	20.33 ±0.33c	22.33 ±0.88c
F-value	51.125 **	113.167 **	49.709 **	112.318 **	10.330 **	10.331* *	39.755 **	26.176* *	101.391 **	249.461 **
Zero of development	10.3	11.7	9.2	10.76	8.9	8.39	9.38	11.76	9.8	11.4
DD	67.473	77.547	447.067	584.873	44.343	37.387	111.607	126.982	656.216	794.346

Table (1b): Thermal requirements for treated and untreated S.critica

Temperature	Treatment	Eggs	Larvae	Prepupa	Pupa	Total immature
10°C	Treated	--	--	--	--	--
	Untreated	--	--	--	--	--
	T-value	--	--	--	--	--
20°C	Treated	6.80 ±0.37 b	34.40±1.29b	3.60±0.40a	7.40±0.40b	53.40±0.93b
	Untreated	8.20 ±0.37 a	51.60±1.25a	3.00±0.40a	12.00±0.56a	74.80±1.96a
	T-value	2.640*	9.738**	1.125 NS	6.766**	9.871**
30°C	Treated	3.60 ±0.37b	25.00±2.05b	2.20±0.37a	7.60±0.24a	40.20±2.08b
	Untreated	5.60 ±0.24a	40.20±2.22a	1.75±0.37a	10.20±1.24a	59.20±1.07a
	T-value	4.264**	5.028**	0.753 NS	2.055 NS	5.126**
40°C	Treated	2.20 ±0.80a	14.60±0.24b	1.50±0.24a	3.25±0.48a	20.33±0.33b
	Untreated	2.20 ±0.20a	17.25±0.48a	1.25±0.25a	3.40±0.24a	22.33±0.88a
	T-value	--	5.259**	0.650 NS	0.298 NS	4.243**

**** Denote Highly significant * Denote significant**

NS not significant

In a vertical column, means with the same letter(s) are not significantly different (P>5%).

Table (2): Life table parameters for silica nano-particles/Challenger treated and untreated S. cretica stages at different temperatures

Treatment	Mean + SE						
	r	lambda	R_0	T	GRR	Fecundity	Longevity
20°C treated	0.39 ± 0.00 b	1.48 ± 0.00 b	555.66 ±10.98 a	16.24 ± 0.06 a	887.34 ± 11.80 a	782.97 ± 8.13 a	19.20 ± 0.08 a
20°C untreated	0.40 ± 0.00 a	1.49 ± 0.00 a	561.32 ±11.23 a	15.98 ± 0.05 b	812.35 ± 9.70 b	748.76 ± 5.75 b	19.45 ± 0.08 a
T-value	2.181*	2.220*	0.321 NS	3.130**	4.681**	3.441**	1.912 NS
30°C treated	0.38 ± 0.00 b	1.45 ± 0.00 b	326.49 ± 7.87 b	15.38 ± 0.05 b	565.60 ± 12.32 b	563.34 ± 7.88 b	17.60 ± 0.04 b
30°C untreated	0.39 ± 0.00 a	1.48 ± 0.00 a	504.34 ± 9.98 a	15.81 ± 0.05 a	748.53 ± 8.99 a	695.07 ± 3.63 a	18.83 ± 0.06 a
T-value	6.309**	6.364**	13.989**	7.376**	21.696**	29.085**	17.221 **
40°C treated	0.38 ± 0.00 a	1.48 ± 0.00 a	504.34 ± 9.98 a	15.81 ± 0.05 a	565.60 ± 12.32 a	695.07 ± 3.63 a	18.65 ± 0.06 a
40°C untreated	0.38 ± 0.00 b	1.47 ± 0.00 b	431.87 ± 8.14 b	15.63 ± 0.04 b	551.17 ± 7.51 a	585.27 ± 6.89 b	18.88 ± 0.06 a
T-value	3.333 **	3.323 **	1.679 NS	2.815 **	1.000 NS	2.095 *	2.778 NS

(a)

	Mean + SE						
Treated	R	lambda	R_0	T	GRR	Fecundity	Longevity
20°C	0.39 ± 0.00 a	1.48 ± 0.00 a	555.66 ±10.98 a	16.24 ± 0.06 a	887.34 ± 11.80 a	782.97 ± 8.13 a	19.20 ± 0.08 a
30°C	0.38 ± 0.02 b	1.45 ± 0.00 b	326.49 ± 7.87 c	15.38 ± 0.03 c	465.84 ± 95.55 c	465.61 ± 7.00 c	17.60 ± 0.04 c
40°C	0.38 ± 0.00 b	1.46 ± 0.00 b	410.94 ± 9.45 b	15.82 ± 0.05 b	565.60 ± 12.32 b	563.34 ± 7.88 b	18.65 ± 0.06 b
F-value	10.380**	10.337**	121.424**	64.232**	274.745**	330.882**	186.496**
Untreated							
20°C	0.40 ± 0.00 a	1.49 ± 0.00 a	561.32 ±11.23 a	15.98 ± 0.05 a	812.35 ± 9.70 a	748.76 ± 5.75 a	19.45 ± 0.08 a
30°C	0.39 ± 0.00 a	1.48 ± 0.00 a	504.34 ± 9.98 b	15.81 ± 0.05 b	748.53 ± 8.99 b	695.07 ± 3.63 b	18.88 ± 0.06 b
40°C	0.38 ± 0.00 b	1.47 ± 0.00 b	431.87 ± 8.14 c	15.63 ± 0.04 c	551.17 ± 7.51 c	585.27 ± 6.89 c	18.83 ± 0.06 b
F-value	4.655**	4.784**	43.233**	14.947**	240.452**	222.368**	25.735**

(b)

**** Denote Highly significant * Denote significant**

NS not significant

In a vertical column, means with the same letter(s) are not significantly different (P>5%).

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