DEVELOPMENT OF AMERICAN BOLLWORM, *HELICOVERPA ARMIGERA* (HÜBNER) (LEPIDOPTERA: NOCTUIDAE) IN RELATION TO HEAT UNIT REQUIREMENT

AMER, A.E.A., A.A.A. EL-SAYED AND M.A. NADA

Plant Protection Research Institute, ARC, Dokki Giza

(Manuscript received 10 March 2009)

Abstract

Laboratory Experiment were carried out to study the effect of different temperature's degrees, (15, 20, 25, 27 and 30 °C) on the developmental stages of the American bollworm (ABW) *Helicoverpa armigera* (Hübner) reared on artificial diet. As temperature increased from 15 to 30 °C the life span decreased. The lower thermal threshold for the development of ABW eggs is 13.01 °C, for larvae is 11.98 °C, for pupal stage is 9.79 °C and for pre-ovipostion period is 12.83 °C. The thermal constant for the development of eggs is 36.69 day degree (DD's), for larvae is 245.17 DD's, for the pupal stage is 181.64 DD's and 34.99 DD's for the pre-ovipostion period. The lower thermal threshold for generation of ABW is 11.54 °C and the thermal constant is 494.39 DD's. Obtained results are essential information for predicting the field population of ABW.

INTRODUCTION

Helicoverpa armigera (Hübner) (Lepidoptera: Noctuidae) is an important pest of many crops in many parts of the world (Sharma, 2001). The thermal requirements (degree-days) for the development are often used for estimating developmental times because temperature has a major effect in determining the rate at which insects develop (Zaslavski, 1988). The information of thermal constants and lower development thresholds provide essential information to determine the development rate of a particular species of arthropod (Honek, 1996, Jarosik *et al*. 2002). The lower thermal threshold for total development (from egg to adult emergence) of ABW reared on corn seeds is 11.5 °C and the thermal constant is 625.0 DD's (Bartekova and Praslicka, 2006). Applied biologists have been interested for a long time in predicting the date of emergence of the spring brood of insects. It is well established that the rates of development during different stages of the life-cycle of many insects depend on the temperatures to which they are exposed (Cunningham *et al*. 1981).

The aim of this study is to determine the lower development threshold and thermal constants for development of ABW.

MATERIALS AND METHODS

The present work was carried out in Bollworms research Department, Plant Protection Research Institute, Sharkia Branch to evaluate the effect of temperature on the development of ABW stages. The experiment was performed at five constant temperatures, 15, 20, 25, 27 and 30± 1°C.

Insect rearing

The stage of ABW larvae were collected from cotton fields in Daquahlia Governorate during June and July of 2007 cotton growing season and brought to the laboratory. It was fed separately on un-matured cotton seed in glass tubes (3 × 7.5 cm) covered with absorbent cotton wool. The food was daily renewed until pupation. Pupae were transferred to clean glass tubes and incubated until moth emergence. When adults emerged, moths were sexed and caged to egg laying. Moths were provided with 10 % honey solution on a cotton swab. The eggs were separated daily and placed in glass jars. Obtained eggs were used in experiment.

Development of immature stages:

Eggs laid on the same day (<24 old) were placed in glass jar and incubated under five constant temperatures (15, 20, 25, 27 and 30 °C) and 65±5% R.H. Three replicates of 100 eggs/each were used for each tested temperature's degree. The number of eggs hatched was recorded daily and egg's incubation period was calculated. The hatched Larvae in each temperature's treatment were used for the developmental studies at the respective temperatures.

Newly hatched larvae were transferred individually to glass tubes (3 × 10 cm) containing about 5-6 g artificial diet (Rashad and Ammar, 1985) each tube were plugged tightly with absorbent cotton and placed in an incubator at constant of 15, 20, 25, 27 and 30 °C and 65±5% R.H. Four replicates of 25 larvae/ each were used for each tested temperature. Larvae were examined daily until pupation to record larval duration. Pupae were transferred to clean glass tubes and examined daily until moth emergence to record pupal duration. When adults emerged, moths were sexed and caged to egg laying. Moths were provided with 10 % honey solution. The cages were inspected daily until moth death. The pre-ovipostion, oviposition and post-ovipostion periods and longevity of adult females and males were calculated.

- Statistical analysis

The effect of temperature's degrees (20, 25, 27 and 30 °C) on developmental time of ABW was determined by analysis variance (ANOVA). The relationship between temperature and mean developmental rate of each stage and generation under tested temperature was determined using liner regression. Except rate of ABW's development at 15 C not included in our analysis. For each temperature, developmental rate (DR) were calculated as reciprocals of development time (DT) of individual ABW's stages (DR= 1/DT). The relations between developmental rate (DR) and temperature (T) was determined using liner regression equation: DR= a + bT, whereas: a, b parameters of the liner regression. The lower developmental threshold (LDT), i.e. the temperatures when development ceases, was determined: LDT= -a/b. On the other hand, degree days (DD's) for completion development of each stage was calculated according to Arnold (1959): DD's = DT*(T-t_0) where, DT- development time of a given stage, T- temperature in degree centigrade and t_0- lower developmental threshold.

RESULTS AND DISCUSSION

Temperature dependence of ABW development is summarized in Table (1). The incubation period of ABW was13.7 days on 15 °C, with increasing temperature, the developmental times of the egg stage were shortened, i.e. on 20 °C to 5.0 days, on 25 °C to 3.2 days, on 27 °C to 2.7days and on 30 °C to 2.1 days. The statistical analysis of the obtained data showed that there are significant differences between the average of incubation period at 20 °C and all other regimes. There are no significant differences between the values on 25, 27 and 30 °C degrees. These results are in agree with those obtained by Jallow and Matsumura (2001) who reported that 2.5 – 14.1 days of egg development, depending on temperature (32.5-13.5 °C).

Table (1) show the rate of development of the different life history stages in relation to temperature is expressed by the linear regression equation. According to the regression line, equation the lower developmental threshold of ABW's eggs was13.01 °C, and the thermal constant for their development was 36.69 DD's. Kay (1981) reported that the lower developmental threshold of ABW's egg was 11.7 °C. Bartekova and Praslicka (2006) found that the lower developmental threshold of ABW's egg's was 14.8°C when fed on corn seeds.

The development of larvae On 15 °C, required 44.0 days. With increasing temperature, the developmental times of the larval stage were shortened, i.e. on 20 °C to 31.1 days, on 25 °C to 18.4 days, on 27 °C to 16.3 day and on 30 °C to 13.7 days. There were significant differences in the duration of larval stage on the different temperatures (Table 1). Other authors recorded similar values for larval stage. Jallow and Matsumura (2001) reported that the duration of larval stage ranged from 59.1± 4.69 days at 13.3 °C to 10.9± 0.14 days at 32.5 °C. Bartekova and Praslicka (2006) reported 18.27-39.30 days for larval development, depending on temperature. According to the regression line equation, the lower developmental threshold of ABW's larvae was 11.98 °C, and the thermal constant for their development was 245.17 DD's (Table 1). A developmental threshold of 11.3 °C and 215.1 day-degrees were estimated for ABW larvae by Jallow and Matsumura (2001).

Table 1. Effect of different temperatures on biological aspect of *Helicoverpa armigera*.

Temp. (°C)	Egg stage			Larval stage			Pupal stage			Pre-ovipostion			Generation		
	DT	DR	DD	DT	DR	DD	DT	DR	DD	DT	DR	DD	DT	DR	DD
15	13.7	-	-	44.0	-	-	251.0	-	-	-	-	-	-	-	-
20	5.0a	0.20	34.95	31.1a	0.03	249.42	17.9a	0.06	182.76	4.7a	0.21	33.70	58.7a		496.60
25	3.2b	0.31	38.37	18.4b	0.05	239.57	11.8b	0.08	179.48	3.0b	0.33	36.51	36.4b		489.94
27	2.7bc	0.37	37.77	16.3c	0.06	244.83	10.6bc	0.09	182.43	2.5b	0.40	35.43	32.1c		496.27
30	2.1c	0.48	35.68	13.7d	0.07	246.87	9.0c	0.11	181.89	2.0b	0.50	34.34	26.8d		494.73
Mean			36.69			245.17			181.64			34.99			494.39
LSD 0.05	1.188			1.883			1.833			1.930			3.766		
Regression equation a	-0.355411			-0.04894			-0.05391			-0.36649			-0.02334		
Regression equation b	0.027211			0.004084			0.005507			0.028549			0.002023		
LDT	13.01			11.98			9.79			12.83			11.54		

DT= Development time in days, DR= development rate

DD= degree days LDT= Lower developmental threshold

a = intercept b = slope

Pupa entered diapause at 15 °C, while pupae were classified as having entered diapause if adult emergence was delayed beyond 251.0 days at 15 °C (Table 1). The duration of non-diapaused pupa decreased as temperature increased from 17.9 days on 20 °C to 11.8 days on 25 °C, 10.6 days on 27 °C and 9.0 days on 30 °C. Statistical analysis of the obtained data showed that there are significant differences between the average of pupal stage duration on 20 °C and all other regimes. There are no significant differences between the values on 25, 27 and 30 °C. The previously mentioned results are similar to those obtained by Mironidis and Soultani (2008) who reported that the duration of pupal stage of ABW ranged from 9.07 day on 30.0 °C to 20.8 days on 20°C. According to the regression line equation the lower developmental threshold of *H. armigera* pupa was 9.79 °C, and the thermal constant for their development was 181.64 DD's (Table 1).

The mean time required for maturation of the ovaries and starting egg laying, decreased as the temperature increased from 4.7 days on 20°C to 2.00 days at 30 °C. Statistical analysis of the obtained data showed that there are significant differences between the average of pre-ovipostion period on 20 °C and all other regimes. There are no significant differences between the values at each of 25, 27 and 30 °C. The lower development threshold of pre-ovipostion period was 12.83 °C, and the thermal constant for their development was 34.99 day-degrees (Table 1).

Generally, the mean duration of generation (from eggs to pre-ovipostion) for ABW were 58.7 days on 20°C, 36.4 day on 25°C, 32.1 days on 27°C and 26.8 days on 30 °C. There were significant differences in the generation time at the different temperatures (Table 1). According to the regression line equation the lower developmental threshold of ABW generations was 11.54 °C, and the thermal constant for their development was 494.39 DD's (Table 1). Bartekova and Praslicka (2006) reported that the lower thermal threshold for the total development (from egg to adult emergency) of ABW is 11.5 °C and the mean thermal constant is 625.0 DD's. Mironidis and Soultani (2008) reported that the lower thermal threshold for total development (from egg to adult emergency) of ABW reared on artificial diet is 9.57 °C and the thermal constant is 476.19 day-degrees. Differences between the results obtained in this study and those of other studies could be attributed to the different origin of ABW, i.e. strain and geographical region, as well as the different experimental condition, i.e. rearing techniques and food. Population from different geographical regions may differ in various reproductive and life history aspects (Papadopulos *et al*. 2002).

On the other hand, the oviposition and post-oviposition periods of ABW were also affected by temperature. The longest periods (8.7 and 3.4 days) were achieved on 20 °C and the lowest 4.25 and 1.5 days on 30 °C, respectively. Statistical analysis of the obtained data showed that there are significant differences between the oviposition period or post-ovipostion periods at 20°C and all other regimes. There are non significant differences between the values at 25, 27 and 30°C (Table 2).

In addition, the average life span of adult female and male of ABW decreased as the temperature increased from 16.18 and 15.00 days on 20°C to 7.75 and 7.30 days on 30°C, respectively. Statistical analysis of the obtained data showed that there are significant differences between the adult female longevity on 20°C and all other regimes. There are no significant differences between values on 25 and 27 °C, for female longevity and 27 and 30 °C for male longevity (Table 2).

Table 2. Effect of different temperatures on female and male longevity of *Helicoverpa armigera*

Temperature (°C)	Oviposition period	Post- oviposition	Longevity	
			♂	♀
20	8.7a	3.4a	15.0a	16.8a
25	6.2b	2.2b	11.1b	11.4b
27	5.7bc	1.7bc	9.5c	9.9b
30	4.25c	1.5c	7.3c	7.75c
LSD 0.05	1.883	0.449	1.883	1.883

Results obtained from these studies may provide important information for predicting the field population of ABW or for predicting the timing of a barrier chemical treatment against ABW larvae in field crops.

REFERENCES

1. Arnold, C.Y. 1959. The determination and significance of the base temperature in a linear heat unit system. In Proc. Am. Soc. Hortic. Sci., 74:430-445.
2. Bartekova, A. and J. Praslicka. 2006. The effect of ambient temperature on the development of cotton bollworm (*Helicoverpa armigera* Hubner). Plant Protect. Sci., 42: 135-138.
3. Cunningham, R. B., T. Lewist and A. G. L. Wilson. 1981. Biothermal development: a model for predicting the distribution of emergence times of diapausing *Helicoverpa armigera*. App. Statist. 30(2): 132-140.

4. Honek, A. 1996. The relationship between thermal constants for insect development: a verification. Acta Societaris Zoologicae Bohemicae, 60: 115-152.

5. Jallow, M. F. A. and M. Matsumura. 2001. Influence of temperature on the rate of development of *Helicoverpa armigera* (Hubner) (Lepidoptera: Noctuidae). Appl. Entomol. Zool., 36(4):427-430.

6. Jarosik, V., A. Honek and A. F. G. Dixon. 2002. Developmental rate isomorphy in insects and mites. The American Naturalist, 160:497-510.

7. Kay, I. R. 1981. The effect of constant temperatures on the development time of eggs of *Heliothis armigera* (Hübner) (Lepidoptera: Noctuidae) . J. Aust. Entomol. Soc., 20:155-156.

8. Mironidis, G. K. and S. Soultani. 2008. Development, survivorship, and reproduction of *Helicoverpa armigera* (Lepidoptera: Noctuidae) under constant and altermating temperatures. Environ. Entomol. 37(1):16-28.

9. Papadopoulos, N. T., B. I. Katsogianos And J. R. Carey. 2002. Demographic parameters of the Mediteranedn fruit fly (Diptera tephrididae) reared in apples, Ann. Entomol. Soc. Am , 95: 561-569.

10. Rashad- Amira, M. and Ammar. 1985. Mass rearing of spiny bollworm, *Earias insulana* (Boisd.) on semi artificial diet. Bull. Soc. Entomol., Egypt, 65:239-244.

11. Sharma, H. C. 2001. Cotton bollworm legume pod borer *Helicoverpa armigera* (Hubner) (Noctuidae Lepidoptera) biology and management. Crop Protection Compendion. International Crops Research Institute for the Semi-Arid Tropics.

12. Zaslavski, V. A. 1988. Insects development (Photo periodic and temperature control). Spinger-Verlag, Berlin. 187 pp.

تطور دودة اللوز الأمريكية وعلاقتها بالوحدات الحرارية

عادل السيد على عامر ، علي أحمد السيد ، محمد أحمد ندا

معهد بحوث وقاية النباتات – مركز البحوث الزراعية – الدقي – الجيزة

أجريت دراسات معملية بمعهد بحوث وقاية النباتات فرع الشرقية لدراسة تأثير درجات الحرارة (١٥ ، ٢٠، ٢٥، ٢٧و ٣٠ درجة مئوية) علي تطور أطوار دودة اللوز الأمريكية المرباه علي بيئة صناعية. أوضحت الدراسة أن فترات هذه الأطوار قد قصرت بزيادة درجة الحرارة من ١٥ إلي ٣٠ درجة مئوية. كما أوضحت الدراسة أن صفر النمو كان ١٣.٠١ و ١١.٩٨ و ٩.٧٩ و ١٢.٨٣ درجة مئوية لطور البيضة و اليرقة و العذراء وما قبل وضع البيض علي التوالي. وكانت الوحدات الحرارية المتجمعة اللازمة لاكتمال نمو الأطوار السابقة هي ٣٦.٦٩ و ٢٤٥.١٧ و ١٨١.٦٤ و ٣٤.٩٩ وحدة حرارية علي الترتيب. وبصفة عامة أوضحت الدراسة أن صفر النمو للجيل ١١.٥٤ درجة مئوية و الوحدات الحرارية المتجمعة اللازمة لاكتمال الجيل ٤٩٤.٣٩ وحدة حرارية. تتضح أهمية النتائج المتحصل عليها في إمكانية التنبؤ بتعداد دودة اللوز الأمريكية تحت الظروف الحقلية.