THERMAL REQUIREMENTS AND PREDICTION MODELS OF COTTON LEAFWORM *SPODOPTERA LITTORALIS* (BOISD)

Kh. Gh. El-Malki
Plant Protection Res. Inst.

Abstract

Mean developmental rate of immature cotton leafworm stages and generation at 4 constant temperature regimes over the range of 17.5 to 32.5°c with increments of 5.0°c is fit with a thermal summation (linear regression) and logistic curve. Egg didn't hatch at 10°c and 37.5°c, larvae and pupae also exhibited high mortality at 37.5°c. The developmental rate of all cotton leaf worm stages increased with rise of temperature over range of 17.5°c to 32.5°c. Embryonic, larval, pupal, maturation (pre ovi position period), ovi position and generation threshold temperatures were estimated at: 11.81, 12.5, 11.33, 10.66, 10.8 and 12.6.

Thermal summation, linear and logistic models were chosen to express the relationship between temperature and developmental rates. However, the logistic showed the highest accurate simulation for this relationship.

Upper thermal thresholds as well as other biological constants such as thermolability. Coefficients and thermal units were also estimated.

Introduction

One element of Integrated Pest Management (IPM) involves the forecasting of seasonal occurance of agricultural pests. Management of Cotton leaf worm populations could be detected substantially by models of development.

Mathematical representations of the functional relationship between temperature and development is an important part of any attempt to model the population dynamics of insect species. The majority of phenology models of insect development are based on laboratory data and many use a linear temperature summation or degree day approach (Stinner et al, 1974 and Preuss, 1983). Several investigators have improved the linear model for warm and cold temperatures where rates are nonlinear (Davidson, 1944; Taylor, 1981; Logan, 1983 and Lamb et al, 1984).

Pervious studies of cotton leaf worm developmental times have been reported by Nasr, 1962 and Nasr and Ibrahim, 1965. Several studies have been conducted on its phenology (Khaleel, 1963, abul-Nasr et al, 1973 and Moftah, 1976). However, little work has been done on the use of temperature accumulation as an aid in forecasting the various stages of this pest (el-shafei et al, 1981 and Younis, 1991).

This paper focuses on the temperature dependencies of cotton leafworm rates in an effort to improve models of its population dynamics.

Materials and Methods

A laboratory Colony of Cotton leafworm *Spodoptera littoralis* (Boisd.) using a field-collected larve from cotton was used in the present study. Experiments were carried out Hereus incubators to determine the developmental time of each life stage at the tested constant temperature regimes over the range of 17.5 – 32.5° with increments of 5°c and 12 :12 (L :D hours).

The lower threshold temperature for development was estimated using linear regression equation, x-intercept method. The Parameters to (thermal threshold) and K (thermal constant) are derived from the regression equation as follows:

$$Y = a + bx$$

$$To = \frac{a}{b}$$

$$K = \frac{1}{b}$$

where Y is the reciprocal of the duration in days (development rate) and X is the temperature in °c. For the upper threshold temperature, however Y is the development time in the same equation (Park, 1988). Thermolability Coefficient was determined as the reciprocal of the average thermal units (Kajanchikov, 1946).

Two models were chosen to express the data, i. e. linear regression and Segmoid curve (logistic equation, Davidson, 1944) as follow:

$$\frac{100}{4} = \frac{k}{1+e^{a-bx}}$$

Where:

- K is the parameter representing the distance between the upper and lower a sympotote of the curve.
- a Is the parameter which indicate the relative position of the origin of the curve on the abscissa.
- b Is the parameter representing the slope and course of the curve.

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Egg Studies

Newly deposited eggs were taken from laboratory culture and maintained at constant temperatures of 17.5, 22.5, 27.5 and 35.5°c. The eggs were kept in petri dishes. Each treatment consisted of 150 eggs (5 replicates, 30 egg per dish). Eggs were checked twice daily for hatching.

Larval Studies

Newly hatched larvae came from egg culture held at 25°c were placed with a fine hairbrush on castor oil leaves. At each temperature, newly formed pupae were picked and placed in petri dishes for farther development.

The same way of study was adopted for all stages and life sequences.

Results and Discussion

Data show that development for different stages of cotton leafworm is accelerated with increasing temperatures and the interrelationship approximates the hyperbola (table 1). The temperature limits allowing complete development ranged between 10.5-37.5°c considering rate of development as a function of temperature, the thermal summation and logistic curve were chosen to fit the present data. Thermal summation express a hyperbolic relationship between temperature (X) and developmental time (Y) given by the equations presented in table (3).

Development zero for different stages and generation were: 11.81, 12.5, 11.33, 10.66, 10.8 and 12.6°c for incubation period, ovi position period and the whole generation, (table 2).

The respective values for the upper temperature (tu) were: 36.0, 37.0, 35.5, 36.5, 37.5 and 36°c. Meanwhile the thermal constant or degree. Days required for complete development of various stages and generation were estimated to be: 49.0, 199.0, 145.5, 16.0, 77.5 and 366.0 degree-days, respectively.

Developmental thermolability coefficient values (Te) were: 0.02, 0.005, 0.007, 0.02 and 0.003 for egg, larval, egg, larval, pupal, pre ovi position, ovi position and generation (table 2).

Cotton Leafworm Population Cycles

Survey of cotton leafworm with pheromone traps in Middle Egypt indicates that population Peaks occur in cycles of ca 480 dd's. Thus starting from January 1st , the following averages of dd's for each population peak were recorded as follows:

DD	Peaks
488	1st generation
+495	
983	2nd generation
+488.6	
1471.6	3rd generation
+485.9	
1957.5	4th generation
+489.0	
2446.5	5th generation

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Table 1. Rates of development for various Stages of cotton leafworm and constant temperature regimes.

	Temperature regimes			
Stages	**17.5**	**22.5**	**27.5**	**32.5**
Egg	0.11	0.24	0.35	0.46
Larva	0.02	0.06	0.09	0.11
Pupa	0.05	0.09	0.12	0.17
Adult	0.04	0.05	0.08	0.14
Pre ovi position	0.40	0.58	1.20	1.50
Ovi Position	0.08	0.14	0.20	0.30
Generation	0.012	0.03	0.04	0.06

Table 2. Lower developmental thresholds, upper temperatures, thermal units and thermolability coefficients for cotton leafworm.

Stages	**To**	**Tu**	**DD**	**Tc**
Egg	11.81	36.0	49.0	0.02
Larva	12.50	37.0	199.0	0.005
Pupa	11.33	35.5	145.5	0.007
Pre ovi position	10.66	36.5	16.0	0.07
Ovi position	10.80	37.5	77.5	0.02
Generation	12.60	36.0	366	0.003

Table 3. Prediction models for cotton leafworm under constant temperature regimes.

	Models			
Stages	**Linear**	**R^2**	**Logistic**	**R^2**
Egg	0.236+0.02x	0.89	$0.45 + e^{7.12-0.33x}$	0.87
Larva	0.63+0.005x	0.87	$0.125 + e^{5.05-0.21x}$	0.82
Pupa	0.079+0.007x	0.83	$0.25 + e^{4.16-0.13x}$	0.81
Pre ovi position	0.67+0.063x	0.81	$1.8 + e^{4.95-0.2x}$	0.80
Ovi position	0.139+0.013x	0.82	$0.54 + e^{4.62-0.16x}$	0.79
Generation	0.034+0.0027x	0.82	$0.055 + e^{5.72-0.19x}$	0.80