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Effect of Abiotic Factors on the Life Cycle of *Spodoptera litura* Fabricius, 1775 (Lepidoptera: Noctuidae)

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Abstract Influence of abiotic factors was studied on *Spodoptera litura* Fabricius, 1775 by decreasing temperature & humidity from the optimum conditions (27±2°C Temp & 70±5 % RH). As a result of fluctuation, insect can shorten or elongate their life cycle. Two ranges which were taken for these studies were 40% humidity & 20°C temperature. At normal condition generation time was 35-36 days but at 40% humidity it was prolonged to 48-50 days & at 20°C temperature it was prolonged to 47-49 days. It was observed that when we decrease temperature & humidity from optimum conditions the life cycle elongates. At optimum condition, 40% humidity & 20°C temperature larval growth index was 5.09, 3.15 & 3.32, pupal growth index was 19.96, 16.56 & 16.39 & total developmental index was 2.82, 2.00 & 2.00 respectively. From the results we can see the influence of abiotic factors like temperature and humidity on the lifecycle of *Spodoptera litura* which can help in the prediction of population dynamics of insect pests.

Keywords: *abiotic factors, humidity, temperature, Spodoptera litura*

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1. Introduction

Our ecosystem is largely governed by interactions between abiotic (temperature, humidity, light, wind, soil etc.) and biotic (host, vegetative biodiversity etc.) components. Insects are powerful and rapid adaptive organisms with high fecundity rates and short life cycles. These factors significantly influence insects and their population dynamics. In response to these factors, the insect may prolong its metamorphic stages, survival and rate of multiplication [5]. Global changes are responsible for a wide range of anthropogenic and natural environmental variation. These climatic and weather changes not only affect the status of insect pests but also affect their population dynamics, distribution, abundance, intensity and feeding behavior [1]. The intensity of change in climatic the ecosystem noted by meteorological science has shown a direct and indirect effect on the prey and host relationship, their immune responses and rate of development, their fecundity and various physiological functions [4].

Spodoptera litura Fabricius. (Lepidoptera: Noctuidae) is a moth also known as cluster caterpillar, cotton leaf worm, tobacco cutworm and tropical armyworm in different parts of the world. *S. litura* is an important polyphagous pest in India, China and Japan (Kandagal and Khetagoudar, 2013) of about 290 plants species belonging to 99 families (Dhaliwal *et al.*, 2019) of the agricultural and forestry importance crop such as cotton, chili, castor, groundnut, tobacco, pulses etc. (Ahmed *et al.*, 1979). It is believed that the increasing area of some economically important crops (mainly vegetable) and protected cultivation provide suitable sites for feeding and over wintering of *S. litura* [11]. In India, *Spodoptera litura* is widespread in almost all the states and inflict significant losses to crops of economic importance like soybean, cotton and groundnut [2]. A single larva per square meter is reported to cause an average pod yield loss of 27.3% in groundnut through damage to various plant parts like leaves, flowers and pods [2]. Since 2002, it has frequently been reported that the larvae of *Spodoptera litura* (Fabricius) are causing widespread damage to soybean crops at several localities in India [12]. Recent outbreaks of *Spodoptera litura* (Fabricius) on soybean in Kota (Rajasthan state), and Marathwada and Vidarbha (Maharashtra state) regions of India have been reported to cause monetary losses to the tune of USD4.5 crores and USD 22.5 crores respectively [3]. Due to prominent climatic changes and the non-judicious use of agrochemicals also forced the problem of pest. It is realized that the inherent resistant power of the plant is diminishing day by day [7]. Further [7] noted that there is an urgent need for enhancement of agricultural system productivity due to imminent climate change as agricultural system productivity is going down due to complex problems; insect pests are posing a serious threat to realizing agricultural productivity. Due to the nocturnal nature, the moth of *S. litura* becomes active at night and move overnight for oviposition on a wide range of host plants, which promotes or even ensures the survival of *S. litura* individual over a broad range of environmental conditions [4]. It also becomes resistant to many commonly used insecticides, particularly pyrethroids and carbamates, failing effective controls [3,4,5,6].

Temperature: Being poikilothermic organisms, the developmental rate in insects is highly contingent on external temperature conditions. Hence, the temperature is generally considered the single most significant environmental factor influencing behavior, distribution, development, survival and reproduction in insects [10]. Knowledge of the temperature-dependent population growth potential of insect pests is highly imperative for understanding their population dynamics and implementing agro-eco region specific pest control strategies, especially in the context of predicted global climate warming [12]. The vast majority of studies that infer the effects of temperature on the developmental biology of *Spodoptera litura* have been undertaken only under one constant temperature in the laboratory [13]. Few studies that addressed the development of *Spodoptera litura* at a range of constant temperature was concerned with predicting only developmental rates [13], but no emphasis was given to the simulation of variability in development times, mortality and fecundity with temperature changes. Due to non-linearity in developmental response at temperature extremes, linear models are generally considered poor predictors of insect developmental rates [9]. Yet, the specific effects of associated daily and seasonal temperature extremes on *Spodoptera litura* development are less understood which warrants estimation of the temperature-dependent population growth potential for understanding the impact of climate change on its future incidence and damage activity [4].

Humidity: Moisture also plays a critical role in insect development, especially in the desert. Many insect pests encountered in our crops do not require free moisture to survive. They obtain water through their food supply. For instance, *Liriomyza* leaf miners spend their entire egg and larval stages inside melon or lettuce leaves, extracting water and nutrients from plant tissue. However, relative humidity or lack thereof can influence insect growth and behavior by affecting the insect's ability to regulate water loss. Low humidity is often detrimental to insect development, but most insects found in desert crops have adapted physiological and behavioral mechanisms to prevent dehydration. As a general rule of thumb, cool, wet extremes in weather are the most detrimental to insects because they can promote disease, slow growth rates, and interrupt feeding activities. There is no doubt that weather plays a major role in determining the survival and growth rates of insect populations because of its direct impact on them and their food supply. These interactions have been studied for many years and are fairly well understood. Unfortunately, predicting insect abundance in a particular area is like predicting the weather or vice-versa [13].

2. Materials and Method

2.1. Collection & Multiplication

A colony of *Spodoptera litura* (Fabricius) was collected from the agricultural field (Figure 1 & Figure 2) & reared on an artificial diet [6] and maintained at a constant condition of 27±2°C Temperature & 70±5 % RH. In the laboratory, the larvae were fed with artificial diet placed in plastic trays (Figure 4). The fresh diet was provided every 2-4 days. All the instars of larvae were maintained on artificial diet (Figure 5). Pupae were collected in the plastic container & kept 5 pupae in a single container. Adults were collected as soon as they emerge; this is to avoid starvation of adults. The adult moths were kept inside containers, covered with black cloth. Males and Females chosen for oviposition cage are such that they are healthy i.e. there is no deformity in them concerning their development and have freshly emerged. The cloth & surface of the container serves as a substrate for oviposition. The adult moths were fed with a 10% honey-water solution through a cotton swab. Cotton swabs are prepared by using medicated absorbent cotton. The hatched neonates were allowed to complete their development on an artificial diet.

Figure 1. *S. litura* damage on the castor leaves

Figure 2. Sting bug infesting the castor leaf

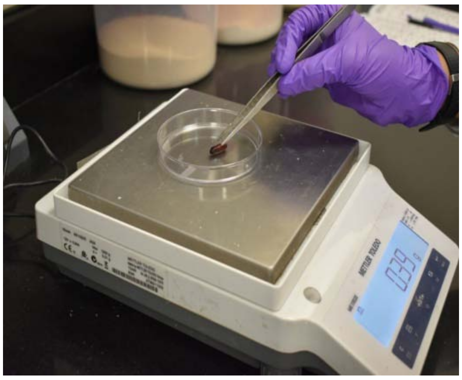

Figure 3. Growth parameters recorded using a weighing balance

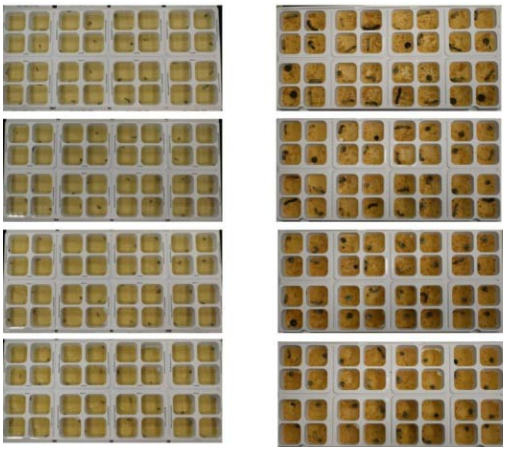

Figure 4. Setup showing larval rearing

2.1.1. Diet Preparation for *Spodoptera litura*

Table 1. List of ingredients used for preparing artificial diet

Sr. No.	Ingredients	500ml
1	Wheat germ	25 gm
2	Chickpea flour	75 gm
3	Sorbic acid	0.75 gm
4	Ascorbic acid	2.50 gm
5	Methyl-p-hydroxy benzoate	2.30 gm
6	Formaldehyde 5%	12 ml
7	Becosule	8 ml
8	Propionic acid	1.8 ml
9	Yeast	28 gm
10	Agar agar	10 gm

Procedure for preparing artificial diet: Distilled water was taken into mixing jar and added propionic acid, formaldehyde and becosule into distilled water and mixed well. Thereafter add ascorbic acid, sorbic acid, methyl p-hydroxybenzoate & mix well. Add wheat germ and chickpea floor, mixed properly by using a hand blender. The remaining half quantity of distilled water was taken in the pan and placed for heating. When bubbles start coming, yeast is added in a pan and dissolved by continuous stirring with the help of the spatula. Agar agar was added slowly. After 10 minutes of cooking, this mixture starts boiling. Mixing was done properly by using hand blender. Pour diet in different plastic trays. For storing it was kept in the refrigerator at 5°C. Careful weighing is done as per Table 1.

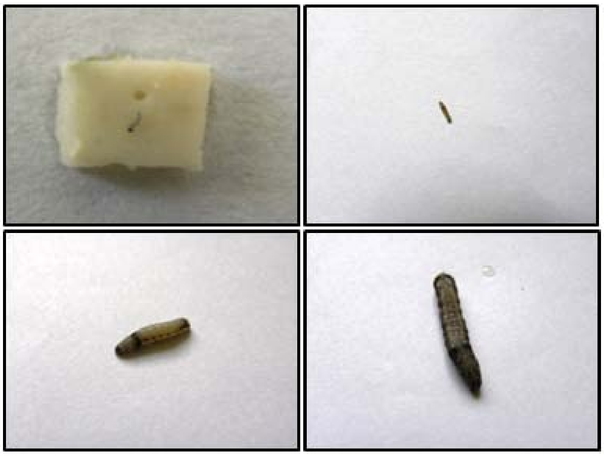

Figure 5. Different stages of *S. litura*

2.1.2. Experimental Design

Abiotic factors like temperature and relative humidity were studied by keeping two different range (20°C Temp & 40% RH) considering optimum range (27±2°C Temp & 70±5 % RH). When testing temperature all the other factors were kept as normal, this will be done to see the only impact of that factor which we were looking for. BOD will be utilized to regulate different abiotic factors. In the current study decrease in these two parameters were studied i.e. 7°C decrease in temperature & 30% decrease in humidity. The duration of the lifecycle was studied by observing whether it prolongs or become shorter due to the fluctuation of these factors. Other growth parameters were observed by weighing different stages (Figure 3).

3. Results & Discussion

The influence of these abiotic factors were studied by observing the life cycle of *Spodoptera litura* i.e. the total number of days were recorded to complete one generation. A total of 100 larvae were taken for this study and data shown in the Table 2 indicates, days taken to complete one generation. When optimum condition provided than it takes 31-35 days to complete one generation but when we provide decreased temperature it will take 47-49 days to complete one generation. Same with the case when we decrease humidity, it will take 48-50 days to complete one generation. Day wise data given in Table 2, Table 3 & Table 4.

Table 2. Completion of life cycle in days

Conditions	Eggs	1st instar	2nd instar
Normal condition	4.5	4.21	4.14
Low humidity 40%	6	6.86	6.69
Low temperature 20°C	7.5	6.3	6.34

Table 3. Completion of life cycle in days

Conditions	3rd instar	4th instar	5th instar
Normal condition	4.11	3.56	3.64
Low humidity 40%	6.61	5.86	5.74
Low temperature 20°C	6.28	5.66	5.56

Table 4. Completion of life cycle in days

Conditions	Pupa	Adult	Total days
Normal condition (27±2°C Temp & 70±5 % RH)	5.01	6.29	35.46
Low humidity 40%	6.04	6.14	49.94
Low temperature 20°C	6.1	6.17	49.91

As Seen from Figure 6 & Figure 7, days will be prolonged when we decrease temperature & humidity. Data on larval and pupal development were recorded. From these observations, the growth and developmental index were calculated as follows:

$$Larval\ growth\ index = \frac{\%\ Pupation}{Larval\ period\ (Days)}$$

$$Pupal\ growth\ index = \frac{\%\ Adult\ emergence}{Pupal\ period\ (Days)}$$

$$\%\ Survival = \frac{\%\ Survival}{Total\ developmental\ period\ (Days)}$$

Table 5. The biological attributes recorded on normal conditions compared with other conditions

Condition	Larval growth index	Pupal growth index	Total developmental index
Normal condition	5.08	19.96	2.82
Low humidity	3.14	16.56	2.00
Low temperature	3.32	16.39	2.00

At optimum condition, 40% humidity & 20ºC temperature larval growth index was 5.08, 3.14 & 3.32, pupal growth index was 19.96, 16.56 & 16.39 & total developmental index was 2.82, 2.00 & 2.00 respectively (Table 5).

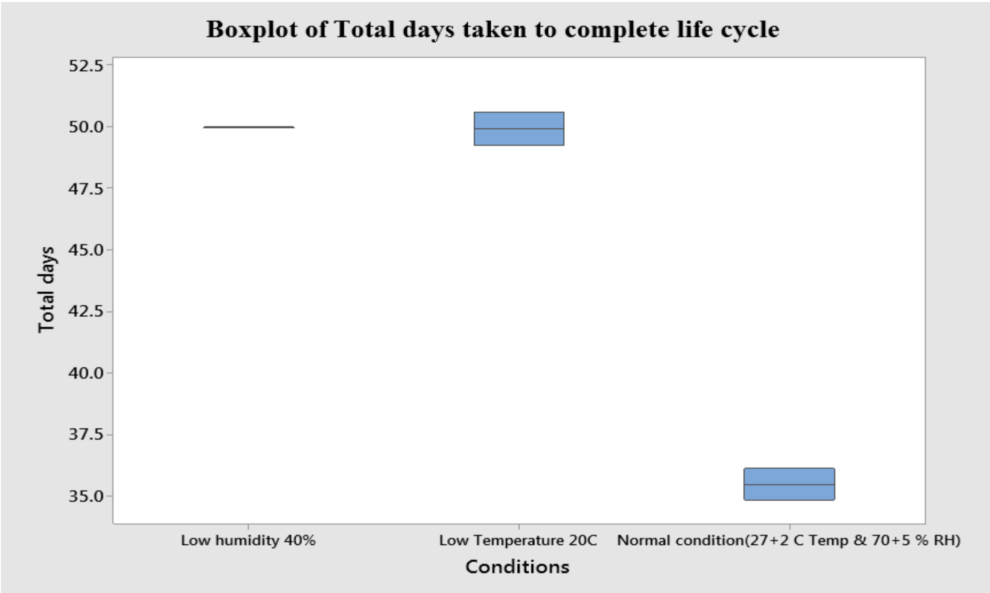

Figure 6. Total days to complete the life cycle at different abiotic conditions

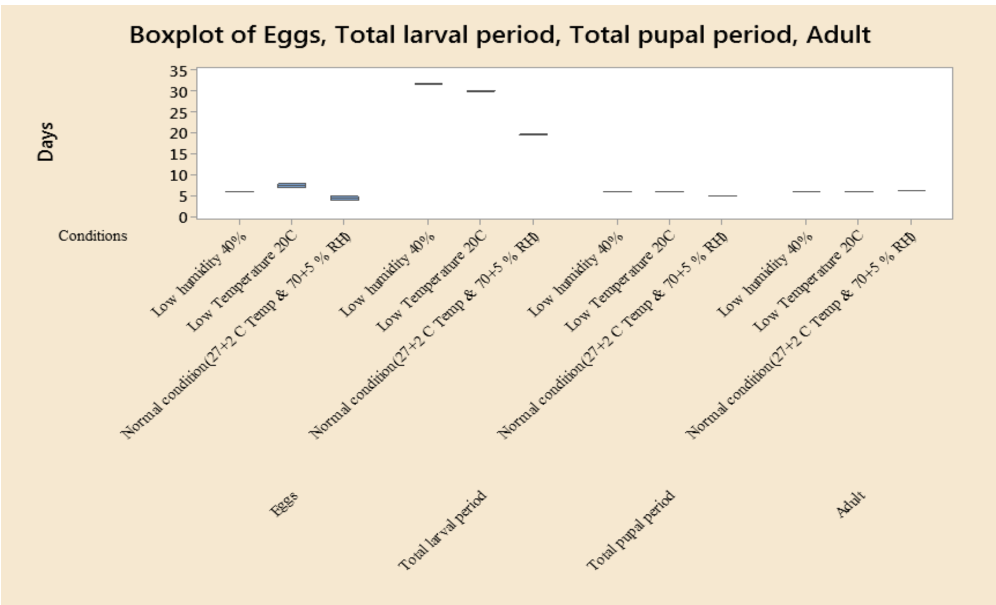

Figure 7. Completion of the life cycle under different conditions

4. Conclusion

Our results are in larger agreement with those reported by [13], who also did not get *S. litura* oviposition at constant high temperatures of 35°C and 37°C, however, the only deviation that existed for the low temperature of 15°C, where they reported egg laying. The studies by [13] on the developmental effects of constant and alternating temperatures on *S. litura* addressed only the development rates and estimation of thermal constants. However, they did not consider the temperature-dependent immature mortality, adult senescence and female fecundity which are considered highly important in understanding pest population dynamics [14]. Rest of the studies that deal with estimating *S. litura* life table parameters were conducted using only a single constant temperature [11]. From the results we can see the influence of abiotic factors like temperature and humidity on the lifecycle of *Spodoptera litura*. When we reduce temperature and humidity the lifecycle was prolonged. This study can be helpful in predicting seasonal distribution of insect pests depending on the weather conditions. Also can be helpful for farmers to see when insect pest can invade the crop. So by this we can reduce the use of pesticides by correlating abiotic factors with the pest of different crops.

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