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*Research Article*

# Effect of Temperature on Life Cycle of *Spodoptera frugiperda* under Laboratory Conditions

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**ABSTRACT**

*Fall armyworm, Spodoptera frugiperda (Diptera:Lepidoptera) is a destructive pest of agricultural crops especially maize in many countries including Pakistan. The environmental factors like temperature play significant role in the growth and development of insect pests. It is very important to know the proper knowledge about effect of temperature on the development of Spodoptera frugiperda before managing this pest. For this purpose, the current study was conducted to check the effect of temperature (20 and 26°C) on the life cycle of S. frugiperda under laboratory conditions. The results showed that the developmental times of all stages (eggs, larvae and pupae) were inversely related to temperature. The incubation period of eggs was 4.01±0.00b and 2.00±0.00b at 20 and 26°C, respectively. The development time of first, second, third, fourth, fifth and sixth larval instar was 3.51±0.10b, 3.04±0.15b, 2.33±0.10b, 2.97±0.14b, 3.45±0.19b and 4.99± 0.22b, respectively at 20°C while 2.77±0.13c, 2.89±0.20bc, 2.09±0.12bc, 2.22±0.17bc, 2.90±0.23c and 3.56±0.19b, respectively at 26°C. The time of growth and development was increased at low temperature while reduced at high temperature. The food consumption rate and molting period of larvae can increase at high temperature for complete their growth and development. The current study concluded that environmental factors like temperature are highly effect the insect pests morphology and biology.*

***Keywords:*** *Polyphagous, Invasive species, Host Plants, Biology, Morphology, Environmental factors.*

## INTRODUCTION

Fall armyworm, *Spodoptera frugiperda* belongs to order Lepidoptera and family Noctuidae, is an emerging pest of several horticultural and agricultural crops. First time, this destructive pest was reported from various areas of Africa (Goergen et al., 2016).

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By adopting different invasion routes, *S. frugiperda* has spread from Africa to many other countries of the world like Australia, Thailand (FAO, 2019a), India (Kalleshwaraswamy et al., 2018), Japan, the Philippines, China, Indonesia, Republic of Korea, Myanmar (FAO, 2019a,b,c,d,e,f,g) and Pakistan (Naeem-Ullah et al., 2019). It is mostly found in tropical and subtropical areas of the world (Du Plessis et al., 2020; & Early et al., 2018).

The biological parameters (egg, larva, pupa, adult), distribution, abundance, population and diversity of *S. frugiperda* are highly affected by various biotic and abiotic factors such as temperature and humidity (Tobin et al., 2003; & Du Plessis et al., 2020). Climate change (temperature, humidity) have significant effect on natural environment especially insects (Battisti, 2006; & Menéndez, 2007). As ectothermic, insect need specific temperature for their development while change in temperature will highly effect insect survival rate, growth and development (Howe, 1967; & Logan et al., 2003). The duration of insect life cycle increases with decrease in temperature while become short (Mironidis, 2014) and faster in high temperature (Begon et al., 2006; & Netherer & Schopf, 2010).

The metabolic process in insect can also increase in ambient temperature (Jaworski & Hilszczański, 2013). The food consumption rate, molting period and number of larval instars are influenced by change in temperature (Aguilon et al., 2015). The life cycle of insects become short during high temperature and its stages attached by several natural enemies such as parasitoids and predators (Porter et al., 1991) by change in environmental conditions (Calvo & Molina, 2005).

The insect studies under controlled conditions at specific temperature and relative humidity can be used to determine pest abundance and diversity as well as best management strategies. The current study was conducted to check the effect of constant temperatures on the life cycle *S. frugiperda*.

## MATERIALS AND METHODS

### Collection and stock colony of *Spodoptera frugiperda*

The *S. frugiperda* larvae were collected from maize fields at Academic block of Muhammad Nawaz Shareef (MNS) University of Agriculture Multan. The collected larvae were brought to rearing laboratory at Institute of Plant protection, MNS-University of Agriculture, Multan for rearing purpose. Larvae was reared in plastic containers (40 × 20 × 15 cm) with maize leaves as food and containers mouth covered with muslin cloth to larvae escape. At two days interval, old leaves were replaced with new and fresh leaves. To avoid cannibalism, third instars to onwards larvae were reared separately in small plastic containers till pupation. Pupae were collected and placed in the separate containers for adult emergence. After emergence of adults, one pair of moths was shifted into rearing cage for oviposition purposes as described by early researcher (Kruger et al., 2012). A maize plant, 10-15 cm in length placed in an upright position in glass/bottle containing soil and kept in rearing cage for adult oviposition. The bottle containing soil was watered for humidity and to keep plant leaves fresh. On daily basis, whole plant was examined for oviposition and collection of egg batches. Adult was provided 10% honey solution for diet.

### Development studies

### Effect of temperature on egg development

The newly laid egg batches (within 12 hours of oviposition) were removed from maize plant leaves by cutting off the leaf pieces containing egg batches. Eggs were counted and 50 eggs kept in plastic container and soaked cotton placed in container to maintain humidity. The plastic containers were placed at 20±1◦C and 26±1◦C temperature and eggs examined on daily basis to check their hatching days.

### Effect of temperature on larva and pupa development

Neonate larvae (within 12 hours of hatching) of equal size and age were randomly selected from stock colony and kept individually in

Petri dishes with maize leaves as food. Larval and pupal stages was studied under the same conditions of constant temperature and photoperiod as described above for egg development. The time duration and survival of larva, pre-pupa and pupa was recorded. Food was daily checked and provided fresh maize leaves until larvae reached to pupal stage. After pupation, duration from pupa to adult was also recorded.

**Statistical analysis**

Data on the effect of temperature on the life cycle of *Spodoptera frugiperda* were verified by means of the Shapiro–Wilk test and Levene's test for homogeneity. Data were statistically analyzed using the Kruskal–Wallis test followed by Duncan's multiple range tests (p = 0.05) because data neither normally distributed not homoscedastic.

## RESULTS AND DISCUSSION

The developmental times of different stages of *S. frugiperda* such as eggs, larvae and pupae were inversely related to temperature between 20 and 26˚C. The incubation period of eggs at 20 and 26˚C, respectively was 4.01±0.00b and 2.00±0.00b. The development time of first, second, third, fourth, fifth and sixth larval instar was 3.51±0.10b, 3.04±0.15b, 2.33±0.10b, 2.97±0.14b, 3.45±0.19b and 4.99± 0.22b, respectively at 20˚C. The duration of first, second, third, fourth, fifth and sixth larval instar was 2.77±0.13c, 2.89±0.20bc, 2.09±0.12bc, 2.22±0.17bc, 2.90±0.23c and 3.56±0.19b, respectively at 26˚C (Table 1). The survival days of larvae increased at very low temperature (10˚C). During low temperature, larvae converted into pupae but moths not emerged (Simmons, 1993).

**Table 1: Mean development time (days ± S.E.) of different life stages (eggs, larvae and pupae) and mortality % of larvae of *Spodoptera frugiperda* at different temperatures**

| Developmental stages | Temperature | | | |
|---|---|---|---|---|
| | 20°C | Range (days) | 26°C | Range (days) |
| **Egg** | 4.01±0.00$^{b}$ | 3−4 | 2.00±0.00$^{b}$ | 2−3 |
| **1st instar** | 3.51±0.10$^{b}$ | 3–4 | 2.77±0.13$^{c}$ | 1-4 |
| **2nd instar** | 3.04±0.15$^{b}$ | 2–4 | 2.89±0.20b$^{c}$ | 2–3 |
| **3rd instar** | 2.33±0.10$^{b}$ | 2–4 | 2.09±0.12b$^{c}$ | 2–3 |
| **4th instar** | 2.97±0.14$^{b}$ | 3–5 | 2.22±0.17b$^{c}$ | 2–3 |
| **5th instar** | 3.45±0.19$^{b}$ | 2–5 | 2.90±0.23$^{c}$ | 3–4 |
| **6th instar** | 4.99±0.22$^{b}$ | 5–8 | 3.56±0.19$^{b}$ | 3–5 |
| **Larvae** | 20.01±0.11$^{b}$ | 18–23 | 14.77±0.29b$^{c}$ | 15–20 |
| **Pupae** | 18.00±0.27$^{b}$ | 16–21 | 12.00±0.20b$^{c}$ | 13–19 |
| **Egg to adult** | 41.78±0.29$^{b}$ | 40–49 | 30.11±0.23b$^{c}$ | 30–43 |
| **Larval mortality (%)** | 35 | | 18 | |

**Note:** Means in a row followed by the same letter are not significantly different (p < 0.05)

The life cycle was found longer at low temperature (20˚C) as compared to high temperature (26˚C). Du Plessis et al. (2020) had reported that developmental times become faster and reduce at high temperature as compared to low temperature. Our findings are in line with their findings. It was observed that high temperature favors the insect growth and development (Jarošík et al., 2002). The duration period of egg to adult was 40-49 and 30-43 days, respectively at 20 and 26˚C. Busato et al. (2005) and Barfield et al. (1978) had reported that duration period is extended at low temperature while shorter at high temperature which is in line with this study.

Insect growth and development become longer while duration of life cycle become shorter at low temperature. The food consumption rate and molting period of larvae can increase at high temperature for complete their growth and development. The similar findings have been reported by many researchers (Montezano et al., 2019; Nagoshi et al., 2019; & Ramzan et al., 2021b) which is similar to our study findings. The significant difference was recorded in the developmental time of larvae and pupae at both temperatures (20 and 26°C) (Table 1).

The life period of insect species increases linearly during favorable environmental conditions like temperature while decrease and become nonlinear at unfavorable conditions. Our findings are similar to findings of many early researchers (Wagner et al., 1984; & Ramzan et al., 2021a). The incubation period was also different at each temperature (20 and 26°C) which is contrast to the findings of scientists (Ali et al., 1990). The insect activity is also influenced by the change in temperature such as the metabolic process (Bale et al. 2002; & Menéndez 2007). The risk of insect attacked by fungus, predators and parasitoids can also increase at low temperature and high humidity (Jaworski & Hilszczański, 2013). Eggs and pupae can tolerate the cold environment (Richard et al., 2010) but larvae not (Kelty & Lee, 2001). The different management strategies can adopt against such destructive pests (Ramzan et al., 2019). The yield or production can increase by their management.

## CONCLUSION

Temperature plays a key role in the development and growth of different stages of *S. frugiperda* stages (egg, larva, pupa and adult). The developmental time of insect stages can increase or decrease by change in temperature. The life period of insect extended at low temperature while reduce at high temperature. The knowledge about temperature is very important for predicting insect models and distribution. It can also helpful for the determination of *S. frugiperda* populations. It provides best information that no population of *S. frugiperda* will exist or establish in geographical regions where temperatures decrease to below these levels.

**Conflict of interest**

Authors have no conflict of interest.

**Author contribution**

MR conducted the study and wrote the manuscript.

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