

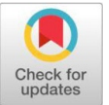
Original Research Article

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Growth and development of *Spodoptera frugiperda* (J.E. Smith) on maize at different temperatures

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ABSTRACT

In India, the invasion of Fall Army Worm (FAW), *Spodoptera frugiperda* (J.E. Smith) (Lepidoptera: Noctuidae), was detected as a new exotic invasive pest in May 2018 on maize from Karnataka. By August 2018, the pest had spread to the entire maize-growing areas of South India, including Maharashtra. The study aims to investigate the effects of different temperature levels viz 20 °C, 25 °C, 30 °C, and 35 °C on the growth, development, and reproductive parameters of the fall armyworm (*Spodoptera frugiperda*) under laboratory conditions. One of the major challenges faced during the study was maintaining consistent environmental conditions and managing high mortality rates at extreme temperatures, which affected the continuity of data collection. Despite these difficulties, the study contributes valuable insights into the thermal thresholds and biological responses of FAW under controlled settings. The larva of *S. frugiperda* passed through six larval instars at all temperatures and successfully completed its life cycle at varying degrees on maize, being shortest at 35 °C (18.13 ± 0.06 days) and longest at 20 °C (60.00 ± 0.07 days). The highest fecundity of *S. frugiperda* was registered at 30 °C (764.40 eggs per female), followed by 25 °C (696.20 eggs per female), 20 °C (451.60 eggs per female), and lowest at 35 °C (195.20 eggs per female). Highest percent pupation and adult emergence were at 30 °C (92 ± 0.60% and 98.2 ± 0.48%) and lowest at 20 °C (34 ± 0.74%) and 35 °C (68.4 ± 0.70%), respectively. Thus, the optimum temperature for the efficient growth and development of *S. frugiperda* was within the range of 25 to 30 °C. The findings can support targeted pest management practices and predictive modeling of FAW outbreaks in varying agro-climatic zones.

Keywords: Developmental period, fecundity, incubation period, mortality, pupal duration total life cycle duration, biology and *Spodoptera frugiperda*.

INTRODUCTION

The Fall armyworm, *Spodoptera frugiperda* (J.E. Smith) (Lepidoptera: Noctuidae) is a polyphagous insect pest resident to tropical and subtropical America (11, 16) which rapidly expanding in most of the maize-growing areas and thus becoming A1 threat to the globe (2). It has long been known as a pest in the Americas and has invaded most of Africa and parts of the Middle East, Asia, and Australia in the last six years (9). *S. frugiperda* has emerged as a great menace to mankind due to its short development period (2, 15) wide host range, high prolificacy (2, 16), high dispersal ability, and absence of diapause (3). *S. frugiperda* is capable of causing a 100 per-cent yield loss due to its unforeseen occurrence from the seedling to the cob formation stage in maize (12). Temperature is one of the most important environmental factors influencing insect growth, development and reproduction (10). Insects can survive only in a narrow band of the temperature range where all the physiological activities of the insect takes place that temperature range is called the preferred temperature range (14). Moreover, since insects are strongly temperature-dependent, it can be expected to significantly affect the seasonal population dynamics by affecting several biological attributes such as adult life span, survival, fecundity, fertility, and rate of

population growth (8). Thus, the response to local environmental conditions is a key component for the adaptation and persistence of insect pests, particularly invasive alien species. Thus, the main objective of the study is to inspect the effects of different temperature regimes on the growth and development of attributes of FAW under laboratory conditions.

METHODOLOGY

Rearing of test insect

The investigation on growth and development, morphometrics and life fecundity tables of *Spodoptera frugiperda* (J.E. Smith) on maize at different temperature levels viz., 20 °C, 25 °C, 30 °C and 35 °C were conducted under laboratory conditions at the Post Graduate Laboratory, Department of Agril. Entomology, College of Agriculture (Vasant Rao Naik Marathwada Krishi Vidyapeeth, Parbhani), Campus Latur, Dist: Latur (MS)-India during 2021-2022. The laboratory culture of fall armyworm, *Spodoptera frugiperda* (J.E. Smith) (Noctuidae: Lepidoptera) was initiated by collecting large sized larvae from maize crop cultivated on the Research Farm of Department of Agricultural Entomology, College of Agriculture, Latur during 2021-2022. The collected larvae were reared individually in clean round plastic vials (measuring diameter 3.5 cm and height 4 cm). These vials were cleaned every day. Daily larvae were fed on unsprayed field collected leaves, stems and whorls of maize plants during the morning hours till pupation. After pupation, the adults that emerged on the same day were sexed. Then one male and one female adult were paired together in oviposition cage for copulation and egg laying. A cotton swab dipped in 50 per-cent honey solution was provided as food to the adults in oviposition

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cage. The fresh leaves of maize were also placed as an oviposition substrate. After every 24 hours, the leaves were examined for presence of eggs or egg masses and replaced with fresh one. Thus; the freshly laid eggs were used for investigation on growth and development of *S. frugiperda* on maize at different temperature levels.

Observations on growth and development of lab-cultured FAW

One hundred freshly laid eggs in a group of 20 per replication were kept in petri dish for recording observations in respect of incubation period and per-cent egg hatching at different temperature levels. The newly hatched larvae were reared individually on leaves and slices stem of maize at different temperature levels viz., 20 °C, 25 °C, 30 °C and 35 °C in round plastic vials (measuring diameter 3.5 cm and height 4 cm). While rearing due care was taken to transfer the larvae into clean plastic vial. Fresh food was provided daily and old food was removed. All the necessary observations were noted which were necessary for the study. After pupation the adults that emerged on the same day were sexed and one male and one female were paired together for copulation and egg laying in oviposition cage. A cotton swab dipped in 50 per-cent honey solution was provided as a food to the adults. The fresh leaves of maize and black cotton cloth were also placed as an oviposition substrate. After every 24 hours, the leaves and black cotton cloth were examined for presence of eggs or egg masses and replaced with fresh one. The number of eggs laid by each female was counted daily till the death of female. The observations on initiation of oviposition, last oviposition and death of female were recorded. From these pre-oviposition, oviposition, and post-oviposition periods were worked out on hybrid maize (GOLD 1166) at 20 °C, 25 °C, 30 °C and 35 °C, respectively.

RESULTS AND DISCUSSION

The results obtained from the study indicate that temperature had a profound and significant impact on the development of all immature stages of FAW (Table 1). The mean incubation period of *S. frugiperda* (table 1) was minimum at 35 °C (1.69 days) followed by 30 °C (2.16 days), 25 °C (3.11 days) and maximum at 20 °C (6.78 days). Egg hatchability was significantly reduced at both high and low extreme temperatures. Shortest incubation period of 1.52 days at 30 °C, the longest one (5.38 days) was observed at 20 °C. Whereas the per-cent egg hatchability was found to be significantly highest at 25 °C (94 per cent) followed by 30 °C (89 per cent), 20 °C (82 per-cent) and the lowest egg hatching was registered at 35 °C (78 per-cent) (17,13). *S. frugiperda* passed through six larval instars on maize at different temperatures. The significant minimum and maximum I, II, III, IV, V and VI instar larval duration of *S. frugiperda* to the extent of 1.31, 1.39, 1.77, 1.35, 1.71 and 2.03 and; 5.13, 4.96, 4.68, 5.21, 5.10 and 6.00 days was recorded on maize at 20 and 35 °C, respectively. Similarly the larval duration for 1 to 6 instars of *S. frugiperda* on maize were 2.78 ± 0.42 , 2.38 ± 0.76 , 2.71 ± 0.75 , 3.20 ± 1.48 , 4.00 ± 0.70 and 5.20 ± 0.83 ; 2.33 ± 0.50 , 1.92 ± 0.60 , 2.13 ± 0.60 , 2.01 ± 0.72 , 2.81 ± 0.82 and 3.72 ± 1.07 and; 3.14 ± 0.79 , 3.02 ± 0.85 , 2.72 ± 0.88 , 2.54 ± 0.95 , 2.81 ± 0.72 and 3.66 ± 0.63 days at 35, 30 and 25 °C, respectively. (17). The mean total larval duration of *S. frugiperda* was shortest at 35 °C (9.56 days) followed by 30 °C (11.84 days), 25 °C (15.26 days) and the highest mean total larval duration was noticed at 20 °C (31.08 days). Studies have shown that larval durations of *Spodoptera frugiperda* were 38.5, 23.7, and 18.6 days at 20, 25, and 30 °C,

respectively, when reared on maize leaves in Egypt. Similarly, some findings reported the shortest total larval duration to be 11.60 days at 35 °C, followed by 13.28 days at 30 °C. The longest larval duration, 19.55 days, was observed at the lowest tested temperature of 20 °C. (5,13).

Highest per cent pupation of *S. frugiperda* was registered at 30 °C (92 per cent) followed by 25 °C (88 per-cent), 35 °C (37 per cent) and the lowest per cent pupation were noticed at 20 °C (34 per cent), whereas the minimum mean pupal duration of *S. frugiperda* was noticed at 35 °C (6.88 days), followed by 30 °C (8.36 days), 25 °C (11.42 days) and the maximum mean pupal duration was recorded at 20 °C (22.14 days). This indicates that the pupal duration of *S. frugiperda* increased with decrease in temperature. The results of the present investigation align with previous findings that reported prepupal and pupal durations of *Spodoptera frugiperda* to be 1.20 ± 0.44 , 1.64 ± 0.75 , and 1.84 ± 1.02 days; and 5.75 ± 0.50 , 8.61 ± 0.75 , and 9.21 ± 1.02 days at 35, 30, and 25 °C, respectively, when reared on maize under controlled conditions. Other studies have recorded pupal durations ranging from 7.82 days at 32 °C to 30.68 days at 18 °C. Additionally, the highest pupal survival rate was observed at 25 °C (83.33%), while the lowest was at 20 °C (60%). (17, 6). The total developmental period of *S. frugiperda* was significantly lowest at 35 °C (18.13 days) followed by 30 °C (22.36 days), 25 °C (29.79 days) and the highest was registered at 20 °C (60.00 days). This indicates that the total developmental period of *S. frugiperda* increased with decrease in temperature. Results were found in accordance with studies that reported the total developmental period of *S. frugiperda* shortened significantly with the increasing of temperatures and reported the pupal duration of 18.36 ± 0.17 , 12.83 ± 0.08 and 7.69 ± 0.11 days at 20, 25 and 30 °C on maize, respectively. (4)

The per-cent adult emergence of *S. frugiperda* varied significantly when reared on maize at different temperatures viz., 20, 25, 30 and 35 °C. Significantly highest adult emergence of 98.2 per-cent was recorded at 30 °C followed by 25 °C (96.4 per-cent), 20 °C (86.00 per-cent) and the lowest adult emergence was registered at 35 °C (68.4 per-cent). This indicates that 30 °C is most suitable and 35 °C is least suitable temperature for the adult emergence of *S. frugiperda* among the evaluated temperatures. The significantly highest adult longevity of male *S. frugiperda* was registered at 20 °C (12.24 days) followed by 25 °C (10.09 days), 30 °C (7.19 days) and the lowest were observed at 35 °C (5.12 days). Similarly, the significant maximum adult longevity of female *S. frugiperda* was recorded at 20 °C (13.84 days) followed by 25 °C (11.16 days), 30 °C (8.51 days) and the minimum were noticed at 35 °C (6.32 days). Adult females lived longer than males. The results of present investigation are in correspondent with the findings of Thissa Kumara *et al.* (2022) who evidenced that the female longevity of *S. frugiperda* was 5.00 ± 1.73 , 9.38 ± 2.06 and 9.00 ± 1.60 days at 35, 30 and 25 °C, respectively on maize under controlled condition in Sri Lanka. Ashok *et al.* (2021) too evidenced similar trend were he observed the adult longevity was 11.02 ± 0.09 , 10.79 ± 0.09 , 10.19 ± 0.22 , 9.41 ± 0.30 and 8.26 ± 0.15 at 32, 33, 34, 35 and 36 °C, respectively on maize at Coimbatore.

Preoviposition, oviposition and post oviposition period was observed to be highest at 20 °C (4.60 ± 0.35 , 2.46 ± 0.02 , and 6.78 ± 0.08) and lowest at 35 °C (2.10 ± 0.36 , 1.12 ± 0.05 , 3.10 ± 0.02). The results of present investigation are in harmony with the study demonstrated the pre-oviposition (2.85 ± 1.11 and 2.82 ± 0.52), oviposition period (4.73 ± 1.77 and 5.25 ± 1.73) and post oviposition period (1.23 ± 0.59 and

1.62 ± 1.06 days) period at 30 and 25 °C. The mean fecundity of *S. frugiperda* varied significantly when reared on maize at different temperature regimes viz., 20, 25, 30 and 35 °C. The significantly highest fecundity of *S. frugiperda* was registered at 30 °C (764.40 eggs per female) followed by 25 °C (696.20 eggs per female), 20 °C (451.60 eggs per female), whereas the significantly lowest fecundity was observed at 35 °C (195.20 eggs per female). Studies by Chen exhibited similar trend for fecundity which was 404.95, 954.92, and 956.83 eggs per female at 20, 25, and 30 °C on maize, respectively in a climate chamber (at 70 ± 5 per-cent RH, with a photoperiod of 14:10 (L-D) h) in China (4). Some studies evidenced that the average fecundity was recorded to be 1203.96 ± 30.09, 1519.87 ± 25.87, 1805 ± 24.17, 784.21 ± 17.73 and 401 ± 18.19 eggs per female at temperature regime of 32, 33, 34, 35 and 36 °C, respectively on maize at Coimbatore (1)

Conclusion

The results of this study clearly validate that temperature has a significant influence on the development of all immature stages, survival, adult longevity, and reproduction of the fall armyworm (*Spodoptera frugiperda*). The developmental period of immature stages decreases as temperature increases. A temperature range of 25°C to 30°C is the most suitable for the

growth, survival, and development of *S. frugiperda*. However, the species can successfully survive to varying degrees in geographical regions where temperatures range between 20°C and 35°C. These population parameters highlight the strong environmental adaptability of *S. frugiperda*, which contributes to its potential to cause severe damage to maize crops in India and worldwide. The findings from this study can be utilized to predict the population dynamics of *S. frugiperda* on maize under different temperature conditions and aid in the development of effective integrated pest management (IPM) strategies.

FUTURE SCOPE: The data generated can be further used for in pest production models. However, impact of temperature with other biotic and abiotic parameters on survival and development of *S. frugiperda* can be studied.

CONFLICT OF INTEREST: The author declares no conflicts of interest.

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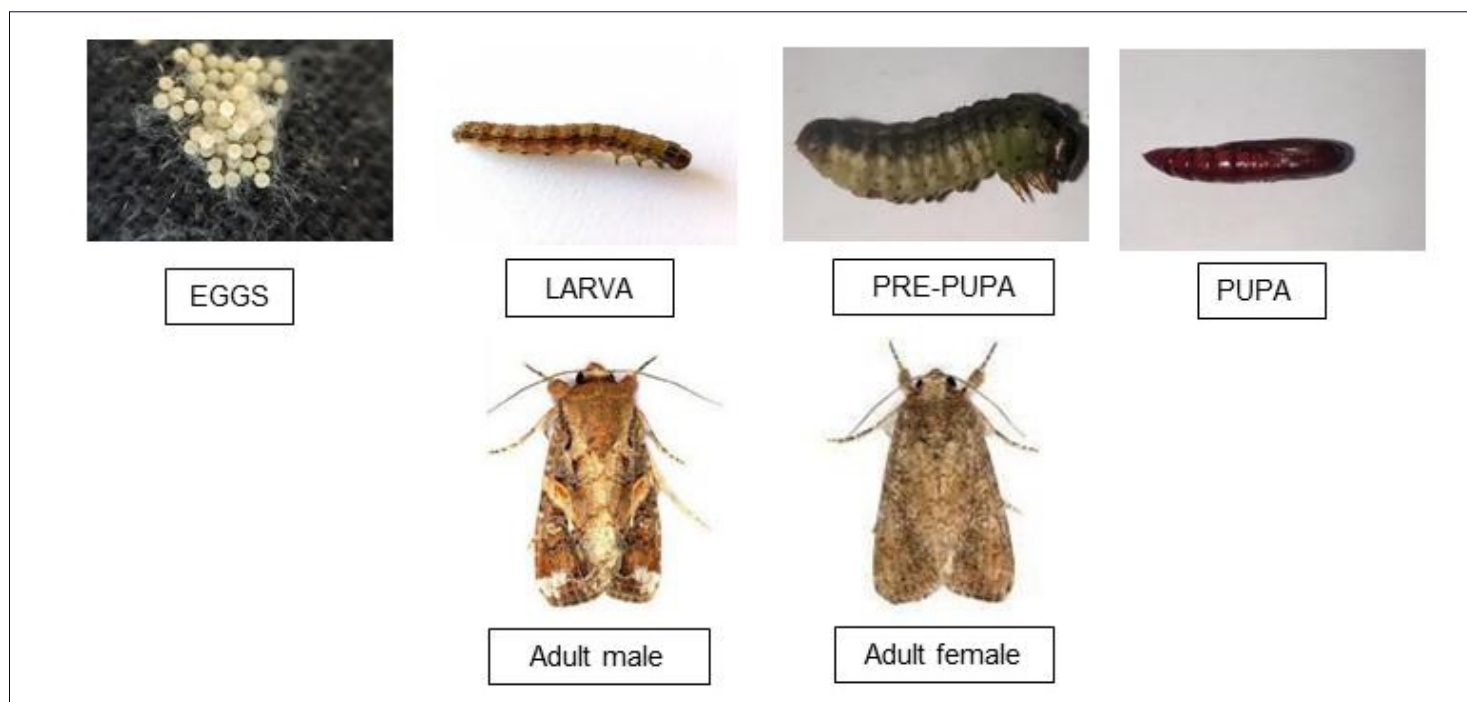


Figure 1: Life Stages of FAW of *Spodoptera frugiperda* (J.E. Smith) on maize

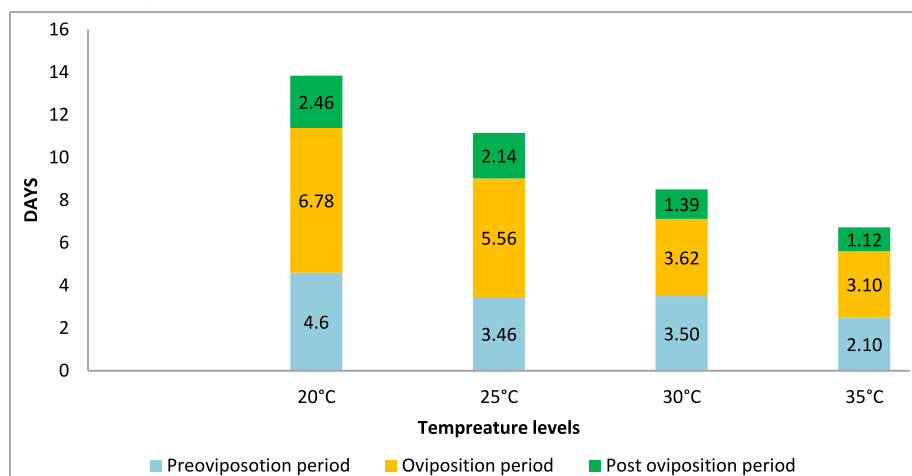


Figure 2: Effect of different temperatures on pre-oviposition, oviposition and post oviposition period of FAW *Spodoptera frugiperda* (J.E. Smith)

Table 1: Survival and development of *Spodoptera frugiperda* on maize at different temperatures

SR No	PARAMETERS	TEMPERATURES			
		20°C	25°C	30°C	35°C
1	Incubation Period (days)	6.78±0.89	3.11±1.01	2.16±0.96	1.69±0.45
2	Egg hatchability (%)	82±1.16	94±1.66	89±1.45	78±1.89
3	Total larval duration (days)	31.08±1.08	15.26±0.65	11.84±0.56	9.56±0.45
4	Instar period (days)				
	I	5.13±0.06	2.91±0.05	2.21±1.0	1.31±0.4
	II	4.96±0.04	2.10±0.04	1.44±1.12	1.39±0.04
	III	4.68±0.03	2.53±0.08	1.91±0.05	1.77±0.03
	IV	5.21±0.03	2.22±1.04	1.70±0.03	1.35±0.02
	VI	6.00±0.08	3.18±0.05	2.58±0.08	2.03±0.02
5	%Pupation	34±0.74	88±1.10	92±0.60	37±1.06
6	Growth Index	1.09±0.36	5.76±0.31	7.77±0.38	3.87±0.28
7	Pupal Duration (days)	22.14±0.64	11.42±0.45	8.36±0.80	6.88±0.44
8	Total developmental Period (days)	60.00±0.07	29.79±0.05	22.36±0.03	18.13±0.06
9	Adult emergence (%)	86±0.90	96.4±0.65	98.2±0.48	68.4±0.70
13	Fecundityeggs per/female	451.60±18.22	696.20±22.25	764.40±24.30	195.20±17.44
14	Adult longevity (days)				
	Male	12.24±0.03	10.09±0.04	7.19±0.04	5.12±0.02
	Female	13.84±0.02	11.16±0.03	8.51±0.04	6.32±0.03
15	Total life cycle duration (days)				
	Male	72.23±0.66	39.88±0.70	29.55±0.55	23.25±0.50
	Female	73.84±0.80	40.95±0.35	30.87±0.75	24.45±0.66
16	Sex ratio (Male: Female)	1:1.18	1:1.05	1:1.02	1:0.66

Mean±SD (n=100/host); SD - Standard deviation

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