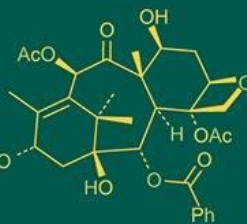


International Journal of Advanced Biochemistry Research



ISSN Print: 2617-4693
 ISSN Online: 2617-4707
 IJABR 2024; SP-8(8): 1236-1243
www.biochemjournal.com
 Received: 26-06-2024
 Accepted: 30-07-2024

Jadav Bheemrao
 MS,C Agri. Entomology
 JNKVV University
 City, Jabalpur,
 Madhya Pradesh, India

Impact of temperature and soybean genotypes on biology of tobacco caterpillar and its mortality assessment with chitin synthesis inhibitors under *in vitro* condition

Jadav Bheemrao

DOI: <https://doi.org/10.33545/26174693.2024.v8.i8Sp.2015>

Abstract

Laboratory experiment was conducted to assess the influence of temperature regimes (20, 25 and 30 °C) on biology of tobacco caterpillar in soybean genotypes and its mortality assessment with chitin synthesis inhibitors at bio control lab, Jabalpur. Soybean genotypes include JS-335, JS 97-52, JS22-09 and JS20-116. Among genotypes JS-335 recorded higher number of eggs (1652.11 eggs/female) and hatchability percentage (88.04), while it were lower on JS JS97-52 as 257.33 eggs/female and 63.65% respectively. Longest incubation period was observed on JS97-52 (6.22 days) and significantly shortest on JS-335 (3.89 days). The mean incubation period significantly decreased with increase in temperature. However, longest incubation period was recorded at 20±2 °C (6.67) days and it was shortest at 30±2 °C (3.92 days), respectively. Among genotypes total larval duration was observed to be shortest on JS-335 (15.89 days). longest on JS97-52 (24.89 days). Among temperature regimes, it significantly decreased with increase in temperature, being 27.58, 20.08 and 14.92 days which were observed at 20±2 °C, 25±2 °C and 30±2 °C, respectively. The total larval survival significantly increased with increase in temperature, being 61.67, 63.33 and 79.17% at 20±2 °C, 25±2 °C and 30±2 °C, respectively. Highest pupation percentage and adult emergence was recorded on JS-335 genotype. The *S. litura* 2nd instar larval mortality marginally increased with increase in concentration coupled with elapse of time in all the treatments. It indicated that mortality was clearly dose and time dependent. Lufenuron at higher concentration (100 ppm) was found to be highly effective as it recorded maximum larval mortality at 3 days after treatment (DAT) followed by Novaluron and Diflubenzuron @ 200 and 300 ppm, respectively.

Keywords: Genotype, temperature, Lufenuron, mortality

Introduction

Soybean (*Glycine max* L. Merrill), belongs to the family Leguminaceae and subfamily Papilionoideae, is an important two dimensional crop grown in tropical, subtropical and temperate climates. The cultivated soybean originated from China and was introduced in India during the tenth century AD through Himalayan routes (Agarwal *et al.*, 2013) [1]. It is an ideal crop for small and marginal farmers with high nutritional value and significantly contributed to “Yellow Revolution” in India. It contains 42% protein, 20% oil, lycin and vitamins A, B and D (Ramesh Babu *et al.*, 2018) [2]. For vegetarians, it is known as “Poor Man’s Meat”. It has innumerable possibilities of not only improving agriculture but also supporting industries and good source of medicinal value, thus it is considered as “Miracle Bean” or “Golden Bean” or “Wonder Crop” of the 20th century (Fattah *et al.*, 2020). India ranks 4th in area and 5th in production of soybean in the world after United States of America, Brazil, Argentina and China (Longchar *et al.* 2018) [4]. In Indian scenario, Madhya Pradesh alone contributes more than 50% in total area and production of soybean; hence this state is usually referred as “Soya State” (Ahirwar *et al.* 2013) [5]. The low productivity of soybean both at national and state level is attributed to abiotic and biotic stresses like drought, weeds, insect pests and diseases. Among these, insect pests often pose a serious threat to soybean production, quantitatively and qualitatively. Soybean is reported to be attacked by more than 380 species of insects in many parts of the world. About 150 insects pests cause damage to soybean in various parts of Madhya Pradesh, out of them a dozen of them cause serious

Corresponding Author:
 Jadav Bheemrao
 MS,C Agri. Entomology
 JNKVV University
 City, Jabalpur,
 Madhya Pradesh, India

damage to the crop from sowing to harvest (Ahirwar *et al.* 2013) ^[5]. Among them, tobacco caterpillar, *Spodoptera litura* Fab. (Lepidoptera: Noctuidae) is a most destructive and serious defoliator throughout the ecological situation. In recent years, *S. litura* regularly occurred as a devastating pest of field crops due to its nocturnal habit, migration ability of adult insect over longer distances, wide host range and also characteristics to survive in the soil during cold spells without undergoing diapauses (Karmakar and Pal, 2017) ^[6]. In Madhya Pradesh, *S. litura* is a regular and serious pest, it damages soybean from mid-August to October in *Kharif* and from November to March in *Rabi* season. It feeds on foliage, flowers and pods causing significant yield losses (Azmi *et al.* (2017) ^[7]. Sudden rise in temperature and sunshine hours would decide the outbreak of *S. litura* in soybean. During, 2008 outbreak of *S. litura* in soybean caused widespread losses in Vidarbha and Marathwada region of Maharashtra (Kawre *et al.*, 2019) ^[8]. Sundar *et al.*, (2018) ^[9] has further emphasized that climate change affects the activity of *S. litura* and caused 40% defoliation. It alters the interaction between host - insect relationship, under such conditions some of the cultivars resistant to specific pest, may become susceptible (Sangle *et al.*, 2015) ^[10]. Billy reported that in central India a 3 °C rise in surface air temperature, abandons out the positive effects of doubling of CO₂ concentration, which results in reduction in the soybean productivity to the extent of 50%. The fourth assessment report of Inter Governmental Panel on Climate Change indicated that the annual average temperature of the earth is likely to increase by 1 °C by 2025 and by 3 °C towards the end of the century. Effect of temperature change on herbivorous insects directly affects the insect physiology and behavior or indirectly by influencing the host plant abundance and quality (Karuppaiah and Sujayanad, 2012) ^[11]. According to Srinivasa Rao *et al.*, (2014) ^[12] temperature is the single most significant climatic factor influencing the metabolism, development, reproduction and survival of the insects. Fand *et al.*, (2015) ^[13] reported *S. litura* incidence will increase in soybean areas like Madhya Pradesh, Maharashtra and Rajasthan due to increased temperature under future climatic condition. Therefore, to manage *S. litura* efficiently, there is a need to study the effect of change in temperature on the biology of the pest on its host plants.

The last four decades have witnessed a massive transition in the development of insecticide resistance in *S. litura*. The first case of insecticide resistance in *S. litura* was documented against BHC in areas around Jaipur and Ajmer (Bhatia, 1986) ^[14]. Hence, *S. litura* has the distinction of being first ever lepidopteran pest in India and second agricultural pest to develop insecticide resistance. Field collected populations of *S. litura* showed resistant to cypermethrin, deltamethrin, chlorpyrifos and profenofos (Ahmed *et al.*, 2005) ^[15]. Problems like resurgence, residue, secondary pest outbreak and environmental safety emerged due to neuroactive insecticides in pest management. Therefore, in the present context ecofriendly management strategies are required for this notorious pest. The insect growth regulators (IGR's) are a group of modern pesticides which may play desirable role in integrated pest management. IGR's are a group of chemical substance that inhibits the lifecycle of an insect by dispensing the moulting processes (Deep *et al.*, 2018) ^[17]. IGR's include compounds such as chitin synthesis inhibitors (CSI's), juvenile hormone

mimics and ecdysone agonists. The CSI's further consist of various compounds acting on the immature stages of insects by inhibiting the chitin formation, thereby causing abnormal endocuticular deposition and abortive moulting (Ahmad and Gull, 2017) ^[18]. Lufenuron specifically acts on the incorporation of N-acetyl glucosamine in the integument, resulting in the formation of abnormal new cuticle and death of the insect (Islam *et al.*, 2015) ^[15]. Novaluron is a relatively new benzoylphenyl urea group with low mammalian toxicity and it acts by ingestion and contact against lepidopteran insects (Hamadah *et al.*, 2015) ^[20].

Materials and Methods

Initiation and multiplication of *S. litura* culture

Initially the *S. litura* egg masses were collected from the unsprayed soybean field of Breeder Seed Production farm, JNKVV and kept in petridishes with tender leaves for enabling the young larvae to feed immediately after hatching and to prevent Mortality of larvae. The rearing space was increased regularly using more number of plastic trays (8 x 4 inch) from third instar onwards to avoid cannibalism and crowding of larvae. For pupation, sixth instar larvae were transferred to the beakers half filled with moist sterile sand. Male and female pupae were separated as proposed by Li *et al* (2014) ^[21]. A pair of emerged adults were released in each plastic container along with cotton swab dipped in 10% honey solution (Plate 5). As proposed by Farahani *et al* (2011) ^[22] the F₁ offsprings obtained were maintained on the tested genotypes for two successive generations before they were used in the experiment. Thus the nucleus culture from third generation F₃, adults were used for further investigation. The glasswares used in the experiment was thoroughly washed in detergents, treated with 2% formalin and then dried in an oven at 30 °C for 8 hours to check microbial contamination in the insect culture as per the methodology suggested by Sharma and Singh (2018) ^[23].

Procurement of soybean seeds

Seeds of soybean genotypes (JS-335, JS 97-52, JS22-09 and JS20-116) were obtained from Soybean Breeder; All India Coordinated Research Project on Soybean, Department of Plant Breeding & Genetics, College of Agriculture, JNKVV, Jabalpur, MP. The seeds were stored in air tight containers for further use as and when required for study (Plate 3).

Raising of test genotypes

Four different genotypes of soybean which were included in the study as main treatment (JS-335, JS 97-52, JS 22-09 and JS 20-116) were grown in suitable soil and compost mixture in 20 cm diameter plastic pots in green house following the recommended package of practices but without any insecticidal spray (Plate 4). Trifoliolate leaves from 20-25 days old crop were used for the study as proposed by Farahani *et al* (2011) ^[22].

Design of temperature regimes

On the basis of last forty years temperature data of *kharif* season in Jabalpur (M.P) the mean range was computed which was further into three temperature regimes (*viz.*, 20±2, 25±2 and 30±2 °C) were considered as sub treatments.

Materials used

The following materials were used to conduct the studies on the biological parameters: 32 mega pixel camera, aluminum foil, BOD, camel hair brush (zero size), cotton swab, digital electronic balance, forceps, glass beakers, laminated graph paper,

marker, measuring scale, muslin cloth, ocular micro meter, paraffin paper, plastic containers for oviposition, plastic petri dishes (15" diameter), plastic pots, plastic trays, refrigerator, rubber bands, soybean cultivars / genotypes, stereomicroscope, students microscope and thermo hygrometer,

Method of observation

Soybean genotypes comprising of four treatments were replicated three times and kept at 20 ± 2 °C, 25 ± 2 °C and 30 ± 2 °C temperature regimes at constant RH $65\pm 5\%$ with 14:10 light / dark cycle as per methodology suggested by Thakur *et al* (2017) [24].

Eggs: 100 eggs were examined on the four genotypes kept at three different temperature regimes. The data on hatching percentage and incubation periods were recorded.

Incubation period: It was calculated from the time of egg laying to the time of hatching.

Hatching percentage: It was calculated from the data on number of eggs hatched out of total number of eggs under observation.

Larval stage

Thirty newly hatched neonates were released @ ten larvae per treatment per replication which were provided with fresh leaves of tested genotypes as food material. The number and duration of different larval instar was determined by the moulting process with casting off head capsule and exuviae. Number of instars and instar wise survival, larval duration were also recorded on all the selected genotypes at subsequent temperature.

Pupa

Observations on pupal percentage, pupal duration were recorded within 24 hours of pupation as suggested by Swetha *et al.* (2017) [35].

Adult stage

Adult emergence: The number of adults emerged out from the total pupae were recorded. Female and male moth as showed in plate-14

Total life cycle: The time period from egg laying to adult emergence was taken as the total life cycle. The individual duration of egg, larvae, pupae and adults were summed to obtain the total developmental duration and were figured out with all the tested genotypes at different temperature.

Chitin synthesis inhibitors

Studies on efficacy of three chitin synthesis inhibitors were carried out on second instar tobacco caterpillar the details of which are mentioned below:

Treatment Details

S. No.	Treatments	Dose (in ppm)
1.	Diffubenzuron 25% WP	75
2.	Diffubenzuron 25% WP	150
3.	Diffubenzuron 25% WP	300
4.	Lufenuron 5.4% EC	25
5.	Lufenuron 5.4% EC	50
6.	Lufenuron 5.4% EC	100
7.	Novaluron 10% EC	50
8.	Novaluron 10% EC	100
9.	Novaluron 10% EC	200
	Control	-

Preparation of Stock solution

The test doses of diflubenzuron, novaluron and lufenuron were measured with micropipette and transferred into 100ml volumetric flask separately and distilled water was added to make the volume up to 100 ml. The flask having one percent of the active ingredients of chitin synthesis inhibitors were taken as stock solution. These stock solutions were kept in refrigerator at 4 °C and removed an hour before use as to bring the solution to room temperature.

Bioassay study against *S. litura* on 2nd instar larvae

Leaf dip bioassay method was carried out against 2nd instar larvae of *S. litura* as per the methodology suggested by Khatun *et al* (2017) [26]. Trifoliate castor leaves were dipped in aqueous solution of different concentration of tested chitin synthesis inhibitors for 10 seconds with gentle agitation and dried on tissue paper. The starved defecated third instar larvae were released on the treated soybean leaves which were placed in petriplates having a moist filter paper to avoid desiccation. In case of control, larvae were treated with distilled water. Ten third instar larvae were used in each treatment, replicated thrice and incubated at 27 ± 1 °C, $65\pm 5\%$ relative humidity and photophase of 14:10 hours.

Observation recorded

Assessment of larval mortality was observed at 72 hrs after treatment and was continued upto their mortality as proposed by Kranthi (2005) [27] and Guptha and Guptha (2014) [28].

- Malformed and shrunked larvae were considered as dead
- Larvae which did not moult or pupate were considered as dead.
- Pupae from which no adults emerged and those appeared as withered away, were also taken as dead.

Results and Discussion

Total number of eggs laid by female moth in her life span

Among genotypes total number of eggs were laid on JS-335 (1652.11 eggs/female), which was significantly superior to rest of genotypes. While it was recorded significantly lowest on JS97-52 (257.33 eggs/female). Among different tested temperature, highest number of eggs were laid at 25 ± 2 °C (1013.83 eggs/female) and lowest at 20 ± 2 °C (511.92 eggs/female), but they differ significantly from each other. It is designated that ambient temperature was more appropriate for reproduction and fecundity of insects compared with other tested temperatures. Similar findings have been reported by Gayathri *et al* (2016) [33] on soybean.

However, fecundity in the present findings on JS-335 genotype (2440 eggs/female at 25 °C) is slightly higher than the findings of Fand *et al* (2015) ^[13] on JS-335 soybean genotype, as they reported maximum and minimum fecundity (1234.9 and 492.3 eggs / female, respectively) was recorded at 25 and 20 °C, respectively. Under similar conditions of suitable food and temperature, such variations are related to genetic variation from different geographic locations or biotypes related to the insect (Murua *et al*, 2008) ^[29].

Incubation period

Among the genotypes, longest incubation period was observed on JS97-52 (6.22 days) which was at par with JS20-116 (6.11 days) and were significantly shortest on JS-335 (3.89 days). Among the temperature regimes, the mean incubation period significantly decreased with increase in temperature. The present findings corroborates the findings of Devi and Jha (2017) ^[30], Thakur *et al* (2017) ^[24] as they also reported that the incubation period was inversely correlated with temperature on different host crops *viz.*, sunflower, jute and tomato, respectively.

Hatchability

The highest hatching was noticed on JS-335 (88.04%) which was significantly superior then the rest of the genotypes. The lowest hatchability was observed on JS97-52 (63.65%) which was statistically at par with JS20-116 (67.90%). However, among the tested temperature the highest hatching was observed at 25±2 °C (80.71%) followed by at 30±2 °C (75.76%) and lowest at 20±2 °C (63.97%), respectively. The present findings confirms the findings of Shukla and Patel (2011) ^[31], Thakur *et al* (2017) ^[24] and Ramaiah and Maheshwari (2018) ^[32], as they also reported that the most favourable temperature was 27±1 °C and 25±2 °C, as hatching of eggs was maximum *i.e.* 97.84, 89.60±3.29 and 87.25 ± 7.42% on jute , banana and castor crops, respectively. The slight deviations in the hatchability that exist might be attributed to host plants used as larval food.

Total larval duration

Among genotypes it was observed to be shortest on JS-335 (15.89 days). While it was recorded longest on JS97-52 (24.89 days). Among temperature regimes, it significantly decreased with increase in temperature, being 27.58, 20.08 and 14.92 days which were observed at 20±2 °C, 25±2 °C and 30±2 °C, respectively. The present findings are in conformity with the findings of Fand *et al* (2015) ^[13], Gayathri *et al* (2016) ^[3] and Thakur *et al* (2017) ^[24] as they also reported that the total larval duration was negatively correlated with temperature being 25.42±1.51

Total larval survival

The mean total larval survival showed significant difference among genotypes and it was minimum on JS97-52 (55.56%), while it was maximum on JS-335 (87.78%). The total larval survival significantly increased with increase in temperature, being 61.67, 63.33 and 79.17% at 20±2 °C, 25±2 °C and 30±2 °C, respectively. while it was maximum on JS-335 (96.67%) at 30±2 °C. The present findings are in accordance with the findings of Fand *et al* (2015) ^[13] as they also claimed that the *S. litura* larval survival was lowest and

highest at 20 °C and 30 °C temperatures, respectively when reared on different crops.

Pupation

Highest pupation was noticed on JS-335 (88.92%) which was significantly superior than the rest of the genotypes and lowest on JS97-52 (70.59%). Among the tested temperature, significantly highest pupation was observed at 25±2 °C (85.87%) and lowest at higher temperature 30±2 °C (71.00%). The present findings corroborates the findings of Fand *et al* (2015) ^[13], Thakur *et al* (2017) ^[24] as they also reported that the highest pupation was observed at 25±2 °C on soybean, jute and castor, respectively.

Pupal duration

Pupal duration was significantly shortest on JS-335 (7.33 days), while longest duration was recorded on JS97-52 (13.00 days). Among temperature regimes, it significantly decreased with increase in temperature, being 13.33, 11.25 and 7.17 days at 20±2 °C, 25±2 °C and 30±2 °C, respectively. The present findings are in accordance with the findings of Fand *et al* (2015) ^[13] and Gayathri *et al* (2016) ^[33], as they also reported similar trend, being 16±0.13, 12±0.12 and 7.6±0.16 days at 20±2 °C, 25±2 °C and 30±2 °C, respectively on soybean crop

Adult emergence

Among genotypes the highest adult emergence was noticed on JS-335 (90.88%) which was significantly superior then the rest of the genotypes and lowest on JS97-52 (59.26%). Among the tested temperature, significantly highest adult emergence was observed at 25±2 °C (80.28%) followed by 30±2 °C (73.53%) and lowest at 20±2 °C (65.60%), but they differed significantly from each other. The present findings slightly deviated with the findings of Thakur *et al* (2017) ^[24], as they also reported the adult emergence was positively correlated with temperature from 18±1 °C to 27±1 °C, being 76.20 to 90.05%, later it decreased to 72.30% at 33±1 °C on jute crop.

Total life span

Male moth

Among genotypes, it was recorded significantly minimum on JS-335 (34.89 days) and maximum in JS97-52 (48.89 days). Among different tested temperature, it significantly decreased with increase in temperature, being 54.75, 43.42 and 30.25 days at 20±2 °C, 25±2 °C and 30±2 °C, respectively.

Female moth

Among genotypes, it was significantly minimum on JS-335 (36.56 days) as compare to other genotypes and maximum in JS97-52 (49.22 days). Among temperature regime, it significantly decreased with increase in temperature, being 56.00, 45.00 and 31.25 days at 20±2 °C, 25±2 °C and 30±2 °C, respectively. Several workers have also reported similar findings, that the total developmental duration of *S. litura* was negatively correlated with temperature from 20±2 °C to 30±2 °C on various host plants (Gayathri *et al*, 2016; Devi and Jha, 2017 and Thakur *et al*, 2017) ^[33, 30, 24]. Factors other than temperature *viz.* genetic differences, sex, food, humidity, photoperiod, geographic origin and number of instars can change the developmental duration. Female moth

lived longer than the male moth also confirm the findings of Farahani *et al.* (2011)^[22] and Fand *et al* (2015)^[13].

Chitin synthesis inhibitors

In the present investigation at 24 and 48 hours after treatment, none of the treatments exhibited mortality of *S. litura* 2nd instar larvae. The larval mortality was first observed at 72 hrs after treatment. Similar findings have been reported by Islam *et al* (2015)^[19].

3 days after treatment

At 3 days after treatment, significantly maximum larval mortality was recorded in Lufenuron 100 ppm (56.67%), which was superior over all the remaining treatments. The next best treatment was novaluron 200 ppm (46.67%), followed by diflubenzuron 300 ppm (40.00%) and lufenuron 50 ppm (33.33%). The latter two treatments were at par with each other. Minimum larval mortality was observed in diflubenzuron 75 ppm (13.33%)

5 days after treatment

At 5 days after treatment, significantly maximum larval mortality was recorded in Lufenuron 100 ppm (85.00%), which was superior over all the remaining treatments. The next best treatment was novaluron 200 ppm (75.55%), followed by diflubenzuron 300 ppm (66.67%) and lufenuron 50 ppm (65.07%). Lowest larval mortality was observed in diflubenzuron 75 ppm (6.29%).

7 days after treatment

At 7 days after treatment, significantly highest larval mortality of 100.00% was recorded in Lufenuron 100 ppm and novaluron 200 ppm and were superior over all the remaining treatments. The next best treatment was diflubenzuron 300 ppm (88.89%), which was at par with lufenuron 50 ppm (83.33%).

In the present study Lufenuron at higher concentration (100 ppm) was found to be highly effective as it recorded maximum larval mortality at 3 days after treatment (DAT) followed by Novaluron and Diflubenzuron @ 200 and 300 ppm, respectively. The present findings confirm the findings of Radhika *et al* (2002) as they also reported that the order of toxicity of

Chitin synthesis inhibitor was Lufenuron > Novaluron > Diflubenzuron at 72 hrs after application and the order of efficacy was same at 5 days and 7 DAT. The present findings are in accordance with the findings of Islam *et al* (2015)^[19], as they also reported maximum larval mortality (100%) which was attained by the application of higher concentration of Lufenuron @ 75 ppm after 3 days of treatment. The present findings contradicts the findings of as they reported Novaluron was highly effective than lufenuron and diflubenzuron. Such differences in the order of toxicity might be due to variation in the doses, larval stages and application methods that they have incorporated in the investigation (Islam *et al*, 2015)^[19].

Table 1: Impact of temperature and soybean genotypes on fecundity development of *S. litura* f

Genotypes (Factor-A)	Mean Fecundity performance of <i>S. litura</i> *											
	Total no. of eggs laid/female moth				Incubation period (days)*				Hatching (%) #			
	Temperature (°C) (Factor-B)											
	T ₁	T ₂	T ₃	Mean	T ₁	T ₂	T ₃	Mean	T ₁	T ₂	T ₃	Mean
JS-335	1065.33 (32.62)	2440.00 (49.32)	1451.00 (38.07)	1652.11 (40.08)	5.33 (2.31)	3.67 (1.91)	2.67 (1.63)	3.89 (1.95)	81.83 (64.70)	95.09 (77.18)	87.21 (69.04)	88.04 (70.30)
JS22-09	545.33 (23.30)	936.33 (30.48)	711.33 (26.64)	731.00 (26.81)	6.67 (2.58)	5.33 (2.31)	3.67 (1.91)	5.22 (2.27)	63.80 (52.98)	83.18 (65.73)	76.00 (60.63)	74.33 (59.78)
JS20-116	275.33 (16.54)	469.67 (21.63)	341.67 (18.41)	362.22 (18.86)	7.00 (2.64)	6.33 (2.51)	5.00 (2.23)	6.11 (2.46)	57.08 (49.04)	78.52 (62.36)	68.09 (55.57)	67.90 (55.66)
JS97-52	161.67 (12.56)	209.33 (14.47)	401.00 (20.02)	257.33 (15.68)	7.67 (2.77)	6.67 (2.58)	4.33 (2.08)	6.22 (2.48)	53.16 (46.78)	66.06 (54.35)	71.72 (57.86)	63.65 (53.00)
Mean	511.92 (21.25)	1013.83 (28.98)	726.25 (25.79)	-	6.67 (2.57)	5.50 (2.33)	3.92 (1.96)	-	63.97 (53.38)	80.71 (64.90)	75.76 (60.78)	-
	SEm±		CD at 5%		SEm±		CD at 5%		SEm±		CD at 5%	
Factor-A	0.662		1.947		0.049		0.145		0.349		1.020	
Factor-B	0.573		1.682		0.043		0.125		0.302		0.883	
Factor A×B	1.156		3.369		0.086		NS		0.605		1.763	

T₁ : 20±2 °C, T₂ : 25±2 °C, T₃ : 30±2 °C

Table 2: Impact of temperature and soybean genotypes on larval development of *S. litura*

Genotypes (Factor-A)	Mean duration of <i>S. litura</i> larvae (days) and larval survival							
	Mean duration				Larval survival percentage			
	Temperature (°C) – (Factor –B)							
	T ₁	T ₂	T ₃	Mean	T ₁	T ₂	T ₃	Mean
JS-335	21.00 (4.58)	15.33 (3.91)	11.33 (3.37)	15.89 (3.95)	80.00 (63.44)	86.67 (68.85)	96.67 (83.85)	87.78 (72.05)
JS22-09	24.33 (4.93)	19.00 (4.36)	14.00 (3.74)	19.11 (4.34)	60.00 (50.77)	70.00 (56.79)	76.67 (61.22)	68.89 (56.26)
JS20-116	30.67 (5.54)	21.67 (4.65)	18.33 (4.28)	23.56 (4.82)	56.67 (48.85)	53.33 (46.92)	70.00 (56.76)	60.00 (50.84)
JS97-52	34.33 (5.86)	24.33 (4.93)	16.00 (4.00)	24.89 (4.93)	50.00 (45.00)	43.33 (41.15)	73.33 (59.01)	55.56 (48.39)
Mean	27.58 (5.23)	20.08 (4.46)	14.92 (3.850)	-	61.67 (52.01)	63.33 (53.43)	79.17 (65.21)	-
	SEm±		CD at 5%		SEm±		CD at 5%	
Factor-A	0.044		0.129		1.35		3.95	
Factor-B	0.038		0.111		1.17		3.42	
Factor A×B	0.076		0.223		2.34		6.84	

Table 3: Impact of temperature and soybean genotypes on emergence and developmental period of *S. litura* pupae

Genotypes (Factor-A)	Mean pupation and pupal duration of <i>S. litura</i>							
	Pupation (%) #				Pupal duration (days)*			
	Temperature (°C) – (Factor –B)							
	T ₁	T ₂	T ₃	Mean	T ₁	T ₂	T ₃	Mean
JS-335	87.50 (69.30)	100.00 (90.00)	79.26 (62.90)	88.92 (74.07)	9.67 (3.11)	7.67 (2.77)	4.67 (2.16)	7.33 (2.68)
JS22-09	72.22 (58.43)	85.71 (67.78)	69.64 (56.64)	75.86 (60.95)	12.67 (3.56)	10.67 (3.27)	6.67 (2.58)	10.00 (3.13)
JS20-116	71.11 (57.61)	81.11 (64.25)	66.66 (54.95)	72.96 (58.94)	14.67 (3.83)	12.33 (3.51)	9.00 (3.00)	12.00 (3.45)
JS97-52	66.67 (54.99)	76.67 (61.15)	68.45 (53.45)	70.59 (56.53)	16.33 (4.04)	14.33 (3.79)	8.33 (2.89)	13.00 (3.57)
Mean	74.37 (60.08)	85.87 (70.80)	71.00 (56.98)	-	13.33 (3.63)	11.25 (3.33)	7.17 (2.59)	-
	SEm±		CD at 5%		SEm±		CD at 5%	
Factor-A	1.423		4.157		0.030		0.089	
Factor-B	1.235		3.596		0.029		0.084	
Factor A×B	2.468		7.192		0.057		0.159	

Table 4: Impact of temperature and soybean genotypes on adult emergence and total developmental duration of *S. litura* female moth

Genotypes (Factor-A)	Adult emergence (%) #				Life span							
					Male				Female			
	Temperature (°C) (Factor-B)											
	T ₁	T ₂	T ₃	Mean	T ₁	T ₂	T ₃	Mean	T ₁	T ₂	T ₃	Mean
JS-335	85.72 (67.78)	100.00 (90.00)	86.91 (68.79)	90.88 (75.52)	45.00 (6.71)	35.33 (5.94)	24.33 (4.93)	34.89 (5.86)	47.67 (6.90)	36.67 (6.05)	25.33 (5.03)	36.56 (6.05)
JS22-09	76.67 (61.15)	83.34 (65.88)	75.55 (60.53)	78.52 (62.52)	51.00 (7.14)	42.00 (6.48)	28.67 (5.35)	40.56 (6.32)	53.33 (7.30)	44.00 (6.63)	29.33 (5.41)	42.22 (6.45)
JS20-116	50.00 (45.00)	76.67 (61.15)	65.00 (53.85)	63.89 (53.33)	58.67 (7.66)	46.33 (6.81)	35.67 (5.97)	46.89 (6.81)	60.67 (7.79)	47.67 (6.90)	36.67 (6.05)	48.33 (6.92)
JS97-52	50.00 (45.00)	61.11 (61.15)	71.67 (58.07)	59.26 (50.48)	64.33 (8.02)	50.00 (7.07)	32.33 (5.69)	48.89 (6.93)	62.33 (7.89)	51.67 (7.19)	33.67 (5.80)	49.22 (7.03)
Mean	65.60 (54.73)	80.28 (67.12)	73.53 (59.54)	-	54.75 (7.38)	43.42 (6.57)	30.25 (5.49)	-	56.00 (7.47)	45.00 (6.69)	31.25 (5.58)	-
	SEm±		CD at 5%		SEm±		CD at 5%		SEm±		CD at 5%	
Factor-A	1.464		4.273		0.042		0.124		0.059		0.174	
Factor-B	1.267		3.700		0.037		0.108		0.051		0.150	
Factor A×B	2.531		7.401		0.074		0.216		0.103		0.301	

Table 5: Effect of chitin synthesis inhibitors on *S. litura* 2nd instar larvae at different days after treatment

Treatments	Dose (ppm)	Mean larval mortality at DAT (%) #			Overall mortality (%)
		3	5	7	
Diflubenzuron 25% WP	75	13.33 (21.58)	46.29 (41.56)	56.67 (49.14)	80.00 (63.44)
Diflubenzuron 25% WP	150	23.33 (29.09)	60.71 (51.48)	69.44 (56.81)	90.00 (71.56)
Diflubenzuron 25% WP	300	40.00 (39.47)	66.66 (55.08)	88.89 (78.36)	96.67 (83.85)
Lufenuron 5.4% EC	25	16.67 (24.24)	55.55 (48.55)	63.89 (53.55)	86.67 (68.85)
Lufenuron 5.4% EC	50	33.33 (35.46)	65.07 (54.15)	83.33 (75.10)	96.67 (83.85)
Lufenuron 5.4% EC	100	56.67 (49.14)	85.00 (71.35)	100.00 (90.00)	100.00 (90.00)
Novaluron 10% EC	50	20.00 (26.91)	58.33 (50.12)	69.45 (56.81)	90.00 (71.56)
Novaluron 10% EC	100	26.67 (31.28)	63.69 (53.30)	77.78 (66.72)	93.33 (77.70)
Novaluron 10% EC	200	46.67 (43.35)	75.55 (60.89)	100.00 (90.00)	100.00 (90.00)
Control	-	0.00 (4.05)	0.00 (4.05)	0.00 (4.05)	0.00 (4.05)
SEm±	-	1.87	3.60	7.22	3.86
CD at 5%	-	10.67	10.71	21.46	10.66

Conclusion

The study highlights the significant influence of genotype and temperature on the reproductive and developmental parameters of female moths. JS-335 genotype consistently outperformed others in terms of fecundity, hatching, pupation, and adult emergence, especially at the ambient temperature of 25±2 °C, which was most favorable for these parameters. Conversely, JS97-52 exhibited the lowest values across most metrics. Temperature played a crucial role, with higher fecundity, shorter developmental durations, and increased survival rates observed at higher temperatures. The study also validated the efficacy of Lufenuron as a potent chitin synthesis inhibitor, showing maximum larval mortality, especially at higher concentrations.

References

- Agarwal DK, Billore SD, Sharma AN. Soybean introduction, improvement and utilization in India: problems and prospects. *Agricultural Research*. 2013;2(4):293-300.
- Ramesh Babu S, Ramgopal D, Prahlad Kumar M, Rokadia P. Estimation of available losses due to *Spodoptera litura* (Fabricius) in different varieties of soybean. *International Journal of Current Microbiology and Applied Sciences*. 2018;7(8):3078-3085.
- Fattah A, Sjam S, Diana Daud I, Sartika Dewi V, Ilyas A. Impact of armyworm *Spodoptera litura* attack, damage, and loss of yield of three soybean varieties in South Sulawesi, Indonesia. *Journal of Crop Protection*. 2020;9(3):483-495.

4. Longchar PS, Imitinano L, Longkumer Y. Evaluation of novel insecticides against *Spodoptera litura* in soybean. *International Journal of Pure and Applied Biosciences*. 2018;6(2):1129-1133.
5. Ahirwar KC, Marabi RS, Bhowmick AK, Das SB. Evaluation of microbial pesticides against major foliage feeders on soybean. *Journal of Biopesticides*. 2013;6(2):144-148.
6. Karmakar P, Pal S. Influence of temperature on food consumption and utilization parameters of the common cutworm, *Spodoptera litura* (Fab.) (Lepidoptera: Noctuidae). *Journal of Entomology and Zoology Studies*. 2017;5(5):92-95.
7. Aftarika A, Abhishek S, Kailash C. Laboratory screening of soybean varieties/genotypes against *Spodoptera litura* (Fabricius). *Bulletin of Environment, Pharmacology and Life Sciences*. 2017;6(2):315-319.
8. Kawre PR, Vrunda ST, Sadwarte AK, Ingle YV. Food consumption and conversion efficiency of *Spodoptera litura* on different germplasm of soybean. *Journal of Entomology and Zoology Studies*. 2019;7(4):1085-1090.
9. Sundar B, Rashmi V, Sumith HK, Sandhya S. Study of the incidence and period of activity of *Spodoptera litura* on soybean. *Journal of Entomology and Zoology Studies*. 2018;6(5):331-333.
10. Sangle PM, Satpute SB, Khan FS, Rode NS. Impact of climate change on insects. *Trends in Biosciences*. 2015;8(14):3579-3582.
11. Karuppaiah V, Sujayanad K. Impact of climate change on population dynamics of insect pests. *World Journal of Agricultural Sciences*. 2012;8(3):240-246.
12. Srinivasa Rao M, Manimanjari D, Rama Rao CA, Vennila S. Prediction of number of generations of *Spodoptera litura* on peanut under climate change scenarios. *Global Journal of Biology, Agriculture and Health Sciences*. 2014;3(1):244-248.
13. Fand BB, Nitin T, Santanu K, Bal PS, Minhas K. Temperature impacts the development and survival of common cutworm (*Spodoptera litura*). Simulation and visualization of potential population and growth in India under warmer temperatures through life cycle modeling and spatial mapping. *PLOS ONE*. 2015;10(4):1-25.
14. Bhatia SK. Pesticide resistance in agricultural pests in India. *Proceedings of the Indian National Science Academy, Section B*. 1986;52(1):148-164.
15. Ahmed Munir, Musthaq AS, Musthaq A. Time-oriented mortality in leafworm, *Spodoptera litura*, by some new chemistry insecticides. *Pakistan Entomologist*. 2005;27(1):67-70.
16. Srivastava K, Sharma D, Anal AKD, Sonika S. Integrated management of *Spodoptera litura*. *International Journal of Life Sciences and Scientific Research*. 2018;4(1):1536-1538.
17. Deep G, Patil J, Yadav S, Kumar B, Ravinder N. Novel insecticides: a potential tool for the management of insect pests. *Journal of Entomology and Zoology Studies*. 2018;6(5):277-281.
18. Ahmad M, Gull S. Susceptibility of armyworm to novel insecticides in Pakistan. *The Canadian Entomologist*. 2017;149(5):649-661.
19. Islam T, Das G, Ali MD. Efficacy of lufenuron, a chitin synthesis inhibitor, on the mortality of *Spodoptera litura* under laboratory conditions. *Journal of Entomology and Zoology Studies*. 2015;3(3):480-483.
20. Hamadah KH, Tanani M, Ghoneim K, Basiouny A, Waheeb H. Effectiveness of novaluron, a chitin synthesis inhibitor, on the adult performance of *Spodoptera littoralis* (Fab.) (Lepidoptera: Noctuidae). *International Journal of Research Studies in Zoology*. 2015;1(2):45-55.
21. Li YY, Yu JF, Lu Q, Xu J, Ye H. Female and male moths display different reproductive behaviors when facing new versus previous mates. *PLOS ONE*. 2014;9(10):1-6.
22. Farahani S, Talebi AA, Fathipour Y. Life cycle and fecundity of *Spodoptera exigua* on five soybean varieties. *Journal of the Entomological Society of Iran*. 2011;30(2):1-12.
23. Sharma S, Singh TB. Effects of elevated temperature and carbon dioxide on food consumption and growth of *Spodoptera litura* Fabricius on cauliflower. *Journal of Agrometeorology*. 2018;20(4):305-310.
24. Thakur N, Gotyal BS, Selvaraj K, Satpathy M. Effect on biology of jute indigo caterpillar, *Spodoptera litura* (Fabricius) under five different constant temperatures. *Journal of Entomology and Zoology Studies*. 2017;5(4):102-106.
25. Shwetha K, Sreenivas AG, Ashoka J, Nadagoud S, Kuchnoor PH. Host-mediated effects on *Spodoptera litura* due to climate change. *International Journal of Current Microbiology and Applied Sciences*. 2017;6(7):641-650.
26. Khatun R, Das G, Ahmed SK. Potentiality of buprofezin, an insect growth regulator, on the mortality of *Spodoptera litura*. *Journal of Entomology and Zoology Studies*. 2017;5(2):736-740.
27. Kranthi KR. Insecticide resistance monitoring, mechanism and management. Publication CICR, Nagpur, India and ICAC, Washington; c2005. p. 153.
28. Gupta AK, Gupta S. Experimental observation of fourth-generation insecticides on third instar of *Euproctis icillia* mortality. *Trends in Biosciences*. 2014;7(10):856-860.
29. Mura MG, Vera MT, Abraham S, Juarez ML, Prieto S, Head GP, Willink E. Fitness and mating compatibility of *Spodoptera frugiperda* (Smith) (Lepidoptera: Noctuidae) populations from different host plant species and regions in Argentina. *Annals of the Entomological Society of America*. 2008;101:639-649.
30. Devi RA, Jha S. Effect of different temperature regimes on biology and food utilization of tobacco leaf-eating caterpillar (*Spodoptera litura* F.) on sunflower (*Helianthus annuus* L.) under laboratory conditions. *Journal of Entomology and Zoology Studies*. 2017;5(5):602-606.
31. Shukla A, Patel PR. Biology, food utilization and seasonal incidence of *Spodoptera litura* (Fab.) on banana cv. Grand Naine. *Journal of Agricultural Sciences*. 2011;2(1):49-51.
32. Ramaiah Mogili, Maheswari T Uma. Biology studies of tobacco caterpillar, *Spodoptera litura* Fabricius. *Journal of Entomology and Zoology Studies*. 2018;6(5):2284-2289.
33. Gayathri M, Sailaja V, Prasad YG, Prabhakar M, Ramachandra Rao G, Rekha G. Temperature-dependent developmental biology and survival of *Spodoptera*

- litura* life stages on soybean. Indian Journal of Plant Protection. 2016;44(2):419-422.
34. Radhika P. Insecticide resistance in *Spodoptera litura* and its management. Ph.D. (Ag) Thesis, Acharya N.G. Ranga Agricultural University, Hyderabad; c2002.
35. Swetha TV, Gopinath G, Thrivikramji KP, Jesiya NP. Geospatial and MCDM tool mix for identification of potential groundwater prospects in a tropical river basin, Kerala. Environmental Earth Sciences. 2017 Jun;76:1-7.