Biology of Fall Armyworm *Spodoptera frugiperda* (J.E. Smith) on Maize under laboratory conditions

Abstract

Maize is asignificance cereal crop grown for food, fodder and raw material throughout the world. It is rick source of proteins, carbohydrates and vitamins. Maize production is decreasing day by day due to attacked of more than 353 insect speciesand mites. Among insect pests, Fall Armyworm, *Spodoptera frugiperda*is best destructive pest for maize production. The rearing of Fall Armyworm, *Spodoptera frugiperda* was conducted under laboratory conditions in Department of Entomology, Acharya Narendra Deva University of Agriculture & Technology, Kumarganj, Ayodhya, U. P. during 2023. The complete metamorphosis (egg, larva, pupa and adult) was recorded in *Spodoptera frugiperda.* The average fecundity was 2.59±0.40 days. There were six larval instar of *Spodoptera frugiperda* and total larval period was 15-20 days. The growth period of first, second, third, fourth, fifth and sixth larval instar was 2-3, 2.5-3, 2.2-3, 2-2.5, 2.5-3, 4-6 days respectively on maize leaves. The average duration of pupa was 10.33±1.07 days. The female was long lived than male. The total developmental period from egg to adult was 45-47 days.

Keywords: Fall Armyworm, *Spodoptera frugiperda*, Biology, Complete metamorphosis, Maize.

Introduction–

Fall armyworm (FAW) *Spodoptera frugiperda* (J. E. Smith) (Lepidoptera: Noctuidae) which was native to the tropical and subtropical region of America and is one of the important invasive polyphagous pestsKranthi *et al.*, (2021). Maize (*Zea mays* L.) is the second bestsignificance cereal crop in the world in terms of acreage and is called the 'Queen of Cereals'. After riceand wheat, maize is the third best grown cereal crop within India; however, in terms of overall value, it is one of the bestsignificance cereal crops of the world (Dubale*et al.*, 2022).Larvae can live on 353 plant species belonging to 76 botanical families. The reproductive potential, fecundity and fertility of *S. frugiperda* is known under a variety of both natural and controlled environmental conditions. This indicates a wide variation in those parameters, which might be influenced by temperature, larval diet and the strain of *S. frugiperda* (Ashok *et al.*, 2020). The fall armyworm is native to the tropical region of the western hemisphere from the United States to Argentina. The first infestation of this pest in India was found on maize crop during Karnataka in May - June 2018 and thereafter it was reported in different states on several crops like sorghum, cotton, sugarcane, rice, tomato, soybean and other millets (Helen *et al.*, 2021). Maize stalk borer, pink stem borer and shoofly are the insects of national importance, Apart from these the recently introduced pest fall armyworm, *Spodoptera frugiperda* is a serious concern due to its notorious and polyphagous behaviour became an invasive challenge across the world (Reddy *et al.*, 2021).World over FAW alone is responsible for causing millions of dollar losses to farmers. In India maize, bajra and sorghum are crops grown by many marginal farmers for sustenance. The earnings

from these crops are meagre. Considering the ravaging nature of FAW the economic damage would be too high to be ignored. Initially the pest created a panic between farmers. Now some farmers are able to recognise it and look forward for suitable advisory from the dependable sources (Shankar *et al.,* 2019).

Materials and Methods

Biological and morphometries parameters of *Spodoptera frugiperda* were studied at Laboratory, Department of Entomology, Acharya Narendra Deva University of Agriculture and Technology, Kumarganj, Ayodhya, (U.P.) during Kharif - 2023. In order to study life cycle of *S. frugiperda* on maize, initiallylarvae were collected larvae in the insect tubesfrom maize field at Student's Instructional Farm (SIF), ANDUA&T Kumarganj, Ayodhya, brought into the insects culture room (Laboratory) and was allowed to grow until they become adult.After adult emergence the male and female moths were separated and placed for mating in transparent mating cage (Silver cage 25x20x20 cm), covered with a fine muslin cloth and was secured with rubber band. The inner surface of transparent mating cage was lined with a black paper sheet, which provided clear visibility of eggs on the surface. 10 percent honey solution on a cotton swab was placed in each cage for moth feeding.Eggs of fall armyworm laid on black paper sheet were collected for further multiplication and use.The egg mass was collected and transferred to a clean container/Borosil test tube (20x4 cm.) by providing young fresh maize leaves. The leaf was kept in the plastic container containing moist filter paper to keep it fresh. This served as immediate source of food for the first instar larvae. The leaf was changed when the larvae entered into the second instar. There after containers were cleaned with 2 per cent formaldehyde, shade dried and fresh maize leaves were given every day till the larvae entered into the last instar larval stage. These late larval instars were collected from containers and released in to petri plate (15 cm lower side and 15.5 cm upper side). Pupae thus obtained were collected and kept in small plastic jars (22x11x6 cm) covered with muslin cloth for adult emergence. During the process, male and female pupae were separated based on external genitalia. Data was recorded on fecundity, incubation period, larval period, pupal period and adult longevity of male and females. Morphometries observations were taken with the help stereo zoom binocular microscope and by visually graphical method.

Results and Discussion -

Egg:-Eggs laid by gravid female in clusters ranged from 985-1243 on the under or upper surface of the maize leaf, base of the plant and also in whorls. Mean fecundity was observed as 1104.4 ± 93.60 eggs per female. Incubation period was noticed as 3.63±0.60 days with hatching rate of 86.9 per cent (Table 1). Freshly laid eggs were dorso-ventrally flattened, were pale green, later on turned to golden yellowish and finally appeared somewhat darkish. Dubale*et al.,* (2022) recorded average fecundity of 1125.4±176.24 eggs with incubation period of 2.4±0.52 days. Reddy *et al.,* (2021) Recorded average fecundity of 1015 ± 115.48 eggs with average incubation period of 3.32 ± 0.67 days. Sharanabasappa*et al.,* (2018) recorded average fecundity of 1064.80 ±109.53 eggs with incubation period of 2.50±0.50 days.

Larvae:-

First instar larvae:-The first larval instars were very small. They completely devoured the egg shells from which they hatched. They had a comparatively large flattened circular black head and a whitish body covered with minute hairs. The duration of first instar larvae ranged from 2 - 3 days with an average of 2.62±0.32 days (Table No 1). Chaudhary *et al.,* (2023) reported the mean duration of first instar larva of *Spodoptera frugiperda* was 2.47 ± 0.50 and 2 – 3 days respectively which support the present findings. The mean length of first instar larvae were 1.68 ± 0.14 mm, respectively (Table No 2). Helen *et al.,* (2021) who reported the mean length of 1.75 ± 0.11 mm. Kalyan *et al.,* (2020) reported the mean length of 1.8 ± 0.15 mm.

Second instar larvae:-The second instar larvae had amber coloured head and a pale white to yellowish coloured body with a tinge of brown on the dorsum. The body also developed faint white dorsal and sub-dorsal lines at this stage. The duration of second instar larvae ranged from 2.5-3.0 days with an average of 2.73 ± 0.20 days (Table No 1).According to Reddy *et al.,* (2021) the average duration of second instar larvae was 2.7 ± 0.48 days which is in conformity with present investigation. According to Siddhapara*et al.,* (2021) the average duration of second instar larvae was 2.40± 0.50 days which is in conformity with present investigation. According to Dubale*et al.,* (2022) the average duration of second instar larvae was 2.33±0.48 days which is in conformity with present investigation. The average length of second instar larvae were 3.60 ± 0.31 mm, respectively (Table No 2). Kalyan *et al.,* (2020) reported the average length of 3.5±0.45 mm.

Third instar larvae:–The colour of the body shifted from light white to a greenish brown. On the dorsal side the larvae were light brown, while on the ventral side, they were greenish. The white lines on the dorsal and sub-dorsal sides were clearly visible and the black dots became more prominent. The duration of third instar larvae ranged from 2.2 - 3.0 days with a average of 2.69 ± 0.28 days (Table No 1). According to Kranthi *et al.,* (2021) the average duration of third instar larvae was 2.18±0.075 days which is in conformity with present investigation. According to Ashok *et al.,* (2020). the average duration of third instar larvae was 2.08 ± 0.344 days which is in conformity with present investigation. The average length of third instar larvae were 6.04 ± 0.46 mm, respectively (Table No 2). Kalyan *et al.,* (2020) reported the average length of 6.2±0.30 mm.

Fourth instar larvae:–The larvae showed a distinct difference from third to fourth instar in their appearance. Their body colour varied from olive brown to dark brown. The dorsal and sub-dorsal white lines also became conspicuous. The larvae exhibit a prominent inverted "Y" on head capsule. The duration of fourth instar larvae ranged from 2.0 - 2.5 days with a average of 2.24 ± 0.18 days (Table N0 1). In past Ashok *et al.,* (2020) reported the average duration of fourth instar larvae was 2.00 ± 0.20 days. The average length of fourth instar larvae were 10.19 ± 0.55 mm, respectively (Table No 2). Similar observations was recorded by Reddy *et al.,* (2021) reported average length as 10.0 ± 0.60 mm.

Fifth instar larvae: –Fifth instar larvae were observed similar to their older instar but increased in size. Larvae has a distinct pattern of four "dots" on the eighth abdominal

segment. The duration of fifth instar larvae ranged from 2.5 - 3 days with a average of 2.81±0.19 days (Table No 1). In past Maharani *et al.,* (2021) reported the average duration of fifth instar larvae of *Spodoptera frugiperda* was 1.99±0.03 days which support the present findings. The average length of fifth instar larvae were 16.60 ± 0.82 mm, respectively (Table No 2). Similar observations was recorded by Reddy *et al.,* (2021) reported average length as 16.5 ± 0.99 mm.

Sixth instar larvae:–During this stage, the larvae was more thick and bulged and it was slightly cylindrical. Their body was smooth with clear and distinct segmentation. The head was dark and bilobed in appearance. The body was greyish brown on the dorsum and greenish speckled with reddish brown colour on the ventral and sub-ventral sides. The duration of sixth instar larvae ranged from 4.0 - 6.0 days with a average of 5.16 ± 0.65 days (Table No 1). In past Helen *et al.,* (2021) reported the average duration of Sixth instar larvae was 4.4 ± 0.41 days. The average length of sixth instar larvae were 34.46 ± 1.57 mm, respectively (Table No 2). Similar observations was recorded by Kalyan *et al.,* (2020) reported average length as 33.5±1.30 mm.

Total larval period:–The total larval duration varied from 14.6-19.6 days with average duration of 17.65±1.59 days. (Table No 1). The results showed similarity with the earlier findings of Maharani *et al.,* (2021) who reported that the average duration of larva of *Spodoptera frugiperda* was 16.65±0.61 days. The results showed similarity with the earlier findings of Helen *et al.,* (2021) reported the duration of total larval period ranges from 16-18 days with a average of 16.6 ± 0.82 days.

Table No 1: Duration oflifecycle of fall armyworm, *Spodoptera frugiperda* (J. E. Smith) on maize.

Sr. No	**Particulars (Stages)**	**Duration (days)**	**Range (days)**	
		Average ± SD	**Min**	**Max**
1	Incubation period	3.63±0.60	2-4	4
2	**Larval period**			
	I Instar	2.62±0.32	2	3
	II Instar	2.73±0.20	2.5	3
	III Instar	2.69±0.28	2.2	3
	IV Instar	2.24±0.18	2	2.5
	V Instar	2.81±0.19	2.5	3
	VI Instar	5.16±0.65	4	6
	Total larval period	17.65±1.59	14.6	19.6
3	Pupal period	10.33±1.07	8.5	11.8
4	Fecundity (No. of eggs/female)	1104.4±93.60	985	1243
5	Egg hatchability %	86.90±7.07	76.9	96.1
6	**Adult longevity**			
	Male	9.5±0.68	8.5	10.5
	Female	11.47±0.74	10.3	12.5
7	**Total life cycle (egg to adult)**			
	Male	37.48±3.34	31.6	41.9
	Female	39.45±3.40	33.4	43.9

Table No 2: Morphometric data of Fall armyworm *Spodoptera frugiperda*

Sr. No	Stages	Length (mm)	Range (mm)	
		Average ± SD	Min	Max
1	I Instar	1.68 ± 0.14	1.5	1.9
	II Instar	3.60 ± 0.31	2.9	4.0
	III Instar	6.04 ± 0.46	5.6	6.9
	IV Instar	10.19 ± 0.55	9.3	10.8
	V Instar	16.60 ± 0.82	15.5	17.9
	VI Instar	34.46 ± 1.57	32.4	36.5
2	Pupa	16.21 ± 1.11	14.7	17.8
3	**Adult Male**			
	Body length	15.85 ± 0.80	14.5	16.9
	Wing length	14.03 ± 0.45	13.5	14.8
	Wing span	32.73 ± 1.42	30.5	34.4
4	**Adult Female**			
	Body length	14.46 ± 0.73	13.5	15.6
	Wing length	13.39 ± 0.83	12.4	14.5
	Wing span	30.81 ± 1.02	29.5	32.6

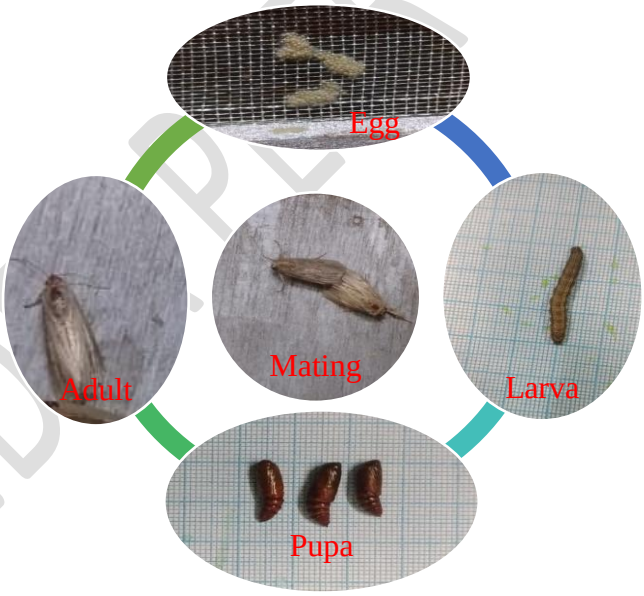

Fig 1. Life cycle ofFall armyworm *Spodoptera frugiperda*

Pupa period:-The newly developed pupae of *Spodoptera frugiperda* were orange-brown in appearance and changed to dark reddish brown with time. The distance between the genital and anal entrance slots were used to differentiate male and female pupae. This distance was greater in female pupae than in male pupae.The pupal period was found varied from 8.5-11.8 days with average duration of 10.33±1.07 days (Table No 1). According to Kranthi *et al.*, (2021) the duration of pupa was 7.00 - 8.00 days with average duration of 7.88±0.075

days.The average length of pupa was 16.21 ± 1.11 mm, respectively (Table No 2). Similar observations was recorded by Kalyan *et al.,* (2020) reported average length as 15.7±1.55 mm.

Adult:-The adult of *Spodoptera frugiperda* is a small to medium sized moth. Sexual dimorphism was clearly evident, in males the forewings were generally shaded in grey and brown colour, with triangular white spots at the tip and near the center, while in females the forewings were less distinctly marked, ranging from a uniform greyish brown to a fine mottling of grey and brown. The hind wings were iridescent silver white with a narrow dark border in both sexes. Morphometric data of the adults reveal that the males were slightly larger than the females. The average body length (mm) of the male moths were 15.85 ± 0.80 mm while that of the female moths were, 14.46 ± 0.73 mmrespectively (Table No 2). The present findings are more or less similar with Helen *et al.,* (2021) who reported average body length of male and female was reported as 15.99 ± 0.18 mm and 15.16 ± 0.69 mm. The Average wing length of male and female was 14.03 ± 0.45 mm and 13.39 ± 0.83 mm, respectively (Table No 2).which is similar in accordance with Kalyan *et al.,* (2020) who recorded wing length of male and female moth is 13.7±0.85 mm and 13.1±0.75 mm.Wing span (mm) of the male moth is 32.73 ± 1.42 mm while that of the female moths were 30.81 ± 1.02mm respectively, (Table No 2).Which is similar in accordance with Reddy *et al.,* (2021) who recorded wing span of male and female moth is 32.4 ± 2.07mm and31.8 ± 2.38 mm.

Longevity of Adults:-

The observations revealed that female moths lived more than the male moths. Male longevity was varied from 8.5 - 10.5days with average duration of 9.5±0.68 days While that of female longevity was observed as 10.3 - 12.5days with average duration of 11.47±0.74 days (Table No 1).The results are in accordance with Mohamed*et al.,* (2022) who observed male longevity as 7.12±0.48 days and female longevity as 8.25±0.41 days.The results are in accordance withKranthi*et al.,* (2021) who observed male longevity as 6.34±0.205 days and female longevity as 8.78±0.318 days.

Total life span:-The average life span of male and female of *Spodoptera frugiperda* was observed to be 37.48±3.34 and 39.45±3.40 respectively (Table No 1). The present findings are in line with the results noticed by Helen *et al.,* (2021) who reported life cycle of male and female was 36.2 ± 1.25 and 38.2 ± 1.35 days.

Conclusion:-

The knowledge of life cycle of fall armyworm can be utilized for effective control of this pest. Studies on life cycle of fall armyworm on maize revealed that the female adult laid 1104.4±93.60 eggs per female the incubation period was 3.63±0.60 days. Average longevity of males was observed as 9.5±0.68 days while in case of females, it was 11.47±0.74 days. The total larval duration was observed to be 17.65±1.59 days. The pupal period lasted for 10.33±1.07 days. The total life cycle of male and female was completed in 37.48 ± 3.34 and 39.45 ± 3.40 days. The morphometric data viz., larval body length; pupal length and adult body length and wing span were measured.

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