

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

Abstract

Maize is an important cereal harvest developed for food, fodder and raw material throughout the country. It is a rich source of proteins, carbohydrates and vitamins. Corn production is decreasing day by day due to attack of more than 353 insect species and mites. Among insect pests, Fall armyworm, *Spodoptera frugiperda* is the best destructive pest for corn production. The rearing of Fall armyworm, *Spodoptera frugiperda* was conducted under laboratory conditions in the 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 certified in *Spodoptera frugiperda*. The average fecundity was 2.59 ± 0.40 days. There were 6th instar larval of *Spodoptera frugiperda* and total larval period was 15-20 days. The growth period of 1st, 2nd, 3rd, 4th, 5th and 6th larval instar was 2-3, 2.5-3, 2.2-3, 2-2.5, 2.5-3, 4-6 days respectively on corn leaves. The average period of pupa was 10.33 ± 1.07 days. The female was long lived than male. The total evolved period from egg to adult was 45-47 days.

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

Introduction:- Fall armyworm *Spodoptera frugiperda* (J. E. Smith) (Lepidoptera: Noctuidae) which was innate to the tropical and subtropical area of America and is single of the important aggressive polyphagous pests Kranthi *et al.*, (2021). “Corn (*Zea mays* L.) is the most important grain harvest in the country in terms of area and is called the ‘Queen of grains’. After rice and wheat, corn is the third best developed grain harvest inside India; though, in terms of total value, it is single of the most important cereal harvests of the country” (Dubale *et al.*, 2022). “Larvae can live on 353 plant species belonging to 76 botanical families. The reproductive possibility, 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 impacted by temperature, larval diet and the strain of *S. frugiperda*” (Ashok *et al.*, 2020). “The fall armyworm is innate to the tropical area of the western hemisphere from the United States to Argentina. The first infective of this pest in India was found on corn harvests during Karnataka in May - June 2018 and thereafter it was noted in dissimilar states on several harvests like sorghum, cotton, sugarcane, rice, tomato, soybean and other millets” (Helen *et al.*, 2021). “Shoot fly, pink stem borer and corn stem borer are insects in the country's significance, apart from these the lately pest fall armyworm, *Spodoptera frugiperda* is a complex anxiety due to its infamous and polyphagous temperament became an aggressive daunting across the country” (Reddy *et al.*, 2021). “Country over FAW single is accountable for causing millions of dollar injuries to farmers. In India corn, sorghum and bajra are harvests developed by many marginal farmers for nourishment. The incomes from these harvests are scanty. Considering the ravaging nature of FAW the economic loss 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

The studies on the biology of the corn FAW, *Spodoptera frugiperda* were conducted under laboratory conditions of the Department of Entomology, Acharya Narendra Deva University of Agriculture and Technology, Kumarganj, Ayodhya, (U.P.) undertook laboratory-based investigations on the life cycle of the corn FAW, *Spodoptera frugiperda*, between Kharif and 2023. Initially, larvae were collected in insect tubes from the corn field at Student's Instructional Farm (SIF), ANDUA&T Kumarganj, Ayodhya, and brought into the insect laboratory where they were allowed to grow until they became adults in order to study the life cycle of *S. frugiperda* on corn leaves. Each of the plastic containers holding the fresh maize leaves was filled with one larvae. The male and female moths were separated upon their adult emergence and found a translucent mating cage (a silver cage measuring 25x20x20 cm.), which they covered with a regular muslin cloth and was secured with rubber band. A dark paper sheet lined the inside of the translucent mating cage, making the eggs on the surface easily visible. Each cage included a cotton swab containing a 10% honey solution for the moths to eat. Fall armyworm eggs were gathered and used for future growth after being placed on a sheet of dark paper. The egg mass was collected and shifted to a clean container/Borosil test tube (20x4 cm.) by offering tender, new corn leaves. To keep it fresh, the leaf was stored in a plastic jar with wet filter paper inside. It took 2.4 to 4.0 days for the eggs to hatch, providing the 1st instar larvae with an instant feeding source. Following that, containers were cleaned using 2% formaldehyde, and until the larvae reached the final instar larval stage, fresh maize leaves were provided daily. After being removed from their containers, the 6th instar larvae were placed into a petri plate (15 cm. on the lower side and 15.5 cm. on the upper side). Thus, pupae were gathered and stored in little plastic jars measuring 22x11x6 cm. Male and female pupae were separated during the process according to their external genitalia. During the analysis, every stage of the current pest life cycle from egg to adult was recorded.

Results and Discussion -

Egg:-Gravid females deposit their eggs in masses between 985 - 1243 on the underside or upper surface of the corn leaves, the plant's base, and in whorls. The mean fecundity per female was found to be 1104.4 ± 93.60 eggs. A hatching rate of 86.90 % was observed throughout the 3.63 ± 0.60 day incubation period (Table 1). Newly laid eggs were pale green, dorso-ventrally flattened, eventually turning golden yellowish, and finally seeming rather blackDubaleet *al.*, (2022) certified mean fecundity of 1125.4 ± 176.24 eggs with incubation duration of 2.4 ± 0.52 days. Reddy *et al.*, (2021) Certified average fecundity of 1015 ± 115.48 eggs with average incubation duration of 3.32 ± 0.67 days. Sharanabasappaet *al.*, (2018) certified mean fecundity of 1064.80 ± 109.53 eggs with incubation period of 2.50 ± 0.50 days.

Larvae:-

1st instar larvae:-The larvae in their first instar were little. The egg shells they hatched from were completely consumed by them. They had a pale body speckled with tiny hairs and a rather large black head that had been flattened into a spherical shape. Larvae in their first instar stage lasted an average of 2.62 ± 0.32 days, ranging from 2.0 to 3.0 days (Table 1). The current findings are supported by Chaudhary *et al.*, (2023) observation that the mean duration

of *Spodoptera frugiperda* first instar larvae was 2.47 ± 0.50 and 2.0–3.0 days from respectively. First-instar larvae had a mean length of 1.68 ± 0.14 mm, measuring from respectively. (Table 2). Helen *et al.*, (2021) who noted the mean length of 1.75 ± 0.11 mm. Kalyan *et al.*, (2020) noted the mean length of 1.8 ± 0.15 mm.

2nd instar larvae:—“The 2nd instar larvae had amber coloured head and a pale white to yellowish coloured body with a tinge of coffee on the dorsum. The body also evolved faint white dorsal and sub-dorsal lines at this stage”. [14] The period of 2nd instar larvae megerment from 2.5-3.0 days with an average of 2.73 ± 0.20 days (Table 1). Allowing to Reddy *et al.*, (2021) the meanperiod of 2nd instar larvae was 2.7 ± 0.48 days which is in conformity with present inspection. Allowing to Siddhapaet *et al.*, (2021) the meanperiod of 2nd instar larvae was 2.40 ± 0.50 days which is in conformity with present inspection. Allowing to Dubaleet *et al.*, (2022) the meanperiod of 2nd instar larvae was 2.33 ± 0.48 days which is in conformity with present inspection. The average length of 2nd instar larvae were 3.60 ± 0.31 mm, respectively (Table 2). Kalyan *et al.*, (2020) noted the average length of 3.5 ± 0.45 mm.

3rd instar larvae:—The colour of the insect body initially appears light white and later appears light greenish brown. Light brown colour appears on the dorsal side, while on the ventral side they were greenish. The white coloredlines was visible on the dorsal side and sub-dorsal side of the insect body and black colored points are clearly visible. The period of 3rd instar larvae ranged from 2.2 - 3.0 days with a average of 2.69 ± 0.28 days (Table 1). Allowing to Kranthi *et al.*, (2021) the meanperiod of 3rd instar larvae was 2.18 ± 0.075 days which is in conformism with currentinspection. According to Ashok *et al.*, (2020). the meanperiod of 3rd instar larvae was 2.08 ± 0.344 days which is in conformism with currentinspection. The average length of 3rd instar larvae were 6.04 ± 0.46 mm, respectively (Table 2). Kalyan *et al.*, (2020) noted the average length of 6.2 ± 0.30 mm.

4th instar larvae:—The larvae presented a discretemodification from 3rd to 4th instar in their arrival. Their body colour diverse from olive brown to dark brown. The dorsal and sub-dorsal white lines also became conspicuous. The larvae show a prominent upturned “Y” on head capsule. The period of 4th instar larvae magerment from 2.0 - 2.5 days with a average of 2.24 ± 0.18 days (Table 1). In past Ashok *et al.*, (2020) noted the average period 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 2). Similar remarks wererecertified by Reddy *et al.*, (2021) noted average length as 10.0 ± 0.60 mm.

5th instar larvae:—5th instar larvae were witnessd similar to their mature instar but improved in size. Larvae has a different pattern of four “dots” on the 8th abdominal segment. The period of 5th instar larvae megerment from 2.5 - 3 days with anaverage of 2.81 ± 0.19 days (Table 1). In past Maharani *et al.*, (2021) noted the meanperiod of 5th instar larvae of *Spodoptera frugiperda* was 1.99 ± 0.03 days which support the current findings. The average length of 5th instar larvae were 16.60 ± 0.82 mm, respectively (Table 2). Similar remarks wererecertified by Reddy *et al.*, (2021) noted average length as 16.5 ± 0.99 mm.

6th instar larvae:—During this stage, the larvae were thicker and more bulged and it was slightly cylinder-shaped. Their body was soft with clear and different segmentation. The head was dark and bilobed in arrival. The body was greyish brown on the dorsum and greenish speckled with reddish brown colour on the ventral and sub-ventral sides. The period of 6th

instar larvae megerment from 4.0 - 6.0 days with an average of 5.16 ± 0.65 days (Table 1). In past Helen *et al.*, (2021) noted the average period of 6th instar larvae was 4.4 ± 0.41 days. The average length of sixth instar larvae were 34.46 ± 1.57 mm, respectively (Table 2). Similar remarks werercertified by Kalyan *et al.*, (2020) noted average length as 33.5 ± 1.30 mm.

Total larval period:–The total larval period different from 14.6-19.6 days with average period of 17.65 ± 1.59 days. (Table 1). The results showed likeness with the before findings of Maharani *et al.*, (2021) who noted that the mean period of larvae of *Spodoptera frugiperda* was 16.65 ± 0.61 days. The results showed likeness with the before findings of Helen *et al.*, (2021) noted the period of total larval period ranges from 16-18 days with a average of 16.6 ± 0.82 days.

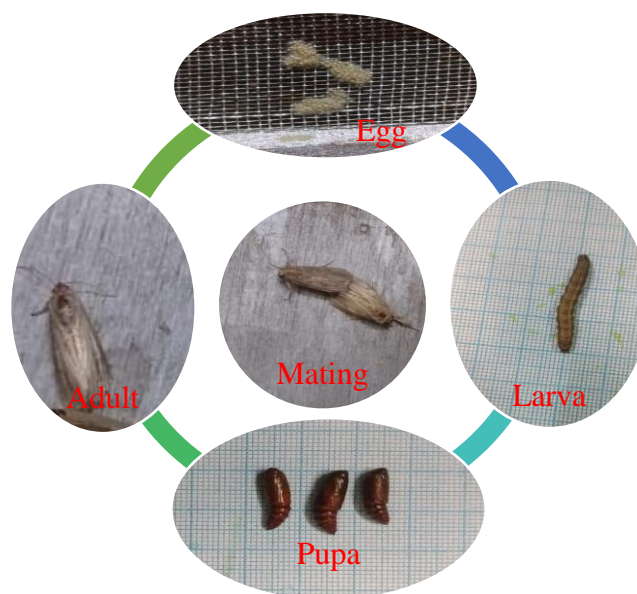
Table 1:Period of lifecycle of fall armyworm, *Spodoptera frugiperda* (J. E. Smith) on corn.

Sr. No	Particulars (Stages)	Period (days)	Range (days)	
		Average \pm SD	Min	Max
1	Incubation period	3.63 ± 0.60	2.4	4
2	Larval period			
	1 st Instar	2.62 ± 0.32	2.0	3
	2 nd Instar	2.73 ± 0.20	2.5	3
	3 rd Instar	2.69 ± 0.28	2.2	3
	4 th Instar	2.24 ± 0.18	2.0	2.5
	5 th Instar	2.81 ± 0.19	2.5	3
	6 th Instar	5.16 ± 0.65	4.0	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 2: Morphometric data of Fall armyworm *Spodoptera frugiperda*

Sr. No	Stages	Length (mm)	Range (mm)	
		Average \pm 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



Pupa period:-The just now evolved pupae of *Spodoptera frugiperda* were orange-brown in arrival and shifted to dark brown reddish with period. The space between the genital and anal entering holes were utilized to dissimilate male and female pupae. This distance was greater in female pupae than in male pupae. The pupal period was found different from 8.5-11.8 days with average period of 10.33 ± 1.07 days (Table 1). According to Kranthi *et al.*, (2021) the period of pupa was 7.00 - 8.00 days with mean period of 7.88 ± 0.075 days. The mean length of pupa was 16.21 ± 1.11 mm, One-to-single (Table 2). Similar remarks were certified by Kalyan *et al.*, (2020) noted average length as 15.7 ± 1.55 mm.

Adult:-*Spodoptera frugiperda* is a small to medium-sized moth as an adult. There was no doubt about the presence of sexual dimorphism; the forewings of males were primarily brown and grey in color, with triangular white spots near the center and at the tip, while the forewings of females were less clearly marked, varying from a uniform greyish brown to a fine mottling of brown and grey. In both sexes, the hind wings had a short dark border and an iridescent silver white color. The mature males were somewhat larger than the females, according to morphometric data. 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 mm respectively (Table 2). The current findings are more or less alike with Helen *et al.*, (2021) who noted average body length of male and female was noted 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 2).which is alike in according with Kalyan *et al.*, (2020) who certified 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 ± 1.02 mm respectively(Table 2).Which is alike in according with Reddy *et al.*, (2021) who certified wing span of male and female moth is 32.4 ± 2.07 mm and 31.8 ± 2.38 mm.

Adults Longevity:-

The remarkss shown that female moths survived more than the male moths. Male longevity was different from 8.5 - 10.5 days with average period of 9.5 ± 0.68 days While that of female longevity was witnessd as 10.3 - 12.5 days with average period of 11.47 ± 0.74 days (Table 1).The results are in according with Mohamed *et al.*, (2022) who witnessd male longevity as 7.12 ± 0.48 days and female longevity as 8.25 ± 0.41 days.The results are in according with Kranthi *et al.*, (2021) who witnessd male longevity as 6.34 ± 0.205 days and female longevity as 8.78 ± 0.318 days.

Total life span:-The mean life span of male and female of *Spodoptera frugiperda* was witnessd to be 37.48 ± 3.34 mm.and 39.45 ± 3.40 mm. respectively (Table 1). The current results are in line with the results reported by Helen *et al.*, (2021) who noted 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 used for effective management of this pest. Studies on life cycle of fall armyworm on corn shown 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 witnessd as 9.5 ± 0.68 days while in case of females, it was 11.47 ± 0.74 days. The total larval period was witnessd to be 17.65 ± 1.59 days. The pupal period lasted for 10.33 ± 1.07 days. The total biology 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 dignified.

References

1. Ashok K., Kennedy J. S., Geethalakshmi V., Jeyakumar P., Sathiah N. and Balasubramani V (2020) Lifetable study of fall army worm *Spodoptera frugiperda* (J. E. Smith) on corn. *Indian Journal of Entomology*, 82(3): 574-579.
2. Chaudhary L. S., Patel C. J. and Ghetiya L. V (2023) Biology and Morphometrics of Fall Armyworm *Spodoptera frugiperda* (J. E. Smith) on Corn. *Int.J.Curr.Microbiol.App.Sci*, 12(05): 184-198.
3. Dubale J. J, Shinde B. D., Mehendale S. K., Bodake P. S. and Sawardekar S. V (2022) Life cycle of fall armyworm *Spodoptera frugiperda* (J. E. Smith) (Lepidoptera; Noctuidae) on corn in Konkan area of Maharashtra. *The Pharma Innovation Journal*, 11(12): 1842-1845.
4. Kalyan D., Mahla M. K., Babu R. S., Kalyan R. K. and Swathi P (2020) Biological Parameters of *Spodoptera frugiperda* (J. E. Smith) under Laboratory Conditions. *Int.J.Curr.Microbiol.App.Sci*, 9(5): 2972-2979.

5. Helen A. P., Tamboli N.D., Kulkarni S. R., More S. A. and Kumbhar J. S(2021) Life cycle of fall armyworm *Spodoptera frugiperda* (J.E. Smith) on corn under laboratory conditions. *Journal of Entomology and Zoology Studies*, 9(3): 125-127.
6. Maharani Y., Puspitaningrum D., Istifadah N., Hidayat S. & Ismail A (2021) Biology and life table of Fall Armyworm, *Spodoptera frugiperda* (J.E. Smith) (Lepidoptera: Noctuidae) on Corn and Rice. *Serangga*, 26(4): 161-174.
7. Reddy A. N., Saindane Y. S., Chaudhari C. S. and Landage S. A (2021) Life cycle of fall armyworm *Spodoptera frugiperda* (J.E. Smith) on corn under laboratory conditions. *The Pharma Innovation Journal*, 10(9): 1997-2001.
8. Shankar G. and Adachi Y (2019) First report of the occurrence of fall armyworm, *Spodoptera frugiperda* (J.E. Smith) (Lepidoptera: Noctuidae) on Ginger (*Zingiber officinale*) in Haveri district, Karnataka, India. *Journal of Entomology and Zoology Studies*, 7(5): 78-80.
9. Sharanabasappa, kalleshwaraswamy C. M., Maruthi M. S. and Pavithra H. B (2018) Life cycle of aggressive fall army worm *Spodoptera frugiperda* (J.E. Smith) (Lepidoptera: Noctuidae) on corn. *Indian Journal of Entomology*, 80(3): 540-543.
10. Siddhpara M. R., Patel K. M. and Patel A. G (2021) Biology and Morphometrics of Fall Armyworm *Spodoptera frugiperda* (J. E. Smith) on Corn. *Indian Journal of Entomology*, 83Online published Ref. No. e20193.
11. Kranthi P., Devi R. S., Rajanikanth P. and Ramya V (2021) Biology of an aggressive fall armyworm, *Spodoptera frugiperda* (J.E. Smith) (Lepidoptera: Noctuidae) on chickpea flour based artificial diet. *The Pharma Innovation Journal*, SP-10(10): 1449-1452.
12. Mohamed H. O (2022) Assessment of cohort laboratory rearing on performance and biology of the fall armyworm, *Spodoptera frugiperda* (J.E. Smith) (Lepidoptera: Noctuidae). *International Journal of Entomology Research* : Page No. 120-128, 2455-4758.
13. Kranthi P., Devi R. S., Rajanikanth P. And Ramya V (2021) Biology of fall armyworm, *Spodoptera frugiperda* (J.E.Smith) (Lepidoptera : Noctuidae) on sorghum. *Annals of Plant and Soil Research* 23 (4):526-528.
14. Reddy NA, Saindane YS, Chaudhari CS, Landage SA. Biology of fall armyworm *Spodoptera frugiperda* (JE Smith) on maize under laboratory condition. *The Pharma Innovation Journal*. 2021;10(9):1997-2001.