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First record, seasonal incidence and life cycle of fall armyworm, *Spodoptera frugiperda* (J.E.Smith) in maize at Sabour, Bhagalpur, Bihar

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Abstract
Fall armyworm, *Spodoptera frugiperda* was noticed for the first time in the month of August, 2019 feeding on maize crop at Sabour, Bhagalpur, Bihar. The experiment was conducted for seasonal incidence and life cycle studies of fall armyworm. Seasonal incidence studies revealed that the incidence of fall armyworm started in the 1st week of August at 30 days old crop with initial percent infestation 9.71and reached to peak 35.43 percent infestation in the third week of August at 45 days old crop during *Kharif*, 2019 cropping season while its activity started from the first week of January with initial percent infestation of 3.54 at 30 days old crop and the peak infestation was noticed in the fourth week of February at 82 days old crop during Rabi, 2019-20. The life cycle studies of fall armyworm during 2019-20 revealed that the incubation period was 2-3 days. Larval period ranged from 15 to 18 days in which first to fourth instar larval period ranged with 2-3 days, fifth and sixth instar with 3-4 days and 3-5 days, respectively. Pupal period was 8-10 days and adults lived for 6-8 days.

Keywords: Fall armyworm, seasonal incidence, life cycle, percent infestation

Introduction
Maize is one among the versatile emerging crops having wider adaptability under varied agro-climatic conditions. It is the staple food in many parts of the world. Insects are major elements of agricultural eco-systems which impact crop yield in several ways. About 20% losses occur in maize due to insect damage. The recently introduced pest in India, Fall armyworm, *Spodoptera frugiperda* (J.E. Smith) was recognized as a destructive pest of many agricultural crops. It was first reported from the Indian subcontinent in 2018 [1, 2].

Fall Armyworm (*Spodoptera frugiperda*) was recorded for the first time in the month of August, 2019 feeding on maize crop of Research Farm, Bihar Agricultural University, Sabour, Bhagalpur, Bihar. It was identified on the basis of literature and illustrations [3]. All the stages were found feeding on maize crop. Young larvae feed on leaf tissues and the leaf lamina were skeletonised (Fig.1: a). Second and third instar larvae make holes on the leaves and also found feeding from the edge (Fig.1: b). Fourth instar to sixth instar larvae burrowed into the growing point, cut the whorl which representing damage done by rat (Fig.1: c). They pupated in the soil. The adult females were larger than males.

Fall Armyworm (*Spodoptera frugiperda*) is of serious concern due to its notorious and polyphagous behaviour. Keeping all this in view, the present investigation was conducted for seasonal incidence in relation to weather parameters and life cycle of Fall Armyworm, *Spodoptera frugiperda* on maize.

Materials and Methods
Experimental Details
The experiment was conducted at the research farm, maize section, Bihar Agricultural University, Sabour, Bhagalpur (Bihar) during *Kharif*, 2019 and *Rabi* season of 2019-20. Maize variety (Sabour Hybrid Maize 1) was sown during last week of June for *kharif* and last week of November for *Rabi* in 8m × 3m area with spacing of 60cm × 20cm for the seasonal incidence study. The plot was divided into four blocks each having 10 rows. Two rows were left unsown to maintain gap between adjacent block and similar procedure was adopted for next block. Recommended agronomic practices except plant protection measures were followed for raising the crops. Weekly observations were recorded in each plot from seedling

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to maturity of the crop on the basis of number of damaged plants and percent infestation was calculated.

The percent pest infestation was calculated by using the following formula [4, 5]:

$$Percent\ infestation = \frac{Number\ of\ plants\ damaged}{Total\ number\ of\ plants/plot\ observed} \times 100$$

Statistical Analysis

In order to study the influence of various abiotic factors on percent infestation of fall armyworm, simple correlation coefficients were computed. The weekly average percent infestation was correlated with average weekly minimum and maximum temperature, relative humidity, rainfall and sunshine hours.

Life cycle study

The life cycle study was carried out in the laboratory, department of Entomology, Bihar Agricultural College, Sabour, Bhagalpur. The larvae were collected by splitting the infected maize stalks obtained from the field. The rearing was done in the rearing cage on cut pieces of maize stems (7.5cm long) and leaves till pupation there after pupae were collected and kept in the glass rearing jars (10×15cm) for emergence of adults. A pair of adult moth of one day old age (1:1) was released in each rearing jars for oviposition and replicated thrice. The adults were fed with 10% honey solution soaked on cotton pads in small plastic caps inside the cages and replaced daily. Eggs were collected and kept in rearing cage for hatching. The eggs were then examined for hatching. After hatching, the larvae were reared individually on fresh maize leaf bits which was changed daily as food. The larval along with instar periods and pupal period were observed. Adult longevity was observed in a rearing cage with 10% honey provided and replenished daily as food.

Results and Discussion
Seasonal incidence of fall armyworm

The incidence of fall armyworm started in the 1st week of

August (3rd August, 2019) with average percent infestation of 9.71at 30 days old crop and reached to peak in the third week of August (17th August, 2019) with a mean of 35.43 percent infestation of fall armyworm at 45 days old crop and then declined gradually and low percentage (8.38) of infestation was found throughout the cropping season, *Kharif*, 2019 (Table 1). During *Rabi*, 2019-20 the fall armyworm activity started from the first week of January (4th January, 2020) with initial average percent infestation of 3.54 at 30 days old crop. The peak infestation was noticed in the fourth week of February (22nd February, 2020) with a mean of 26.45 percent at 82 days old crop, thereafter it declined gradually and remained associated throughout the cropping season with 8.32 percent infestation (Table 2).

Correlation studies

The correlation studies of fall armyworm infestation and abiotic factors shown in Table 3 revealed that the maximum and minimum temperature and sunshine hours were positively non-significantly correlated whereas relative humidity and rainfall were negatively non-significantly correlated with fall armyworm infestation during the *Kharif*, 2019. It was quite clear from the Table 4 for *Rabi*, 2019-20 that maximum and minimum temperature, rainfall were positively non-significantly correlated with fall armyworm infestation. Relative humidity was negatively significantly correlated whereas sunshine hours was highly negative significantly correlated with fall armyworm infestation. However, In Andhra Sekhar *et al.* reported that Correlation studies between larval counts at boot leaf stage and minimum temperature indicated a significant positive relationship, suggesting that the lower temperatures positively influenced larval diapauses [6] and in Argentina Murua *et al.* (2009) found that the temperature and rainfall had significantly affected fall armyworm density [5]. Adults of fall armyworm corn strain were found most prevalent during the spring and early summer in Southern Florida in the year 2009 [7].

Table 1: Seasonal incidence of fall armyworm along with meteorological parameter during *Kharif*, 2019

Standard week	Date	% infestation	temperature (ºc)		Relative Humidity (%)	Rainfall (mm)	Sunshine (hrs)
			max	min			
31	03.08.2019	9.71	35.4	26.3	84.0	32.2	7.2
32	10.08.2019	29.71	34.5	26.0	86.1	26.8	5.7
33	17.08.2019	35.43	34.2	26.9	86.0	6.6	6.6
34	24.08.2019	16.86	34.6	26.9	84.4	6.6	5.1
35	31.08.2019	15.25	35.3	27.0	86.1	2.2	8.6
36	07.09.2019	14.34	35.9	28.0	87.6	11.0	5.4
37	17.09.2019	13.20	32.5	25.9	87.6	29.8	4.8
38	21.09.2019	10.54	32.3	25.9	89.0	29.8	0.0
39	28.09.2019	10.23	30.5	23.6	91.6	295.1	0.0
40	05.10.2019	8.64	31.2	23.3	88.6	0.0	2.0
41	12.10.2019	8.38	31.4	31.2	90.0	1.0	4.0

Table 2: Seasonal incidence of fall armyworm along with meteorological parameter during *Rabi*, 2019-20

Standard week	Date	% infestation	temperature (ºc)		Relative Humidity (%)	Rainfall (mm)	Sunshine (hrs)
			max	min			
1	04.01.2020	3.54	20.1	8.9	93.6	1.3	3.8
2	11.01.2020	4.25	19.4	8.5	93.1	4.0	2.8
3	18.01.2020	4.52	23.2	9.5	90.1	0.0	4.5
4	25.01.2020	8.68	24.1	8.3	94.3	0.0	5.1
5	01.02.2020	10.24	24.0	8.2	96.0	0.7	6.1
6	08.02.2020	12.44	24.3	7.6	88.0	0.0	5.6
7	15.02.2020	18.84	23.5	9.1	87.3	0.0	5.4

8	22.02.2020	26.45	24.6	11.1	84.3	2.0	5.2
9	01.03.2020	24.26	25.5	15.2	89.3	36.4	6.5
10	08.03.2020	20.88	29.7	15.8	88.9	0.8	6.0
11	15.03.2020	14.75	29.7	15.8	84.9	37.8	6.8
12	21.03.2020	16.24	31.1	17.4	85.0	9.0	6.6
13	28.03.2020	8.32	32.1	19.5	86.5	0.0	8.5

Life cycle of fall armyworm

The study on life cycle of fall armyworm is presented in Table 5 which revealed that the incubation period ranged from 2-3 days with mean duration of 2.67 ± 0.23 days. Larval period ranged from 15-18 days with mean duration of 16.33 ± 6.86 days. Each larva passed through six distinct instars during the larval period. The observation recorded for first instar larval periods was 2.33 ± 0.29 with a range of 2-3 days. The larvae were greenish with a black head. The data recorded on second instar larval period revealed that it ranged from 2-3 days with mean duration of 2.33 ± 0.29 days. Second instar larvae became greenish brown. The third instar larval period varied from 2-3 days with mean duration of 2.67 ± 0.21. The third instar was greenish brownish with three

distinct dorsal lines. It is apparent from the Table 5 that the fourth instar larval period ranged from 2-3 days with mean duration of 2.33 ± 0.29. The fourth instar turned into brownish black with three distinct dorsal lines. It was clearly seen inverted 'Y' shaped marking on the head and four black spots arranged in square on the dorsal surface of 8th abdominal segment (Fig 2:a). The mean duration for fifth instar larvae was 3.00 ± 0.61 with 3-4 days range. The colour was fifth instar larvae was brownish black with three distinct dorsal lines. Black tubercles with spines were found on the dorsal side of the body. Sixth instar larval period varied from 3-5 days with mean duration of 3.67 ± 0.83 (Table 1). Sixth instar larvae were also brownish black having three distinct dorsal lines and black tubercles with spines (Fig 2:b).

Table 3: The correlation coefficients of abiotic factors with percent infestation of fall armyworm on maize during *Kharif*, 2019

Abiotic factors	Percent infestation of FAW	Max. Temp. (^{0}C)	Min. Temp. (^{0}C)	Relative Humidity (%)	Rainfall (mm)	Sunshine (hrs)
Percent infestation of FAW	1					
Maximum Temperature. (^{0}C)	0.42	1				
Minimum Temperature (^{0}C)	0.02	0.29	1			
Relative Humidity (%)	-0.11	-0.82**	-0.11	1		
Rainfall (mm)	-0.18	-0.48	-0.47	0.57	1	
Sunshine (hrs)	0.41	0.81**	0.41	-0.78**	-0.54	1

*Correlation is significant at 5% level, ** Correlation is significant at 1% level,

Table 4: The correlation coefficients of abiotic factors with percent infestation of fall armyworm on maize during *Rabi*, 2019-20

Abiotic factors	Percent infestation of FAW	Max. Temp. (^{0}C)	Min. Temp. (^{0}C)	R.H. (%)	Rainfall (mm)	Sunshine (hrs)
Percent infestation of FAW	1					
Maximum Temperature. (^{0}C)	0.37	1				
Minimum Temperature (^{0}C)	0.35	0.88**	1			
Relative Humidity (%)	-0.59*	-0.63	-0.61*	1		
Rainfall (mm)	0.36	0.27	0.43	-0.30	1	
Sunshine (hrs)	-0.79**	0.89**	0.76**	-0.50	0.31	1

*Correlation is significant at 5% level, ** Correlation is significant at 1% level,

The data recorded on pupal period revealed that it ranged from 8-10 days with mean duration of 9.00± 2.81 days (Table 5). Sixth instar larvae stopped feeding and turned into bright brown colour pupa (Fig 2:c).

Adult longevity

The observation recorded on adult longevity revealed that the adult longevity was 7.00 ± 1.83 days with the range from 6-8 days. The result further shows that the duration of total life cycle varied from 26-31 days with mean duration of 28.00 ± 2.64 days (Table 5). The result was in agreement with Sharanabasappa *et al.* in 2018 who observed incubation period, larval period and pupal period to be from 2-3 days, 14-19 and 9-12 days, respectively. Total life cycle for male and female was 32-43 and 34-46 days, respectively [2]. The results also confirmed the findings reported by Deole *et al.* 2018 who found that egg stage lasted for 2-3 days, larval

duration for 14-30 days, pupal period for 8-9 days and whole life cycle was about 28-35 days [3].

Table 5: Biology of *S. frugiperda* on maize (Variety-SHM-1)

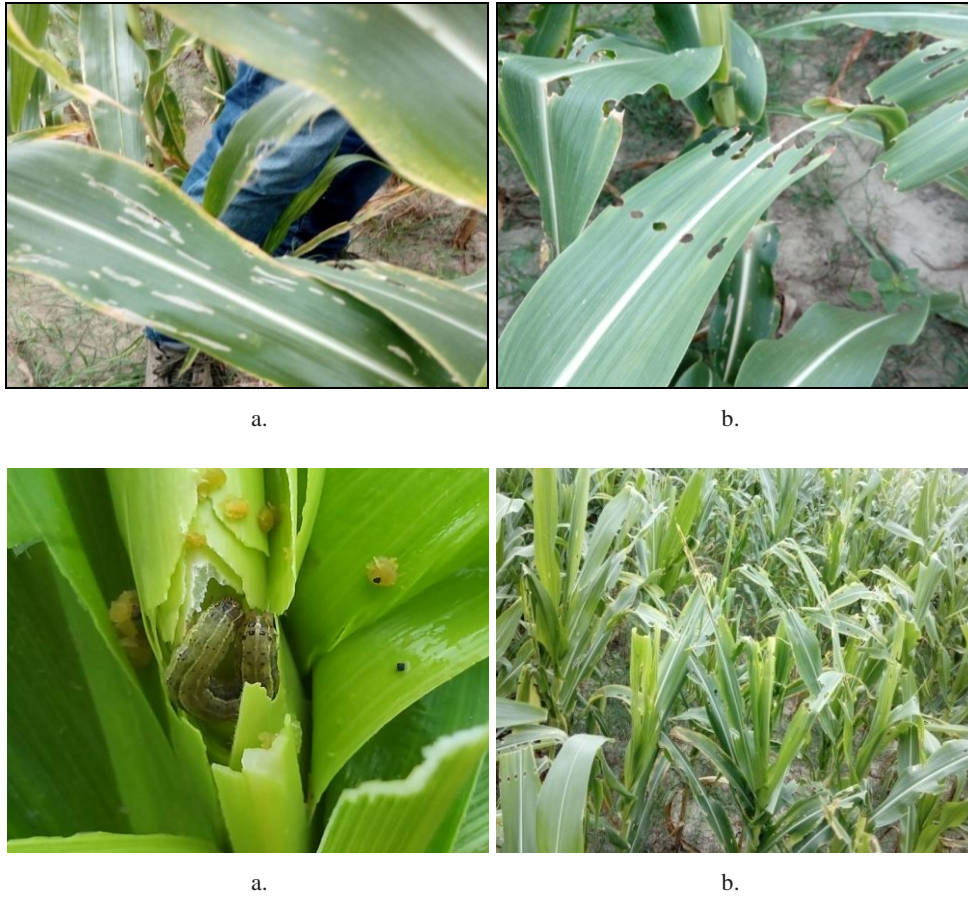| Biology events (days)	Mean ± SE	Range (days)
Incubation period	2.67 ± 0.23	2-3
Larval period	16.33 ± 6.86	15-18
Ist Instar	2.33 ± 0.29	2-3
IInd Instar	2.33 ± 0.29	2-3
IIIrd Instar	2.67 ± 0.21	2-3
IVth Instar	2.33 ± 0.29	2-3
Vth Instar	3.00 ± 0.61	3-4
VIth Instar	3.67 ± 0.83	3-5
Pupal period	9.00 ± 2.81	8-10
Adult longevity	7.00 ± 1.83	6-8
Total life cycle	28.00 ± 2.64	26-31

Fig 1: a) Damage symptoms by 1st instar larvae b) Damage symptoms by 2nd and 3rd instar larvae c) Damage symptoms by 5th and 6th instar larvae d) Field view
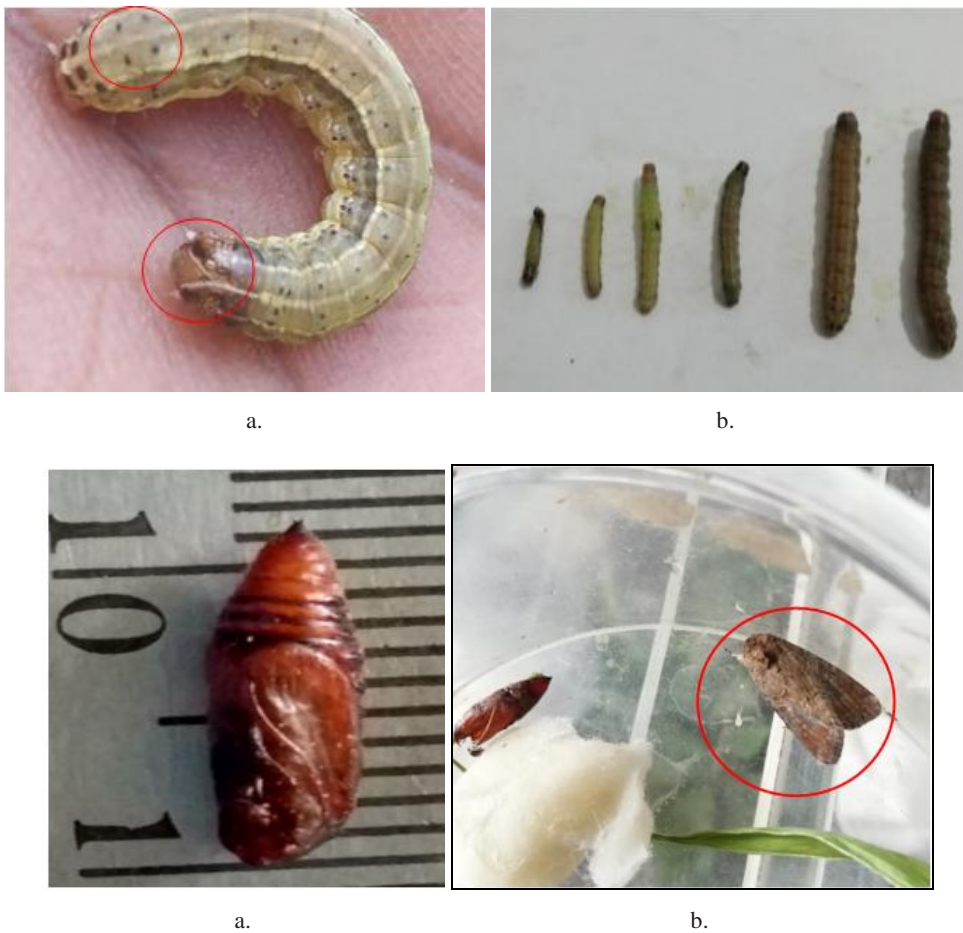

Fig 2: a) Inverted Y shaped on the head and four black spots arranged in square at 8th abdominal segment b) Different instars c) Pupa d) Adult

Conclusion

Incidence of fall armyworm started in the 1st week of August at 30 days old crop and reached to peak in the third week of August at 45 days old crop during *Kharif,* 2019 cropping season whereas its activity started from the first week of January with low percentage of infestation at 30 days old crop and reached peak infestation in the fourth week of February at 82 days old crop during *Rabi,* 2019-20 cropping season. The correlation studies of fall armyworm infestation and abiotic factors during *Kharif*, 2019 revealed that the infestation of fall armyworm as such or its increase or decrease was not significantly correlated with any of the weather parameters whereas during *Rabi*, 2019-20, relative humidity was negatively significantly correlated, and sunshine hours was highly negative significantly correlated with fall armyworm infestation while remaining parameters did not show significant effect on the fall armyworm infestation. Life cycle studies revealed that incubation period, larval period, pupal period and adult longevity was 2-3 days, 15-18 days, 8-10 days and 6-8 days, respectively.

Acknowledgement

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