

International Journal of Advanced Biochemistry Research



ISSN Print: 2617-4693
 ISSN Online: 2617-4707
 NAAS Rating (2026): 5.29
 IJABR 2026; 10(5): 281-286
www.biochemjournal.com
 Received: 12-02-2026
 Accepted: 15-03-2026

Azhaggaraja S
 Department of Entomology,
 Dr. Rajendra Prasad Central
 Agricultural University, Pusa,
 Bihar, India

Tanweer Alam
 Department of Entomology,
 TCA Dholi, Dr. Rajendra
 Prasad Central Agricultural
 University, Pusa, Bihar, India

Studies on population dynamics of fall armyworm, *Spodoptera frugiperda* (J. E. Smith) on Rabi and Kharif Maize in Bihar

Azhaggaraja S and Tanweer Alam

DOI: <https://www.doi.org/10.33545/26174693.2026.v10.i5d.8387>

Abstract

This study focuses on the population dynamics of the fall armyworm (*Spodoptera frugiperda*) on maize crops during both Kharif and Rabi seasons in Bihar. The main objectives were to examine the incidence and spread of FAW and understand the impact of weather conditions and crop phenology on pest populations. The research also investigates the role of natural enemies in regulating pest populations and the correlation between meteorological factors and pest activity.

The study was conducted over two agricultural seasons (2021-2023) at the Research Farm, Tirhut College of Agriculture, Dholi. The experiment was carried out on a 100 m² maize plot under field conditions, following all recommended agronomic practices. Observations were recorded at weekly intervals, including larval population, leaf and cob damage, and natural enemy populations. Data on weather parameters such as temperature, rainfall, humidity, and sunshine hours were collected from the nearby meteorological station.

The results showed that FAW populations were highest during reproductive stages, with significant associations found between temperature, humidity, and pest population dynamics. The Kharif season had a higher incidence of FAW compared to the Rabi season, primarily due to more favorable conditions for pest multiplication. Predators such as ladybird beetles and spiders were found to have a regulatory effect on FAW populations, though their impact was limited under high pest pressure. The findings highlight the importance of integrating natural enemies into pest management strategies for sustainable control.

Keywords: Fall armyworm, maize, population dynamics, weather conditions, natural enemies

Introduction

Maize (*Zea mays* L.), commonly known as corn, belongs to the tribe Maydeae of the family Poaceae and is one of the most widely cultivated cereal crops of the world and is recognised as one of the most adaptable cereal crops worldwide. Owing to its high genetic yield potential, broad adaptability, ease of cultivation and processing, and comparatively low cost of production, maize is widely referred to as the “Queen of Cereals”. The crop originated in Central Mexico and has since attained global importance due to its remarkable capacity to adapt to diverse agro-climatic conditions (Azerefegne *et al.*, 2002) ^[1]. At present, maize is cultivated in more than 170 countries across the world, occupying approximately 188 million hectares of land. Globally, it ranks next only to wheat and rice among cereal crops, in terms of area and production, and it has the highest productivity of any cereal, mostly grown under rainfed condition and contributes about 36 percent to total world food grain production. The maize grain is nutritionally rich, containing about 71-72 percent carbohydrates, 9-10 percent protein, 4 percent oil, 9-10 percent fibre, 2-3 percent sugars and around 1.4 percent minerals, along with appreciable quantities of vitamins such as vitamin A, riboflavin and vitamin E.

Although maize production has increased in recent years due to higher productivity, profitability, lower water requirement and rising industrial demand compared to rice and wheat, its potential yield is often constrained by several biotic and abiotic factors. Among the biotic stresses, insect pests constitute one of the most serious constraints, causing significant yield losses from seedling emergence to harvest. In recent years, the invasion of the fall armyworm (FAW), *Spodoptera frugiperda* (J. E. Smith) (Lepidoptera: Noctuidae), has emerged as a major threat to maize cultivation in India.

Corresponding Author:
Azhaggaraja S
 Department of Entomology,
 Dr. Rajendra Prasad Central
 Agricultural University, Pusa,
 Bihar, India

This alien, invasive and highly polyphagous pest is native to the tropical and subtropical regions of the America and is characterised by high fecundity, strong migratory ability and a wide host range. The pest was first reported in Africa in 2016 and subsequently spread rapidly to several Asian countries, including India. In India, FAW was first recorded on maize during May 2018 in the state of Karnataka, from where it quickly spread to most maize-growing states, including Bihar.

Population dynamics describe how pest populations fluctuate in time and space in response to host plant stage, weather conditions, natural enemies, and human interventions.

Methodology

To study the population dynamics of fall armyworm and its natural enemies under field conditions, a bulk plot experiment was conducted at the Research Farm, Tirhut College of Agriculture, Dholi. A maize plot of 100 m² area was raised during both kharif and rabi seasons (2021-2023) using the maize hybrid Shaktiman-5 (QPM). All recommended agronomic practices were followed to raise a healthy crop, except the application of plant protection measures, in order to allow natural infestation and natural regulation of pest population.

Observations on fall armyworm incidence were recorded at weekly intervals from seedling stage until harvest. Ten plants were selected randomly and tagged permanently for recording observations throughout the crop growth period. The number of live larvae per plant was counted carefully by opening the whorl wherever necessary. Percent plant infestation was worked out based on the number of plants showing characteristic damage symptoms. In addition, leaf damage severity was assessed visually to support larval count data.

Along with pest observations, the population of major natural enemies present on the tagged plants was also recorded at weekly intervals. Predators such as coccinellids, spiders, earwigs, rove beetle, predatory bugs, predatory wasps, ants, carabid beetle, etc. were counted visually.

Number of larvae per plant

The number of larvae per plant was counted on the basis of visual observation as well as by destructive sampling method at weekly interval from 10 randomly selected plants in an area of 100 m² and expressed as number of larvae per plant. This data then correlated with meteorological parameters like temperature °C (max and min), total rainfall (mm), relative humidity% (morning and evening), evaporation (mm), wind speed (km per hour) and bright sunshine hour (hours) by using OPSTAT. The Mean larval population of fall armyworm was calculated as follows,

$$\text{Mean Larval Population} = \frac{\text{Number of larvae}}{10 \text{ selected plants}}$$

Predator population

The population of predators such as ladybird beetles, spiders and rove beetles were also recorded at weekly interval from 10 randomly selected plants and expressed as number of predators/plant and correlated with weather parameters by using OPSTAT. The Mean predator population was calculated as follows,

$$\text{Mean Predator Population} = \frac{\text{Number of predator}}{10 \text{ selected plants}}$$

Percent leaf damage

Observation on fall armyworm incidence in terms of percent leaf damage was recorded at weekly interval, starting from the seedling to till harvest of the crop by observing the total number of fresh damaged leaves on top 5 leaves by selecting 10 random plants and mean percent leaf damage was worked out at weekly interval and effect of weather parameters on percent leaf damage was studied by correlating observations with meteorological variables by using OPSTAT. The percent leaf damage was calculated by using below formula,

$$\text{Percent leaf damage} = \frac{\text{Number of damaged leaves}}{\text{Total number of leaves}} \times 100$$

Per cob damage

Observation on fall armyworm incidence in terms of percent cob damage was recorded at maturity stage of the crop by observing the total number of damaged cobs by selecting 10 random plants and mean percent cob damage was worked out at weekly interval and effect of weather parameters on percent cob damage was studied by correlating observations with meteorological variables by using OPSTAT. The percent cob was calculated by using below formula,

$$\text{Percent cob damage} = \frac{\text{Number of damaged cobs}}{\text{Total number of cobs}} \times 100$$

The data on climatological weather parameters were collected from meteorological station T.C.A Dholi. Meteorological data comprising maximum and minimum temperature, morning and evening relative humidity, rainfall, wind speed and sunshine hours were obtained from the nearby meteorological observatory. These parameters were selected because weather factors are known to play a crucial role in influencing insect development, survival and population build-up. The weekly mean pest population was correlated with corresponding meteorological parameters to understand the influence of weather on seasonal incidence of fall armyworm and activity of natural enemies. Correlation and regression analyses were carried out to determine the relationship between fall armyworm population, natural enemies and different weather parameters using OPSTAT.

Results

Population dynamics of fall armyworm during Rabi 2021-22

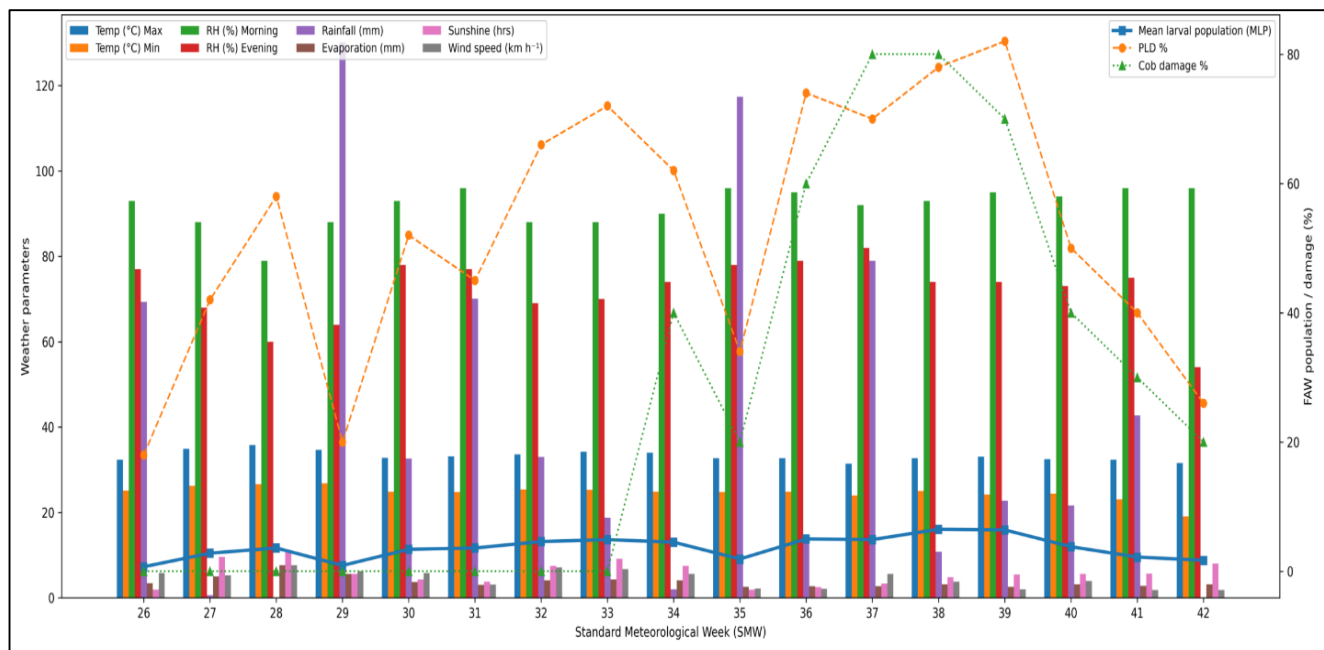
During Rabi 2021-22, fall armyworm (FAW) infestation was absent during SMW 50-51 and first appeared during SMW 52 with 0.6 larvae plant⁻¹ and 6% leaf damage. Larval population increased progressively during January (0.9-1.9 larvae plant⁻¹) with corresponding leaf damage of 12-20%, under moderate temperature and high relative humidity conditions. During February, population fluctuations were observed, with temporary suppression during SMW 5 following 29.6 mm rainfall, followed by a steady increase up to 3.1 larvae plant⁻¹ and 36% leaf damage by SMW 8. Cob damage was not recorded up to February.

Infestation intensified markedly during March, with larval population increasing from 3.6 to 4.2 larvae plant⁻¹ and leaf damage reaching 50% by SMW 12. Cob damage first appeared during SMW 10 (10%) and increased to 40% by

SMW 13. Peak infestation occurred during April, with maximum larval population (4.9 larvae plant⁻¹), 60% leaf damage and 60% cob damage recorded during SMW 15-16. Thereafter, pest incidence declined gradually with crop maturity, reaching 0.7 larvae plant⁻¹, 10% leaf damage and 10% cob damage by SMW 20.

Correlation analysis revealed significant positive associations of larval population with maximum temperature ($r = 0.660^{**}$), minimum temperature ($r = 0.544^{**}$), evaporation ($r = 0.756^{**}$) and sunshine hours ($r = 0.426^{*}$), whereas significant negative correlations were observed

with morning relative humidity ($r = -0.525^{*}$), evening relative humidity ($r = -0.643^{**}$) and rainfall ($r = -0.425^{*}$). Leaf damage showed strong positive correlation with larval population ($r = 0.980^{**}$) and evaporation ($r = 0.783^{**}$), while cob damage was positively associated with temperature, evaporation and larval population, and negatively associated with relative humidity. Overall, FAW incidence initiated at seedling stage, increased during vegetative growth, peaked during reproductive stages and declined at crop maturity.



Population dynamics of fall armyworm in relation to weather parameter during Kharif season (2022)

Months	SMW	Temperature (°C)		Relative Humidity (%)		Wind speed	Total Rainfall (mm)	Evaporation (mm)	Bright sunshine (hr.)	MLP	PLD (%)	Cob damage (%)
		Max	Min	Morning	Evening							
July	26	32.3	25.1	93	77	5.8	69.3	3.4	1.9	0.7	18	0
	27	34.9	26.2	86	68	5.3	0.6	5.0	9.6	2.8	42	0
	28	35.8	26.6	79	60	7.6	0.0	7.6	10.9	3.6	58	0
	29	34.7	26.0	88	64	6.3	130.1	5.6	5.6	0.9	20	0
	30	32.8	24.9	93	78	5.8	32.6	3.7	4.3	3.4	52	0
August	31	33.2	24.8	96	77	3.1	70.1	3.0	3.8	3	46	0
	32	33.6	25.4	88	69	7.1	33.0	4.1	7.5	4.6	66	0
	33	34.2	25.3	88	70	6.7	18.8	4.3	9.1	4.9	72	0
	34	34.0	24.9	90	74	5.6	2.0	4.1	7.5	4.5	62	40
September	35	32.7	24.8	96	78	2.2	117.4	2.6	1.9	1.9	34	20
	36	32.7	24.9	95	79	2.1	13.8	2.7	2.5	5	74	60
	37	31.4	24.0	92	82	5.6	79.0	2.7	3.3	4.9	70	60
	38	32.7	25.0	95	74	3.8	10.8	3.2	4.8	6.1	78	80
	39	33.1	24.2	95	74	2	22.8	2.6	5.4	6.4	82	70
October	40	32.9	24.4	94	73	3.9	21.6	3.2	5.6	3.8	60	50
	41	32.3	23.1	96	75	1.8	42.7	2.8	5.7	2.2	40	40
	42	31.6	19.1	96	54	1.8	0	3.2	8.0	1.7	26	20

SMW: Standard Meteorological Week, MLP: Mean Larval Population, PLD: Plant Leaf Damage

Correlation between Population dynamics of fall armyworm and weather parameters in 2022 (Kharif season)

	Max. Temp.	Min. Temp.	RH Morning	RH Evening	Wind speed	Rainfall	Evaporation	Sunshine	MLP	PLD (%)	Cobdamage (%)
Max.Temp											
Mintemp	0.696**										
RH Morning	-0.841**	-0.588*									
RH Evening	-0.425 ^{NS}	0.270 ^{NS}	0.471 ^{NS}								
Windspeed	0.590*	0.611**	-0.825**	-0.184 ^{NS}							
Rainfall	-0.165 ^{NS}	0.158 ^{NS}	0.206 ^{NS}	0.305 ^{NS}	-0.008 ^{NS}						
Evaporation	0.868**	0.507*	-0.936**	-0.617**	0.726**	-0.156 ^{NS}					
Sunshine	0.672**	0.070 ^{NS}	-0.724**	-0.746**	0.435 ^{NS}	-0.595*	0.712**				
MLP	0.008 ^{NS}	0.156 ^{NS}	-0.005 ^{NS}	0.280 ^{NS}	-0.004 ^{NS}	-0.500*	-0.177 ^{NS}	0.120 ^{NS}			
PLD (%)	0.036 ^{NS}	0.206 ^{NS}	-0.049 ^{NS}	0.310 ^{NS}	0.033 ^{NS}	-0.491*	-0.144 ^{NS}	0.123 ^{NS}	0.988**		
Cobdamage (%)	-0.472 ^{NS}	-0.248 ^{NS}	0.490*	0.375 ^{NS}	-0.532*	-0.209 ^{NS}	-0.549*	-0.321 ^{NS}	0.625**	0.590*	

MLP: Mean Larval Population, PLD: Plant Leaf Damage

NS-Non-Significant: *-Significant at 5% level: **-Significant at 1% level

Population dynamics of fall armyworm during Rabi 2022-23

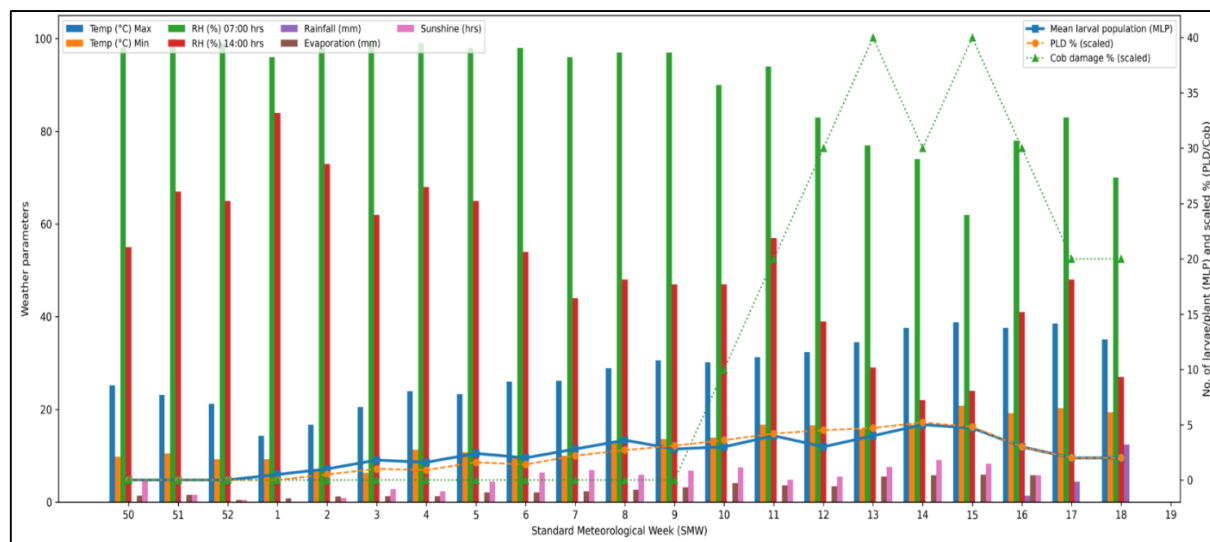
During Rabi 2022-23, fall armyworm (FAW) infestation on maize commenced during SMW 52 with 0.5 larvae plant⁻¹ and 2% leaf damage. Pest population increased progressively during vegetative growth and reached peak incidence during April (SMW 16) with 4.7 larvae plant⁻¹, 64% leaf damage and 70% cob damage. Thereafter, infestation declined gradually with crop maturity, reaching 1.2 larvae plant⁻¹ and 8% leaf damage by SMW 20.

Correlation analysis revealed significant positive associations of larval population with maximum temperature, minimum temperature, evaporation and sunshine hours, whereas significant negative correlations were observed with morning and evening relative humidity. Leaf and cob damage showed strong positive correlation with larval population and temperature-related parameters, while relative humidity exhibited negative association. Overall, FAW incidence increased from late December, peaked during reproductive stage in April and declined thereafter with crop maturity.

Population dynamics of fall armyworm in relation to weather parameter during Rabi season (2022-2023)

Month	SMW	Temperature (°C)		Relative Humidity (%)		Total Rain fall (mm)	Evaporation (mm)	Bright sunshine (hr.)	MLP	PLD (%)	Cob damage (%)
		Max	Min	Morning	Evening						
December	50	25.2	9.8	98	55	0	1.4	4.5	0	0	0
	51	23.1	10.5	100	67	0	1.1	1.6	0	0	0
	52	21.2	9.3	99	65	0	1.2	0.5	0	2	0
January	1	14.3	9.3	96	84	0	0.8	0	0.5	10	0
	2	16.7	6.7	98	73	0	1.2	2.1	0.9	18	0
	3	20.5	6.3	99	62	0	1.3	2.8	1.0	16	0
	4	23.9	11.3	99	68	0	1.3	2.3	1.6	24	0
February	5	23.3	10.8	98	65	0	2.1	4.4	1.4	20	0
	6	26.0	10.0	98	54	0	2.1	6.4	2.2	28	0
	7	26.2	10.0	96	44	0	2.5	6.9	2.7	26	0
	8	29.6	12.8	97	48	0	3.2	5.9	3.1	34	0
March	9	30.6	13.6	97	47	0	3.2	6.8	3.8	38	10
	10	30.2	13.9	90	47	1.8	4.1	7.5	2.5	26	0
	11	31.3	16.7	94	57	0	3.6	4.8	4.0	48	40
	12	28.3	16.5	95	57	18	3.4	5.5	1.1	24	10
	13	32.4	16.6	83	39	0	5.6	7.6	4.2	50	30
April	14	34.5	15.7	77	29	0	6.7	9.1	4.2	52	40
	15	37.6	16.7	74	22	0	6.4	9.2	4.5	58	30
	16	38.8	20.8	62	24	0	6.5	8.3	4.7	64	70
	17	33.6	19.2	78	41	1.4	4.6	5.8	2.9	30	50
	18	32.5	20.3	83	48	4.4	4.4	5.7	2.1	26	30
May	19	38.1	19.4	70	27	0	6.9	9.7	2.4	20	20
	20	35.2	22.1	81	50	12.4	6.4	8.6	1.2	8	20

SMW: Standard Meteorological Week, MLP: Mean Larval Population, PLD: Plant Leaf Damage



Correlation between population dynamics of fall armyworm and weather parameters (Rabi 2022-23)

	Max. Temp	Min. Temp.	RH Morning	RH Evening	Rainfall	Evaporation	Sunshine	MLP	PLD (%)	Cob Damage (%)
Max. Temp.										
Min. Temp.	0.883**									
RH Morning	-0.827**	-0.809**								
RH Evening	-0.918**	-0.678**	0.826**							
Rainfall	0.168 ^{NS}	0.408 ^{NS}	-0.051 ^{NS}	0.039 ^{NS}						
Evaporation	0.931**	0.871**	-0.908**	-0.881**	0.201 ^{NS}					
Sunshine	0.896**	0.702**	-0.726**	-0.908**	0.158 ^{NS}	0.891**				
MLP	0.735**	0.543**	-0.616**	-0.774**	-0.213 ^{NS}	0.713**	0.727**			
PLD (%)	0.642**	0.476*	-0.588**	-0.693**	-0.165 ^{NS}	0.641**	0.619**	0.960**		
Cob Damage (%)	0.743**	0.778**	-0.839**	-0.675**	0.026 ^{NS}	0.753**	0.534**	0.698**	0.713**	

MLP: Mean Larval Population, PLD: Plant Leaf Damage

NS-Non-Significant: *-Significant at 5% level: **-Significant at 1% level

Population dynamics of fall armyworm during Kharif 2023

During Kharif 2023, fall armyworm (FAW) infestation on maize commenced during SMW 26 with 0.3 larvae plant⁻¹ and 16% leaf damage. Pest population increased rapidly during vegetative stages, reaching peak incidence during September (SMW 35-37) with maximum larval population of 6.2 larvae plant⁻¹, 82% leaf damage and 60% cob damage. Heavy rainfall during SMW 32 and SMW 38 resulted in marked reduction in larval population and damage levels. Thereafter, infestation declined gradually with crop maturity, reaching 2.1 larvae plant⁻¹, 18% leaf

damage and 10% cob damage by SMW 42.

Correlation analysis revealed significant positive association of larval population with maximum temperature ($r = 0.526^*$) and significant negative association with rainfall ($r = -0.483^*$). Leaf damage showed strong positive correlation with larval population ($r = 0.923^{**}$) and temperature, while cob damage exhibited positive association with larval population and leaf damage, and negative association with wind speed. Overall, FAW incidence increased during vegetative growth, peaked during September and declined thereafter with crop maturity.

Population dynamics of fall armyworm in relation to weather parameter during Kharif season (2023)

Months	SMW	Temperature (°C)		Relative Humidity (%)		Wind Speed	Total Rain fall (mm)	Evaporation (mm)	Bright sunshine (hr.)	MLP	PLD (%)	Cob damage (%)
		Max	Min	Morning	Evening							
July	26	32.6	24.7	91	71	9.2	118.2	5.2	3.0	0.3	16	0
	27	32.4	24.8	93	75	5.8	1.4	4.0	3.2	1.4	32	0
	28	33.5	25.3	93	80	4.4	35.4	2.6	1.7	2.5	46	0
	29	34.8	25.8	87	63	6.6	0.0	5.5	8.6	3.6	54	0
August	30	35.6	26.0	86	60	6.1	0.0	5.1	7.2	5.4	70	0
	31	33.9	25.3	90	71	6.2	101.4	4.4	5.0	2.5	50	0
	32	30.0	24.2	97	88	4.1	369.7	2.0	0.4	1.8	28	0
	33	33.8	24.9	94	71	2.2	43.2	3.7	5.5	4.4	66	0
September	34	30.8	24.3	95	84	1.8	101.2	3.3	1.6	3.7	42	30
	35	34.4	25.6	89	68	3.1	28.2	4.0	3.5	6.2	82	60
	36	33.3	24.0	93	80	2.0	70.8	3.5	2.7	4.8	76	50
	37	33.5	25.3	93	70	2.8	0.0	4.1	7.0	5.7	78	60
October	38	32.2	23.9	94	80	3.2	293.2	3.2	4.5	1.1	28	10
	39	31.0	24.0	96	78	1.1	42.4	2.4	3.6	2.8	40	20
	40	31.1	24.8	94	78	2.5	38.4	2.7	4.0	3.4	34	40
	41	33.7	24.4	94	62	0.8	0.0	3.2	7.6	3.9	52	70
	42	31.6	21.0	95	65	1.6	1.2	3.1	7.9	2.1	18	10

SMW: Standard Meteorological Week, MLP: Mean Larval Population, PLD: Plant Leaf Damage

Discussion

Population dynamics of fall armyworm and its natural enemies

Population dynamics of fall armyworm during Rabi season (2021-2022)

The seasonal incidence of *Spodoptera frugiperda* during Rabi season exhibited gradual increase in larval population from vegetative to reproductive stages, followed by decline towards crop maturity. Similar trends have been reported in maize ecosystems of India, where FAW infestation increases with crop age due to greater foliage availability and favourable canopy microclimate (Sharanabasappa *et al.*, 2018; Fand *et al.*, 2019) ^[2, 4]. Higher larval population during reproductive stages may be attributed to increased plant biomass providing abundant feeding sites.

Significant positive correlation between FAW population and temperature parameters indicated the important role of temperature in pest population dynamics. Previous studies reported optimum FAW development between 25-30 °C (Du Plessis *et al.*, 2020; Hruska, 2019) ^[8, 9], and similar positive associations between temperature and FAW incidence have been documented in maize ecosystems of Karnataka and Telangana (Sharanabasappa *et al.*, 2018) ^[2]. Conversely, the negative association between FAW population and rainfall observed in the present study may be due to the mechanical. Rainfall has been reported to significantly reduce FAW populations by washing away eggs and early instar larvae from maize leaves (Day *et al.*, 2017) ^[5].

Population dynamics of fall armyworm during Kharif season (2022)

Kharif seasons exhibited higher fall armyworm (FAW) incidence than Rabi due to favourable warm and humid conditions that enhanced reproduction and larval development. Continuous host availability and migratory behaviour of *Spodoptera frugiperda* further contributed to rapid infestation and population build-up (Day *et al.*, 2017; Early *et al.*, 2018) ^[5, 6]. Peak infestation generally occurred during vegetative to reproductive stages owing to greater foliage availability and favourable canopy microclimate (Sharanabasappa *et al.*, 2018; Fand *et al.*, 2019) ^[2, 4].

Positive associations of FAW population with temperature and humidity, and negative association with rainfall, confirmed the strong influence of climatic factors on pest dynamics. Concealed feeding behaviour within maize whorls and tassels also enhanced larval survival during reproductive stages. Overall, FAW incidence increased progressively during crop growth, peaked during reproductive stages and declined towards crop maturity.

Population dynamics of natural enemies associated with fall armyworm

The present study recorded diverse natural enemies associated with *Spodoptera frugiperda* in maize ecosystems, including spiders, coccinellids and predatory bugs, indicating complex trophic interactions. Spiders acted as important generalist predators, particularly during later crop stages with higher canopy complexity, while coccinellids and predatory bugs were observed feeding on FAW eggs and early instar larvae. Similar natural enemy complexes contributing to FAW suppression have been reported globally (Kenis *et al.*, 2023) ^[3].

However, under high pest pressure, the suppressive effect of natural enemies appeared limited, suggesting that biological control alone may not effectively regulate severe infestations. Conservation of these natural enemies through integrated pest management practices may enhance sustainable FAW management.

Conclusion

The study demonstrated that *Spodoptera frugiperda* infestation in maize was strongly influenced by crop phenology and prevailing weather conditions. FAW incidence initiated during early crop stages, increased progressively during vegetative growth and reached peak infestation during reproductive stages, followed by decline towards crop maturity. Higher infestation during Kharif seasons compared to Rabi indicated the favourable effect of warm and humid conditions on pest multiplication. Temperature showed significant positive association with FAW population, whereas rainfall and relative humidity generally exerted suppressive effects.

Natural enemies including spiders, coccinellids and predatory bugs were associated with FAW populations and contributed to natural regulation of the pest. However, their impact was limited under high infestation levels, indicating the need for integrated pest management strategies combining biological control with timely monitoring and other eco-friendly management practices for sustainable FAW suppression in maize ecosystems.

References

1. Azerefege F. Genetic diversity and adaptability of maize. *Afr Crop Sci J*. 2002;10:289-297.
2. Sharanabasappa D, Kalleshwaraswamy CM, Maruthi MS, Pavithra HB. Biology of fall armyworm in India. *Indian J Entomol*. 2018;80:540-543.
3. Kenis M, du Plessis H, Van den Berg J. Ecology and management of fall armyworm. *Annu Rev Entomol*. 2023;68:355-373.
4. Fand BB, Tonnang HEZ, Kumar M. Predicting fall armyworm spread using climatic modelling. *Sci Rep*. 2019;9:1-10.
5. Day R, Abrahams P, Bateman M. Fall armyworm: Impacts and implications for Africa. *Outlooks Pest Manag*. 2017;28:196-201.
6. Early R, González-Moreno P, Murphy ST, Day R. Forecasting global invasion of fall armyworm. *NeoBiota*. 2018;40:25-50.
7. Hailu G, Sisay B, Tefera T. Field evaluation of natural enemies of fall armyworm. *Biocontrol Sci Technol*. 2021;31:674-687.
8. Du Plessis Harrison RD, Thierfelder C, Baudron F. Agroecological options for managing fall armyworm. *Outlooks Pest Manag*. 2019;30:1-8.
9. Hruska AJ. Fall armyworm management by farmers. *J Integr Pest Manag*. 2019;10:1-11.