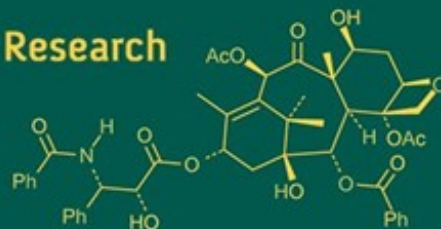


International Journal of Advanced Biochemistry Research



ISSN Print: 2617-4693
ISSN Online: 2617-4707
NAAS Rating (2026): 5.29
Indexing: Embase
IJABR 2026; 10(10): 59-62
www.biochemjournal.com
Received: 01-08-2026
Accepted: 23-09-2026
Published: 03-10-2026

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Seasonal incidence of fall armyworm, *Spodoptera frugiperda* (JE Smith), associated insect pests and their natural enemies on Rabi maize and their relationship with weather parameters

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DOI: <https://www.doi.org/10.33545/26174693.2026.v10.i10a.10287>

ABSTRACT

A field investigation was undertaken during the Rabi season of 2025-26 at Krishi Vigyan Kendra, Dhule, Mahatma Phule Krishi Vidyapeeth, Rahuri (Maharashtra), to study the seasonal incidence of the fall armyworm, *Spodoptera frugiperda* (J. E. Smith), its associated insect pests and their natural enemies on maize (*Zea mays* L.), and to relate their population build-up with prevailing weather parameters. Weekly observations recorded from sowing (2nd December 2025) to harvest revealed that fall armyworm plant damage first appeared during the 52nd Standard Meteorological Week (SMW) (4.00%) and increased progressively to a peak of 50.00 per cent during the 7th SMW of mid-February, thereafter declining to 32.00 per cent by the 13th SMW. Larval population followed a similar trend, peaking at 2.25 larvae/plant during the 7th SMW. Cob damage appeared later, from the 7th SMW (25.00%), and peaked at 40.00 per cent during the 9th SMW. Among the associated pests, stem borer (*Chilo partellus*) incidence peaked at 32.44 per cent during the 6th SMW, while the aphid (*Rhopalosiphum maidis*) population continued to build up towards the later part of the season, peaking at 2.20 aphids/plant during the 12th SMW. Among the natural enemies, coccinellid predators closely tracked fall armyworm activity, peaking at 1.80 beetles/plant during the 7th SMW, whereas the spider population remained comparatively stable, peaking at 0.92 spiders/plant during the 10th SMW. Correlation studies revealed that minimum temperature was the weather parameter most consistently and strongly associated with the build-up of fall armyworm, associated pests and natural enemies, whereas relative humidity exerted a largely non-significant influence. These findings provide a season-specific baseline for timing management interventions against fall armyworm in Rabi maize.

Keywords: *Spodoptera frugiperda*, Fall armyworm, Rabi maize, Seasonal incidence, Natural enemies, Weather correlation, Coccinellids

Introduction

Maize (*Zea mays* L.) is one of the most important cereal crops cultivated globally and is a key component of food, feed, fodder and industrial production systems, with a wide range of applications in livestock and poultry feed, starch production and other industrial processes (Erenstein, 2010) [1]. Maize occupies close to 203.54 million hectares globally, yielding around 1,270.75 million tonnes at an average productivity of 6.24 tonnes per hectare (Anonymous, 2025) [2]. India contributes about 4 per cent of the global acreage and 2 per cent of world production, ranking fourth in area and seventh in production among maize-growing countries, with national production climbing to a record 43.41 million tonnes in 2024-25 (Anonymous, 2025) [2]. Maharashtra grows maize on nearly 0.87 million hectares, producing 1.1 million tonnes at a state average of around 3000 kg/ha.

Maize cultivation in India has historically been constrained by a broad pest complex encompassing 20 to 25 major economic species (Singh et al., 2018) [3], traditionally dominated by the spotted stem borer, *Chilo partellus* (Swinhoe), and the oriental armyworm, *Mythimna separata*. The phytosanitary landscape shifted markedly with the introduction of the invasive fall armyworm, *Spodoptera frugiperda* (J. E. Smith) (Lepidoptera: Noctuidae), first documented in West Africa in 2016 (Goergen et al., 2016) [4] and subsequently confirmed in India at Shivamogga, Karnataka, in May 2018 (Sharanabasappa et al., 2018) [5]. The first incidence in Maharashtra was recorded in September 2018 at Tandulwadi village, Solapur district (Chormule et al., 2019) [6], and by 2020 the pest had established itself across virtually all major maize-growing zones of the country. *Spodoptera frugiperda* is a highly polyphagous pest with a host range spanning 76 botanical families, with a marked preference for Poaceae, particularly maize, sorghum and sugarcane

(Chormule *et al.*, 2019) [6]. Although the pest can infest maize throughout its phenological development, maximum vulnerability occurs during the early vegetative stages, when larvae establish within the whorl. To date, the majority of entomological research on *S. frugiperda* in India has focused predominantly on the *Kharif* cropping season, when pest population dynamics and infestation intensity reach their peak, leaving a critical knowledge gap regarding its seasonal incidence, natural enemy complex and relationship with weather parameters during the cooler, lower-humidity *Rabi* season. Since both larval survival and the population build-up of natural enemies are strictly dependent on ambient temperature and relative humidity, incidence data generated under warm, humid *Kharif* conditions cannot be directly extrapolated to the *Rabi* season. Establishing season-specific management protocols therefore requires a comprehensive baseline understanding of the population dynamics, seasonal incidence and natural enemy complex of *S. frugiperda* through the *Rabi* cropping cycle. Keeping this gap in view, the present investigation was undertaken to study the seasonal incidence of fall armyworm and other associated insect pests along with their natural enemies on *Rabi* maize, and to relate their build-up with prevailing weather parameters.

2. Materials and Methods

The field investigation was carried out during the *Rabi* season of 2025-26 at Krishi Vigyan Kendra, Dhule, and College of Agriculture, Dhule (Maharashtra), under the Department of Entomology, Post-Graduate Institute, Mahatma Phule Krishi Vidyapeeth, Rahuri. Maize hybrid Harlal 7272 was sown by the dibbling method on 2nd December 2025, adopting a spacing of 60 cm between rows and 20 cm between plants, and the field was managed with a basal fertilizer dose of 100:50:50 kg N:P₂O₅:K₂O per hectare along with recommended agronomic practices. A separate biopesticide-free (untreated) plot was maintained, without any plant protection measures, specifically for recording the seasonal incidence of fall armyworm, its associated insect pests and their natural enemies.

For studying seasonal incidence, weekly observations were recorded on five randomly selected and tagged plants in the biopesticide-free plot, avoiding border rows, starting from the date of sowing and continuing until crop harvest. The parameters recorded included per cent plant (whorl/leaf) damage and larval population of fall armyworm, per cent cob damage at harvest, the incidence of the associated stem borer (*Chilo partellus*) and aphid (*Rhopalosiphum maidis*) populations, and the population of the predatory natural enemies, namely coccinellids (family Coccinellidae) and spiders (order Araneae). Per cent plant leaf damage was calculated as the number of damaged leaves per plant expressed as a percentage of the total number of leaves observed, and per cent cob damage as the number of damaged cobs expressed as a percentage of the total cobs observed.

Weekly meteorological data, including maximum and minimum temperature, morning and afternoon relative humidity, rainfall and rainy days, were recorded concurrently from the meteorological observatory at Agronomy section, Government college of agriculture, Dhule, to relate pest and natural enemy build-up with the prevailing weather. Simple correlation coefficients were worked out between the population/damage of fall armyworm, associated pests and natural enemies, and the weather parameters recorded during the corresponding standard meteorological weeks (SMW).

3. Results and Discussion

Seasonal incidence of fall armyworm, associated insect pests and their natural enemies on *Rabi* maize

Fall armyworm plant damage and larval population

Percentage plant damage due to fall armyworm was nil during the 51st SMW and was first recorded during the 52nd SMW of December (4.00%). The damage increased steadily thereafter, touching 13.33, 20.00, 28.00 and 32.00 per cent during the 1st to 4th SMW of January, respectively, and continued to intensify during February,

recording 38.00 and 44.00 per cent in the 5th and 6th SMW and reaching its peak of 50.00 per cent in the 7th SMW (mid-February). The damage then declined gradually to 47.00 and 45.00 per cent in the 8th and 9th SMW, and further to 32.00 per cent by the 13th SMW of March, ranging overall from 0.00 to 50.00 per cent. The larval population followed a closely similar trend, first appearing in the 52nd SMW (0.06 larvae/plant) and increasing progressively to 1.65 larvae/plant by the 4th SMW of January, before attaining its peak of 2.25 larvae/plant in the 7th SMW, coinciding with the peak plant damage, and thereafter declining to 0.70 larvae/plant by the 13th SMW.

These findings are in agreement with Dhar *et al.* (2019) [7], who reported that fall armyworm infestation on *Rabi* maize in Malda district of West Bengal intensified progressively through the vegetative period, and with Deole *et al.* (2018) [8], who observed infestation increasing from the vegetative to reproductive stage, reaching 49.20 per cent at the reproductive stage closely corroborating the peak recorded around the 7th SMW (early reproductive stage) in the present study. Mallapur *et al.* (2018) [9] similarly reported fall armyworm damage on maize in Karnataka ranging between 12.42 and 65.73 per cent across locations, and larval populations varying from 8.00 to 140.00 larvae per unit area, reflecting a comparable magnitude and build-up pattern to that recorded in the present investigation.

2. Cob damage

Cob damage due to fall armyworm first appeared in the 7th SMW of February (25.00%) and increased sharply to 35.00 and 40.00 per cent during the 8th and 9th SMW, coinciding with the reproductive stage of the crop, before declining gradually to 25.00 per cent by the 13th SMW of March, with the overall range extending from 0.00 to 40.00 per cent. The delayed onset of cob damage relative to plant (whorl) damage is consistent with Babu *et al.* (2019) [10], who observed that fall armyworm larvae were present from the vegetative stage through cob formation, with damage between 10 and 40 per cent across maize hybrids and inbreds — a range closely matching the present finding.

3. Stem borer and aphid incidence

The incidence of stem borer, *Chilo partellus*, was first observed in the 52nd SMW (6.66%) and increased steadily to 20.00 per cent by the 4th SMW of January, continuing to rise during February and reaching its peak of 32.44 per cent in the 6th SMW, before declining progressively to 12.80 per cent by the 13th SMW. This build-up-to-peak-then-decline pattern is in agreement with Dindor *et al.* (2016) [11] and Kumar *et al.* (2016) [12], who reported comparable trends in stem borer infestation on maize, and with Kumar *et al.* (2018) [13], who recorded a peak larval population of 2.42 larvae/plant of *C. partellus* during the 4th standard week of the *Rabi* season, closely comparable to the peak period recorded here.

The aphid, *Rhopalosiphum maidis*, population was first recorded in the 1st SMW of January (0.45 aphids/plant) and, unlike fall armyworm, continued to build up progressively through the season, reaching 2.20 aphids/plant during the 12th SMW of March before declining slightly to 1.90 aphids/plant in the 13th SMW. This late-season build-up agrees with Singh *et al.* (2018) [3], who reported that maize aphid populations attained their maximum later in the season and were positively correlated with advancing plant age.

4. Natural enemies: coccinellids and spiders

The predatory coccinellid population appeared in the 52nd SMW (0.13 beetles/plant) and increased steadily, reaching a peak of 1.80 beetles/plant in the 7th SMW, closely tracking the peak activity of fall armyworm, before declining progressively to 0.60 beetles/plant by the 13th SMW. This close synchrony between predator build-up and prey availability is consistent with Swaminathan *et al.* (2016) [14] and Sahito *et al.* (2012) [15], who reported that predator populations on maize were generally governed by the abundance of associated pest prey. The spider population, first recorded in the 1st SMW of January (0.10 spiders/plant), increased gradually and remained comparatively stable, peaking at 0.92 spiders/plant in the 10th SMW of March, a

level closely comparable to the peak spider density (0.89/plant) reported by Kumar *et al.* (2018) [13] during the 4th standard week of the *Rabi* season.

2. Correlation with weather parameters

Maximum temperature showed a highly significant positive correlation with fall armyworm plant damage ($r = 0.603^{**}$), per cent cob damage ($r = 0.862^{**}$), aphids ($r = 0.891^{**}$) and spiders ($r = 0.879^{**}$), while its correlation with fall armyworm larvae ($r = 0.211$) and coccinellids ($r = 0.452$) was positive but non-significant; stem borer showed a negative, non-significant correlation ($r = -0.091$).

Minimum temperature exhibited a highly significant positive correlation with fall armyworm plant damage ($r = 0.840^{**}$), cob damage ($r = 0.835^{**}$), aphids ($r = 0.923^{**}$), coccinellids ($r = 0.679^{**}$) and spiders ($r = 0.912^{**}$), and a significant positive correlation with fall armyworm larvae ($r = 0.511^{*}$) and stem borer ($r = 0.599^{*}$), making it the weather parameter most consistently and strongly associated with the build-up of fall armyworm, associated pests and natural enemies during the season. Morning relative humidity showed a negative, non-significant correlation with all parameters studied, while afternoon relative humidity showed a mixed, non-significant relationship with the different pests and natural enemies.

Table 1. Seasonal incidence of fall armyworm, associated insect pests and their natural enemies on *Rabi* maize (2025-26)

Month	SMW	FAW Plant Damage (%)	% cob damage	FAW Larvae / Plant	Stem borer	Aphids/plant	Coccinellids	Spiders	Temperature Min (°C)		Humidity %	
									MAX (°C)	MIN (°C)	Morning	Evening
Dec	51	0.00	0.00	0.00	0.00	0.00	0.00	0.00	29.00	6.10	88.00	29.00
	52	4.00	0.00	0.06	6.66	0.00	0.13	0.00	28.80	7.30	87.00	32.00
Jan	1	13.33	0.00	0.50	13.33	0.45	0.20	0.10	27.80	9.00	88.00	36.00
	2	20.00	0.00	1.30	14.86	0.51	0.45	0.10	29.80	7.00	88.00	32.00
	3	28.00	0.00	1.40	16.80	0.80	0.60	0.25	29.10	9.70	84.00	34.00
	4	32.00	0.00	1.65	20.00	0.95	0.70	0.15	29.60	11.20	81.00	37.00
Feb	5	38.00	0.00	1.70	26.66	0.90	0.80	0.20	29.90	10.10	89.00	37.00
	6	44.00	0.00	1.90	32.44	1.00	1.00	0.60	31.10	11.00	86.00	36.00
	7	50.00	25.00	2.25	28.60	1.20	1.80	0.80	33.30	12.40	88.00	35.00
	8	47.00	35.00	1.70	26.80	1.60	1.40	0.89	33.40	14.10	85.00	32.00
	9	45.00	40.00	1.60	22.46	1.60	1.00	0.90	33.70	13.20	87.00	35.00
March	10	40.00	37.00	1.40	20.18	1.75	0.80	0.92	34.10	12.80	85.00	36.00
	11	38.00	35.00	1.10	19.00	2.00	0.70	0.85	37.30	14.70	79.00	26.00
	12	33.00	30.00	0.80	15.40	2.20	0.65	0.75	34.00	12.60	86.00	34.00
	13	32.00	25.00	0.70	12.80	1.90	0.60	0.76	37.00	13.00	85.00	33.00

FAW = Fall armyworm

Table 2. Correlation coefficients between fall armyworm, associated pests, natural enemies and weather parameters during *Rabi* 2025-26

Weather parameter	FAW plant damage (%)	Cob damage (%)	FAW larvae/ plant	Stem borer	Aphids	Coccinellids	Spiders
Maximum temperature (°C)	0.603**	0.862**	0.211	-0.091	0.891**	0.452	0.879**
Minimum temperature (°C)	0.840**	0.835**	0.511*	0.599*	0.923**	0.679**	0.912**
Morning relative humidity (%)	-0.248	-0.287	-0.111	-0.091	-0.458	-0.059	-0.301
Afternoon relative humidity (%)	0.314	-0.196	0.458	0.469	-0.020	0.273	-0.040

* Significant at 5% level; ** Significant at 1% level

These findings confirm that fall armyworm incidence, associated pest population and predator activity on maize during the *Rabi* season were governed predominantly by temperature, particularly minimum temperature, rather than relative humidity. This is in agreement with Ahad *et al.* (2008) [16], who reported that stem borer adult catches were significantly and positively correlated with relative humidity as well as maximum and minimum temperature, and with Meti *et al.* (2014) [17], who reported a highly significant positive correlation of minimum temperature with per cent dead heart caused by stem borer. Similarly, Kumar *et al.* (2019) [18] reported a highly significant positive correlation of aphid population with maximum and minimum temperature and a significant negative correlation with morning relative humidity, consistent with the trend recorded in the present investigation.

4. Conclusion

Fall armyworm infestation on *Rabi* maize first appeared during the 52nd Standard Meteorological Week and attained its peak plant damage (50.00%) and larval population (2.25 larvae/plant) during the 7th SMW of mid-February, corresponding to the vegetative-to-reproductive transition of the crop, while cob damage commenced later and peaked (40.00%) during the 9th SMW at the reproductive stage. Among the associated pests, stem borer peaked (32.44%) during the 6th SMW, whereas the aphid population continued to build up towards the later part of the season, peaking during the 12th SMW. The predatory coccinellid population closely tracked fall armyworm activity, peaking during the 7th SMW, while the spider population remained comparatively stable and peaked later, during the 10th SMW. Minimum temperature emerged as the weather parameter most consistently and strongly associated with the build-up of fall armyworm,

its associated pests and natural enemies, whereas relative humidity exerted a largely non-significant influence. These findings provide a season-specific baseline that can guide the timing of biopesticide/biorational interventions against fall armyworm in *Rabi* maize, so as to coincide with the pest build-up phase while conserving the coccinellid and spider natural enemy complex.

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How to cite this article: Ahire AP, BM M, Vasave RO, NB G, JV K. Seasonal incidence of fall armyworm, *Spodoptera frugiperda* (JE Smith), associated insect pests and their natural enemies on Rabi maize and their relationship with weather parameters. *International Journal of Advanced Biochemistry Research*. 2026;10(10):59-62. doi: <https://www.doi.org/10.33545/26174693.2026.v10.i10a.10287>