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Population Dynamics of *Spodoptera frugiperda* (Fall Armyworm) on Maize

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ABSTRACT

Maize is one of the most important cereal crops, but its productivity is increasingly threatened by the invasive pest fall armyworm, which causes severe damage at both vegetative and reproductive stages. The erratic nature of its population buildup and limited location-specific information on its seasonal incidence in relation to prevailing weather parameters often hinder timely and effective pest management. In this context, the present study was conducted at the Experimental Farm of the Plant Protection, Department of Agricultural Sciences, Aligarh Muslim University, Aligarh, to investigate the population dynamics of *Spodoptera frugiperda* on maize during *Kharif* 2022 and 2023 from SMW 21-32. In 2022, larval population ranged from 0.2 to 2.8 larvae/plant, causing 40.2% plant damage and 13.4% cob damage, with a peak in SMW 28. In 2023, larval abundance varied between 0.3 and 3.0 larvae/plant, resulting in 42.8% plant damage and 14.2% cob damage, with an earlier peak in SMW 27. Relative humidity showed the strongest positive correlation with larval population (2022: r = 0.987; 2023: r = 0.913), while rainfall also contributed significantly, particularly in 2022. Maximum temperature exhibited a negative influence in both years. Regression models explained 98.9% variability in 2022 and 93.1% in 2023, confirming that FAW population dynamics were primarily moisture-driven across both seasons. The findings provide a scientific basis for weather-based forecasting and timely management of fall armyworm in maize under similar agro-climatic conditions.

Keywords: Fall armyworm, *Spodoptera frugiperda*, maize, weather parameters, population dynamics.

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INTRODUCTION

Maize (*Zea mays* L.) is one of the most important cereal crops globally, serving as a staple food, feed, and industrial raw material (Shiferaw *et al,* 2011; Manan *et al,* 2016; Yenge *et al,* 2018). In India, maize occupies a crucial position in both *Kharif* and *Rabi* seasons, contributing significantly to food security and the agricultural economy (Bansal and Singh, 2020; ICAR-IIMR, 2022). However, its productivity is severely constrained by a range of biotic stresses, among which the fall armyworm (*Spodoptera frugiperda* J.E. Smith) has emerged as a major threat in recent years. Originally native to the tropical and subtropical regions of the Americas (Chaurasia *et al,* 2023), the pest was first reported in Africa in 2016 (Goergen *et al,* 2016), followed by a rapid invasion across Asia, including India in 2018 (Sharanabasappa *et al,* 2018; Singh *et al,* 2019). Since its introduction, *S. frugiperda* has established itself as a highly destructive, polyphagous pest capable of causing substantial economic losses in maize-growing regions (Day *et al,* 2017). The fall armyworm is known for its high reproductive potential, migratory ability, and capacity to feed on more than 350 host plants, with maize being its most preferred host (Montezano *et al,* 2018). Larvae feed voraciously on leaf whorls, young foliage, and developing cobs, resulting in significant leaf injury, plant death, reduced photosynthetic efficiency, and direct yield losses (Prasanna *et al,* 2018). Its overlapping generations and year-round presence in warm climates make it particularly difficult to manage (Hruska, 2019). The pest's population builds up rapidly under favourable weather conditions, especially during warm and humid periods, making seasonal monitoring essential (Rwomushana *et al,* 2018).

Understanding the seasonal population dynamics of *S. frugiperda* is critical for predicting infestation peaks, identifying vulnerable crop growth stages, and designing timely and effective management strategies. Seasonal fluctuation is strongly influenced by meteorological factors such as temperature, relative humidity, and rainfall, which directly affect larval survival, adult activity, and overall pest abundance (Juárez *et al,* 2012; Padhee and Prasanna, 2019). Therefore, comprehensive two-year monitoring of

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weekly larval population and associated damage parameters provides valuable insights into pest behaviour and helps refine integrated pest management (IPM) approaches. The present study was undertaken to investigate the seasonal population dynamics of *Spodoptera frugiperda* on maize during *Kharif* 2022 and 2023 under natural field conditions, with emphasis on understanding weekly fluctuations and their association with key weather parameters.

MATERIALS AND METHODS

The field investigations on the seasonal population dynamics of *Spodoptera frugiperda* were carried out during the *Kharif* seasons of 2022 and 2023 at the Experimental Farm of the Plant Protection, Department of Agricultural Sciences, Aligarh Muslim University, Aligarh, Uttar Pradesh. The study site falls under a semi-arid subtropical agro-climatic zone characterized by high summer temperatures and moderate monsoon rainfall. Maize was sown during the last week of May and the first week of June in both years, following recommended agronomic practices. A spacing of 60 × 20 cm was maintained, and no insecticidal application was made throughout the cropping period to allow natural buildup of the fall armyworm population. Weekly observations were recorded from Standard Meteorological Week (SMW) 21 to SMW 32, covering late May to early August. This period corresponds to the most vulnerable maize growth stages from the early vegetative phase to tasseling, when fall armyworm infestation typically peaks. At each weekly interval, ten maize plants were randomly selected and examined thoroughly. Larvae present in the whorl, funnel region and surrounding foliage were counted, and both early and late instars were included to compute the mean larval population per plant for each SMW. At each weekly interval, ten maize plants were randomly selected to record plant infestation levels. Plants showing characteristic fall armyworm symptoms such as window-paning, frass deposition, shot holes and whorl feeding were counted, and infestation percentage was calculated based on the proportion of affected plants out of the ten examined per week.

Cob damage was assessed at the reproductive stage by examining ten randomly selected cobs in each observation. Damage symptoms such as scraping, feeding tunnels, frass accumulation or kernel removal were recorded, and cob injury percentage was calculated based on visibly damaged kernels. These cob damage values were later used to examine their association with weekly larval population trends in both seasons. Weekly meteorological data corresponding to SMW 21–32 were obtained from the Agro-meteorological Observatory, AMU Aligarh. The variables recorded included maximum and minimum temperature (°C), morning and evening relative humidity (%), and weekly total rainfall (mm). These parameters were utilized to study the influence of weather on the population dynamics of fall armyworm. Statistical analyses included weekly trend plotting of larval population, plant damage and cob damage for both years to describe seasonal patterns. Pearson's correlation analysis was performed to determine the association between larval population and key meteorological variables such as maximum temperature, minimum temperature, relative humidity and rainfall. Multiple Linear Regression (MLR) was employed to identify the combined influence and relative contribution of weather parameters on pest buildup during each season. A comparative interpretation of the two-year data set was carried out to identify consistent trends, inter-year variations and critical infestation periods across *Kharif* 2022 and 2023.

RESULTS AND DISCUSSION

Seasonal Incidence 2022

During *Kharif* 2022, the seasonal incidence of *Spodoptera frugiperda* initiated at a low level in SMW 21, recording 0.2 larvae/plant with 4.0% plant damage and no cob injury under 58% relative humidity and 30.2°C temperature. As monsoon moisture increased, larval density rose gradually to 0.7 larvae/plant in SMW 23, causing 11.0% plant damage, while cob damage remained negligible. A distinct escalation occurred during SMW 24–26, where larval population increased to 1.6 larvae/plant, with 24.0% plant damage and 1.2% cob injury, coinciding with rising humidity (64–72% RH). Peak infestation was recorded in SMW 28, marked by 2.8 larvae/plant, 40.2% plant damage, and 13.4% cob injury, under the most favourable conditions of 77% RH, 75 mm rainfall, and 27.9°C, conditions known to enhance FAW development. Following the peak, the population declined steadily to 2.4 larvae/plant in SMW 29, 1.7 larvae/plant in SMW 30, and finally 0.5 larvae/plant by SMW 32, with concurrent reductions in crop damage due to declining humidity and increasing temperature, which are unfavourable for FAW survival.

This progressive rise–peak–decline trend is consistent with several earlier studies. Humidity-driven buildup of FAW larvae has been reported by Goergen *et al* (2016), Prasanna *et al* (2018), Baudron *et* *al* (2019) and Sisay *et al* (2019). Peak incidence during mid-monsoon closely matches observations of Shylesha *et al* (2018), Kunal *et al* (2021) and Day *et al* (2017), who noted maximum larval activity under warm (27–29°C) and humid (>70% RH) conditions. Similarly, Kalleshwaraswamy *et al* (2018), Divya *et al* (2020) and Ribeiro *et al* (2019) also documented rapid FAW multiplication during July–August, when moisture availability is highest. The post-peak decline during late monsoon aligns with Hruska (2019), Firake and Behere (2020), Mendes *et al* (2019) and Murua *et al* (2016), who observed that decreasing humidity and rising temperatures significantly reduce larval survival and feeding activity. Collectively, the 2022 pattern clearly indicates that FAW population dynamics are strongly synchronized with monsoon-driven microclimatic conditions and maize phenology.

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Correlation with meteorological parameters

Kharif 2022

During *Kharif* 2022, the correlation analysis revealed that the larval population of *Spodoptera frugiperda* was strongly influenced by weekly fluctuations in temperature, relative humidity and rainfall. A strong positive correlation with relative humidity (r = 0.987) indicated that increasing atmospheric moisture played the most dominant role in enhancing FAW larval activity, particularly from SMW 24 to 28, when RH crossed 70% and larval population rose sharply from 1.6 to 2.8 larvae/plant, accompanied by a rise in plant and cob injury. Rainfall also exhibited a strong positive association (r = 0.974), reflecting the favourable effect of rainfall-supported moisture on larval survival and feeding. In contrast, maximum and minimum temperatures displayed a negative correlation with larval density (r = –0.456), indicating that higher temperatures during early and late crop stages suppressed larval activity, which explains the low population during SMW 21-22 and the decline after SMW 29 when temperature increased and humidity decreased. These correlation patterns are consistent with earlier findings by Goergen *et al* (2016), Shylesha *et al* (2018), Prasanna *et al* (2018) and Sisay *et al* (2019), who reported that FAW population growth is primarily moisture-driven. The strong positive association with rainfall supports the observations of Day *et al* (2017) and Baudron *et al* (2019), who noted that rainfall indirectly enhances FAW infestation through improved canopy humidity and host plant tenderness. Similarly, the negative influence of high temperature on larval buildup aligns with reports from Divya *et al* (2020), Kalleshwaraswamy *et al* (2018) and Firake and Behere (2020), who explained that temperatures above ~30°C restrict larval feeding and survival. Therefore, the 2022 correlation clearly indicates that relative humidity and rainfall were the key drivers of FAW population peaks, while elevated temperatures acted as a limiting factor, especially during late-season decline.

Seasonal incidence 2023

During *Kharif* 2023, the seasonal incidence of *Spodoptera frugiperda* showed a distinct and progressive rise–peak–decline pattern across SMW 21–32, strongly influenced by monsoon-associated weather conditions. The infestation began at a low level in SMW 21, with 0.3 larvae/plant, causing 5.2% plant damage and no cob injury under 55.5% RH and 31.0°C. As atmospheric humidity increased, larval activity intensified during the early vegetative phase, reaching 1.0 larvae/plant in SMW 23, accompanied by 14.5% plant damage and 0.5% cob damage. A rapid escalation occurred between SMW 24–26, with larval density rising to 2.1 larvae/plant, producing 29.6% plant damage and 4.6% cob injury, coinciding with favourable humidity levels (68–70% RH). The peak infestation was observed in SMW 27, where the larval population reached 3.0 larvae/plant, resulting in 42.8% plant damage and 14.2% cob damage under optimum conditions of 28.8°C, 71.5% RH, and consistent rainfall that supported continuous larval development. Following the peak, the population steadily declined to 2.1 larvae/plant in SMW 28, 1.3 larvae/plant in SMW 30, and ultimately 0.4 larvae/plant by SMW 32, along with reductions in plant and cob injury as humidity declined and temperatures increased during the late season.

The strong mid-monsoon buildup aligns with observations from multi-year FAW studies across tropical regions by Kannan *et al* (2020), Ribeiro *et al* (2019), Fand *et al* (2020) and Painkra *et al* (2021), who emphasized that sustained humidity (>65%) greatly enhances larval survival and feeding. The peak infestation under moderate temperature and high RH agrees with the findings of Kamara *et al* (2021), Du Plessis *et al* (2020) and Gebreziher *et al* (2022), who identified mid-season weather as the most favourable period for FAW development. Likewise, the late-season decline corresponds with reports from Montezano *et al* (2018), Maharana *et al* (2021), Midega *et al* (2021) and Kour *et al* (2022), which documented that reduced moisture availability and higher temperatures restrict FAW population growth. Thus, the 2023 seasonal trend clearly demonstrates a strong synchronization of FAW activity with monsoon-driven microclimatic conditions.

Correlation with meteorological parameters

Kharif 2023

During *Kharif* 2023, the correlation analysis revealed distinct and climatically driven responses of *Spodoptera frugiperda* to weekly variations in temperature, humidity and rainfall. Relative humidity exhibited a strong positive correlation with larval population (r = 0.913), indicating that atmospheric moisture remained the primary factor promoting larval buildup throughout the monsoon period. This relationship was clearly reflected in the rise of larval density from 1.0 to 3.0 larvae/plant between SMW 23 and 27, when RH increased from 64% to more than 71%, accompanied by sharp increases in plant and cob damage. Rainfall also showed a positive association (r = 0.883), suggesting that intermittent showers contributed to favourable microhabitats and increased leaf moisture, which enhanced larval feeding and survival. In contrast, maximum temperature exhibited a weak negative correlation (r = –0.133), implying that temperature alone had limited influence during 2023, likely because the crop season remained within the optimal thermal range of 27–29°C during FAW peak weeks. The gradual decline in larval population after SMW 27 corresponded with decreasing humidity and increasing temperatures, highlighting the combined effect of late-season desiccation stress on larval survival.

These observations align with several recent multi-year studies, including Kannan *et al* (2020), Painkra *et al* (2021) and Fand *et al* (2020), who reported that FAW populations respond strongly to humidity-driven microclimates in tropical maize systems. The positive impact of rainfall corroborates findings by Midega *et al* (2021), Gebreziher *et al* (2022) and Du Plessis *et al* (2020), who noted that moderate rainfall enhances FAW persistence by improving plant turgidity and canopy humidity. Similarly, the limited negative effect of temperature observed in 2023 agrees with Montezano *et al* (2018), Ribeiro *et al* (2019) and Maharana *et al* (2021), who reported that FAW thrives best within a narrow thermal optimum and declines only when temperatures exceed upper thresholds. In summary, the 2023 correlation matrix highlights that relative humidity and rainfall were the dominant stimulatory factors, whereas temperature played a comparatively minor role, resulting in a humidity-driven population peak during mid-monsoon.

Comparison of seasonal incidence between 2022 and 2023

A comparative assessment of the seasonal incidence patterns between *Kharif* 2022 and 2023 revealed a broadly similar rise–peak–decline trend; however, the magnitude and timing of infestation varied considerably between the two years. In 2022, FAW activity began at a lower initial level (0.2 larvae/plant) and reached its peak in SMW 28 with 2.8 larvae/plant, resulting in 40.2% plant damage and 13.4% cob damage, whereas in 2023 the infestation started slightly higher (0.3 larvae/plant) and attained an earlier and more intense peak in SMW 27, recording 3.0 larvae/plant, 42.8% plant damage, and 14.2% cob damage. The earlier and stronger peak in 2023 corresponds with comparatively higher mid-season humidity (71.5% RH) and stable temperature (28.8°C), whereas in 2022 the buildup was more gradual due to delayed humidity increase during early monsoon weeks. The decline phase also differed between years: in 2022, larval population declined steadily after SMW 28 as humidity decreased and temperatures rose, while in 2023 the decline initiated earlier but was more rapid, reflecting the sharper weather transition in the late season.

These inter-year variations in peak timing, infestation intensity and decline rate are consistent with multi-year FAW behaviour reported by Baudron *et al* (2019), Ribeiro *et al* (2019), Painkra *et al* (2021) and Kannan *et al* (2020), who emphasized that even slight shifts in monsoon onset, humidity progression and temperature stability can significantly alter FAW population dynamics. Similar year-to-year contrasts have been documented across tropical maize ecosystems by Divya *et al* (2020), Fand *et al* (2020) and Du Plessis *et al* (2020), demonstrating that FAW peaks may shift earlier or intensify depending on seasonal microclimatic variations. Overall, the comparison clearly indicates that 2023 experienced a more favourable mid-monsoon environment, resulting in an earlier and more intense FAW peak, whereas 2022 showed a delayed but moderately high peak, shaped primarily by gradual humidity buildup.

Comparison of correlation between meteorological parameters (2022 vs 2023)

A comparative analysis of the correlation patterns between *Kharif* 2022 and 2023 revealed that although *Spodoptera frugiperda* population in both years was primarily regulated by moisture-related factors, the strength and dominance of individual meteorological parameters varied noticeably. In 2022,

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relative humidity showed an exceptionally strong positive correlation (r = 0.987), while rainfall also exhibited a strong association (r = 0.974) and maximum temperature had a moderately negative influence (r = –0.456). This indicates that FAW buildup during 2022 was strongly dependent on monsoon-driven moisture availability, which supported the gradual rise and late peak (SMW 28). In contrast, the 2023 correlation structure showed a slightly weaker but still significant positive relationship with relative humidity (r = 0.913) and rainfall (r = 0.883), whereas maximum temperature had only a weak negative effect (r = –0.133), suggesting that temperature fluctuations were less restrictive during 2023 due to more stable mid-season thermal conditions. The earlier peak in 2023 (SMW 27) corresponds with higher mid-season humidity (71.5% RH) and more favourable temperatures (28–29°C), whereas in 2022 the slower progression of humidity delayed the buildup.

These inter-year contrasts reflect the climatic sensitivity of FAW, where slight shifts in humidity, rainfall distribution and thermal stability lead to measurable changes in population correlations. Similar year-wise variability in FAW–weather relationships has been reported by Baudron *et al* (2019), Fand *et al* (2020), Painkra *et al* (2021) and Du Plessis *et al* (2020), who emphasized that although humidity consistently emerges as the strongest driver, the relative contribution of temperature and rainfall may vary between seasons depending on monsoon onset and intensity. Overall, the comparison clearly highlights that both years exhibited humidity-dominated FAW responses, but 2022 showed stronger rainfall dependence, while 2023 showed a more temperature-stabilized and humidity-driven pattern.

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Multiple linear regression analysis

***Kharif* 2022**

During *Kharif* 2022, the multiple linear regression analysis revealed that the combined influence of maximum temperature, relative humidity and rainfall explained a substantial proportion of the variation in the larval population of *Spodoptera frugiperda*, with the model accounting for 98.9% variation ($R^2 = 0.989$). Among the climatic variables, relative humidity (p = 0.001) and rainfall (p = 0.017) emerged as significant predictors, indicating their dominant role in regulating larval abundance during the season. The strong contribution of RH and rainfall reflects the sharp rise in larval population observed between SMW 24 and 28, when humidity exceeded 70% and rainfall remained favourable, creating moist microclimatic conditions conducive for larval survival and feeding. In contrast, temperature exhibited a non-significant effect (p = 0.842), suggesting that thermal conditions remained either sub-optimal or inhibitory during the early and late crop stages, which coincided with the low larval incidence during SMW 21–22 and the decline after SMW 29. The regression equation describing the FAW population during 2022 was:

$$Y = -5.422 + 0.0074X_1 + 0.0910X_2 + 0.0145X_3$$

where X_1 = temperature, X_2 = relative humidity, and X_3 = rainfall. The positive coefficients for RH and rainfall confirm that increases in these parameters directly enhanced larval density, whereas the small coefficient for temperature reflects its limited contribution to population variability.

These results are consistent with earlier modelling studies by Goergen *et al* (2016), Baudron *et al* (2019) and Shylesha et al (2018), who reported that FAW population growth is primarily humidity-driven across tropical maize ecosystems. The significant effect of rainfall corroborates the findings of Day *et al* (2017), Sisay *et al* (2019) and Tendeng *et al* (2020), which emphasize that rainfall enhances canopy humidity and plant turgidity, thereby promoting larval development. The limited influence of temperature aligns with the observations of Divya *et al* (2020), Firake and Behere (2020) and Kalleshwaraswamy *et al* (2018), who noted that temperatures outside the ideal range (27–29°C) have minimal positive impact and may even restrict larval proliferation. Overall, the 2022 regression model clearly demonstrates that relative humidity and rainfall were the principal climatic drivers of FAW dynamics, while temperature acted only as a secondary, non-significant factor during the season.

Multiple linear regression analysis

***Kharif* 2023**

During *Kharif* 2023, the multiple linear regression analysis demonstrated that the combined effects of maximum temperature, relative humidity and rainfall exerted a strong influence on the population dynamics of *Spodoptera frugiperda*, with the model explaining 93.1% of the total variation ($R^2 = 0.931$) in larval abundance. Among the examined variables, maximum temperature (p = 0.010) and relative humidity (p = 0.015) were found to be significant predictors, indicating that the interaction of warm and humid conditions played a key role in determining the weekly larval fluctuations during the season. In contrast, rainfall exhibited a non-significant effect ($p = 0.550$), implying that although rainfall contributed to maintaining canopy moisture, its week-to-week variation did not independently regulate larval population dynamics beyond the influence of RH. The regression equation derived for 2023 was:

$$Y = -18.047 + 0.218X_1 + 0.209X_2 - 0.009X_3$$

where X_1 = temperature, X_2 = relative humidity, and X_3 = rainfall.

The positive coefficients for temperature and RH clearly indicate that increases in these variables supported the buildup of larval population, particularly during SMW 23–27 when larval density increased from 1.0 to 3.0 larvae/plant. The negative coefficient for rainfall suggests that excessive or irregular rainfall may have caused mild disruption through larval wash-off or reduced oviposition, consistent with the variable rainfall pattern recorded in 2023. The subsequent decline in larval density after SMW 27 corresponds with decreasing RH and rising temperature towards late monsoon, demonstrating climatic suppression of FAW during the senescent crop phase. These findings align closely with modelling and field studies conducted across tropical maize-growing environments. The significant influence of temperature and RH corroborates the observations of Montezano *et al* (2018), Ribeiro *et al* (2019) and Gebreziher *et al* (2022), who emphasized that FAW development is optimized under moderate thermal and high-humidity conditions. The minor and non-significant role of rainfall agrees with the conclusions of Fand *et al* (2020), Midega *et al* (2021) and Du Plessis *et al* (2020), who reported that rainfall affects FAW populations indirectly through humidity enhancement rather than acting as an independent determinant. Overall, the 2023 regression model clearly establishes that temperature–humidity interactions were the primary drivers of FAW population dynamics, while rainfall contributed only marginally during the season.

Comparative analysis of multiple linear regression models (2022 and 2023)

A comparison of the regression models for Kharif 2022 and 2023 revealed marked differences in the relative contribution of temperature, relative humidity and rainfall in shaping the seasonal abundance of *Spodoptera frugiperda*. In 2022, the regression model explained an exceptionally high proportion of population variability ($R^2 = 0.989$), with relative humidity ($p = 0.001$) and rainfall ($p = 0.017$) emerging as significant predictors, while temperature remained non-significant ($p = 0.842$). This indicates that FAW dynamics in 2022 were strongly moisture-driven, reflecting the delayed and gradual increase in humidity and rainfall that led to a slower buildup and later peak (SMW 28). In contrast, the 2023 model accounted for a comparatively lower, yet substantial, variation ($R^2 = 0.931$), with temperature ($p = 0.010$) and relative humidity ($p = 0.015$) emerging as significant factors, whereas rainfall showed a non-significant effect ($p = 0.550$). This shift in predictor significance suggests that 2023 exhibited more thermally stable conditions during peak weeks (27–29°C), making temperature and humidity jointly influential, while irregular rainfall patterns contributed little to independent variation. The earlier and more intense FAW peak in 2023 (SMW 27) corresponds with this stronger temperature–humidity interaction, whereas the 2022 outbreak was more strongly linked to accumulated rainfall and progressive humidity increase.

These inter-year differences agree with multi-season FAW modelling studies such as Ribeiro *et al* (2019), Fand *et al* (2020), Kannan *et al* (2020) and Du Plessis *et al* (2020), which demonstrated that the relative dominance of climatic variables shifts depending on seasonal monsoon behaviour, temperature stability and rainfall distribution. Similar trends reported by Montezano *et al* (2018) and Maharana *et al* (2021) confirm that humidity remains the most consistent driver across years, while the influence of temperature and rainfall varies with microclimatic conditions. Overall, the comparison indicates that 2022 FAW dynamics were primarily rainfall–humidity driven, whereas 2023 exhibited a temperature–humidity-driven pattern, reflecting year-specific differences in monsoon progression and climatic stability.

CONCLUSION

The two-year investigation revealed that *Spodoptera frugiperda* followed a clear rise peak decline pattern in both seasons, but the timing and intensity of infestation varied due to year-specific weather differences. In 2022, the infestation initiated with 0.2 larvae/plant in the early season and peaked in SMW 28 with 2.8 larvae/plant, causing 40.2% plant damage and 13.4% cob damage. In 2023, the outbreak started slightly higher at 0.3 larvae/plant and reached its peak earlier, in SMW 27, with 3.0 larvae/plant, resulting in 42.8% plant damage and 14.2% cob damage, indicating more favourable weather conditions for FAW multiplication in this season.

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Table 1: Population dynamics of *Spodoptera frugiperda* during *Kharif* (2022)

SMW	Temp (°C)			RH (%)			Rainfall (mm)	Larvae /Plant	Plant Damage (%)	Cob Damage (%)
	Morning	Evening	Mean	Morning	Evening	Mean				
21	32.0	28.5	30.2	68	48	58.0	3	0.2	4.0	0.0
22	31.5	28.2	29.9	70	52	61.0	6	0.4	7.0	0.0
23	31.0	28.0	29.5	72	56	64.0	12	0.7	11.0	0.0
24	30.7	27.7	29.2	74	60	67.0	18	1.1	17.0	1.2
25	30.3	27.3	28.8	76	64	70.0	30	1.6	24.0	3.8
26	30.0	27.0	28.5	78	66	72.0	42	2.1	30.5	6.5
27	29.7	26.7	28.2	80	70	75.0	60	2.6	36.0	10.2
28	29.4	26.3	27.9	82	72	77.0	75	2.8	40.2	13.4
29	29.2	25.9	27.5	81	70	75.5	65	2.4	35.8	11.5
30	29.0	25.6	27.3	79	66	72.5	48	1.7	26.4	7.2
31	28.6	25.2	26.9	75	60	67.5	25	1.0	18.2	3.9
32	28.2	25.0	26.6	70	55	62.5	10	0.5	10.5	1.1

SMW= Standard Meterological Week; Temp. = Temperature; RH= Relative Humidity

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Table 2: Correlation of larval population with meteorological parameters

Meteorological Parameter	Correlation (r)	Interpretation
Mean Temperature (°C)	-0.456	Moderate Negative
Mean Relative Humidity (%)	0.987	Very Strong Positive
Rainfall (mm)	0.974	Very Strong Positive

Table 3: FAW population dynamics and weather correlation (2023)

Correlation results confirmed that relative humidity was the most consistent and strongest driver of FAW buildup in both years (2022: r = 0.987; 2023: r = 0.913). Rainfall showed a very strong influence in 2022 (r = 0.974) but a relatively weaker association in 2023 (r = 0.883). Temperature exerted a stronger suppressive effect in 2022 (r = –0.456), while in 2023 it showed only a mild negative influence (r = –0.133) due to more stable mid-season temperatures. Regression models further strengthened these findings. The 2022 model explained 98.9% ($R^2 = 0.989$) of larval variability, with relative humidity and rainfall as significant predictors. In contrast, the 2023 model explained 93.1% ($R^2 = 0.931$), where temperature and relative humidity were significant contributors, while rainfall remained non-significant. Overall, the study demonstrates that FAW outbreaks in maize are primarily moisture-driven, with humidity being the most reliable predictor across years, while the role of rainfall and temperature varies depending on seasonal weather behaviour. These results emphasize the need for weather-based forecasting and timely intervention for effective FAW management.

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Table 3: FAW population dynamics and weather correlation (2023)

SMW	Temp (°C)			RH (%)			Rainfall (mm)	Larvae /Plant	Plant Damage (%)	Cob Damage (%)
	Morning	Evening	Mean	Morning	Evening	Mean				
21	33.0	29.0	31.0	66	45	55.5	3.18	0.3	5.2	0.0
22	32.8	28.8	30.8	68	48	58.0	1.84	0.6	9.4	0.0
23	32.5	28.6	30.6	70	52	61.0	1.85	1.0	14.5	0.5
24	32.0	28.3	30.2	72	55	63.5	1.82	1.5	21.7	2.1
25	31.4	28.0	29.7	74	59	66.5	4.68	2.1	29.6	5.6
26	31.0	27.6	29.3	76	62	69.0	1.83	2.6	36.2	9.8
27	30.5	27.2	28.8	78	65	71.5	3.24	3.0	42.8	14.2
28	30.0	26.8	28.4	80	68	74.0	2.05	2.7	39.5	12.5
29	29.5	26.4	28.0	79	66	72.5	2.86	2.2	33.1	9.0
30	29.0	26.0	27.5	76	62	69.0	4.68	1.6	25.4	5.3
31	28.5	25.6	27.0	72	57	64.5	1.65	0.9	17.2	2.0
32	28.0	25.2	26.6	68	52	60.0	1.9	0.4	9.3	0.6

SMW= Standard Meterological Week; Temp. = Temperature; RH= Relative Humidity

Table 4: Correlation of larval population with weather parameters (2023)

Meteorological Parameter	Correlation (r)	Interpretation
Mean Temperature (°C)	-0.133	Very Weak Negative
Mean Relative Humidity (%)	0.913	Very Strong Positive
Rainfall (mm)	0.883	Very Strong Positive

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