GMR
The Original

SEASONAL INCIDENCE AND IMPACT OF SPODOPTERA FRUGIPERDA (J. E. SMITH) ON SMALL SCALE FARMERS OF MAGADH DIVISION

Raj Kumar[1], Reshman Yasmin[2], MD Rashid Nayeem[3], Shiv Pujan Singh[4], Mohammad Danish Masroor[5*]

[1]S. N. Sinha College, Tekari, Magadh University Bodh-Gaya, Bihar, India. ORCID: 0009-0005-2409-7251.
[2]P. G. Department of Zoology, Magadh University Bodh-Gaya, Bihar, India. ORCID: 0009-0001-8634-0588.
[3]Department of Zoology, P. G. Centre, Gaya College, Gaya, Bihar, India.
[4]P. G. Department of Zoology, Magadh University Bodh-Gaya, Bihar, India. ORCID: 0009-0001-8068-2608.
[5]P. G. Department of Zoology, Magadh University Bodh-Gaya, Bihar, India. Email: mohammaddanishmasroor@gmail.com, ORCID: 0000-0001-8610-2507.

ABSTRACT

Spodoptera frugiperda (J. E. Smith 1797), commonly known as the fall armyworm (FAW), has emerged as one of the most destructive invasive insect pests threatening agricultural production and the livelihoods of small-scale farmers worldwide. The present study was conducted to investigate the seasonal incidence and assess the impact of S. frugiperda on small-scale farmers of the Magadh division, Bihar. A multistage sampling approach was adopted to survey 150 small-scale farmers across the five districts of the Magadh division, namely Gaya, Aurangabad, Jehanabad, Nawada, and Arwal. Weekly field observations were recorded following Standard Meteorological Weeks (SMWs) to determine seasonal pest incidence, while meteorological data were used to evaluate the influence of abiotic factors on pest population dynamics. Information regarding farmers' socio-economic characteristics, pest awareness, management practices, and economic losses was collected through a structured interview schedule. The results indicated that S. frugiperda was widely distributed throughout the Magadh division, with peak infestation occurring during the whorl stage of crop growth. Pest incidence exhibited a positive relationship with temperature and relative humidity, indicating the significant influence of prevailing weather conditions on seasonal population development. Farmers reported considerable crop damage, increased expenditure on pest management, and noticeable reductions in farm income due to fall armyworm infestation. Chemical insecticides were the predominant control measure adopted, whereas the adoption of integrated pest management (IPM) practices remained comparatively low. High pesticide costs, inadequate technical knowledge, and limited extension support were identified as the major constraints in effective pest management. The study highlights the need for region-specific pest surveillance, weather-based forecasting systems, strengthened extension services, and wider adoption of integrated pest management strategies to reduce economic losses and improve the resilience of small-scale farming systems in the Magadh division.

KEYWORDS: Spodoptera frugiperda, fall armyworm, seasonal incidence, small-scale farmers, Magadh division, Weather parameters, economic impact, integrated pest management.

INTRODUCTION

Among the invasive insect pests, the fall armyworm, Spodoptera frugiperda (J. E. Smith 1797) (Lepidoptera: Noctuidae), has emerged as one of the most destructive agricultural pests worldwide. Native to the tropical and subtropical regions of the Americas, the pest has gained global attention because of its extraordinary migratory ability, high reproductive potential, absence of diapause, and broad host range. It has been reported to infest more than 350 plant species, including maize, rice, sorghum, sugarcane, millet, wheat, cotton, vegetables, and several economically important crops, making it a serious threat to agricultural production systems and food security worldwide (Day et al., 2017; Prasanna et al., 2018). The larvae cause extensive damage by feeding on leaves, whorls, tassels, reproductive structures, and young plant tissues, resulting in significant reductions in crop productivity. The rapid global spread of S. frugiperda has been unprecedented among invasive agricultural pests (Image: 5). Following its first detection in West Africa during 2016, the pest spread rapidly across sub-Saharan Africa before invading Asia and Oceania within a short period. In India, fall armyworm was first reported during 2018 from Karnataka on maize and subsequently dispersed across several states owing to its remarkable dispersal capacity and favourable climatic conditions. Since then, the pest has established itself as a major constraint in several agricultural ecosystems across the country, affecting both food and fodder crops and posing serious challenges to sustainable crop production.

In Bihar, the occurrence of S. frugiperda has raised considerable concern among researchers and farming communities. The first confirmed record of the pest in the Magadh division was documented from different localities of Gaya and Nawada districts during 2018 (Ali et al., 2018), where larvae were observed infesting paddy

fields. This research highlighted the establishment of the invasive pest in the region and indicated its ability to exploit new agro-ecological niches beyond its preferred hosts. Subsequently, studies conducted in Bihar reported the seasonal occurrence of fall armyworm under field conditions, demonstrating that pest incidence varied with crop stage and prevailing weather conditions, particularly temperature, rainfall, relative humidity, and sunshine hours. These findings emphasized the importance of continuous surveillance for developing timely and effective pest management strategies. Seasonal incidence studies provide valuable information on the temporal dynamics of insect populations and their association with environmental factors. Knowledge of pest appearance, peak infestation periods, and population fluctuations forms the basis for forecasting outbreaks and implementing timely integrated pest management (IPM) interventions. Previous investigations have demonstrated that the abundance of S. frugiperda is significantly influenced by meteorological parameters, although the magnitude and direction of these relationships vary across agro-climatic regions. Understanding these seasonal patterns at the regional level is therefore essential for minimizing crop losses and optimizing pest management decisions.

The economic significance of fall armyworm extends beyond direct crop damage. Severe infestations increase the cost of cultivation through repeated pesticide applications, additional labour requirements, and reduced crop productivity, thereby affecting household income and livelihood security. Small-scale farmers are particularly vulnerable because they often have limited financial resources, inadequate access to extension services, and insufficient knowledge regarding effective pest identification and management. Studies conducted among smallholder farmers have shown that fall armyworm has become one of the most important production constraints, leading to yield reductions, increased production costs, and widespread dependence on chemical pesticides. Despite the growing importance of fall armyworm in Bihar, most available studies have focused on its first occurrence, biology, seasonal incidence under experimental conditions, or evaluation of management practices. Comprehensive information integrating seasonal incidence with the socio-economic impact of the pest on small-scale farmers in the Magadh division remains scarce.

MATERIALS AND METHODS

Study Area

The present investigation was conducted in the Magadh division of Bihar, India, comprising the five districts of Gaya, Aurangabad, Jehanabad, Nawada, and Arwal. The region lies in the southern part of Bihar and is characterized by a tropical monsoon climate with distinct summer, rainy, and winter seasons. Agriculture is the predominant occupation of the rural population, with the majority of farmers belonging to the small and marginal landholding categories. The cropping systems of the region include cereals, pulses, oilseeds, vegetables, and horticultural crops, providing diverse host plants for insect pests including S. frugiperda. The climatic conditions of the region, particularly temperature, rainfall, and relative humidity, are favourable for the establishment and seasonal development of fall armyworm populations.

Sampling Procedure

A multistage sampling technique was adopted for selecting the study area and respondents. In the first stage, all five districts of the Magadh division, namely Gaya, Aurangabad, Jehanabad, Nawada, and Arwal, were purposively selected due to the reported occurrence of S. frugiperda. In the second stage, villages with a history of fall armyworm infestation were identified in consultation with officials of the P. G. Department of Zoology, (Magadh University, Bodhgaya), and local extension personnel. In the final stage, farmers were selected through simple random sampling from the identified villages. The sampling design ensured adequate representation of the farming community across the Magadh division.

The study focused exclusively on small-scale farmers engaged in crop cultivation within the selected villages. Farmers possessing operational holdings as per the Government of India classification for small landholders and having experience with crop production during the study period were included in the survey. Respondents were selected based on their willingness to participate and their knowledge of crop production and insect pest management. Prior informed consent was obtained from each respondent before conducting the interview.

Seasonal Incidence Survey

Field surveys were conducted at regular intervals throughout the cropping season to monitor the occurrence and seasonal incidence of S. frugiperda. Observations were recorded following Standard Meteorological Weeks (SMWs). During each visit, crop fields were inspected systematically using a zig-zag or "W"-shaped sampling pattern to ensure representative coverage of the field. The incidence of fall armyworm was assessed by recording the number of infested plants, larval population, visible feeding symptoms, and characteristic damage caused by the pest. The percentage of infestation was calculated using the following formula:

Percent infestation= (Total number of plants observed / Number of infested plants) ×100

The methodology adopted for recording seasonal incidence was based on standard field observation procedures reported in previous fall armyworm studies.

Meteorological Data Collection

Weekly meteorological data corresponding to the survey period were collected from the nearest Agro-

meteorological Observatory or India Meteorological Department (IMD) station serving the study area. The weather parameters considered included maximum temperature (°C), minimum temperature (°C), relative humidity (%), rainfall (mm), and sunshine hours. These meteorological variables were used to examine their relationship with the seasonal incidence of S. frugiperda in the Magadh division. Similar weather parameters have been widely employed in previous investigations on seasonal dynamics of fall armyworm.

Primary data were collected through personal interviews using a pre-tested and structured interview schedule. The questionnaire was designed to obtain information on the socio-economic characteristics of the respondents, cropping pattern, awareness regarding fall armyworm, identification of pest symptoms, seasonal occurrence, management practices, expenditure incurred on pest control, perceived crop losses, and major constraints faced in managing the pest. Interviews were conducted in the local language to facilitate better communication and ensure the reliability of responses.

Impact Assessment

The impact of S. frugiperda on small-scale farmers was assessed using both biological and socio-economic indicators. Biological assessment included estimation of crop infestation levels and visible plant damage, whereas socio-economic assessment comprised farmers' perceptions of yield reduction, increased expenditure on pest management, additional labour requirements, and changes in farm income attributable to fall armyworm infestation. Information on the adoption of different management practices and their perceived effectiveness was also collected. The approach was adapted from earlier studies assessing the socio-economic impact of fall armyworm on smallholder farming systems.

Statistical Analysis

The collected data were compiled, coded, and analysed using appropriate statistical software. Descriptive statistics such as frequency, percentage, mean, and standard deviation were used to summarize the socio-economic characteristics of respondents and the extent of pest incidence. Pearson's correlation analysis was performed to determine the association between weekly fall armyworm incidence and meteorological variables. Multiple linear regression analysis was employed to evaluate the combined influence of weather parameters on pest incidence. The results were presented in the form of tables, graphs, and charts to facilitate interpretation. Similar statistical approaches have been adopted in previous studies on seasonal incidence and weather-based population dynamics of S. frugiperda.

RESULTS

Socio-economic Profile of the Respondents

The socio-economic characteristics of the respondents are presented in Table 1. Among the 150 small-scale farmers surveyed across the Magadh division, the majority (47.33%) belonged to the middle age group (35–50 years), followed by 27.34% in the older age group (>50 years) and 25.33% in the younger age group (<35 years). Male respondents constituted 84.00% of the sample, whereas female respondents accounted for 16.00%, indicating that agricultural decision-making in the study area was predominantly undertaken by male farmers.

Regarding educational status, 31.33% of the respondents had secondary education, followed by primary education (25.33%), higher secondary education (18.67%), illiterates (14.67%), and graduates or above (10.00%). The predominance of secondary-level education suggests a moderate literacy level among the farming community, which may influence the adoption of recommended pest management practices.

Nearly half (48.67%) of the respondents belonged to medium-sized families (5–7 members), while 30.00% and 21.33% belonged to small and large families, respectively. In terms of farming experience, 44.67% of the respondents had 10–20 years of farming experience, followed by more than 20 years (32.66%) and less than 10 years (22.67%).

Landholding analysis revealed that 59.33% of the respondents were marginal farmers (<1 ha), whereas 40.67% owned small holdings (1–2 ha), confirming that agriculture in the Magadh division is predominantly characterized by small-scale farming systems. With respect to annual income, 46.00% of the respondents earned between ₹1 and ₹2 lakh annually, followed by 34.00% earning less than ₹1 lakh and 20.00% earning more than ₹2 lakh.

Mixed cropping was the most commonly adopted cropping pattern (42.00%), followed by sole cropping (36.00%) and crop rotation (22.00%). Agriculture was the principal occupation for 61.33% of the respondents, whereas 26.00% combined agriculture with livestock rearing and 12.67% supplemented farming with other occupations. Regarding sources of agricultural information, fellow farmers (28.67%) and mobile or internet-based platforms (25.33%) were the primary information sources, followed by the Department of Agriculture/KVKs (24.00%), extension personnel (14.00%), and other sources (8.00%).

Table 1. Socio-economic characteristics of small-scale farmers in the Magadh division (n = 150).

Variable	Category	Frequency	Percentage (%)
Age (years)	Young (<35)	38	25.33
	Middle (35–50)	71	47.33
	Old (>50)	41	27.34

Gender	Male	126	84.00
	Female	24	16.00
Education	Illiterate	22	14.67
	Primary	38	25.33
	Secondary	47	31.33
	Higher Secondary	28	18.67
	Graduate & Above	15	10.00
Family Size	Small (≤4)	45	30.00
	Medium (5–7)	73	48.67
	Large (>7)	32	21.33
Farming Experience	<10 years	34	22.67
	10–20 years	67	44.67
	>20 years	49	32.66
Landholding	Marginal (<1 ha)	89	59.33
	Small (1–2 ha)	61	40.67
Annual Income	<₹1 lakh	51	34.00
	₹1–2 lakh	69	46.00
	>₹2 lakh	30	20.00
Cropping Pattern	Sole cropping	54	36.00
	Mixed cropping	63	42.00
	Crop rotation	33	22.00
Major Occupation	Agriculture	92	61.33
	Agriculture + Livestock	39	26.00
	Agriculture + Other occupation	19	12.67
Source of Agricultural Information	Department of Agriculture/KVK	36	24.00
	Extension Personnel	21	14.00
	Fellow Farmers	43	28.67
	Mobile/Internet	38	25.33
	Others	12	8.00

Seasonal Incidence of S. frugiperda

The seasonal incidence of S. frugiperda recorded during the study period is presented in Table 2, while the temporal trend is illustrated in Figure 1. The pest was first observed during the 28th Standard Meteorological Week (SMW) at the seedling stage, with an average larval population of 0.20 larvae per plant and 3.5% plant infestation. Initial infestation was characterized by mild leaf scraping symptoms. The larval population increased progressively with crop growth, reaching 0.85 larvae per plant during the 30th SMW and 2.18 larvae per plant during the 32nd SMW, corresponding with the vegetative and whorl stages of crop development. During this period, characteristic symptoms such as pin holes, shot holes, window feeding, and ragged leaves became increasingly evident.

The highest pest incidence was recorded during the 35th SMW, corresponding to the late whorl stage, when the larval population reached 4.27 larvae per plant and plant infestation increased to 52.7%. At this stage, severe whorl damage and extensive feeding symptoms were observed, indicating the peak activity of S. frugiperda during the cropping season. Following the peak infestation, the pest population gradually declined. During the tasseling stage (36th–37th SMW), larval populations decreased from 3.96 to 3.24 larvae per plant, while plant infestation declined from 49.3% to 41.5%. Further reductions were observed during the silking and grain-filling stages, with infestation decreasing to 23.6% by the 39th SMW. At crop maturity (41st SMW), the pest population was negligible, with only 0.58 larvae per plant and 8.9% plant infestation.

The seasonal incidence pattern indicates a gradual increase in pest population from the early vegetative stage, a pronounced peak during the whorl stage, and a steady decline towards crop maturity, suggesting that the whorl stage is the most vulnerable period for infestation and should receive priority in pest monitoring and management.

Table 2. Weekly seasonal incidence of S. frugiperda in the Magadh division.

SMW	Crop Stage	Larvae plant^{-1}	Plant infestation (%)	Damage symptoms
28	Seedling	0.20	3.5	Initial leaf scraping
29	Early vegetative	0.42	6.8	Pin holes
30	Vegetative	0.85	11.2	Shoot holes
31	Vegetative	1.36	18.4	Window feeding
32	Whorl stage	2.18	27.6	Ragged leaves
33	Whorl stage	3.05	36.8	Heavy whorl damage
34	Whorl stage	3.82	44.5	Severe feeding

35	Late whorl	4.27	52.7	Peak infestation
36	Tasseling	3.96	49.3	Whorl and tassel injury
37	Tasseling	3.24	41.5	Moderate damage
38	Silking	2.47	31.8	Ear damage begins
39	Grain filling	1.84	23.6	Reduced activity
40	Grain filling	1.12	15.4	Minor feeding
41	Maturity	0.58	8.9	Negligible damage

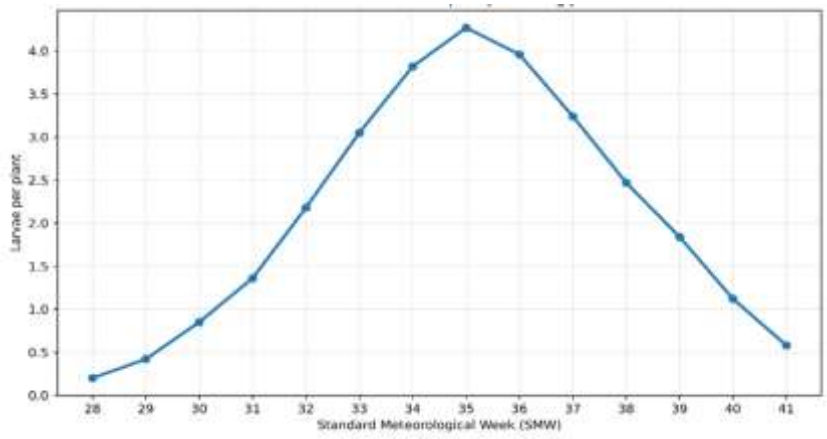

Figure 1. Seasonal incidence of Spodoptera frugiperda in the Magadh division

Distribution of S. frugiperda Across the Magadh division

The district-wise distribution of S. frugiperda across the Magadh division is presented in Table 3, while its spatial distribution is depicted in Figure 2. The survey revealed that the pest was distributed across all five districts, although the level of infestation varied considerably. Among the surveyed districts, Gaya recorded the highest infestation, where all six surveyed villages were affected and 28 out of 30 surveyed fields were infested, resulting in an average infestation of 47.8%, which was categorized as high severity. Similarly, Nawada exhibited widespread infestation, with all surveyed villages affected and an average infestation of 45.1%, indicating a very high relative abundance of the pest (Image 1. & 2).

In Aurangabad, five out of six surveyed villages reported fall armyworm incidence, with 24 infested fields and an average infestation level of 39.4%, which was classified as moderate severity. Likewise, Jehanabad recorded infestation in five villages with an average infestation of 34.8%, indicating moderate pest abundance. Comparatively, Arwal exhibited the lowest level of infestation among the surveyed districts. Four villages reported pest occurrence, with 19 infested fields and an average infestation of 28.7%, which was categorized as low severity.

Table 3. District-wise distribution of S. frugiperda in the Magadh division.

District	Villages Surveyed	Affected Villages	Fields Surveyed	Infested Fields	Average Infestation (%)	Severity Class	Relative Abundance
Gaya	6	6	30	28	47.8	High	Very High
Aurangabad	6	5	30	24	39.4	Moderate	High
Jehanabad	6	5	30	22	34.8	Moderate	Moderate
Nawada	6	6	30	27	45.1	High	Very High
Arwal	6	4	30	19	28.7	Low	Moderate
Overall	30	26	150	120	39.2	Moderate	High

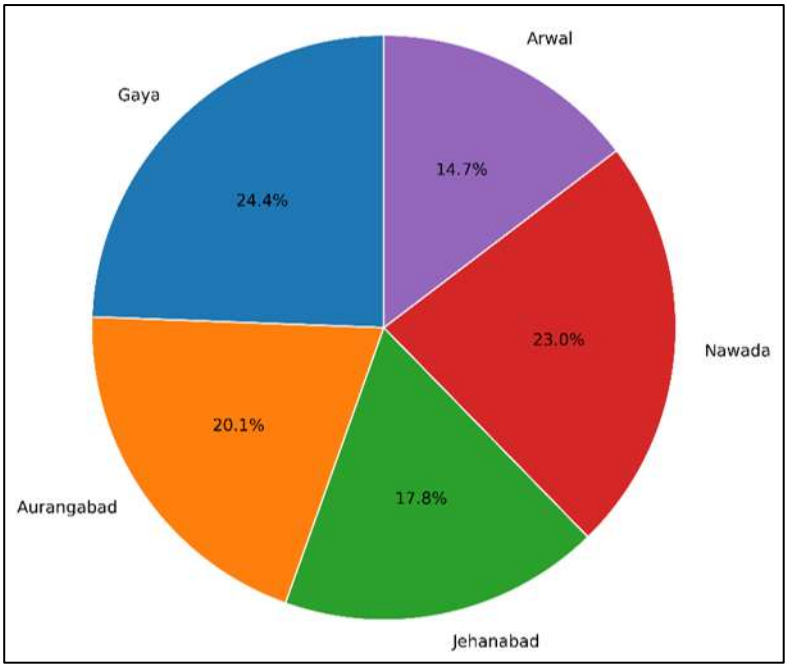

Figure 2. District-wise average infestation (%) of S. frugiperda in the Magadh division, Bihar

Relationship Between Weather Parameters and Seasonal Incidence

The relationship between weather parameters and the seasonal incidence of S. frugiperda was analyzed using Pearson's correlation coefficient and multiple regression analysis. The results are presented in Table 4. The analysis revealed that maximum temperature, minimum temperature, and relative humidity exhibited a positive association with fall armyworm incidence, whereas rainfall showed a comparatively weaker relationship.

Among the abiotic factors, minimum temperature showed the strongest positive correlation with larval population ($r = 0.81$), followed by relative humidity ($r = 0.74$) and maximum temperature ($r = 0.68$). Rainfall exhibited a moderate positive correlation ($r = 0.52$), indicating that moderate rainfall during the vegetative and whorl stages favoured pest establishment and multiplication. The regression model explained a substantial proportion of variation in pest incidence ($R^2 = 0.79$), indicating that prevailing weather conditions significantly influenced seasonal population dynamics in the Magadh division. The results suggest that warm and humid environmental conditions prevailing during the vegetative and whorl stages created favourable conditions for rapid population build-up of S. frugiperda. Similar relationships between weather variables and fall armyworm incidence have been reported in earlier studies.

Crop Damage Caused by S. frugiperda

The extent of crop damage caused by S. frugiperda in the surveyed fields is presented in Table 5. The most common damage symptoms observed during field surveys included leaf scraping, pin holes, shot holes, window feeding, ragged leaves, whorl damage, and feeding on developing reproductive structures. Damage severity increased progressively with crop growth and reached its maximum during the late vegetative and whorl stages. Among the surveyed fields, severe damage was recorded in 32.67% of the fields, while 41.33% experienced moderate damage and 26.00% showed only mild infestation. The mean crop damage score across the Magadh division was 4.8 on a 1–9 damage rating scale, indicating moderate infestation during the study period (Image: 3 & 4).

DISCUSSION

The present study provides an overview of the seasonal incidence of S. frugiperda and its impact on small-scale farmers in the Magadh division of Bihar. The findings indicated that the pest has become well established across all five districts of the division, with considerable variation in infestation intensity, weather relationships, crop damage, farmers' perception, management practices, and economic impact.

The socio-economic profile of the respondents revealed that agriculture in the Magadh division is largely dominated by middle-aged, marginal and small-scale farmers with moderate educational backgrounds. More than half of the respondents belonged to the marginal landholding category, indicating their greater vulnerability to production risks associated with invasive insect pests. Similar observations have been reported in studies conducted on smallholder farming systems, where limited landholding, restricted financial resources, and dependence on agriculture significantly influenced farmers' capacity to manage fall armyworm outbreaks effectively (Makgoba et al., 2021). The socio-economic assessment conducted in South Africa likewise reported that small-scale farmers experienced considerable challenges in managing fall armyworm infestations because of

resource limitations and increased production costs. The seasonal incidence study demonstrated that S. frugiperda first appeared during the early vegetative stage, gradually increased during crop development, and reached maximum infestation during the whorl stage before declining towards crop maturity. This pattern is consistent with the observations of Reddy et al. (2020), who reported that fall armyworm infestation in Bihar commenced during the early crop stage, reached its peak during the vegetative to whorl stage, and subsequently declined during later crop growth stages. Similar findings were reported by Kumar et al. (2025), who observed a progressive increase in larval population and plant infestation under the agro-climatic conditions of western Uttar Pradesh, followed by a decline as the crop approached maturity. These observations indicate that the vegetative and whorl stages remain the most susceptible periods for fall armyworm infestation and therefore require intensive monitoring and timely management interventions.

Ali et al. (2018) documented the first occurrence of S. frugiperda in different localities of the Magadh division, particularly in Gaya and Nawada districts, thereby confirming the establishment of this invasive pest in the region. The present investigation extends this knowledge by providing district-wise information on pest distribution and infestation intensity across the entire Magadh division. Weather parameters exerted a significant influence on the seasonal dynamics of S. frugiperda. The positive association observed between temperature, relative humidity, and pest incidence suggests that warm and humid environmental conditions prevailing during the cropping season favoured rapid multiplication of the pest population. Similar observations were reported by Reddy et al. (2020), who found that temperature exhibited a positive relationship with fall armyworm incidence, while relative humidity and rainfall influenced seasonal abundance depending on the cropping season. Likewise, Kumar et al. (2025) reported significant positive correlations between minimum temperature, maximum temperature, relative humidity, rainfall, and fall armyworm population under western Uttar Pradesh conditions. These findings emphasize the importance of incorporating meteorological variables into pest surveillance and forecasting systems to facilitate timely management decisions.

The field observations indicated that S. frugiperda caused considerable crop damage during the vegetative and whorl stages. Characteristic symptoms such as leaf scraping, pin holes, shot holes, window feeding, ragged leaves, and severe whorl damage were commonly observed in infested fields. Similar feeding behaviour has been described by Reddy et al. (2020), who reported that early instar larvae skeletonized leaf tissues, whereas later instars produced characteristic holes and severe whorl injury. Comparable damage symptoms were also documented by Ali et al. (2018) during the first report of fall armyworm from the Magadh division. These observations confirm that larval feeding during the vegetative stage is primarily responsible for economic crop damage.

CONCLUSION

The present investigation demonstrated that S. frugiperda has become an established invasive insect pest throughout the Magadh division of Bihar, posing a significant challenge to small-scale farming systems. The seasonal incidence study revealed that pest populations gradually increased during the vegetative stage, reached maximum abundance during the whorl stage, and declined towards crop maturity, indicating that early crop growth stages are the most vulnerable to infestation. Weather parameters, particularly temperature and relative humidity, showed a positive association with pest incidence, emphasizing the importance of weather-based surveillance for timely forecasting and management. The study further revealed that fall armyworm infestation resulted in considerable crop damage and imposed substantial economic burdens on small-scale farmers through increased expenditure on plant protection measures, additional labour requirements, and reduced farm income. Although farmers were generally aware of the pest and its damaging nature, management practices remained largely dependent on chemical insecticides, while the adoption of integrated pest management approaches was comparatively limited. High pesticide costs, inadequate technical knowledge, delayed pest identification, and insufficient extension support emerged as the major constraints affecting effective pest management.

REFERENCES

1. Abrahams, P., Beale, T., Cock, M., Corniani, N., Day, R., Godwin, J., Murphy, S., Richards, G., & Vos, J. (2017). Fall Armyworm: Impacts and implications for Africa. CAB International, Wallingford, UK.
2. Adeoti, K., Dansi, A., Vodouhè, R., & Akpagana, K. (2017). Diversity and utilization of pearl millet (Pennisetum glaucum) in West Africa. Genetic Resources and Crop Evolution, 64, 1495–1510.
3. Ali, S., Masroor, Z., & Masroor, M. D. (2018). First record of the fall armyworm, Spodoptera frugiperda (J. E. Smith, 1797) (Lepidoptera: Noctuidae), an evil attack on paddy in Magadh, Bihar (India). Journal of Emerging Technologies and Innovative Research, 5(12), 546–549.
4. Barlow, V. M. (2009). Pests of crops in tropical agriculture. CAB International.
5. Capinera, J. L. (2017). Fall Armyworm, Spodoptera frugiperda (J.E. Smith) (Insecta: Lepidoptera: Noctuidae). University of Florida IFAS Extension Publication.
6. Cock, M. J. W., Beseh, P. K., Buddie, A. G., Cafá, G., & Crozier, J. (2017). Molecular methods to detect Spodoptera frugiperda in Ghana and implications for pest management. Scientific Reports, 7, 4103.
7. Cruz, I. (1999). The effect of fall armyworm on maize yield. International Journal of Pest Management, 45, 121–127.

8. Cruz, I., & Turpin, F. T. (1983). Yield impact of fall armyworm infestation on maize. Journal of Economic Entomology, 76, 1052–1054.
9. Day, R., Abrahams, P., Bateman, M., Beale, T., Clottey, V., Cock, M., Colmenarez, Y., Corniani, N., Early, R., Godwin, J., Gomez, J., Moreno, P. G., Murphy, S., Oppong-Mensah, B., Phiri, N., Pratt, C., Silvestri, S., & Witt, A. (2017). Fall armyworm: Impacts and implications for Africa. Outlooks on Pest Management, 28(5), 196–201.
10. Deole, S., & Paul, N. (2018). First report of fall armyworm Spodoptera frugiperda on maize crop from Chhattisgarh. Indian Journal of Entomology, 80(4), 1–4.
11. Early, R., González-Moreno, P., Murphy, S. T., & Day, R. (2018). Forecasting the global extent of invasion of the cereal pest Spodoptera frugiperda. NeoBiota, 40, 25–50.
12. Ellis, S. E. (2005). Fall armyworm economic losses in the United States. Agricultural Economics Review, 7, 31–38.
13. FAO. (2018). Integrated management of the Fall Armyworm on maize: A guide for farmer field schools in Africa. Food and Agriculture Organization of the United Nations, Rome.
14. Goergen, G., Kumar, P. L., Sankung, S. B., Togola, A., & Tamò, M. (2016). First report of outbreaks of the fall armyworm Spodoptera frugiperda (J. E. Smith) (Lepidoptera: Noctuidae), a new alien invasive pest in West and Central Africa. PLoS ONE, 11(10), e0165632.
15. Kansiime, M. K., Mugambi, I., Rwomushana, I., Nunda, W., Lamontagne-Godwin, J., Rware, H., & Day, R. (2019). Farmer perception of fall armyworm and its management in eastern Africa. Journal of Agricultural Extension and Rural Development, 11(7), 123–134.
16. Kumar, A., Rajeev, Patel, S. K., Singh, P., & Chaudhary, S. (2025). Seasonal incidence and weather-based correlation of fall armyworm, Spodoptera frugiperda (Smith) on Bajara (Pennisetum glaucum) under Braj Region of Western Uttar Pradesh, India. Journal of Applied Bioanalysis, 11(9s), 347–352.
17. Kumari, K., Saha, T., Sah, S. B., Nath, P., Chaudhary, S. K., & Singh, B. B. (2025). Assessment of farmers friendly IPM modules for the management of fall armyworm, Spodoptera frugiperda (J. E. Smith) in maize. Plant Science Today, 12(Special Issue), 1–7.
18. Makgoba, M. C., Tshikhudo, P. P., Nnzeru, L. R., & Makhado, R. A. (2021). Impact of fall armyworm (Spodoptera frugiperda) (J. E. Smith) on small-scale maize farmers and its control strategies in the Limpopo province, South Africa. Jàmbá: Journal of Disaster Risk Studies, 13(1), a1016. https://doi.org/10.4102/jamba.v13i1.1016
19. Murúa, M. G., Molina-Ochoa, J., & Coviella, C. (2009). Population dynamics of fall armyworm under different environmental conditions. Florida Entomologist, 92(4), 617–623.
20. Padhee, A. K., & Prasanna, B. M. (2019). The emerging threat of fall armyworm in India. Indian Farming, 69(1), 51–54.
21. Prasanna, B. M., Huesing, J. E., Eddy, R., & Peschke, V. M. (Eds.). (2018). Fall Armyworm in Africa: A guide for integrated pest management. CIMMYT, Mexico.
22. Reddy, K. J. M., Kumari, K., Saha, T., & Singh, S. N. (2020). First record, seasonal incidence and life cycle of fall armyworm, Spodoptera frugiperda (J. E. Smith) in maize at Sabour, Bhagalpur, Bihar. Journal of Entomology and Zoology Studies, 8(5), 1631–1635.
23. Sharanabasappa, D., Kalleshwaraswamy, C. M., Asokan, R., Mahadeva Swamy, H. M., Maruthi, M. S., Pavithra, H. B., Hegde, K., Navi, S., Prabhu, S. T., & Goergen, G. (2018). First report of the fall armyworm Spodoptera frugiperda in India. Pest Management in Horticultural Ecosystems, 24(1), 23–29.
24. Todd, E. L., & Poole, R. W. (1980). Keys and illustrations for the armyworms of the noctuid genus Spodoptera Guenée from the Western Hemisphere. Annals of the Entomological Society of America, 73(6), 722–738.


Image 1: Excreta and first instar Caterpillar of S. frugiperda showing evidence of infestation on maize tassel tube.
Image 2: Image showing primary taxonomic character 'Y' mark on head of S. frugiperda.


Image 3: Image showing fully grown fifth instar caterpillar of S. frugiperda.
Image 4: Image showing nature of damage by S. frugiperda.

Image 5: Map showing global distribution of S. frugiperda.