Journal of Experimental Agriculture International

Volume 46, Issue 10, Page 738-743, 2024; Article no.JEAI.125415
ISSN: 2457-0591
(Past name: American Journal of Experimental Agriculture, Past ISSN: 2231-0606)

Assessment of Lepidopteran Pest Dynamics in Maize: Dominance of *Spodoptera frugiperda* and Implications for Targeted Management in Himachal Pradesh, India

Diksha Kharwal [a*], Aarushi Sharma [a] and Pawan Kumar Sharma [a]

[a] Department of Entomology, College of Agriculture, CSK Himachal Pradesh Krishi Vishvavidyalaya, Palampur-176062, India.

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: https://doi.org/10.9734/jeai/2024/v46i102997

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/125415

Original Research Article

Received: 20/08/2024
Accepted: 24/10/2024
Published: 28/10/2024

ABSTRACT

Maize (*Zea mays* L.) plays a crucial role in the agricultural economy of India, particularly in Himachal Pradesh, where it serves as a vital crop for food, feed, and fodder. This study assessed the distribution, and relative abundance of lepidopteran pests infesting maize during the *kharif*, 2022-23 across two agro-climatic zones of Himachal Pradesh. Surveys identified five key lepidopteran pests: *Spodoptera frugiperda*, *Chilo partellus*, *Mythimna separata*, *Agrotis ipsilon*, and *Euproctis* spp. Among all, *S. frugiperda* is the only pest occurring among the major three crop

**Corresponding author: E-mail: dikshakharwal20@gmail.com;*

Cite as: *Kharwal, Diksha, Aarushi Sharma, and Pawan Kumar Sharma. 2024. "Assessment of Lepidopteran Pest Dynamics in Maize: Dominance of Spodoptera Frugiperda and Implications for Targeted Management in Himachal Pradesh, India". Journal of Experimental Agriculture International 46 (10):738-43. https://doi.org/10.9734/jeai/2024/v46i102997.*

stages of maize. The findings revealed that *S. frugiperda* was the most dominant pest, with relative abundance values of 19.57 per cent in Zone I and 18.94 per cent in Zone II during the seedling stage, increasing to 30.87 per cent and 30.40 per cent during the vegetative stage, respectively. In contrast, other pests like *C. partellus*, *M. separata*, *A. ipsilon*, and *Euproctis* spp. exhibited variable distribution patterns, with some showing limited occurrence. In conclusion, this study underscores the necessity for targeted pest management strategies to address dominant and subdominant lepidopteran pests in maize cultivation in Himachal Pradesh. The results offer valuable insights that can inform focused pest control efforts, with the potential to significantly enhance sustainable maize production, crop resilience and overall productivity in the region.

Keywords: Maize; lepidoptera; pests; Spodoptera frugiperda; relative abundance.

1. INTRODUCTION

Maize (*Zea mays* L.) is a significant crop for food, feed, fodder and industrial applications. Maize production is experiencing significant growth in South Asia, serving both human consumption and animal feed needs. Domesticated over 9,000 years ago in southern Mexico, maize has rapidly spread across the globe, establishing itself as the leading staple cereal worldwide [1]. In India, maize can be cultivated year-round due to its high yield potential and strong market demand, contributing to its expanding production [2]. *Kharif* maize accounts for about 83 per cent of the total area planted with the crop, while *rabi* maize accounts for 17 per cent. The area under maize cultivation in India is 9.89 million ha with a production of 31.65 million metric tonnes and productivity of 3.19 t/ha [3]. In Himachal Pradesh, maize is cultivated on 0.26 million ha area with a production of 0.78 million tonnes and productivity of 2.97 t/ha [4].

Species displacement occurs when native species are removed by exotic species or when a newly introduced exotic species displaces a previously established one. Over 100 such events have been recorded, primarily involving insects and arthropods, where invasive species, often lacking natural enemies, rapidly become predominant due to their superior competitive abilities [5]. The fall armyworm (*Spodoptera frugiperda*, Nocuidae) is one such pest of maize which is very well studied particularly since its recent invasion in Africa and Asia from America. The pest primarily damages maize by feeding on both vegetative and reproductive parts of the plant, with larvae causing significant crop harm through defoliation. The caterpillars of *S. frugiperda* are notably more voracious than many other noctuid maize pests, with each of its six larval instars extensively feeding on young maize leaves, often destroying the plant's growth point. They may also feed on tassels, silks and young maize cobs [6,7]. All stemborers occur as single or mixed species communities, with their structure varying by locality, altitude and season. These stemborers include *Chilo partellus*, *Sesamia calamistis* and *Busseola fusca*. These pests share the same resource, leading to high competition. Both intra and interspecific competition has been observed among all pests, with stronger interspecific interactions recorded between the noctuids and the crambid than between the two noctuids [8]. The current study aims to identify the various lepidopteran pests that infest maize crop at different growth stages, as well as to determine the relative composition of these pests.

2. METHODOLOGY

Present study was carried out by surveying different locations of Zone I (low-hills) and Zone II (mid-hills) of Himachal Pradesh, India, between the month of June and September in the year 2022 and 23 in order to identify the lepidopteran pests associated with maize in Himachal Pradesh. Two locations in Zone I (Berthin and Sundernagar) as well as two locations in Zone II (Palampur and Bajaura) were chosen. The details of the geospatial coordinates for the locations selected to record lepidopteran pests of maize are provided below:

List 1. Details of the geospatial coordinates for Zone-I and Zone-II

Zones	Location	Altitude (amsl)	Latitude (°N)	Longitude (°E)
Zone-I	Berthin	630	31.41° N	76.64° E
	Sundernagar	656	31.54° N	76.91° E
Zone-II	Palampur	1290	32.10°N	76.52°E
	Bajaura	1090	31.84° N	77.16° E

Surveys were conducted across all locations during various stages in maize growth, including the seedling, vegetative, tasseling and maturity stages. In each location, four distinct localities were selected and their replicates to ensure data accuracy and representativeness. Detailed information on pest incidence, distribution and the relative abundance of various lepidopteran species associated with maize was recorded at each growth stage. The distribution of pests was documented by noting their presence or absence at different crop stages across al surveyed zones, proving a comprehensive view of pest dynamics throughout the maize growth cycle.

Relative abundance of prevailing lepidopteran species was worked out using the following formula:

$$\text{Relative Abundance (\%)} = \frac{\text{Total number of individuals of each species}}{\text{Total number of individuals of all species}} \times 100$$

Relative abundance was worked out and dominance structure of identified species was determined using Englemann's scale of dominance elaborated and used by Dalal and Gupta [9] as given below:

List 2. Relative abundance and dominance structure of identified species

Dominance structure	Relative abundance
Eudominant	≥ 31.7
Dominant	10.1-31.6
Subdominant	3.2-10.0
Recedent	1.1-3.1
Subrecedent	≤ 1

3. RESULTS AND DISCUSSION

3.1 Lepidopteran Pests on Maize in Himachal Pradesh

The lepidopteran pests recorded during different crop growth stages on maize in Himachal Pradesh during *kharif*, 2022 and 2023 are listed in Table 1. Five lepidopteran pests *viz*., fall armyworm (*Spodoptera frugiperda*), stem borer (*Chilo partellus*), armyworm (*Mythimna separata*), cutworm (*Agrotis ipsilon*) and tussock moth (*Euproctis* spp.) were observed on maize belonging to three families namely Noctuidae, Crambidae and Erebidae. Based on the incidence, *S. frugiperda* (Lepidoptera: Noctuidae) was present throughout the crop season from seedling to maturity stage. Stem borer, *C. partellus* (Lepidoptera: Crambidae) incidence was recorded from vegetative to maturity stage. Cutworm, *A. ipsilon* (Lepidoptera: Noctuidae) and armyworm, *M. separata* (Lepidoptera: Noctuidae) population was present during seedling and vegetative stage, respectively. Tussock moth, *Euproctis* spp. (Lepdioptera: Erebidae) was found in traces from vegetative to tasseling stage.

3.2 Distribution of Pests in Different Zones of Himachal Pradesh

The distribution of lepidopteran pests in Zone I and Zone II at different crop growth stages is given in Table 2. *Spodoptera frugiperda* was recorded throughout the crop growth period starting from the seedling stage till maturity at all locations of Zone I and Zone II. The infestation by *C. partellus* was observed during vegetative, tasseling and maturity stage at Sundernagar (Zone I). However, it was observed during tasseling and maturity stage at Berthin (Zone I) and all locations of Zone II. *M. separata* infestation was observed only during vegetative stage of crop growth at Palampur (Zone II). However, the infestation was not observed at any crop growth stage in other locations of Zone I and II. *Agrotis ipsilon* was only observed during seedling stage of maize crop in Bajaura and was not observed at any other locations. The results are also corroborated with findings of Arifie et al. [10], who reported maize stem borer, cutworms and armyworm as major pest of maize crop in North Kashmir at different phenological stages of maize crop. During a survey at different locations of Himachal Pradesh, Ankita et al. [11] also reported *C. partellus* and *M. separata* as major pests of maize crop. Fall armyworm, *S. frugiperda* was also reported for the first time in maize crop at Palampur in Himachal Pradesh by Ankita et al. [12].

Table 1. Lepidopteran pests recorded on maize in Himachal Pradesh during *kharif*, 2022 and 23

Common name	Scientific name	Family	Order	Stage of incidence
Fall armyworm	*Spodoptera frugiperda*	Noctuidae	Lepidoptera	Seedling to maturity stage
Stem borer	*Chilo partellus*	Crambidae	Lepidoptera	Vegetative to maturity stage
Armyworm	*Mythimna separata*	Noctuidae	Lepidoptera	Vegetative stage
Cut worm	*Agrotis ipsilon*	Noctuidae	Lepidoptera	Seedling stage
Tussock moth	*Euproctis* spp.	Erebidae	Lepidoptera	Vegetative to tasseling stage

Table 2. Distribution of lepidopteran pests associated with maize in Zone-I and Zone -II of Himachal Pradesh during *kharif*, 2022 and 23

Sr. No.	Insect	Crop stage	Zone I		Zone II	
			Berthin	Sundernagar	Palampur	Bajaura
1.	*Spodoptera frugiperda*	Seedling	+	+	+	+
		Vegetative	+	+	+	+
		Tasseling	+	+	+	+
		Maturity	+	+	+	+
2.	*Chilo partellus*	Seedling	-	-	-	-
		Vegetative	-	+	-	-
		Tasseling	+	+	+	+
		Maturity	+	+	+	+
3.	*Mythimna separate*	Seedling	-	-	-	-
		Vegetative	-	-	+	-
		Tasseling	-	-	-	-
		Maturity	-	-	-	-
4.	*Agrotis ipsilon*	Seedling	-	-	-	+
		Vegetative	-	-	-	-
		Tasseling	-	-	-	-
		Maturity	-	-	-	-
5.	*Euproctis* spp.	Seedling	-	-	-	-
		Vegetative	-	+	+	-
		Tasseling	-	-	+	-
		Maturity	-	-	-	-

+ Indicates presence - Indicates absence

Table 3. Relative abundance and Engelmann's scale of dominance for lepidopteran pest species on maize in Zone-I and Zone -II of Himachal Pradesh during *kharif*, 2022 and 23

Stages	Pest	Zone I		Zone II	
		Relative abundance (%)	Dominance structure	Relative abundance (%)	Dominance structure
Seedling	*S. frugiperda*	19.57	Dominant	18.94	Dominant
	A. ipsilon	-	-	0.88	Subrecedent
Vegetative	*S. frugiperda*	30.87	Dominant	30.40	Dominant
	C. partellus	3.91	Subdominant	0.00	-
	M. separate	-	-	1.76	Recedent
	Euproctis spp.	3.48	Subdominant	1.76	Recedent
Tasseling	*S. frugiperda*	13.48	Dominant	21.15	Dominant
	C. partellus	5.65	Subdominant	3.52	Subdominant
	Euproctis spp.	-	-	1.76	Recedent
Maturity	*S. frugiperda*	15.65	Dominant	17.62	Dominant
	C. partellus	7.39	Subdominant	2.20	Recedent

3.3 Relative Abundance

The data presented on the relative abundance of lepidopteran pests at Palampur in Table 3 revealed that in Zone I, *S frugiperda* was recorded as dominant during seedling (19.57%), vegetative (30.87%), tasseling (13.48%) and maturity stage (15.65%). Species dominance structure was elaborated as subdominant for *C. partellus* during vegetative (3.91%), tasseling (5.65%) and maturity stage (7.39%) of crop growth, respectively. *Euproctis* spp. was also found subdominant during vegetative stage with relative abundance of 3.48 per cent. These findings align with the study by Fan et al. [13], which reports that *S. frugiperda* has become the dominant maize pest following its invasion and colonization. This species has progressively replaced traditional pests of Guangxi Zhuang, China. *Spodoptera frugiperda* was also recorded as dominant in Zone II during seedling (18.94%), vegetative (30.40%), tasseling (21.15%) and maturity stage (17.62%). *A. ipsilon* is only present during the seedling stage in Zone II with relative abundance of 0.88 per cent with subrecedent dominant structure. *Mythimna*

separata was notably subdominant during both vegetative and tasseling stage with relative abundance of 1.76 and 1.76 per cent, respectively. Recedent dominance structure was found to be associated with *Euproctis* spp. With relative abundance of 1.76 per cent during both vegetative and tasseling stage of crop growth. On the other hand, *C. partellus* was found to be subdominant during tasseling stage (3.52%) and recedent during maturity stage (2.20%).

In the current findings, *S. frugiperda* abundance in Zone II was highest during the vegetative stage (30.40%), followed by the tasselling stage (21.15%). This aligns with the findings of Ajam et al. [14], who reported that overall larval abundance was highest during the late vegetative and tasselling stages. Similarly, our findings, which reported peak abundance of *S. frugiperda* larvae during the vegetative stage in July, are consistent with the research by Pradeep et al. [15]. Their study observed the highest larval density per plant during the early whorl stage of maize in July, followed by a slight decline in August. These findings are also consistent with Niassy et al. [16], who observed high maize infestation during the vegetative and reproductive stages, attributed to the gradual larval population build-up and increased feeding by older larvae [17]. Similarly, in Egypt, *S. frugiperda* damage was reported to increase with maize age due to new moth influx and local multiplication [17]. Ramzan et al. [18] also concluded in their study that *S. frugiperda* is a primary pesr and poses a major threat to both the vegetative and reproductive parts of the maize crop, leading to significant economic losses. In contrast to this study, where *C. partellus* was most abundant from the vegetative to maturity stages, with the highest levels observed during the tasseling stage, a study found that *C. partellus* abundance was highest at the early growth stages and decreased as the plants matured [19]. The difference in *C. partellus* abundance patterns may be due to environmental conditions, maize varieties, and local practices. *C. partellus* was abundant during the vegetative to tasseling stages, likely due to favorable larval conditions. However, Nega and Getu [19] found higher abundance at early growth stages, possibly due to early pest pressure or different management practices. In Southeast Asia, the potential distribution areas of *S. frugiperda* are expected to expand northward and the total suitable area for the pest is projected to increase by 5 to 23 per cent [20].

4. CONCLUSION

This study provides a detailed assessment of lepidopteran pests in maize across different zones in Himachal Pradesh. The dominance of *S. frugiperda* across all growth stages and locations necessitates focused management strategies. While less prevalent, pests like *C. partellus* and *M. separata* still pose significant threats and require attention in pest management plans. The variability in pest distribution underscores the importance of location-specific strategies to ensure effective pest control and minimize yield losses.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Erenstein O, Jaleta M, Sonder K, Mottaleb K, Prasanna BM. Global maize production, consumption and trade: trends and R&D implications. Food Security. 2022;14(5): 1295-1319.
2. Ghosh D, Brahmachari K, Brestic M, Ondrisik P, Hossain A, Skalicky M, Bell RW. Integrated weed and nutrient management improve yield, nutrient uptake and economics of maize in the rice-maize cropping system of Eastern India. Agronomy. 2020;10(12):1906-1923.
3. IIMR. 2024. India Maize Scenario. ICAR – Indian Institute of Maize Research (IIMR), (2nd August, 2024).
Available:http://iimr.icar.gov.in
4. GoHP. 2024. Statistical abstract of Himachal Pradesh 2022-2023. Department of Economic and Statistics Government of Himachal Pradesh Shimla, (24th August, 2024).
Available:https://himachalservices.nic.in
5. Divya J, Kalleshwaraswamy CM, Mallikarjuna HB, Deshmukh S. Does recently invaded fall armyworm, *Spodoptera frugiperda* displace native lepidopteran pests of maize in India. Current Science. 2021;120(8):1358-1367.

6. Makgoba MC, Tshikhudo PP, Nnzeru LR, Makhado RA. Impact of fall armyworm (*Spodoptera frugiperda*) (JE Smith) on small-scale maize farmers and its control strategies in the Limpopo province, South Africa. Jàmbá: Journal of Disaster Risk Studies. 2021;13(1):1016-1024.
7. Toepfer S, Fallet P, Kajuga J, Bazagwira D, Mukundwa IP, Szalai M, Turlings TC. Streamlining leaf damage rating scales for the fall armyworm on maize. Journal of Pest Science. 2021;94(4):1075-1089.
8. Sokame BM, Musyoka B, Obonyo J, Rebaudo F, Abdel-Rahman EM, Subramanian S, Calatayud PA. Impact of an exotic invasive pest, *Spodoptera frugiperda* (Lepidoptera: Noctuidae), on resident communities of pest and natural enemies in maize fields in Kenya. Agronomy. 2021;11(6):1074.
9. Dalal A, Gupta S. A comparative study of aquatic insect diversity of two ponds located in Cachar district, Assam, India. Turkish Journal of Zoology. 2014;40(3): 392-401.
10. Arifie U, Bano P, Ahad I, Singh P, Dar ZA, Badri Z, Maqbool S, Aafreen S, Kumar R. Insect pests of maize at different altitudes of North Kashmir, J&K. Journal of Entomology and Zoology Studies. 2019; 7(2):1123-1128.
11. Ankita, Sharma PK, Mehta V. Insect fauna associated with maize (*Zea mays* L.) in sub-montane low hills and mid-hill zones of Himachal Pradesh (India). Journal of Entomological Research. 2021;45(2):290-297.
12. Ankita, Sharma PK, Sharma PC. Fall armyworm *Spodoptera frugiperda* (J.E. Smith) and other insects on maize in Himachal Pradesh. Indian Journal of Entomology. 2020;82(3):519-522.
13. Fan Z, Song Y, Zhao S, Wu K. Invasion of fall armyworm led to the succession of maize pests in Southwest China. Journal of Integrative Agriculture. 2024;23(4):1300-1314.
14. Ajam AL, Karungi J, Ogwal G, Adumo S A, Paparu P, Otim MH. Population dynamics of fall armyworm (Lepidoptera: Noctuidae) in Maize fields in Uganda. Insects. 2024; 15(5):301.
15. Pradeep P, Deshmukh SS, Sannathimmappa HG, Kalleshwaraswamy CM, Firake DM. Seasonal activity of *Spodoptera frugiperda* (JE Smith) in maize agroecosystem of South India. Current Science. 2022;123(1):81-86.
16. Niassy S, Agbodzavu MK, Kimathi E, Mutune B, Abdel-Rahman EFM, Salifu D, Hailu G, Belayneh YT, Felege E, Tonnang HEZ. Bioecology of fall armyworm *Spodoptera frugiperda* (J. E. Smith), its management and potential patterns of seasonal spread in Africa. PLoS ONE. 2021;16:e024904.
17. Bakrya MMS, Abdel-Baky NF. Population density of the fall armyworm, *Spodoptera frugiperda* (J.E. Smith) (Lepidoptera: Noctuidae) and its response to some ecological phenomena in maize crop. Brazilian Journal of Biology. 2023;83: e271354.
18. Ramzan M, Ilahi H, Adnan M, Ullah A, Ullah A. Observation on fall armyworm, *Spodoptera frugiperda* (Lepidoptera: Noctuidae) on maize under laboratory conditions. Egyptian Academic Journal of Biological Sciences. A, Entomology. 2021; 14(1):99-104.
19. Nega A, Getu E. Relative abundance of *Chilo partellus* (Swinhoe) (Lepidoptera: Crambidae) and its natural enemies at different growth stages of sorghum crop at Kalu, Bati and Dawa Chefa districts; 2019.
20. Jiang C, Zhang X, Xie W, Wang R, Feng C, Ma L, ... Wang H. Predicting the potential distribution of the fall armyworm *Spodoptera frugiperda* (JE Smith) under climate change in China. Global Ecology and Conservation. 2022;33:e01994.

Peer-review history:
The peer review history for this paper can be accessed here:
https://www.sdiarticle5.com/review-history/125415