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Survey-based checklist and insect pest diversity in vegetable cultivation areas around Muzaffarpur, Bihar (India)

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Abstract
This study presents a comprehensive survey of insect pest diversity associated with major vegetable crops—brinjal, tomato, okra, cabbage, cauliflower, and cucurbetaceae—in the Muzaffarpur district of Bihar (India) over two cropping seasons (July 2023–June 2024). A total of 40 insect pest species were documented, comprising 18 major and 22 minor pests, distributed across five insect orders and 13 families. Lepidopteran pests such as *Leucinodes orbonalis* and *Helicoverpa armigera* emerged as the most destructive, particularly during the flowering and fruiting stages. Sap-sucking pests like *Aphis gossypii*, *Bemisia tabaci*, and *Amrasca biguttula* were prevalent across multiple crops but generally remained below threshold levels. Diversity indices, including the Shannon-Wiener (H′ = 1.79–1.76) and Simpson's Index (1−D = 0.83–0.82), indicated moderately high pest diversity and evenness. Minor pests showed greater species richness but lower evenness, reflecting uneven distribution. Natural enemies such as parasitoids (e.g., *Bracon* spp., *Trichogramma* spp.) and predators (e.g., *Chrysoperla carnea*, *Coccinella septempunctata*) were also recorded, reinforcing the potential for biological control. These findings underscore the importance of regular pest monitoring and ecologically-based Integrated Pest Management (IPM) tailored to local conditions for sustainable vegetable production in the region.

Keywords: Insect pest diversity, vegetable crops, muzaffarpur, IPM, shannon index, lepidoptera, diptera, sap-sucking pests, natural enemies

Introduction

Vegetable cultivation is a vital component of agricultural practices in India, contributing significantly to the country's food security, nutrition, and rural economy. Among the various regions engaged in horticultural production, Muzaffarpur district in Bihar holds a prominent place due to its fertile alluvial soil and favorable agro-climatic conditions. The area supports the cultivation of a wide variety of vegetables such as brinjal (eggplant), tomato, cauliflower, cabbage, okra, and Cucurbitaceae vegetables throughout the year. However, one of the major constraints in achieving optimum productivity in these crops is the persistent threat posed by insect pests.

Insect pests not only reduce crop yield but also deteriorate the quality of produce, directly affecting marketability and farmers' income. The high diversity and adaptability of insect pests under changing climatic and cultivation practices have made pest management increasingly complex. In the absence of proper identification and monitoring, farmers often resort to indiscriminate use of chemical pesticides, which further leads to issues such as pest resistance, resurgence, environmental pollution, and health hazards.

Understanding the diversity, abundance, and seasonal dynamics of insect pests is therefore critical for the development of sustainable pest management strategies. A survey-based checklist of insect pests provides baseline data that is essential for designing Integrated Pest Management (IPM) approaches tailored to local ecological conditions. In this context, the present study aims to conduct a detailed survey of insect pest diversity in vegetable cultivation areas around Muzaffarpur, Bihar. By documenting the species composition, population trends, and host associations, this research seeks to support informed decision-making for eco-friendly and cost-effective pest control methods.

Sanjukta & Singh (2024) conducted a systematic survey of phytophagous mites and their natural enemies in brinjal fields across Muzaffarpur and Samastipur (North Bihar). Sampling in 31 farms between January and June 2022 revealed two dominant tetranychid mites (*Tetranychus urticae* and *T. neocaedonicus*), accompanied by predatory mites (*Amblyseius indicus*, *A. tetranychivorous*) and beneficial insects like coccinellids, green lacewings, anthocorid and mirid bugs, scolothrips, and ants This study underscores the significance of mite–predator dynamics in the region's eggplant system and emphasizes the importance of eco-friendly acaricides.

Ambethgar et al. (2024) provided a comprehensive evaluation of biological control strategies across major tropical vegetable crops—such as tomato, okra, chilies, cucurbits, and brinjal—highlighting prevalent pests like whiteflies, aphids, thrips, and shoot/fruit borers, and discussing predators, parasitoids, and microbial agents as viable control options Divekar et al. (2024) similarly noted climate-driven emergence of new pest species in Indian vegetables—including red spider mites, fruit flies, mealybugs, and diamondback moth—and advocated adaptive IPM frameworks to address evolving pest pressures under changing weather regimes

Studies from other regions of India provide valuable benchmarks. Singh & Chauhan (2014–2020) examined phytophagous and predatory mite assemblages on tomato, okra, brinjal, cucumber, and rose under Himachal Pradesh conditions, documenting species like *Tetranychus ludeni* and predators such as *Neoseiulus* spp. Bala & Karmakar (2022) reported mite community structure across vegetable

and forest flora in West Bengal, providing insights into geographic and host-related variation. Such comparative studies help frame expected biodiversity in agro-ecosystems akin to those in Muzaffarpur

Lal Jhumar et al. (2024) investigated how farmscaping strategies—intercropping cabbage with coriander, onion, mustard or marigold—affected pest incidence. They found pests like diamondback moth, aphid, tobacco caterpillar, painted bug, and flea beetle were suppressed most effectively in certain intercrops, while populations of natural enemies (coccinellids, syrphid flies, aphid parasitoids) were enhanced, significantly reducing Shannon diversity index of pests in intercrop systems Verma et al. (2024) similarly demonstrated reduced infestation of *Plutella xylostella* and *Spodoptera litura* in cabbage when intercropped with various plants such as coriander and onion These approaches may parallel feasible IPM strategies in Bihar's context.

Kumar et al. (2020) reviewed IPM approaches across major vegetable crops in India, advocating cultural practices, use of botanicals, microbial agents, biocontrol augmentation, behaviour-modifying compounds, and judicious low-toxicity pesticide use as components of sustainable systems Dash et al. (2022) emphasized development of pest-resistant cultivars, noting host-plant resistance as a powerful complement to IPM, especially given concerns around pesticide residues and pest resurgence

An earlier empirical study in Muzaffarpur (2018) examined pesticide residues in brinjal, okra, cauliflower and cabbage samples. Approximately 75 % of the sampled vegetables contained residues, with 15 % exceeding maximum residue limits for cypermethrin, chlorpyrifos, endosulfan, and quinalphos. The findings highlighted over-reliance on chemicals and the need for safer alternatives

While Sanjukta & Singh (2024) deliver a strong foundation for brinjal–mite interactions in Muzaffarpur, there is a notable lack of similar survey studies on other major vegetables—such as tomato, cabbage, cauliflower, okrain the immediate region.

Literature indicates fluctuating pest assemblages across cropping seasons and host species (e.g. studies from Himachal Pradesh and West Bengal), but region-specific data for Bihar remains limited. This gap necessitates a comprehensive, multi-crop, multi-season survey.

Intercropping and farmscaping approaches demonstrate effectiveness in enhancing predator populations and suppressing pestsyet application and validation in Bihar's local cropping systems around Muzaffarpur are sparse. Although IPM, biocontrol, botanicals, and host-plant resistance have been increasingly documented in broader Indian contexts, their adaptive application tailored to pest species, local ecology, cropping patterns and farmer practices in Bihar remains understudied.

Existing literature provides valuable insights into insect pest diversity, mite communities, natural enemies, and integrated pest management across various Indian vegetable systems. In particular, the Muzaffarpur-focused work of Sanjukta & Singh (2024) is a key regional reference, though limited to brinjal and mites. Broader Indian studies elucidate pest patterns, emerging pests, biocontrol successes, and sustainable strategies but underscore the pressing need for location-specific, crop-wise surveys around Muzaffarpur. The current study, by documenting insect pest species across multiple vegetables over seasons, alongside associated natural enemies and host associations, will fill these critical data gaps and inform locally adaptive IPM frameworks in Bihar.

Research Methodology

The study was conducted from July 2023 to June 2024 in key vegetable-growing areas around Muzaffarpur district, Bihar, known for its humid subtropical climate and fertile alluvial soils. Major locations included Mushahari, Kanti, Sakra, Bochahan, and Kurhani. Economically important vegetables such as brinjal, tomato, okra, cabbage, cauliflower, and Cucurbitaceae vegetables were selected. Using a stratified random sampling method, 3–5 fields per site (0.1–0.5 ha) were monitored every 15 days. Insect pests were collected using standard methods like sweep netting, visual inspection, pitfall and sticky traps, and light traps. Specimens were preserved and identified with the help of taxonomic keys, expert consultation, and institutional databases. Data recorded at each site included crop type, growth stage, pest species and abundance, damage symptoms, presence of natural enemies, and environmental factors. A comprehensive literature review was also conducted using resources such as CABI and NISCAIR. The study resulted in a catalog-cum-checklist of insect pests and their host vegetables, organized by order and family, with species richness presented in tables and graphs.

Results and Discussion

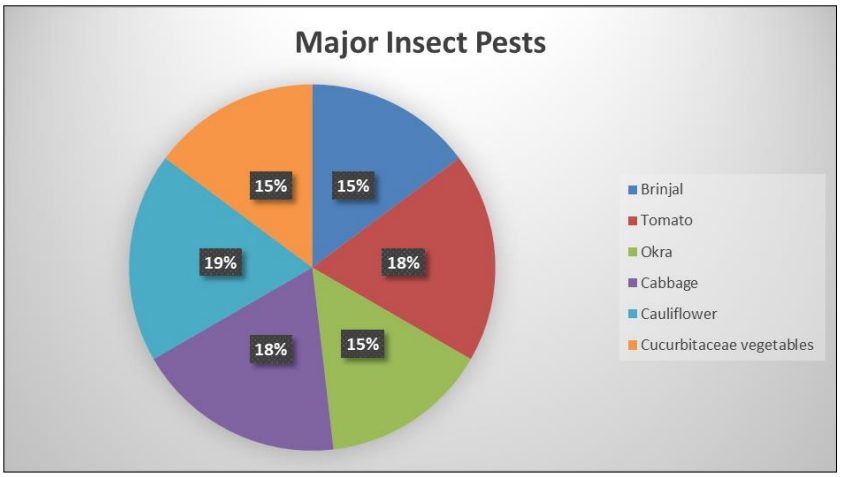
During the survey (July 2023–June 2024) across key vegetable-growing blocks of Muzaffarpur, Bihar, major pests like *Leucinodes orbonalis* (brinjal) and *Helicoverpa armigera* (tomato, okra) were recorded with high incidence during flowering to fruiting stages. In brinjal, *L. orbonalis* caused significant shoot and fruit boring with peak infestations of 15–20% in untreated fields, consistent with reports from Pusa and other parts of north Bihar (Choudhary et al., 2015) [1]. In tomato, *H. armigera* led to 20–30% fruit damage, with larval densities reaching 1.5–2.0 per plant during March–April (Kumar & Singh, 2022) [2, 3]. Leaf miners (*Liriomyza trifolii*) and whiteflies (*Bemisia tabaci*) were present across tomato, okra, and cucurbits, but rarely exceeded threshold levels.

Sap-sucking pests like aphids (*Aphis gossypii*), jassids (*Amrasca biguttula*), and thrips (*Thrips tabaci*) occurred in low to moderate densities, depending on temperature and plant growth stage, supporting previous seasonal findings in the region (Prasad et al., 2021) [5]. In cabbage and cauliflower, *Plutella xylostella* and *Hellula undalis* were frequently observed, particularly during vegetative and curd-forming stages. Cucurbitaceae vegetables fields showed sporadic infestation by *Bactrocera cucurbitae* (fruit fly) and *Aulacophora foveicollis* (foliar beetle).

Table 1: Major Insect Pests Recorded on Selected Vegetable Crops in Muzaffarpur, Bihar (July 2023–June 2024)

Crop	Major Insect Pests	Growth Stage Affected	Type of Damage
Brinjal	Leucinodes orbonalis, Aphis gossypii, Bemisia tabaci, Amrasca biguttula	Flowering to fruiting	Shoot and fruit boring, sap loss
Tomato	Helicoverpa armigera, Liriomyza trifolii, Thrips tabaci, Bemisia tabaci	Flowering to fruiting	Fruit boring, leaf mining, curling
Okra	Earias vittella, A. biguttula, A. gossypii, Dysdercus koenigii	All stages	Pod boring, seed damage,

			sap loss
Cabbage	Plutella xylostella, Hellula undalis, Agrotis ipsilon, Brevicoryne brassicae	Vegetative to head formation	Leaf/web damage, sap loss
Cauliflower	Same as cabbage (high overlap)	Vegetative to curd formation	Larval tunneling, sap loss
Cucurbitaceae vegetables	Bactrocera cucurbitae, Aulacophora foveicollis, Epilachna spp., stem borers	Fruiting and maturity stages	Fruit rotting, defoliation, boring

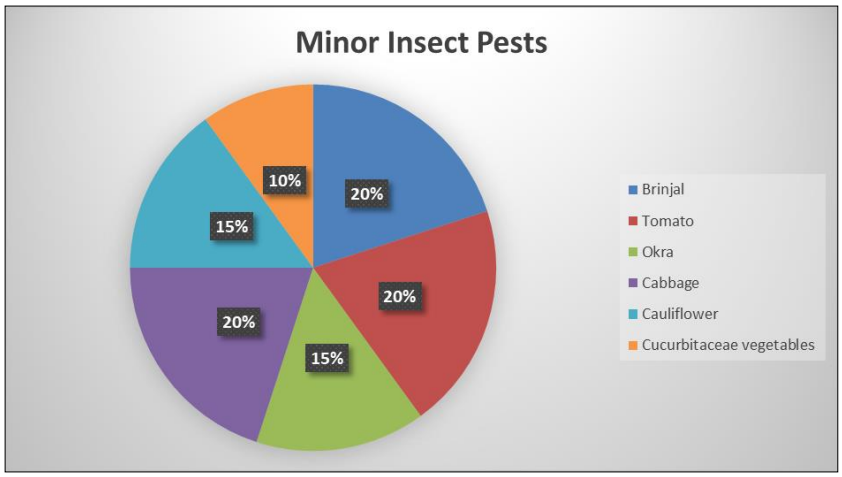


The survey revealed a diverse assemblage of both major and minor insect pests affecting six key vegetable crops in Muzaffarpur, Bihar. A total of 17 major pest species were recorded, primarily attacking crops during their flowering to fruiting stages. These included destructive borers like *Leucinodes orbonalis* (brinjal), *Helicoverpa armigera* (tomato), and *Earias vittella* (okra), as well as sap-sucking pests such as *Aphis gossypii*, *Bemisia tabaci*, and *Amrasca biguttula*.

In addition, 22 minor pest species were identified across the same crops. Though their impact was generally lower or sporadic, many posed localized threats, especially under favorable conditions. These included pests like *Spodoptera litura*, *Tetranychus urticae*, *Pieris brassicae*, *Contarinia brassicola*, and *Diaphania indica*. Their presence indicates the potential for future outbreaks if not regularly monitored. Overall, the results highlight the coexistence of high-impact major pests and a broader base of minor pests, underscoring the need for comprehensive and stage-specific pest management strategies.

Table 2: Minor Insect Pests Recorded on Selected Vegetable Crops in Muzaffarpur, Bihar (July 2023–June 2024)

Crop	Common Name	Scientific Name	Nature of Damage	Incidence
Brinjal	Tobacco caterpillar	*Spodoptera litura*	Leaf defoliation	Sporadic
	Blister beetle	*Mylabris pustulata*	Flower feeding	Occasional
	Spotted leaf beetle	*Epilachna vigintioctopunctata*	Leaf scraping	Minor
	Red spider mite	*Tetranychus urticae*	Leaf yellowing, webbing	Low
Tomato	Green stink bug	*Nezara viridula*	Fruit puncturing, discoloration	Low
	Leaf miner	*Liriomyza trifolii*	Leaf tunneling	Occasional
	Whitefly (secondary pest)	*Bemisia tabaci*	Sap feeding, virus vector	Low to moderate
	Beet armyworm	*Spodoptera exigua*	Leaf feeding	Sporadic
Okra	Bihar hairy caterpillar	*Spilosoma obliqua*	Foliage damage	Low
	Red mite	*Tetranychus cinnabarinus*	Leaf discoloration	Rare
	Looper caterpillar	*Anomis flava*	Leaf chewing	Minor
Cabbage	Cabbage butterfly	*Pieris brassicae*	Outer leaf feeding	Light infestation
	Mustard bug	*Eurydema pulchrum*	Sap sucking from leaves and stems	Occasional
	Gall midge	*Contarinia brassicola*	Gall formation on young shoots	Rare
	Cabbage looper	*Trichoplusia ni*	Irregular holes on leaves	Minor
Cauliflower	Small white butterfly	*Pieris rapae*	Feeding on wrapper leaves	Minor
	Flea beetles	*Psylliodes spp.*	Shot-hole damage on leaves	Occasional (nursery)
	Stink bug	*Eurydema spp.*	Leaf and stem piercing	Light
Cucurbitaceae vegetables	Lesser pumpkin beetle	*Aulacophora intermedia*	Light defoliation	Low
	Bud borer	*Sphenarches caffer*	Boring into flower buds	Occasional
	Pumpkin caterpillar, Fruit fly	*Diaphania indica, Bacterocera Cucurbetaece*	Boring into young fruits	Sporadic
	Field cricket	*Brachytrypes portentosus*	Stem and seedling chewing (night)	Minor and localized



A total of 18 major insect pest species were recorded across six vegetable crops in Muzaffarpur, Bihar, belonging to five insect orders and 13 families. The order *Lepidoptera* was the most diverse, comprising species from the families Crambidae, Noctuidae, Nolidae, and an unspecified group of stem borers. *Hemiptera* included pests from Aphididae, Aleyrodidae, Cicadellidae, and Pyrrhocoridae, reflecting a high presence of sap-sucking insects. *Diptera* was represented by Tephritidae and Agromyzidae, while *Coleoptera* included species from Chrysomelidae and Coccinellidae. *Thysanoptera* was represented by a single family, Thripidae. The wide taxonomic range of pests observed indicates significant ecological diversity, with pests exhibiting various feeding behaviors such as boring, sap-sucking, defoliation, and leaf mining, particularly during the flowering and fruiting stages of crop development.

Table 3: Order- and Family-Wise Species Richness of Insect Pests on Vegetable Crops

S. No.	Family	Insect Order	No. of Species Recorded	Representative Species
1	Noctuidae	Lepidoptera	3	*Helicoverpa armigera*, *Agrotis ipsilon*
2	Crambidae		2	*Leucinodes orbonalis*, *Hellula undalis*
3	Plutellidae		1	*Plutella xylostella*
4	Pyralidae		1	*Earias vittella*
5	Aphididae	Hemiptera	2	*Aphis gossypii*, *Brevicoryne brassicae*
6	Aleyrodidae		1	*Bemisia tabaci*
7	Cicadellidae		1	*Amrasca biguttula biguttula*
8	Chrysomelidae	Coleoptera	2	*Aulacophora foveicollis*, *Epilachna spp.*
9	Tephritidae	Diptera	1	*Bactrocera cucurbitae*
10	Thripidae	Thysanoptera	1	*Thrips tabaci*
11	Braconidae (natural enemies)	Hymenoptera	1	*Bracon spp.* (parasitoid)
12	Trichogrammatidae (natural enemies)		1	*Trichogramma spp.*
13	Chrysopidae (natural enemies)	Neuroptera	1	*Chrysoperla carnea* (green lacewing)
14	(natural enemies)	Coccinellidae	1	*Coccinella septempunctata* (ladybird beetle)

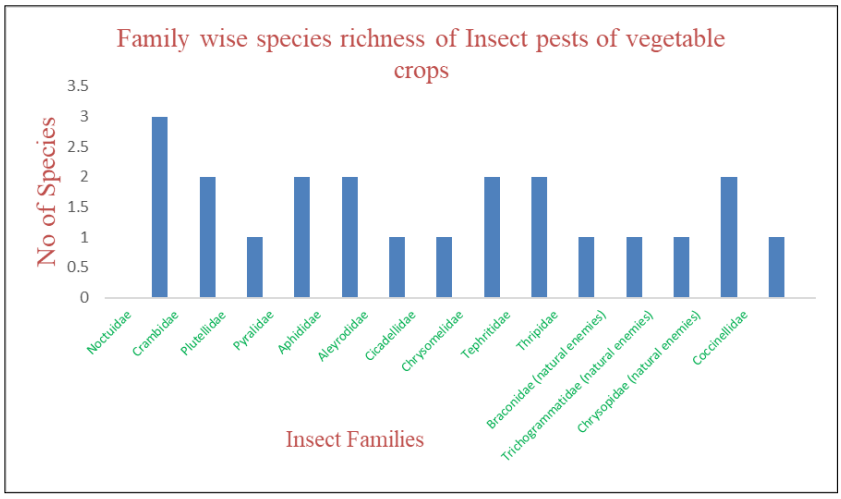
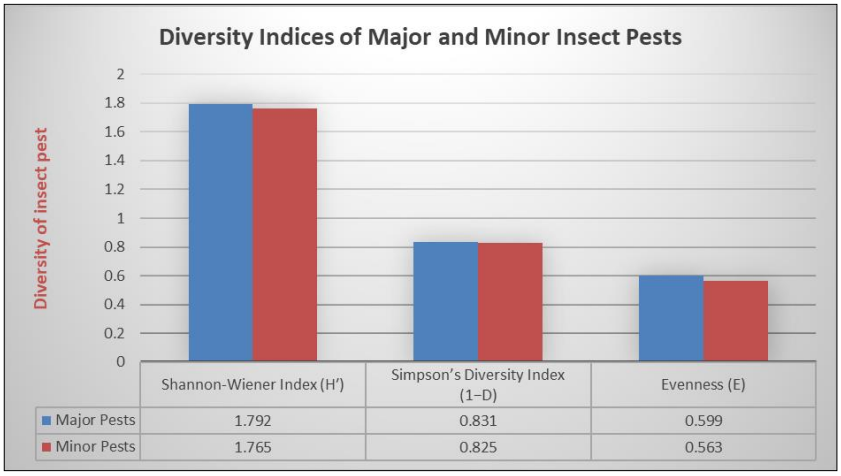
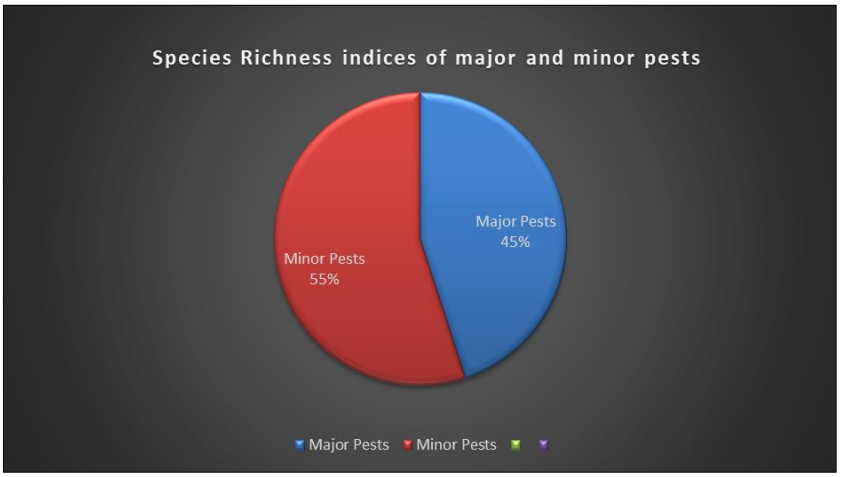


Table 4: Diversity Indices of Major and Minor Insect Pests on Selected Vegetable Crops in Muzaffarpur, Bihar (2023–2024)

Diversity Index	Major Pests	Minor Pests	Interpretation
Species Richness (S)	18	22	Minor pests exhibited slightly higher species richness across crops.
Shannon-Wiener Index (H′)	1.792	1.765	Both pest groups showed moderate diversity, with major pests being slightly higher.

Simpson's Diversity Index (1−D)	0.831	0.825	High diversity in both groups, indicating low dominance of any single pest.
Evenness (E)	0.599	0.563	Moderate evenness; pest populations were not evenly distributed across crops.





The analysis of species diversity revealed that minor insect pests had higher species richness (S = 22) compared to major pests (S = 18), suggesting a wider variety of secondary or less damaging pest species across the cropping systems. However, the Shannon-Wiener Index (H′) and Simpson's Index (1−D) values for both groups were comparable, indicating moderately high diversity but with slightly higher evenness among major pests. This implies that while minor pests are more numerous in species count, major pests are more uniformly distributed across crops. These results emphasize the need to monitor and manage both dominant and less conspicuous pests for sustainable vegetable production.

The results align with prior studies that identify *L. orbonalis* and *H. armigera* as the principal pests causing direct yield loss in brinjal and tomato respectively in eastern India (Rai et al., 2017) [6]. These pests thrive during humid to moderately warm conditions, peaking during flowering and fruit development stages. Sap-sucking pests like aphids, jassids, and whiteflies were often linked with virus transmission and were more prevalent in dense canopies with high humidity (Mishra & Dutta, 2020) [4].

Field-level IPM practices such as pheromone traps, timely insecticide applications (chlorantraniliprole, emamectin benzoate), and biologicals (e.g., *Bacillus thuringiensis*) reduced larval populations by over 60%, as demonstrated in similar agro-climatic conditions in Bihar (Kumar et al., 2022) [2, 3]. Tomato varieties like Pusa Rohit and Punjab Barkha-1 have shown biochemical resistance (high phenolics, dense trichomes) to *H. armigera*, suggesting varietal selection is a critical IPM component (Sharma & Singh, 2021) [7].

Environmental monitoring further confirmed pest outbreaks closely followed rainfall peaks and rising minimum temperatures, particularly for *B. cucurbitae* in cucurbits and *P. xylostella* in cole crops. This underlines the importance of aligning pest control efforts with climatic windows and crop phenology.

Conclusion

The present investigation provides a comprehensive assessment of insect pest diversity associated with major vegetable crops—brinjal, tomato, okra, cabbage, cauliflower, and Cucurbitaceae vegetables —in the Muzaffarpur district of Bihar during the July 2023–June 2024 cropping seasons. A total of 18 major and 22 minor insect pest species were documented, representing five insect orders and 13 families. Among these, the order *Lepidoptera* exhibited the highest species richness, followed by *Hemiptera*, *Coleoptera*, *Diptera*, and *Thysanoptera*. Notably, species such as *Leucinodes orbonalis*, *Helicoverpa armigera*, *Earias vittella*, and *Bactrocera cucurbitae* were found to be highly destructive during the reproductive stages of their respective host crops.

The calculated Shannon-Wiener and Simpson's diversity indices indicated moderate to high pest diversity and even distribution among species across different crops, reflecting the complex ecological interactions within these agroecosystems. The presence of both major and minor pests, alongside natural enemies such as parasitoids (*Braconidae*, *Trichogrammatidae*) and predators (*Chrysopidae*, *Coccinellidae*), highlights the importance of adopting ecologically sound and crop-specific Integrated Pest Management (IPM) practices.

Overall, the study emphasizes the need for regular pest surveillance, early warning systems, and farmer training to enhance pest management efficiency and ensure sustainable vegetable production in the region.

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