Pakistan J. Zool., pp 1-6, 2026. DOI: https://dx.doi.org/10.17582/journal.pjz/20230918062825

Population Dynamics of Insect Fauna Associated with Brinjal Crop Grown in Peri-Urban Agroecosystems in District Faisalabad

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Article Information
Received 18 September 2023
Revised 05 January 2026
Accepted 19 January 2026
Available online 31 March 2026 (early access)

Authors' Contribution
MAY: Designed the study. ZA: Conceptualized the study, led the research project. SETR: Participated in laboratory work. MAY, ZA, HH, SN and SETR: Analysed the data.. MAY, SETR and WA: Collected data. WA: Assisted in fieldwork. HH, WA and ZA: Wrote the manuscript. HAK, UAC and SN: Reviewed and revised the manuscript. HAK: Provided expertise in zoology and helped in conceptualization. HH and UAC: Participated in data entry. SN: Organized the data.

Key words
Brinjal, Population dynamics, Insect pests, Natural enemies, Shannon diversity index, Species richness

ABSTRACT

The present study investigated the population dynamics of the insect pests and their natural enemies of the brinjal crop in the peri-urban agroecosystem of district Faisalabad. For this purpose, brinjal crops were grown in nine different locations of district Faisalabad. At maturity of the crop, the healthy plants were selected for data collection. A field survey was carried out at weekly intervals in two different locations during March 2022-2023. Results showed that the percent shoot damage caused by brinjal shoot and fruit borer (*Leucinodes orbonalis*) increased slowly till the 10th standard week and then started to decline. Similarly, the fruit damage also increased till the 12th standard week and then started to decline. The average number of Epilachna grubs per plant indicated their abundance starting from the sixth standard week till the 14th standard week. The damage decreased with decreasing number of grubs. The population of white flies started to increase during the mid-season of the crop (8th standard week) and continued in an increasing trend till the 16th standard week. The mealybug incidence was absent till the sixth standard week and started to increase thereafter. However, the peak incidence was reported only in the late season crop starting from the 13th standard week. The population of insects was analyzed using the Shannon diversity index. The highest and minimum diversity of insects was determined along with the maximum species evenness and richness in the brinjal agroecosystem.

INTRODUCTION

Agriculture is the main source of Pakistan's economy and plays a vital role in development. It contributes 21.8% of Pakistan's GDP, employs 28% of the workforce, and helps the economy in other ways (GOP, 2019). Vegetables are the cheapest way to get the vitamins and nutrients you need to stay healthy. All over Pakistan, vegetables are grown and fetched to the market throughout the year. Vegetables are a big part of food security and making sure that a rapidly growing population gets the nutrition, it needs (Alam *et al*., 2003).

Brinjal (*Solanum melongena* L.) is grown on more than 1,600,000 ha around the world, and 50 million tonnes of yield has been obtained every year. About 9,000 hectares are used for farming in Pakistan, which grows about 87,000 tonnes of brinjal every year (FAO, 2018). China produces more brinjal than any other country followed by India. Nine percent of all the vegetables made in India are brinjal. In terms of nutrition, it has vitamins A, B, and C, phosphorous, calcium, and iron. In the current agro-ecosystem, different kinds of insect pests attack brinjal from the time it is in the nursery until it is picked. There are many kinds of insects that attack the brinjal crop (Anwar *et al*., 2015).

Brinjal is called the "poor man's vegetable" because it is cheap to grow, easy to take care of, and available all year long. Brinjal comes from the Solanaceae family. From the time brinjal plants are seedlings until they are ready to be picked, different kinds of pest insects attack them. The brinjal shoot and fruit borer (BSFB), whitefly, leafhopper, and Epilachna beetle (Eswara and Srinivasa, 2001; Soto *et al*., 2010). Insect pests like these have been known to damge brinjal's shoots and fruit at every stage of its growth. These pests cause the crop to lose between 70%

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0030-9923/2026/0001-0001 $ 9.00/0

and 92% of its yield. Lepidopteran insects are the most common pests on brinjal. They do a lot of damage to the growing shoot tips and fruits. To get better crop yield, it is important to keep these pests in check. Looking at how often these pests show up at different times of the year can help to figure out how their populations change, which will facilitate keeping them in check (Mandal *et al*., 2014).

The pests are seen from the time the seeds are planted until the crop is picked, which makes it hard to grow this crop. The shoot borers, aphids, leaf minors, white spotted flea beetles, white flies, thrips, spider mites, and jassids (Thakur *et al*., 2012). Most of the time, the jassids are around during August. Flea beetles, on the other hand, are only active from August to the mid of November. The red spider mite is another very damaging pest of brinjal, along with brinjal borer (Nzanza and Mashela, 2012). Insect pest infestation at different stages of crop growth is one of the biggest problems with increasing brinjal yields because of changes in the climate over the past few years; there have been a lot more insect pests, especially the *Leucinodes orbaonalis* (Dhandapani *et al*., 2003).

It not only lowers productivity, but it also lowers the quality of fruits, making them unsafe to eat. The BSFB has become a big problem because the larvae live separately (Sardana *et al*., 2004) and is hard to get rid of even with a lot of insecticides. In different parts of the world, 20–89% of crops have been lost because of BFSB (Raju *et al*., 2007). Aside from BSFB, brinjal is vulnerable to attacks from many other insects and non-insect pests, such as red spider mites, which cause heavy losses to brinjal by reducing chlorophyll by sucking the sap and making webs, which leads to losses of 30–40% (Srinivasan, 1993).

MATERIALS AND METHODS

The present research was conducted in the Insect Molecular Biology Laboratory, Department of Entomology, University of Agriculture Faisalabad with the objective to evaluate the population dynamics of insect pests and their natural enemies of brinjal crop in peri-urban agroecosystem of district Faisalabad. In this study, brinjal crops grown in different locations of Faisalabad were selected for collecting the insect pests of the brinjal crop.

During the winter of 2022–2023, an experiment was done on the number, variety, and distribution of insects in brinjal agroecosystems in Pensra, Chak Jhumra, Faisalabad Sadar, Jaranwala, Samundri, and Tandlianwala, Khurrian wala, AARI and Young wala colony UAF. For that purpose, the brinjal crop was sown in the aforementioned research site by adopting standard production technology of the brinjal crop. At maturity of the crop, the healthy plants were selected for data collection. To determine insect biodiversity, vegetable fields containing brinjal crops were selected for examining the occurrence of insects at weekly intervals. The brinjal crops grown at different agroecosystem was selected for data collection.

Insects were identified in the Insect Molecular Biology Laboratory, Department of Entomology, University of Agriculture Faisalabad, using taxonomic keys and literature from the study. All of the work on taxonomy was done in the Laboratory with the help of microscopes.

For future studies, insect taxonomy keys were also be made up to the species level. The SMZ-745, Nikon Trinocular Microscope was used to examin the insect specimens. A-13 MP digital camera were placed on the top of the microscope so that clear pictures of the specimens can be taken. With the help of a digital camera that is attached to the microscope, morphological characters were looked at.

The Shannon Diversity Index was used to look at the collected data.

$$H' = \sum_{1=1}^{s} (P_i / nP_i)$$

where H' is diversity index, s is the number of species and Pi is the proportion of individuals of each species belonging to the ith species of the total number of individuals.

We used the following diversity indices:

H' = n log n- fi log fi (diversity)
H'max = log N (Max diversity) H'
J' (Evenness) H'max
D= 1-J' (Richness)

where H' is the diversity index of all the specimens that was collected and fi is the number of species. H'max is the maximum 200 diversity, N is the total number of species in the whole crop area. J' measures how even things are, D shows which species are most common, and n is the number of species in each observation.

RESULTS

A total of 178 specimens belonging to 6 insect pests were recorded during the month of March. The collected species were Shoot and fruit borer, aphid, hadda beetles, ladybird beetles, praying mantis, and predatory bugs, and their Shannan Wiener Index values are 0.2, 0, 1, 1.6, 2, 1.6, and Higher values of Shannon Diversity Index 1.6 shows the higher diversity of species in the ecosystem. Species evenness was 2.7 which is approximately equal as shown in Figure 1A and all the species have the same almost the same frequency of abundance.

A total of 279 specimens belonging to pest and predator species were recorded during March. The collected species were shoot and fruit borer, aphid, hadda beetle, ladybird beetles, praying mantis, and predatory bugs and their

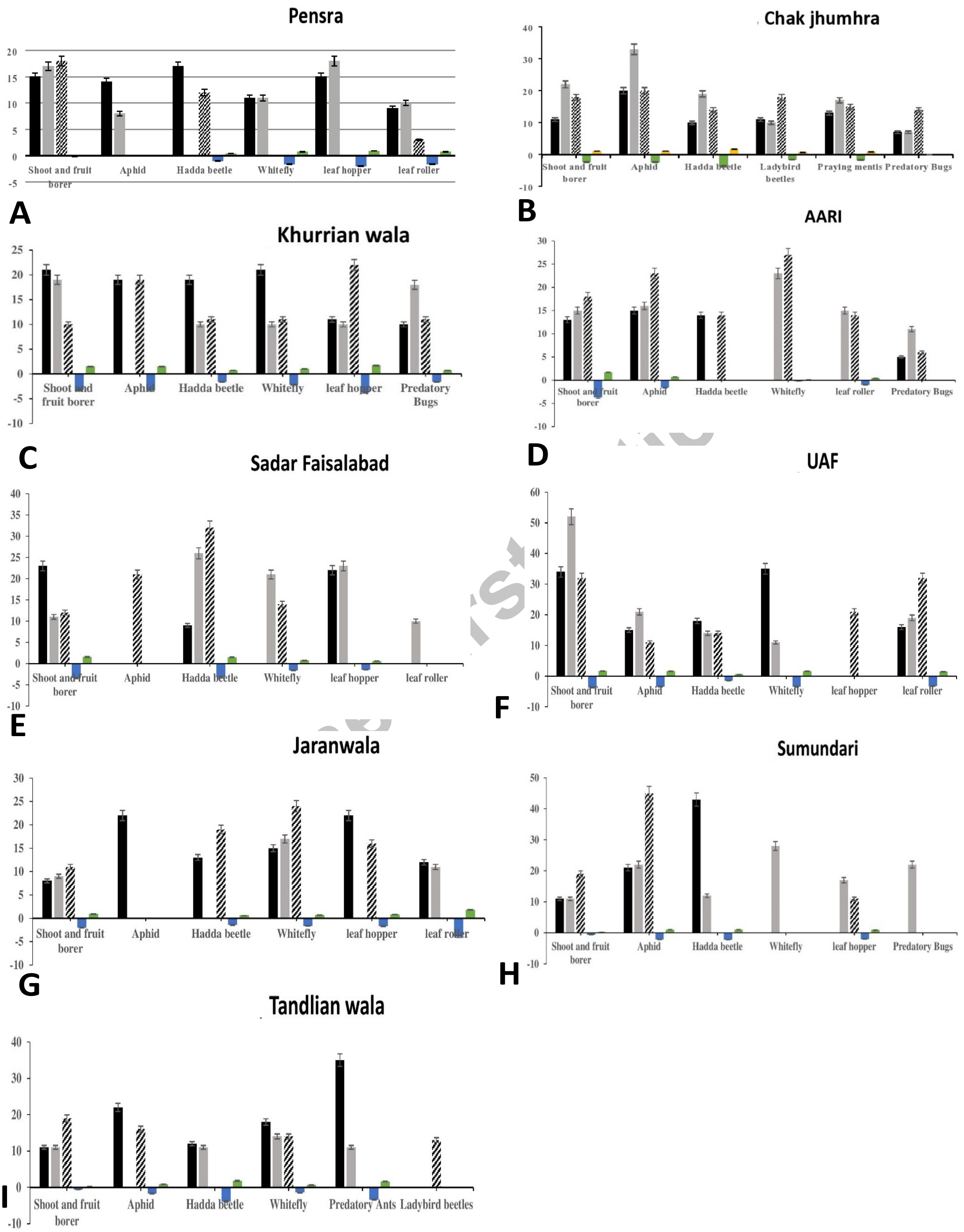

Fig. 1. Population of pests and predators on brinjal crop in Pensra (A), Chak Jhumhra (B), Khurrian wala (C), AARI (D), Sadar Faisalabad (E), UAF (F), Jarawala (G), Sumundari (H) and Tandlian wala (I) district Faisalabad (Punjab, Pakistan).

Shannan Wiener Index values are 2.3, 2.4, 3.7, 1.6, 1.7, and 0. Higher value of the Shannon Diversity Index of 3.7 shows the higher diversity of species in the ecosystem. Species evenness was 5.4 which is approximately equal as shown in Figure 1B and all the species have the same almost the same frequency of abundance.

A total of 177 specimens belonging to pest and predator species were recorded during March. The collected species were Shoot and fruit borer, aphid, hadda beetle, whitefly, leaf hopper, and predatory bugs and their Shannan Wiener Index values are 3.2, 3.3, 1.6, 2.2, 3.7, and 1.6. The higher value of the Shannon Diversity Index of 3.7 shows the higher diversity of species in the ecosystem. Species evenness was 7.1. Which is approximately equal as shown in Figure 1C and all the species have the same almost the same frequency of abundance.

A total of 229 specimens belonging to predator and pest species on the brinjal crop were recorded during March. The collected species were shoot and fruit borer, aphid, hadda beetle, whitefly, leaf roller, and predatory bugs and their Shannan Wiener Index values are 3.7, 1.6, 0, 0.2, 0, and 1. The higher value of the Shannon Diversity Index of 3.7 shows the higher diversity of species in the ecosystem. Species evenness was 2.8 which is approximately equal as shown in Figure 1D and all the species have the same almost the same frequency of abundance.

A total of 224 specimens belonging to pest and predator species on the brinjal crop were recorded during March. The collected species were shoot and fruit borer, aphid, hadda beetle, whitefly, leaf hopper, and leaf roller and their Shannan Wiener Index values are 3.4, 0, 3.2, 1.6, 1.4, and 0. The higher value of Shannon Diversity Index 3.4 shows the higher diversity of species in the ecosystem. Species evenness was 4.4 which is approximately equal as shown in Figure 1E and all the species have the same almost the same frequency of abundance.

A total of 345 specimens belonging to 6 pest and predator species were recorded during March. The collected species were shoot and fruit borer, aphid, hadda beetle, whitefly, leaf hopper, and leaf roller and their Shannan Wiener Index values are 3.7, 3.4, 1.4, 3.4, 0, and 3.2. The higher value of the Shannon Diversity Index of 3.7 shows the higher diversity of species in the ecosystem. Species evenness was 7.0 which is approximately equal as shown in Figure 1F and all the species have the same almost the same frequency of abundance

A total of 207 specimens belonging to 6 pest and predator species were recorded during the month of March. The collected species were shoot and fruit borer, aphid, hadda beetle, whitefly, leaf hopper, and leaf roller and their Shannan Wiener Index values are 2, 0, 1.4, 1.6, 1.7, and 3.9. The higher value of the Shannon Diversity Index of 3.9 shows the higher diversity of species in the ecosystem. Species evenness was 4.8, which is approximately equal as shown in the Figure 1, and all the species have the same almost the same frequency of abundance.

A total of 261 specimens belonging to 6 pest and predator species were recorded during March. The collected species were shoot and fruit borer, aphid, hadda beetle, whitefly, leaf hopper, and predatory bugs and their Shannan Wiener Index values are 0.6, 2.1, 2.2, 0, 2, and 0. The higher value of Shannon Diversity Index 2.2 shows the higher diversity of species in the ecosystem. Species evenness was 3.1 which is approximately equal as shown in Figure 1 and all the species have the same almost the same frequency of abundance.

A total of 261 specimens belonging to 6 pest and predator species were recorded during March. The collected species were shoot and fruit borer, aphid, hadda beetle, whitefly, predatory ants, and ladybird beetles, and their Shannan Wiener Index values are 0.6, 1.7, 3.9, 1.4, 3.4, and 0. The higher value of the Shannon Diversity Index of 3.9 shows the higher diversity of species in the ecosystem. Species evenness was 5 which is approximately equal as shown in the Figure 1 and all the species have the same almost the same frequency of abundance.

DISCUSSION

In this study, brinjal crops grown in different locations of Faisalabad were selected for collecting the insect pests of the brinjal crop.

During the winter of 2022–2023, an experiment was done on the number, variety, and distribution of insects in brinjal agroecosystems in Pensra, Chak Jhumra, Faisalabad Sadar, Jaranwala, Samundri, and Tandlianwala, Khurrian wala, AARI and Young wala colony UAF. For that purpose, the brinjal crop was sown in the aforementioned research site by adopting the standard production technology of the brinjal crop. At maturity of the crop, the healthy plants were selected for data collection. To determine insect biodiversity, vegetable fields containing brinjal crops were selected for examining the occurrence of insects at weekly intervals. The brinjal crops grown at different agroecosystem was selected for data collection.

A field survey was carried out at weekly intervals in two different locations during March 2022-2023. The percentage of shoot damage caused by Brinjal shoot and fruit borer increased slowly till the 10th standard week and then started to decline. Similarly, the fruit damage also increased till the 12^{th} standard week and then started to decline. The average number of *Epilachna* grubs per plant indicated their abundance starting from the sixth standard week till the 14^{th} standard week. The damage decreased with decreasing number of grubs. The population of white flies started to increase during the mid-season of the crop (8^{th} standard week) and continued in an increasing trend till the 16^{th} standard week. The mealybug incidence was absent till the sixth standard week and started to increase thereafter. However, the peak incidence was reported only in the late season crop starting from the 13th standard week. Correlation with weather parameters revealed their influence on population fluctuation.

CONCLUSION

In conclusion, This study was a comprehensive effort to understand the intricacies of insect interactions with brinjal crops in different locations, shedding light on their distribution, variety, and the impact of environmental factors. The findings of this research can serve as a valuable resource for local farmers, agricultural extension services, and policymakers. Farmers can make more informed decisions about when and how to implement pest management measures by gaining a deeper understanding of the population dynamics of insect pests. Furthermore, this research underscores the need for integrated pest management approaches that consider the ecological context of brinjal agroecosystems.

The research conducted in the Department of Entomology at the University of Agriculture Faisalabad contributes significantly to the field of insect ecology and pest management. It provides a foundation for future studies and practical strategies to enhance brinjal crop production while minimizing the impact of insect pests on agricultural sustainability and food security in peri-urban areas of District Faisalabad.

DECLARATIONS

Funding

This research work is funded by HEC-Govt of Pakistan for providing funds to support this Master level research work (HEC NRPU 20-16512).

IRB approval

Not applicable.

Ethical approval and informed consent

This research received ethical approval from the relevant institutional review board at the University of Agriculture, Faisalabad. Informed consent was obtained from all participants or property owners where data collection and sampling were carried out.

Availability of data and material (data transparency)

The raw data, software code, and materials utilized in this study are available upon reasonable request to facilitate the verification, replication, and further analysis of our findings. For access to the data and materials, please contact the corresponding author, Zain ul Abdin, at zainentomology@uaf.edu.pk.

Code availability

The software code, scripts, are in form of tables and excel sheets which done on MiniTab19 in this research are available to interested parties upon request to promote transparency and facilitate the replication of our study. To obtain access to the code, please contact the corresponding author, Zain ul Abdin, at zainentomology@uaf.edu.pk.

Generative AI and AI-assisted technology statement

The authors declare that no generative AI and AI assisted technology was used in the creation of this manuscript.

Statement of conflict of interest

The authors have declared no conflict of interest.

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