



Efficacy of Neonicotinoids against Brinjal Leaf Footed Bug (Hemiptera; Coreidae) Under Laboratory Conditions

Shouket Zaman Khan^{*1}, Ayesha Farheen¹, Azmat Ali¹, Muhammad Rizwan Ashraf¹, Muhammad Ashfaq¹, Muhammad Talha Nasir¹, Asad Sultan¹, Ahmad Ammar²

¹ University of Agriculture, Faisalabad, Constituent College Burewala, 61010, Punjab, Pakistan

² Pestex Maldives PVT Limited, 200002, Male, Maldives

Corresponding author's email: shouket.zaman@uaf.edu.pk

Article Info

Keywords:

Brinjal, vitamins, leaf footed bug, pesticides, serial dilution

Date:

Received: 10 March 2025

Accepted: 10 April 2025

Published: 15 December 2025

Volume: 04 (01), 2025



Copyright: © 2025 by the authors. This article is distributed under the Creative Commons Attribution (CC BY) license, allowing for open access and sharing under specified terms and conditions. (<https://creativecommons.org/licenses/by/4.0/>).

Abstract

Brinjal (*Solanum melongena*) is an extensively consumable vegetable due to its unique taste and medical importance; it is rich in vitamins, iron, and phosphorus and highly recommended in kitchens. Brinjals are attacked by many insect pests, which cause the economic loss. One of them is the brinjal leaf-footed bug (*Leptoglossus phyllopus*) that causes damage in the brinjal crop. The damage occurs during the nymph and adult stages, and it is caused by sucking cell sap, which weakens and impairs the plant's ability to function. In brinjal plants, sucking cell sap is also a major cause of disease transmission, which results in economic loss. Conventional chemical control is more efficient, but excessive chemical use has negative effects and raises environmental concerns. The goal of this experiment was to control the brinjal leaf-footed bug using an economical chemical method that minimizes any residual effects on crops while maintaining environmental and human safety. Additionally, it encourages the judicious use of pesticides and increases brinjal yield for financial gain. The chemicals used in the experiment were also serially diluted, with the concentration of the compounds decreasing from higher to lower. In our experiment, we employed serial dilutions of acetamiprid, imidacloprid, nitenpyram, and thiamethoxam. In order to assess the mortality percentage of brinjal leaf-footed bugs, the experiment was conducted with concentrations of 100, 50, 25, 12.5, and 6.75%. The findings were observed at intervals of 16, 24, and 36 hours. The results revealed that every chemical is different at each time interval. Imidacloprid was more effective than acetamiprid, nitenpyram, and thiamethoxam for controlling the brinjal leaf-footed bug.

1. Introduction

Brinjal (*Solanum melongena*) is a highly used vegetable due to its wonderful taste and medical importance. This vegetable is familiar by the name of eggplant due to its shape's resemblance to an egg (Meenakshi, 2021) and is also called the king of vegetables (Deekshith, 2020). From a medical perspective, brinjal has a variety of healthy ingredients, including iron, phosphorus, and vitamins A, B, and C (Meenakshi, 2021; Paritosh, 2023). Because of its amazing flavor, brinjal is frequently recommended in kitchens for cooking. The most common use of this vegetable in Pakistan and India is in a delicious and well-known meal called Bhatha. The brinjal is grown in

temperate, tropic, and subtropical regions of the world (Paritosh, 2023). India is the country with the most native growth and production of brinjal in the world (Meenakshi, 2021). Brinjal is a major vegetable of India, as it is cultivated on 7.27 lakh hectares with an annual turnover of 123.23 lakh tons during 2016-17 (Rudra, 2019). Due to low cultivation, poor biotic and environmental conditions, and poor management, Pakistan's brinjal output turnover is lower than that of other Asian nations (Yousafi, 2013, 15, 16). In 2014, Pakistan produced 88,148 tons of brinjal from 9,000 hectares of cultivation (FAO, 2014).

In Punjab, 54,159 tons of brinjal were produced on 4,452 hectares of land (GOP, 2014-15). Fifty-three species

of insects are known to attack the brinjal plant (Mamatha et al., 2024). From the nursery stage to the harvesting stage, multiple biotic and abiotic factors are involved in decreasing the yield; especially insect pests play a vital role in decreasing brinjal yield. The rate of production losses of brinjal is very high in South Asia due to insect pest attacks (Thapa, 2010). Insects such as shoot borers, fruit borers, aphids, stem borers, and beetles are responsible for brinjal yield loss. 90% of the overall yield loss in brinjal is caused by fruit and shoot borers alone (Chakraborti et al., 2011; Padwal et al., 2016; Taylo et al., 2016). Aphids, whiteflies, mealybugs, jassids, and lacewing bugs are among the sucking insect pests that significantly lower yield (Aslam et al., 2004; Swaminathan et al., 2010).

However, the leaf-footed beetle (*Leptoglossus phyllopus*) also damages the brinjal plant by sucking the cell sap. Its host plants include a variety of crops, fruits, and vegetables (Christoph and Falguni, 2010). This insect is distributed in the United States and then moves toward Argentina (Gonzaga et al., 2013). The nymph and adult stages are more destructive, as these stages suck the cell sap, and in response, the plant leaf becomes yellow. The

the past, it was recommended to prevent this pest by growing brinjal nurseries in separate rooms or fields covered with 50-64 mesh nylon net or by using seedling trays for better pest management (Srinivasan, 2009). Additionally, chemicals are very helpful in managing this pest. Modern, wide-range neonicotinoid insecticides are used to manage sucking and chewing pests of brinjal (Jeschke and Nauen, 2008). On the other hand, overuse of chemicals pollutes the environment and harms human health (Gelaye and Negash, 2024). Some chemicals reduce the quality of vegetables, which causes economic loss. The aim of this experiment is to manage the brinjal leaf-footed bug while reducing the residual effects of neonicotinoids on vegetables and taking human health and environmental factors into consideration. Neonicotinoids are a very famous class of systemic insecticides known for their effectiveness against a variety of agricultural pests. They affect the nervous system of insects, which results in their mortality (Lazarević and Leskovac, 2025). In this experiment we use four neonicotinoids imidacloprid, nitenpyram, thiamethoxam, and acetamiprid against the brinjal leaf-footed bug. Imidacloprid and nitenpyram are widely used

Table 1. Experimental treatments and their details for the bioassay against brinjal leaf footed bug

Treatment	Control Method	Trade name and manufacturer	Time of Application	Dose/ 100 ml Water
1.	Serial dilution	(Actara 25 WG; Syngenta)	Last week of November	5g
2.	Serial dilution	(Instant Super 50 SG; Syngenta)	Last week of November	5ml
3.	Serial dilution	(Imidacloprid 20 SL; Syngenta)	Last week of November	5g
4.	Serial dilution	(Acetamiprid, 20 SP; Swat Agro)	Last week of November	5g
5.	Control	-	-	-

Table 2. Descriptive Statistics of Concentration Levels and Corresponding Death Percentages

Descriptive Statistics					
Treatments	N	Minimum	Maximum	Mean	Std. Deviation
Concentration (%)	42	.00	100.00	37.0000	34.61161
Death %	42	0.00%	100.00%	76.1905%	30.21891%
Concentration (%)	42	.00	100.00	37.0000	34.61161
death%	42	0.00%	25500.00%	612.5000%	3933.91775%
Concentration (%)	40	6.75	100.00	38.8500	34.43373
death%	42	0.00%	200.00%	10.1190%	43.14593%
Valid N (listwise)	40				

optimum time period is from August to September, when population incidence is high due to rains and causes 50% crop damage (Davi, 2021). However, the management of this pest in the past was done by the cultural, mechanical, botanical, and chemical methods (Thomas et al., 2010). In

neonicotinoids that disrupt insect nerve transmission by binding to nicotinic acetylcholine receptors, making them effective against most insect pests (Thany, 2023).

While thiamethoxam, a second generation neonicotinoid, offers enhanced water solubility and systemic

uptake, targeting a broad spectrum of pests (Frias et al., 2024). This study analyzes low-cost chemical control methods to stop overuse, increase brinjal yield for financial gain, and educate the local population about the proper use of pesticides to control this pest.

2. Materials and Methods

The experiment was conducted at the University of Agriculture Faisalabad Constituent College, Burewala, Punjab, Pakistan. The required material for the experiment was brinjal leaf, insects, chemicals, measuring weight, a camel hair brush, and a polythene bag, holding plates, forceps, flasks, scissors, and distilled water.

2.1 Insect collection and rearing

The brinjal leaf footed bug was collected from a farmer’s brinjal field at 329/EB Burewala using the beating tray method to dislodge the bugs from the brinjal plant. After collection, these bugs are safely transferred with the help of forceps into ventilated containers containing fresh brinjal leaves as a food source. The brinjal leaf footed beetle was reared at the insectary of the Department of Entomology at the University of Agriculture Faisalabad Sub-campus Burewala for 3 generations in order to get genetic uniformity and to eliminate field variability. The growth chamber was maintained at a 32±2°C temperature, 70±5% relative humidity (r.h), and a 12-hour light/12-hour dark photoperiod. The third-generation adults of the brinjal leaf-

used 256 adult insects in total, of which 80 were used to test each chemical at different concentrations, and 16 adult insects served as the control group.

2.2 Plant material

The brinjal leaf footed bug was fed fresh brinjal leaves (*Solanum melongena* L., variety Punjab Bahar) in the experiment. The leaves were taken from the field of a farmer in 329 EB, where the plants were grown. Every day, fresh leaves were gathered and fed in petri dishes. The leaves were changed every 24 hours to guarantee a steady and fresh source of nourishment.

2.3 Chemical insecticides

Four different chemicals were applied against brinjal leaf footed bug in lab to check and compare the efficacy of chemicals. The serial dilution of thiamethoxam, nitenpyram, imidacloprid, and acetamiprid was used in our conducted experiment. Each chemical moves from higher concentration to lower concentration. C₁ with 100% chemical, C₂ with 50% chemical, C₃ with 25% chemical, C₄ with 12.5% chemical, and C₅ with 6.75% chemical.

2.4 Bioassay

The insects were dipped in different concentrations and drop on the leaf and leaf were placed on holding plates for different time intervals to check the efficacy of chemicals. We studied the activity of these chemicals at 32±2 °C for 16, 24, and 36 hours under normal conditions. We saw varied results after 16 hours, as well as unexpected results

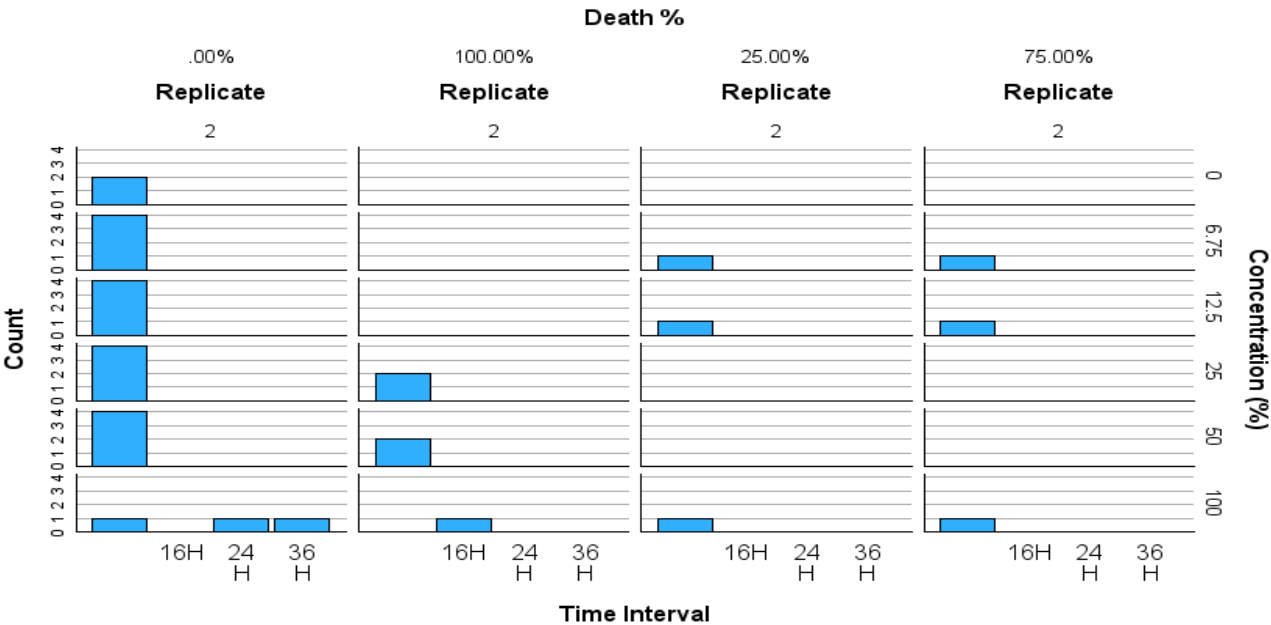


Fig 1. Mortality of brinjal leaf-footed bug at different concentrations of thiamethoxam at different times

footed bug were used in the experiment. The experiment after 24 and 36 hours. In order to assess their importance in

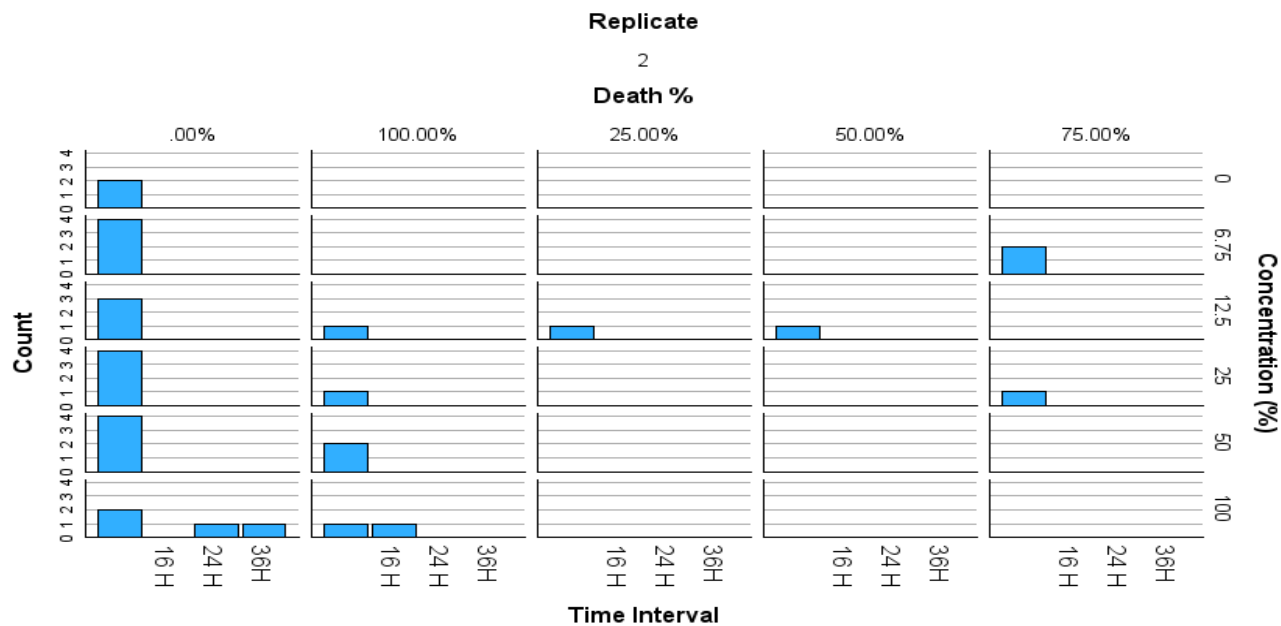


Fig 2: Mortality of brinjal leaf-footed bug at different concentrations of nitenoyram at different times

the experiment, chemicals were also applied under controlled circumstances. Each concentration in the experiment was replicated four times, with 16 insects in each concentration and 16 insects in the control group.

3. Results

In the conducted experiment, the results of each chemical are different depending upon the concentration percentage and the time intervals. Imidacloprid give more efficient results as compared to Thiamethoxam, Nitenpyram and acetamiprid to control the brinjal leaf footed bug. The results are given in this graphical representation. The concentrations of each chemical are 100%, 50%, 25%, 12.5%, and 6.75% in experiment and observed the results for three different time intervals 16 hours, 24 hours and 36 hours intervals to evaluate the mortality percentage of brinjal leaf footed bug. At the 24-hour interval, Thiamethoxam and Acetamiprid each caused a 77.5% mortality rate, leaving 22.5% of the insects alive. Nitenpyram showed the highest efficacy with 90% mortality, while Imidacloprid also resulted in 77.5% mortality. In contrast, the control treatment showed 0% mortality, indicating no natural deaths occurred. The second interval is 16 hours, and the findings of acetamiprid and thiamethoxam are comparable to those obtained after 24 hours. Imidacloprid shows 95% death and 5% alive, Nitenpyram shows 92.5% death and 7.5 alive, and the

control group still showed 0% mortality. Similar results are seen after 12 hours for the third time interval (36 hours) of Thiamethoxam and Acetamiprid. Nitenpyram shows a 95% death rate and a 5% alive rate, whereas imidacloprid shows a 100% death rate but a 0% death rate in the control group. Compared to other treatments, imidacloprid is more effective; nonetheless, it requires longer time intervals.

The graphical representation of (Fig 1) is indicate the results of Thiamethoxam at different concentration at different time intervals of these 2 replications of brinjal leaf footed bug, The concentration moves from higher to lower in form of serial dilution and the results also showed variation in each concentration. The graphical representation of (Fig 2) is indicate the results of Nitenpyram at different concentration at different time intervals of these 2 replications of brinjal leaf footed bug, The concentration moves from higher to lower in form of serial dilution and the results showed variation in each concentration. The graphical representation in Fig 3 indicates the results of imidacloprid at various concentrations and time intervals for two replications involving the brinjal leaf-footed bug. The concentrations decrease from higher to lower through serial dilution, and the results show variation at each concentration.

The graphical representation of (Fig 4) is indicate the results of Acetamiprid at different concentration at different time intervals of these 2 replications of brinjal leaf

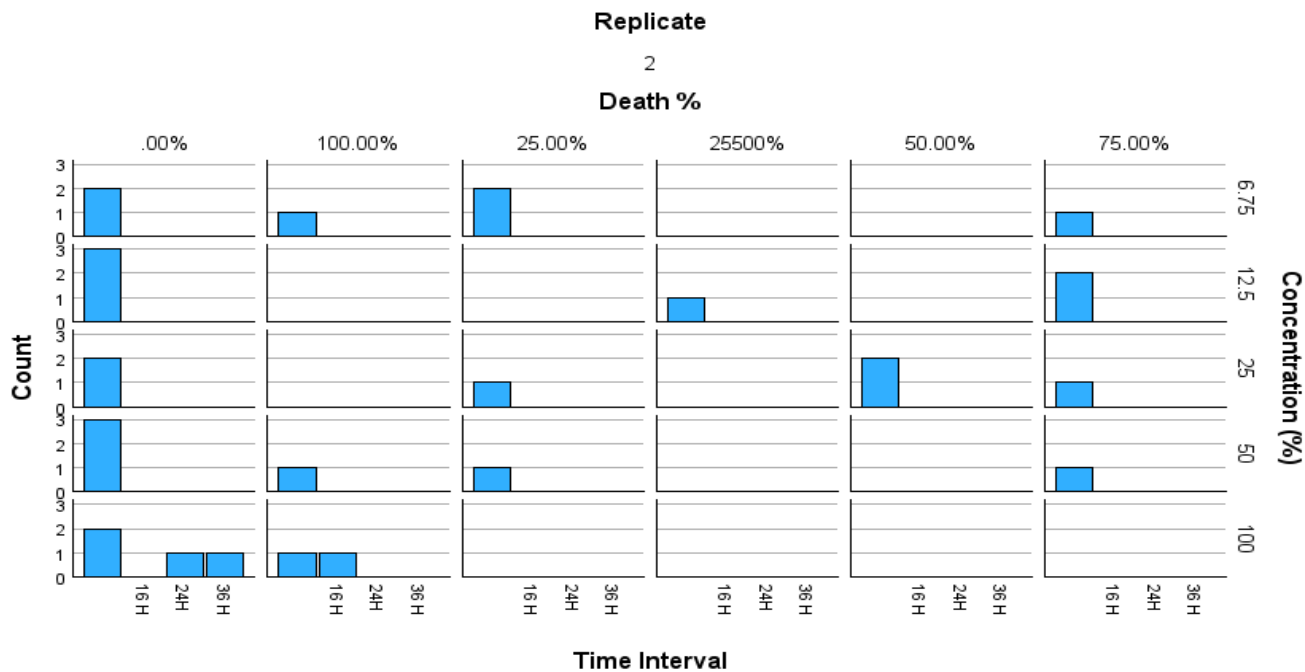


Fig. 3: Mortality of brinjal leaf-footed bug at different concentrations of imidacloprid at different times

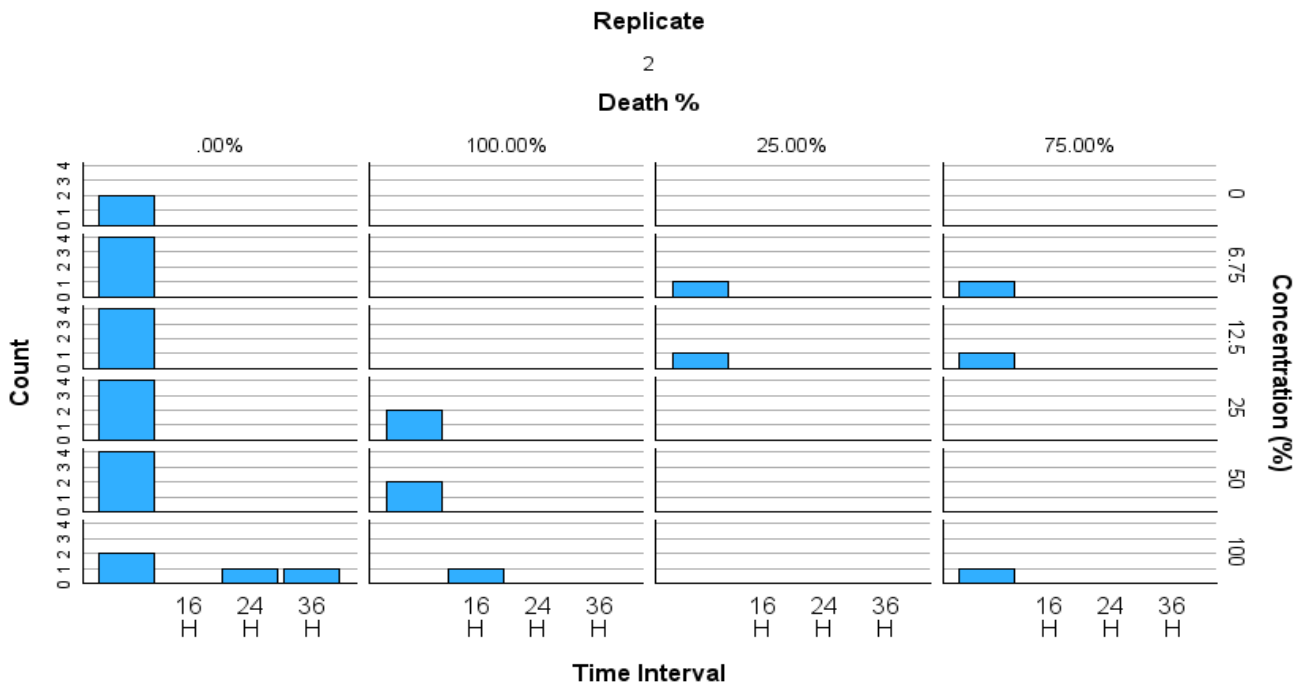


Fig. 4: Mortality of brinjal leaf-footed bug at different concentrations of acetamiprid at different times

footed bug, The concentration moves from higher to lower in form of serial dilution and the results showed variation in each concentration. The graphical representation of (Fig. 5) indicates the results of all chemicals that are used in our

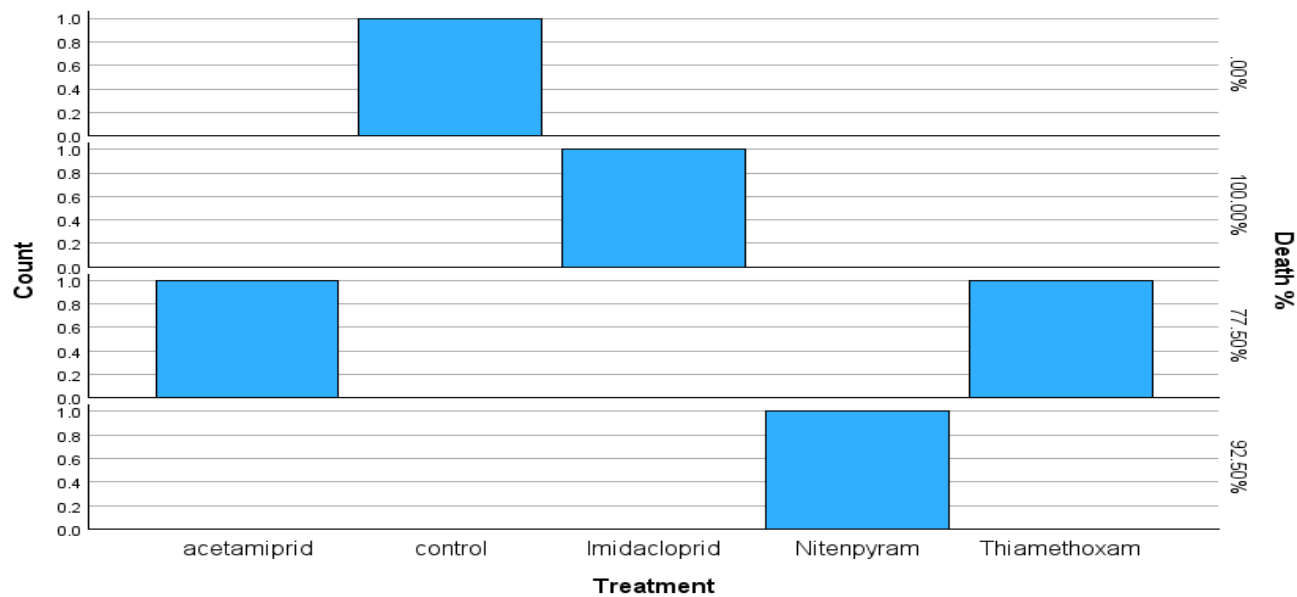


Fig. 5: Comparative effectiveness of Acetamiprid, Imidacloprid, Nitenpyram, and Thiamethoxam against brinjal leaf-footed bug

experiment showing variations. This representation represents that imidacloprid shows more efficiency as compared to other chemicals.

4. Discussion

The leaf-footed bug is a significant challenge for agricultural productivity, mainly in crops like tomatoes, peppers, and brinjal (Vallad et al., 2018). This research aims to evaluate the effects of various concentrations of insecticides on the mortality of this pest through a structured approach using serial dilution. The results of our study show a clear dose-response relationship, where increasing concentrations of all three tested insecticides correlated with higher mortality rates in leaf-footed bugs. The finding of our experiment aligns with the existing literature that suggests that many insecticides exhibit increased efficacy at higher concentrations (Riedle-Bauer and Brader, 2023). Our finding indicates that while tested insecticides exhibit high initial efficacy, particularly at 100% concentration, their effectiveness reduces significantly over time. At 16-hour intervals, all the tested insecticides, i.e., thiamethoxam, nitenpyram, imidacloprid, and acetamiprid, achieved 100% mortality at the highest concentrations, confirming their potent effectiveness against this pest.

This aligns with previous research indicating that neonicotinoids, including thiamethoxam and imidacloprid, are highly effective against a variety of pests of agricultural crops (Ullah et al., 2024). The immediate lethality observed

is especially critical for managing pest populations in eggplant cultivation, where prompt intervention is necessary to protect crop yields. However, our results also demonstrate a concerning trend: mortality rates decreased to 0% at lower concentrations and following the initial 16-hour exposure. This rapid decline in effectiveness supports findings from Bass et al. (2015), who noted that many insecticides, including neonicotinoids, can lose potency due to metabolic resistance mechanisms developed by target pests. While high concentrations of neonicotinoids like Thiamethoxam, Nitenpyram, Imidacloprid, and Acetamiprid exhibit immediate efficacy against this pest, their persistence in the environment can have unintended consequences. Research has shown that neonicotinoids can accumulate in water channels and soil, which adversely affects the non-target organisms. It is necessary to adapt targeted application and reduced dosage strategies.

Overreliance on sublethal doses not only reduces the effectiveness of pest control but also increases the development of resistance in pest populations. To alleviate the risk of resistance development, it is crucial to implement integrated pest management (IPM) strategies that combine chemical control with other control tactics like biological control, use of resistant crop varieties, and cultural practices to manage pest populations sustainably (Barzman et al., 2015). While high concentrations of neonicotinoids like Thiamethoxam, Nitenpyram, Imidacloprid, and Acetamiprid exhibit immediate efficacy against this pest, their persistence in the environment can have unintended

consequences. Research has shown that neonicotinoids can accumulate in water channels and soil, which adversely affects the non-target organisms (Basley, 2019). Additionally, rotating insecticides with different modes of action can help delay the development of resistance (Sparks et al., 2021). By alternating between neonicotinoids and other classes of insecticides, such as pyrethroids or insect growth regulators, pest managers can reduce the selection pressure on populations of brinjal leaf-footed bugs and prolong the effectiveness of chemical control measures.

5. Conclusion

In the conducted experiment, the results of each chemical are different depending upon the concentration percentage and the time intervals. Imidacloprid gives more efficient results as compared to thiamethoxam, nitenpyram, and acetamiprid to control the brinjal leaf-footed bug. The results are given in this graphical representation. The concentrations of each chemical are 100%, 50%, 25%, 12.5%, and 6.75% in the experiment, and the results were observed for three different time intervals, 16H, 24H, and 36H intervals, to evaluate the mortality percentage of the brinjal leaf-footed bug. At the 24-hour interval, Thiamethoxam and Acetamiprid each caused a 77.5% mortality rate, leaving 22.5% of the insects alive. Nitenpyram showed the highest efficacy with 90% mortality, while imidacloprid also resulted in 77.5% mortality. In contrast, the control treatment showed 0% mortality, indicating no natural deaths occurred. The second interval is 16 H, and the findings of acetamiprid and thiamethoxam are comparable to those obtained after 24 hours. Imidacloprid shows 95% death and 5% alive, nitenpyram shows 92.5% death and 7.5% alive, and the control group still showed 0% mortality. Similar results are seen after 12 hours for the third time interval (36 hours) of thiamethoxam and acetamiprid. Nitenpyram shows a 95% death rate and a 5% alive rate, whereas imidacloprid shows a 100% death rate but a 0% death rate in the control group. Compared to other treatments, imidacloprid is more effective; nonetheless, it requires longer time intervals.

6. Funding

No funding was received for this study.

6. Acknowledgment

The authors are grateful to the Syngenta, Pakistan and Sawat Agro chemicals Private Ltd. for providing insecticides.

7. Conflict of Interest

The authors declare no conflict of interest.

8. Authors' Contribution

SZK designed the study and conducted bioassay

AF helped in collecting data and provided guidelines on bioassay setting and proof read the MS

AI performed statistical analysis and prepared data tables

MRA completed write up and finalized the MS

MA Proof read the document

MTN Prepared tables and figures

AS help in collecting and rearing population

AA Crop plantation and logistic sport

References

- Aslam, M., Razaq, M., Shah, S.A. and Ahmad, F. (2004). Comparative efficacy of different insecticides against sucking pests of cotton. *Journal of Research Science*, 15: 53-58.
- Barzman, M., Bärberi, P., Birch, A.N.E., Boonekamp, P., Dachbrodt-Saaydeh, S., Graf, B. and Kudsk, P. (2015). Eight principles of integrated pest management. *Agronomy for Sustainable Development*, 35: 1199-1215.
- Basley, K. (2019). The effect of neonicotinoid pesticides on non-target organisms. A University of Sussex PhD thesis Available online via Sussex Research Online: <http://sro.sussex.ac.uk/>.
- Bass, C., Denholm, I., Williamson, M.S. and Nauen, R. (2015). The global status of insect resistance to neonicotinoid insecticides. *Pesticide Biochemistry and Physiology*, 121: 78-87.
- Chakraborti, S. and Sarkar, P.K. (2011). Management of *Leucinodesor bonalis* Guenee on eggplants during the rainy season in India. *Journal of Plant Protection Research*, 51: 325-328.
- Gelaye, Y. and Negash, B. (2024). Residue of pesticides in fruits, vegetables, and their management in Ethiopia. *Journal of Chemistry*, 1: 9948714.
- Grimm, C. and Guharay, F. (1998). Control of leaf-footed bug *Leptoglossus zonatus* and shield-backed bug *Pachycoris klugii* with entomopathogenic fungi. *Biocontrol Science and Technology*, 8: 365-376.
- Anjali, M., Singh, N.P., Mahesh Meena, M.M. and Swaroop Singh, SS. (2012). Seasonal incidence and effect of abiotic factors on population dynamics of major insect pests on Brinjal crop. *Journal of Environmental Research and Development*, 7: 431-435.
- Frias, Y.A., Cruz, V.H., Moreira, B.R.D.A., Pincerato, G.M.T. and Lopes, P.R.M. (2024). Understanding the Environmental Impact of Thiamethoxam and Implementing Biological Mitigation Strategies. In *Neonicotinoids in the Environment: Emerging Concerns to the Human Health and Biodiversity* (pp. 163-170). Cham: Springer Nature Switzerland.
- Ghosh, S.R.K. and Chakraborty, K. 2012. Incidence and abundance of important predatory beetles with

- special reference to *Coccinella septempunctata* in sub-Himalayan region north-east India. *International Journal of Plant, Animal and Environmental Sciences*, 2: 157-162.
- Gonzaga-Segura, J., Valdez-Carrasco, J. and Castrejón-Gómez, V.R. (2013). The metathoracic scent gland of the leaf-footed bug, *Leptoglossus zonatus*. *Journal of Insect Science*, 13: 149.
- GoP. (2015). Fruit, vegetables and condiments statistics of Pakistan. Government of Pakistan Ministry National Food Security and Research Economic Wing Islamabad, 2014-2015; pp.11-14.
- Jeschke, P. and Nauen, R. (2008). Neonicotinoids—from zero to hero in insecticide chemistry. *Pest Management Science: formerly Pesticide Science*, 64: 1084-1098.
- Javed, H., Hussain, S.S., Javed, K., Mukhtar, T. and Abbasi, N.A. (2017). Comparative infestation of brinjal stem borer (*Euzophera perticella*) on six aubergine cultivars and correlation with some morphological characters. *Pakistan Journal of Agricultural Sciences*, 54: 753-758.
- Lazarević-Pašti, T., Milanković, V., Tasić, T., Petrović, S. and Leskovac, A. (2025). With or Without You?—A Critical Review on Pesticides in Food. *Foods*, 14: 1128.
- Meenakshi, D. (2021). Insect Pests of Brinjal and Their Management, Department of Entomology SGT University, Gurugram (Haryana). 122505.
- Meenakshi, D. (2020). Botanical for the management of pest of brinjal, Department of agriculture of entomology collage of agriculture vellayani, Thiruvananthapuram, kerala, India. 522-695.
- Thodusu, M., Hath, T.K., Kasi, I.K., Pal, S. and Mandal, P. (2024). Arthropod Richness and Abundance in Brinjal Crop Ecosystems. *Uttar Pradesh journal of zoology*, 45: 10-21.
- Jotwani, M. G., Sarup, P. and Pradhan, S. (1961). Relative Toxicity of Some Important Insecticides to the Adults of Lacewing Bug, *Urentius Echinus* Distant (Tingidae: Heteroptera), a Pest of Brinjal. *Indian Journal of Horticulture*, 18: 81-84.
- Padwal, K.G., Singh, S.M. and Sharma, S.K. (2016). Major Insect Pests of Brinjal and Their Management. *Popular Kheti*, 4: 48-53.
- Riedle-Bauer, M. and Brader, G. (2023). Effects of insecticides and repellents on the spread of 'Candidatus Phytoplasma solani' under laboratory and field conditions. *Journal of Plant Diseases and Protection*, 130: 1057-1074.
- Borkakati, R. N., Venkatesh, M. R., and Saikia, D. K. (2019). Insect pests of Brinjal and their natural enemies. *Journal of Entomology and Zoology Studies*, 7: 932-937.
- Regupathy A, Palanisamy S, Chandramohan N, and Gunathilagaraj, K. (1997). A guide on crop pests. Sooriya Desk Top Publishers, Coimbatore, 264.
- Srinivasan, G., and Babu, P.C.S. (2001). Field evaluation of neem products against whitefly, *Bemisia tabaci* Gennadius on brinjal. *Annals of Plant Protection Sciences*, 9: 19-21.
- Srinivasan, R. (2009). Insect and mite pests on eggplant. AVRDC-world vegetable center. 9: 729.
- Sparks, T. C., Storer, N., Porter, A., Slater, R., and Nauen, R. (2021). Insecticide resistance management and industry: the origins and evolution of the Insecticide Resistance Action Committee (IRAC) and the mode of action classification scheme. *Pest Management Science*, 77: 2609-2619.
- Thany, S. H. (2023). Molecular mechanism of action of neonicotinoid insecticides. *International Journal of Molecular Sciences*, 24: 5484.
- Kuhar, T. P., Jenrette, J., and Doughty, H. (2010). Leaf-footed bugs. Virginia Polytechnic Institute and State University, 3012-1522.
- Thapa, R. B. (2010). Integrated management of brinjal fruit and shoot borer, *Leucinodes orbonalis* Guen: An overview. *Journal of the Institute of Agriculture and Animal Science*, 30: 1-16.
- Taylor, L.D., Sison, M.L.J., and Hautea, D.M. (2016). Use of artificial infestation for field bio efficacy assessment of Bt eggplant against the eggplant fruit and shoot borer, *Leucinodes orbonalis* Guenee (Lepidoptera: Crambidae). *Philippine Agricultural Scientist*. 99: 119-126.
- Thompson, D.A., Lehmler, H.J., Kolpin, D.W., Hladik, M.L., Vargo, J.D., Schilling, K.E., LeFevre, G.H., Peeples, T.L., Poch, M.C., LaDuca, L.E. and Field, R.W. (2020). A critical review on the potential impacts of neonicotinoid insecticide use: current knowledge of environmental fate, toxicity, and implications for human health. *Environmental Science: Processes & Impacts*, 22: 1315-1346.
- Ullah, F., Güncan, A., Abbas, A., Gul, H., Guedes, R.N.C., Zhang, Z., Huang, J., Khan, K.A., Ghramh, H.A., Chavarín-Gómez, L.E. and Lu, Y. (2024). Sublethal effects of neonicotinoids on insect pests. *Entomologia Generalis*, 44: 1145-1160.
- Vallad, G.E., Messelink, G., & Smith, H.A. (2018). Crop protection: Pest and disease management. Boston, MA, USA: CAB International. pp. 207-257.
- Wei, J., Wang, X., Tu, C., Long, T., Bu, Y., Wang, H., Jeyakumar, P., Jiang, J. and Deng, S. (2023). Remediation technologies for neonicotinoids in contaminated environments: Current state and

- future prospects. *Environment International*, 178: 108044.
- Yousafi, Q., Afzal, M., & Aslam, M. (2015). Management of brinjal shoot and fruit borer, *Leucinodes orbonalis* Guenee, with selected insecticides. *Pakistan Journal of Zoology*, 47: 1413-1420.
- Yousafi, Q., Afzal, M., Aslam, M., Razaq, M., & Shahid, M. (2013). Screening of brinjal (*Solanum melongena* L.) varieties sown in autumn for resistance to cotton jassid, *Amrasca bigutulla bigutulla* (Ishida). *Pakistan Journal of Zoology*, 45: 897-902.
- Yousafi, Q., Afzal, M., Aslam, M. (2016a) Screening of brinjal (*Solanum melongena* L.) varieties for resistance to brinjal shoot and fruit borer (*Leucinodes orbonalis* G.). *Pakistan Journal of Zoology*, 48: 1649-1663.

Disclaimer/Publisher's Note: The views, opinions, and data presented in all publications are exclusively those of the respective author(s) and contributor(s) and do not reflect the stance of Pagepal or its editorial team. Pagepal and the editor(s) disclaim any responsibility for harm to individuals or damage to property resulting from the use of any ideas, techniques, instructions, or products mentioned in the content.