



RESEARCH ARTICLE

Bioefficacy of botanical and chemical insecticides against brown planthopper, *Nilaparvata lugens* (Stal) (Hemiptera: Delphacidae), in paddy crop

Kamaldeep Singh Matharu* & Shubham Anand

Krishi Vigyan Kendra (Moga), Punjab Agricultural University, Ludhiana 142 001, Punjab, India

*Correspondence email - kmatharu@pau.edu

Received: 28 January 2026; Accepted: 05 May 2026; Available online: Version 1.0: 27 August 2026

Cite this article: Kamaldeep SM, Shubham A. Bioefficacy of botanical and chemical insecticides against brown planthopper, *Nilaparvata lugens* (Stal) (Hemiptera: Delphacidae), in paddy crop. Plant Science Today (Early Access). <https://doi.org/10.14719/pst.13877>

Abstract

The present study was conducted to evaluate the bioefficacy of botanical and chemical insecticides against brown planthopper, *Nilaparvata lugens* (Stal), in paddy. The experiment was conducted using the following treatments Azadirachtin 5 % (60, 70 and 80 mL), Brahamastra (7.5, 10.0 and 12.5 L), homemade neem (2.0, 3.0 and 4.0 L), Oshean 20 SG (80 g) and an untreated control. Two sprays were applied, the first at the initial appearance of the pest and the second at the economic threshold level (ETL). Oshean 20 SG (80 g) recorded the lowest brown planthopper population and the maximum percentage reduction over the control after both sprays. Among different treatments, Azadirachtin (5 %) at 80 mL dose recorded lowest brown planthopper population. All botanical insecticides were safe for the spider population. Grain yield was recorded higher in Oshean 20 SG treatment followed by the botanical insecticides. Azadirachtin 80 mL proved to be the most effective and environment friendly alternative for brown planthopper management in paddy.

Keywords: azadirachtin; botanical insecticides; brown planthopper; eco-friendly; paddy; sustainable agriculture

Introduction

Punjab plays a crucial role in India's overall rice production despite covering a small fraction of India's geographical area. It contributes nearly 28 % of rice to the country's central pool (1). Paddy, being short-day plant, is grown in regions of high temperature, high humidity, long sunshine hours and assured rainfall (2). In Punjab, it covered an area of 31.79 lakh hectares with an annual production of 14.56 lakh tonnes in 2023-24 and an average yield of 67.40 quintals per hectare (3). A temperature range of 20-37.5 °C facilitates optimum growth of paddy, while tillering stage requires a relatively higher temperature than the early growth stage under Punjab conditions. The flowering stage requires temperature range of 26.5-29.5 °C. The humidity range is 83-85 % and 67-68 % for the early- and late-sown varieties respectively (3). The paddy crop is attacked by more than 100 species of insects and 20 of them can cause economic damage. The brown planthopper, *Nilaparvata lugens* (Stal), a small brownish, sap-sucking insect-pest is regarded as one of the most damaging pests of paddy (*Oryza sativa* L.) in Asia (2, 4). It requires maximum and minimum temperature in the range 30.2-33.4 °C and 20.6-22.5 °C, while relative humidity must be in the range of 86-90 % in the morning and 48-60 % in the evening for its high abundance. Hot, cloudy and humid conditions are conducive to brown planthopper multiplication (4). Both the nymph and adult stages of this pest directly damage the crop by sucking sap from the xylem and phloem, which leads to yellowing, wilting, drying up and ultimately the death of rice plant. Under severe conditions, the damage

spreads in a circular fashion, a condition referred to as "hopper-burn". It causes indirect damage by transmitting grassy stunt virus and reducing protein content in the leaves (5).

The insect caused heavy damage in year 2016 and its significant buildup compelled farmers to harvest crop prematurely in Punjab (6). Yield losses of up to 60 % have been reported under epidemic conditions (7). Monitoring this pest is a very difficult task and significant yield loss is inevitable by the time plant damage becomes evident. Farmers can manage this pest effectively by regular monitoring of the paddy field, followed by need-based application of recommended insecticides (8). Besides the recommendation of numerous insecticides for the control this insect, many conventional insecticides have failed to provide adequate control. Application of non-recommended insecticides for the control of this insect disrupts the ecological balance and causes pest resurgence and the development of multiple insecticide resistance (9).

Botanicals have been used for controlling agricultural pests in ancient civilisations such as China, Egypt, Greece and India (10, 11). Traditional pest control strategies using botanicals prepared from whole plant material or extracts in field crops and during storage are still common among many farmers (12). More than 2500 plant species belonging to 235 families have been reported globally to have detrimental effects on agricultural pests (13, 14). The supporting evidence for the use of botanicals is primeval and their effectiveness needs re-evaluation. Some botanicals used for controlling pests may be devoid of active ingredients and may not

control pests effectively. Moreover, results may be inconsistent due to variations in active ingredient concentration, the concentration in the plant material used and the preparation method (15). Finally, their toxicity to natural enemies has often not been evaluated. Therefore, the present study was planned to evaluate the bioefficacy of various botanical and chemical insecticides against the brown planthopper in paddy under conventional cultivation.

Materials and Methods

The present investigation was conducted to study bioefficacy of various botanical and chemical insecticides against brown planthoppers on paddy under conventional conditions during kharif 2021 in Faridkot district of Punjab by Krishi Vigyan Kendra. Faridkot (30°68' N latitude and 74°76' E longitude) is a part of the south-western region of Punjab, having a semi-arid climate and falls under agroclimatic zone IV of Punjab (Fig. 1). In general, this region is characterised by hot and dry weather with a short rainy season. Additionally, the region experiences high temperatures during March to June. The annual rainfall is 420 mm, out of which >70 % is received during southwest monsoon season (June–September). The period from the second fortnight of September to October experiences low rainfall. The cold season extends from November to March. The soil of the district is sandy loam in texture. The experiments were laid out in randomised complete block design (RCBD) using variety PR 114 with insecticide treatments viz. Azadirachtin 5 % (60, 70 and 80 mL), Brahamastra (7.5, 10 and 12.5 L), homemade neem (2, 3 and 4 L), Oshean 20 SG (80 g) (dinotefuran) along with an untreated control, with 3 replications.

All these insecticides were applied with knapsack sprayers. The first spray was given on the appearance of the pest, while the second spray was given on economic threshold level (ETL) of five brown planthopper per hill. The brown planthopper population (adult and nymphs) were recorded one day before spray (DBS) on the 3rd, 7th and 10th days after spray (DAS). The observations were recorded from randomly selected 10 hills in each treatment field. The total count of brown planthopper population was averaged and expressed on a per hill basis. The percent reduction over control was calculated using following formula:

$$\text{Percent reduction over control} = \frac{(\text{Brown planthopper population in control} - \text{Brown planthopper population in treatment})}{\text{Brown planthopper population in control}} \times 100$$

The spider population was also recorded after both sprays of the different insecticides. The data thus obtained from the field experiments were analysed statistically by analysis of variance (ANOVA) at five level of significance. The grain yield of different treatments was also calculated and analysed. Microsoft excel was used for preparing graphs.

Results

Brown planthopper population at first spray of different insecticides

Differences in BPH populations were statistically non-significant before spraying, implying uniform pest incidence across all plots at the initiation of the experiment. After the first spray, all treatments resulted in a reduction in planthopper population compared to the untreated control. Among the botanical insecticides, Azadirachtin 5 % (80 mL/acre) recorded a decrease in brown planthopper population at 3 DAS (3.33 brown planthopper/hill), 7 DAS (2.53 brown planthopper/hill) and 10 DAS (2.23 brown planthopper/hill). The highest percent reduction over control was observed as 44.17 % at 10 DAS, compared to 12.28 % and 34.48 % at 3 and 7 DAS respectively (Fig. 2 and 3). Lower doses (60 and 70 mL/acre) also reduced the brown planthopper population but were comparatively less effective than 80 mL/acre. Brahamastra treatment also reduced brown planthopper population at 10 and 12.5 L/acre doses. The reduction in brown planthopper population occurred at a comparatively slower rate and was less efficient than Azadirachtin. Homemade neem formulations at higher doses also suppressed brown planthopper population. Oshean 20 SG caused maximum reduction in brown planthopper population from 3.53 brown planthopper/hill (before spray) to 1.30 brown planthopper/hill (10 DAS), along with the highest reduction of 29.82 %, 47.41 % and 67.50 % at 3, 7 and 10 DAS. However, in the untreated control, a gradual increase in brown planthopper population over time, highlighting unchecked pest multiplication.

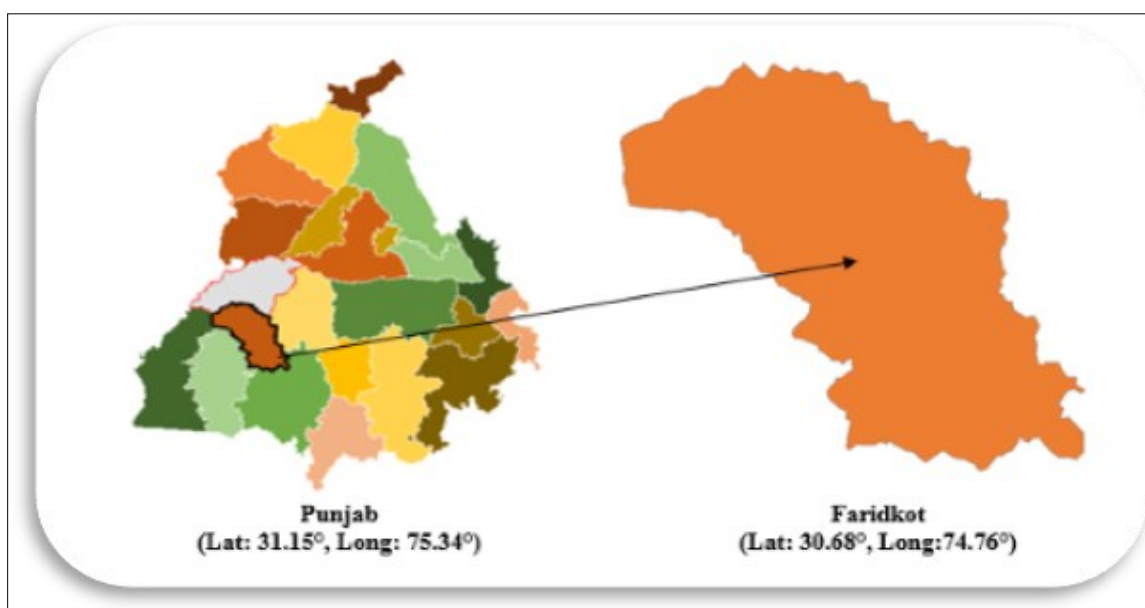


Fig. 1. Study area: Faridkot, Punjab.

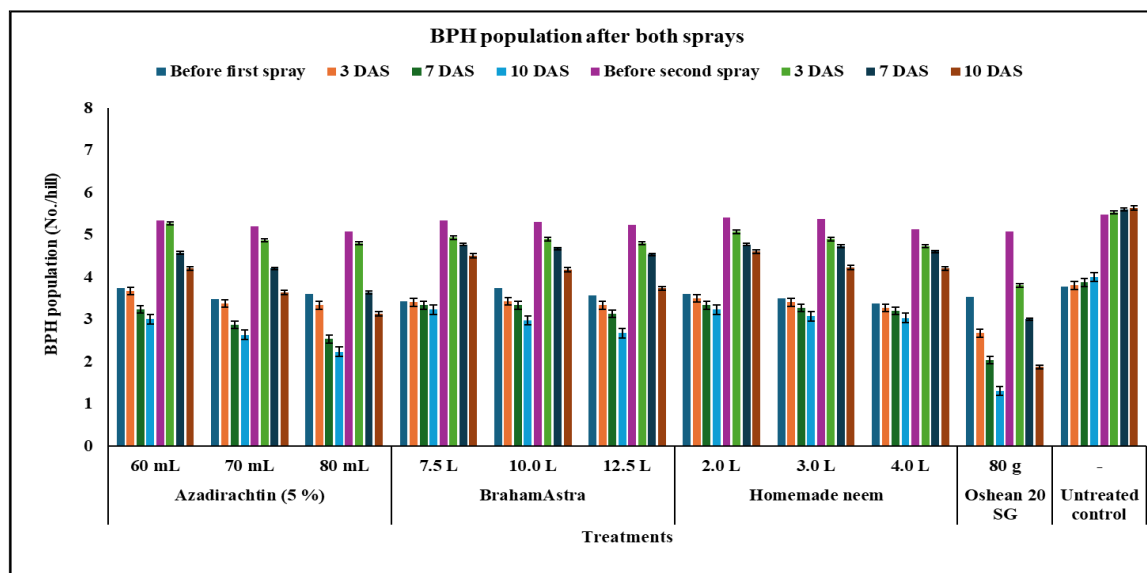


Fig. 2. Brown planthopper population after both sprays of different bio-rational insecticide treatments.

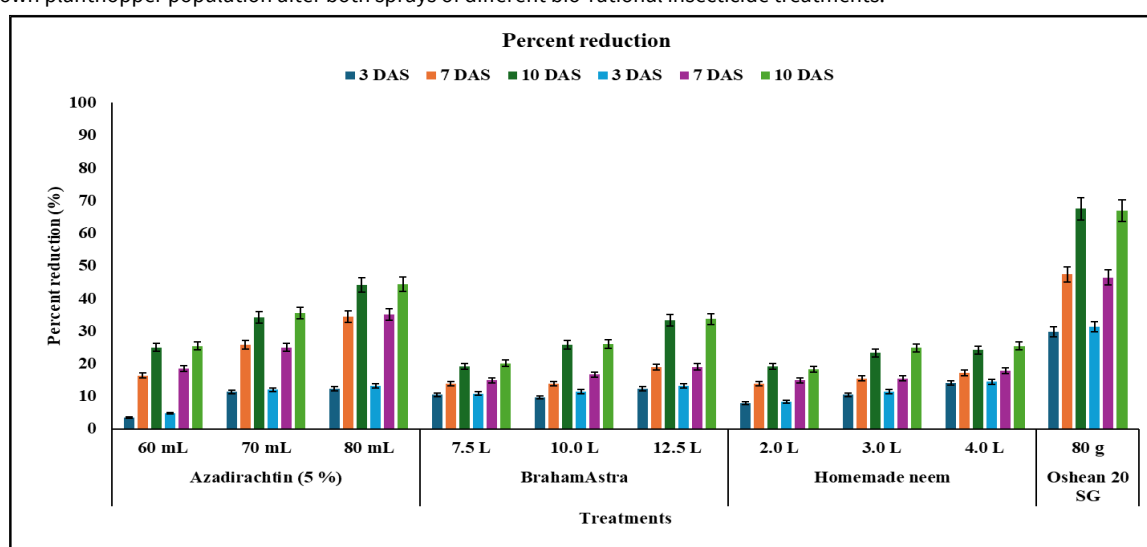


Fig. 3. Percent reduction in brown planthopper population after both sprays of different bio-rational insecticide treatments.

Brown planthopper population at second spray of different insecticides

The pre-spray population of planthoppers did not differ significantly among treatments, confirming uniform pest incidence at the time of the second spray. After the second spray, all treatments recorded a decrease in brown planthopper population over the untreated control. Among botanical insecticides, Azadirachtin (5 %) at the highest dose (80 mL/acre) reduced brown planthopper population at 3 DAS (4.80 brown planthopper/hill), 7 DAS (3.63 brown planthopper/hill) and 10 DAS (3.13) DAS. The percent reduction over time was observed as 13.25 % (3 DAS), 35.12 % (7 DAS) and 44.38 % (10 DAS) respectively. Brahmastra and homemade neem formulations provided moderate control of planthoppers. Increasing the dose enhanced their effectiveness, but their overall performance remained statistically less than Azadirachtin at higher doses. Oshean 20 SG recorded the lowest brown planthopper population and highest percent reduction over control at all observation intervals, whereas an increase in brown planthopper population was observed in the untreated control.

Spider population after both sprays of different insecticides

Across the treatments, the spider population (No./plant) showed clear differences. The Azadirachtin (5 %) treatments (60–80 mL)

and Brahamastra doses (7.5–12.5 L) maintained moderate to high spider activity (0.17–0.30) throughout both spray cycles. Similarly, spider populations ranging between 0.20 and 0.30 were observed in the homemade neem formulations (2.0–4.0 L) after both sprays, with values remaining relatively stable, indicating minimal adverse effects (Fig. 4). In contrast, the Oshean 20 SG (80 g) treatment caused a sharp and continuous decline in spider population, falling from 0.27 before spray to only 0.03 at 10 DAS after the first spray and from 0.13 to 0.03 at 10 DAS after the second spray, demonstrating the highest negative impact on predatory spiders. The untreated control-maintained spider populations similar to those in the safer treatments (0.23–0.30), confirming natural stability without chemical interference.

Yield

A higher grain yield was recorded in all the treatments compared to the untreated control. Oshean 20 SG recorded the highest yield (28.9 q/acre), owing to better reduction of the brown planthopper population compared to the other treatments (Fig. 5). Azadirachtin (80 mL/acre) recorded a higher grain yield than the 60 mL/acre dose but was statistically ($p = 0.05$) at par with the 70 mL/acre dose. Brahamastra (12.5 L) recorded a significantly ($p = 0.05$) higher grain yield compared to the lower doses, whereas all the doses of homemade neem were statistically at par with each other.

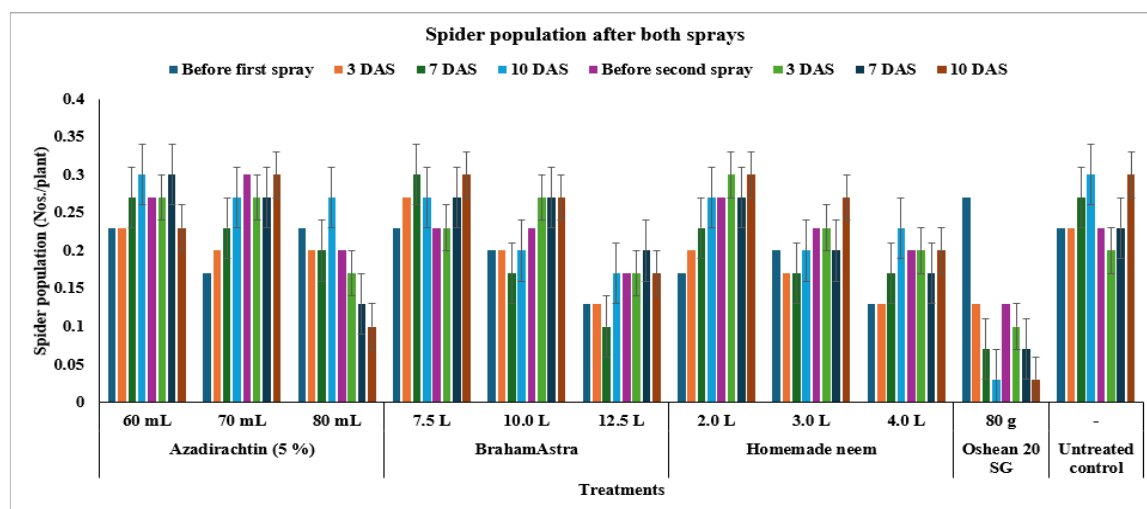


Fig. 4. Spider population after both sprays of different bio-rational insecticide treatments.

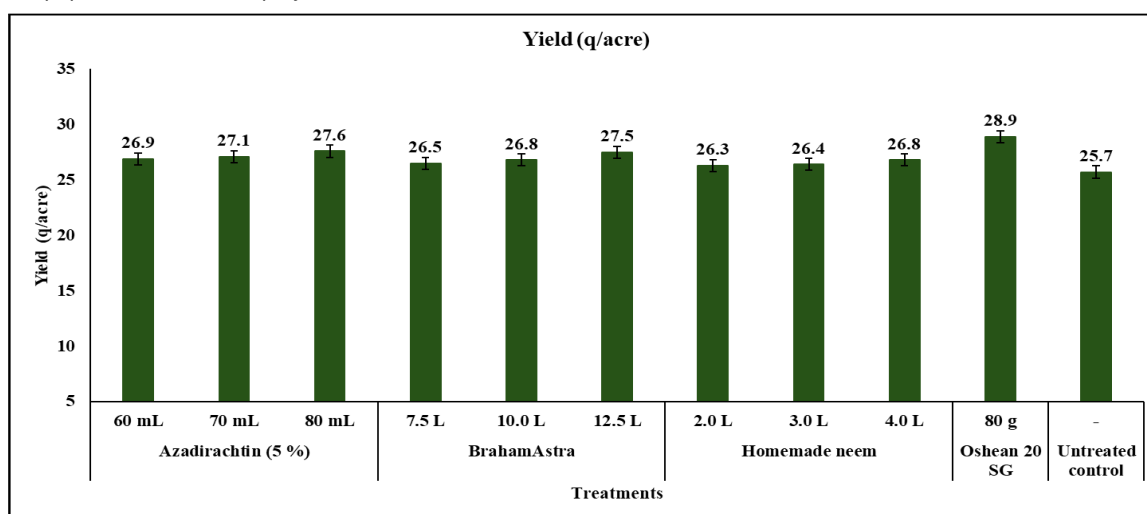


Fig. 5. Grain yield of rice under different bio-rational insecticide treatments.

Discussion

All insecticides significantly decreased brown planthopper population in compared to the untreated control. Differences in pre-spray brown planthopper population were non-significant owing to uniform insect pressure. Azadirachtin (5 %) at 80 mL/acre caused maximum suppression of the brown planthopper population after both sprays. The gradual increase in percent reduction over control from 3 to 10 DAS indicates a slow-acting but persistent insecticidal action. Similar toxicity of Azadirachtin has been reported with almost 100 % nymphal mortality observed at 0.5 ppm and higher concentrations (16). When higher concentrations were applied, the effects appeared shortly after treatment and mortality was higher. Many insects died after remaining inactive for several days or during prolonged moulting. At lower concentrations, if moulting was achieved, disturbed growth and abnormalities were likely to occur during the moulting process. The insecticidal property of neem is due to the presence of limonoids. Azadirachtin A is most active compound, but other limonoids may contribute to the efficacy of neem insecticides and may even prevent resistance build-up against azadirachtin A (17, 18). BrahmaAstra and homemade neem formulations also decreased the brown planthopper population with efficiency improving at higher concentrations. The comparatively lower performance of homemade neem extract and BrahmaAstra than formulated Azadirachtin could be explained by differences in stability and standardisation. These biopesticides are more prone to rapid degradation under field conditions, which may

limit their residual activity. Moreover, while the presence of active compounds is known, their exact concentration in such preparations is not determined, resulting in variability in effectiveness. Effective control of insects pests of importance in the paddy crop has also been reported (19). Homemade aqueous extracts of neem plant material (leaves, seeds, seed cake and unformulated oil) have been successfully used for control of hemipteran insects and are well documented in the literature (20–22). Oshean 20 SG caused the maximum reduction in the brown planthopper population, confirming its rapid insecticidal action. The spider population data clearly revealed that botanical insecticides were safer to natural enemies than chemical insecticide. Botanical insecticides maintained an optimum balance between effective brown planthopper control, natural enemy safety and yield. Thus, use of botanical insecticides is promising alternative sustainable paddy pest management.

Conclusion

All insecticide treatments significantly suppressed brown planthopper populations compared to the untreated control after both sprays. However, Azadirachtin 5 % at 80 mL/acre consistently proved the most effective botanical, recording the lowest brown planthopper population and highest percent reduction of control among the botanical options at all observation intervals. Botanical

treatments were observed relatively safer to predatory spiders, maintaining moderate to high spider populations after both sprays. Azadirachtin may be effectively incorporated into integrated pest management (IPM) as a key component of botanical-based insecticide strategies for the management of brown planthoppers.

Acknowledgements

The authors sincerely acknowledge the Head, School of Organic Farming, Punjab Agricultural University, Ludhiana, for providing botanical and chemical insecticides used in this study.

Authors' contributions

KSM carried out the field experiments and data collection. SA and KSM done data analysis and prepared the manuscript. Both authors have read and approved the final manuscript.

Compliance with ethical standards

Conflict of interest: Authors do not have any conflict of interest to declare.

Ethical issues: None

References

- Majumder A, Dhaliwal LK. Assessment of phenology and agro-climatic indices of direct-seeded and transplanted rice crop under Punjab conditions. *J Agric Phys*. 2024;24:56–66.
- Dhaliwal LK, Anand S, Suri KS. Effect of row spacing on brown planthopper incidence in basmati rice under Punjab conditions. *Int J Environ Clim Change*. 2024;14:191–206. <https://doi.org/10.9734/ijecc/2024/v14i34032>
- Anonymous. Package of practices for the crops of Punjab. Ludhiana: Punjab Agricultural University; 2025. p. 2.
- Anand S, Dhaliwal LK, Suri KS. Effect of different meteorological parameters on seasonal abundance of rice brown planthopper under Punjab conditions. *Agric Res J*. 2023;60:52–8. <https://doi.org/10.5958/2395-146X.2023.00009.1>
- Matharu KS, Tanwar PS. Efficacy of different insecticides against brown planthopper, *Nilaparvata lugens* (Stål) in rice. *Int J Chem Stud*. 2020;8:870–3. <https://doi.org/10.22271/chemi.2020.v8.i3k.9310>
- Anonymous. Crop devastation: after whitefly, brown planthopper turns nemesis for Punjab's farmers. *Indian Express*; 2016.
- Kumar H, Maurya RP, Tiwari SN. Studies on antibiosis mechanism of resistance in rice against brown planthopper, *Nilaparvata lugens* (Stål). *Ann Plant Prot Sci*. 2012;28:98–101.
- Sarao PS. Integrated management of insect-pests of rice and basmati. *Prog Fmg*. 2015;51:9–12.
- Matsumura M, Morimura SS. Recent status of insecticide resistance in Asian planthoppers. *JARQ*. 2010;44:225–30. <https://doi.org/10.6090/jarq.44.225>
- Isman MB. Botanical insecticides, deterrents and repellents in modern agriculture and an increasingly regulated world. *Annu Rev Entomol*. 2006;51:45–66. <https://doi.org/10.1146/annurev.ento.51.110104.151146>
- Matharu KS, Mehta PK. Antifeedant and ovipositional deterrent activity of medicinal plants of western Himalaya on *Plutella xylostella*. *J Environ Biol*. 2018;39:966–72. <https://doi.org/10.22438/jeb/39/6/MRN-559>
- Belmain S, Stevenson PC. Ethnobotanicals in Ghana: reviving and modernising age-old farmer practice. *Pestic Outlook*. 2001;12:233–8. <https://doi.org/10.1039/b110542f>
- Roy S, Handique G, Muraleedharan N, Dashora K, Roy SM, Mukhopadhyay A, et al. Use of plant extracts for tea pest management in India. *Appl Microbiol Biotechnol*. 2016;100:4831–44. <https://doi.org/10.1007/s00253-016-7522-8>
- Stevenson PC, Isman MB, Belmain SR. Pesticidal plants in Africa: a global vision of new biological control products from local uses. *Ind Crops Prod*. 2017;110:2–9. <https://doi.org/10.1016/j.indcrop.2017.08.034>
- Sarasan V, Kite GC, Sileshi GW, Stevenson PC. Applications of phytochemical and *in vitro* techniques for reducing over-harvesting of medicinal and pesticidal plants and generating income for the rural poor. *Plant Cell Rep*. 2011;30:1163–72. <https://doi.org/10.1007/s00299-011-1047-5>
- Nathan SS, Choi MY, Paik CH, Seo HY, Kim JD, Kang SM. The toxic effects of neem extract and azadirachtin on the brown planthopper, *Nilaparvata lugens* (Stål) (Homoptera: Delphacidae). *Chemosphere*. 2007;67:80–8. <https://doi.org/10.1016/j.chemosphere.2006.09.045>
- Boursier CM, Bosco D, Coulibaly A, Negre M. Are traditional neem extract preparations as efficient as a commercial formulation of azadirachtin A? *Crop Prot*. 2011;30:318–22. <https://doi.org/10.1016/j.cpro.2010.11.022>
- Lynn OML. Effects of azadirachtin and neem-based formulations for the control of sweet potato whitefly and root-knot nematode. *J Korean Soc Appl Biol Chem*. 2010;53:598–604. <https://doi.org/10.3839/jksabc.2010.092>
- Chandraker M, Chandrakar G, Kumar B, Patel R. Bio-efficacy of plant-based materials against major insect pest under organic rice cultivation system. *Int J Adv Biochem Res*. 2025;9:488–94. <https://doi.org/10.33545/26174693.2025.v9.i9g.5679>
- Aziz MA, Ahmad M, Nasir MF. Efficacy of different neem (*Azadirachta indica*) products in comparison with imidacloprid against English grain aphid (*Sitobion avenae*) on wheat. *Int J Agric Biol*. 2013;15:279–84.
- Degri M, Mailafiya D, Wabekwa J. Efficacy of aqueous leaf extracts and synthetic insecticide on pod-sucking bugs infestation of cowpea (*Vigna unguiculata* (L.) Walp) in the Guinea Savanna Region of Nigeria. *Adv Entomol*. 2013;1:10–4. <https://doi.org/10.4236/ae.2013.12003>
- Gupta MP, Pathak RK. Bioefficacy of neem products and insecticides against the incidence of whitefly, yellow mosaic virus and pod borer in black gram. *Nat Prod Radiance*. 2009;8:133–6.

Additional information

Peer review: Publisher thanks Sectional Editor and the other anonymous reviewers for their contribution to the peer review of this work.

Reprints & permissions information is available at https://horizonpublishing.com/journals/index.php/PST/open_access_policy

Publisher's Note: Horizon e-Publishing Group remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Indexing: Plant Science Today, published by Horizon e-Publishing Group, is covered by Scopus, Web of Science, BIOSIS Previews, Clarivate Analytics, NAAS, UGC Care, etc
See https://horizonpublishing.com/journals/index.php/PST/indexing_abstracting

Copyright: © The Author(s). This is an open-access article distributed under the terms of the Creative Commons Attribution License, which permits unrestricted use, distribution and reproduction in any medium, provided the original author and source are credited (<https://creativecommons.org/licenses/by/4.0/>)

Publisher information: Plant Science Today is published by HORIZON e-Publishing Group with support from Empirion Publishers Private Limited, Thiruvananthapuram, India.