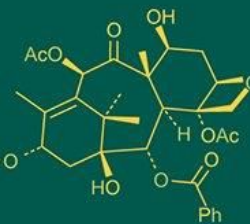


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Behavioral and antibiosis effects of non-edible seed oils and essential oils on the brown plant hopper, *Nilaparvata lugens* (stal)

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Abstract

The brown plant hopper (*Nilaparvata lugens* Stal) is a key sap-sucking pest of rice, responsible for severe yield losses due to feeding damage and hopper burn. The present investigation was conducted to study the behavioral responses and antibiosis effects of selected essential oils and non-edible seed oils against *N. lugens*. Repellency or attractancy responses were assessed using a six-arm olfactometer, while feeding deterrence was evaluated through probing mark tests on TN1 rice seedlings. Essential oils tested included eucalyptus, cedarwood, lemongrass, citronella, and camphor, whereas non-edible seed oils comprised neem, pongamia, jatropha, mahua, and annona. Results revealed that neem oil among non-edible seed oils and eucalyptus oil among essential oils were least preferred by brown plant hopper adults, indicating strong repellent activity. Neem oil induced the highest number of probing marks, suggesting pronounced antifeedant and antibiosis effects. Essential oils also significantly altered probing behavior compared to the control. The study demonstrates that plant-derived oils can disrupt host selection and feeding behavior of *N. lugens* and may serve as eco-friendly alternatives for inclusion in integrated pest management programs in rice.

Keywords: Brown plant hopper, *Nilaparvata lugens*, essential oils, non-edible seed oils, repellency, antibiosis, olfactometer, rice

Introduction

Rice is one of the most important staple food crops cultivated worldwide, particularly in Asia, where it sustains a large proportion of the human population. Productivity of rice is severely affected by insect pests, among which the brown plant hopper, *Nilaparvata lugens* Stal, is recognized as a major constraint. Both nymphs and adults feed on phloem sap, causing hopper burn symptoms, plant wilting and drying, and in severe infestations, complete crop failure. The pest is also an efficient vector of viral diseases, resulting in substantial yield and economic losses in rice-growing regions (Sogawa *et al.*, 2009; Heong and Hardy, 2009) [3, 9].

Chemical insecticides have been widely adopted for the management of brown plant hopper; however, their excessive and repeated use has led to several negative consequences such as rapid development of resistance, pest resurgence, disruption of ecological balance, and adverse effects on non-target organisms (Tanaka *et al.*, 2000; Wu *et al.*, 2011) [10, 12]. Reports of resistance to multiple insecticide groups in *N. lugens* populations across Asia have raised serious concerns regarding the sustainability of chemical-based control strategies (Zhang *et al.*, 2014) [13].

In recent years, botanical products including essential oils and non-edible seed oils have attracted attention as alternative pest management tools due to their eco-friendly nature, rapid biodegradability, and low mammalian toxicity. These plant-derived oils exert multiple effects on insects such as repellency, feeding inhibition, growth disruption, and antibiosis, thereby reducing the likelihood of resistance development (Pavela, 2007; Nerio *et al.*, 2010) [6, 7]. Essential oils are known to affect insect sensory perception by interfering with olfactory and gustatory receptors, leading to altered host selection and feeding behavior (Bruce *et al.*, 2005) [1].

Behavioral bioassays such as olfactometer studies are effective tools for evaluating insect responses to volatile compounds,

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while probing mark techniques provide insights into feeding behavior and host acceptance. Despite the increasing interest in botanical oils, detailed information on the combined behavioral and probing responses of *N. lugens* to essential oils and non-edible seed oils remains limited. Therefore, the present study was undertaken to evaluate the repellency, attractancy, and probing behavior of *N. lugens* in response to selected plant-derived oils, with the objective of identifying eco-friendly alternatives for brown plant hopper management in rice ecosystems.

Materials and Methods

Olfactometer Bioassay

Repellency or attractancy studies were conducted using a six-arm olfactometer. Essential oils, namely eucalyptus, cedarwood, lemongrass, citronella, and camphor, were tested at a dose of 10 μ l, while non-edible seed oils including neem, pongamia, jatropha, mahua, and annona were tested at 50 μ l. The oils were applied to cotton swabs using a micropipette and placed individually in different arms of the olfactometer.

Twenty adult brown plant hoppers were released at the center of the olfactometer using an aspirator. The apparatus was covered with a black cloth to minimize external disturbances, and airflow was maintained using a pressure machine. Insect movement toward or away from different arms was observed for 15 minutes. Percentage response and approaching time were recorded.

Probing Mark Test

The probing mark test was conducted following the method suggested by Naito (1964) [5]. Seeds of the susceptible rice variety TN1 were germinated in petri dishes and later transplanted into wooden trays containing puddled soil. Seven-day-old seedlings were carefully removed, washed, and transferred individually into test tubes containing a few drops of water.

One- to two-day-old female brown plant hoppers were introduced individually into each test tube and allowed to feed for 12 hours. The tubes were plugged with sterilized cotton swabs. After feeding, the seedlings were stained in 1.0% erythrosine aqueous solution for 30 minutes, and probing marks were counted visually. Five replications were maintained for each treatment.

Statistical Analysis

All observations were recorded systematically and analyzed statistically using a completely randomized design (CRD). Appropriate data transformation was applied wherever necessary to ensure normality.

Results and Discussion

Behavioral Response of *Nilaparvata lugens* to Non-Edible Seed Oils in Six-Arm Olfactometer

The behavioral response of adult female *Nilaparvata lugens* to different non-edible seed oils showed significant variation in the six-arm olfactometer assay (Table 1). Among the treatments, neem oil was the least preferred, attracting only 5.0% of the insects, followed by jatropha (8.5%), pongamia (15.0%), mahua (15.0%) and annona oil (23.5%). In contrast, the untreated control recorded the highest attraction (30.0%). The shortest approaching time was observed in neem oil (18.0 min), indicating a strong repellent effect.

The reduced attraction and delayed movement toward neem-treated arms suggest disruption of host-finding behavior due to volatile bioactive compounds present in the oil. The preference pattern of brown plant hopper adults to different non-edible seed oils is clearly illustrated in Fig. 1, which highlights the pronounced repellency of neem oil. Similar olfactory-mediated repellency effects of plant oils have been reported earlier, where volatile compounds interfere with insect sensory perception and host recognition.

Effect of Non-Edible Seed Oils on Probing Behaviour of *Nilaparvata lugens*:

Significant differences were observed in the probing behavior of *N. lugens* females on rice seedlings treated with non-edible seed oils (Table 2). Neem oil recorded the highest number of probing marks (35.40 per seedling), followed by jatropha oil (26.60), pongamia oil (24.80) and annona oil (23.40). Mahua oil showed comparatively fewer probing marks (19.80), while the control recorded the lowest probing activity (14.80).

Increased probing marks indicate repeated feeding attempts caused by feeding deterrence, suggesting strong antifeedant and antibiosis effects of neem oil. Repeated unsuccessful probing ultimately reduces nutrient intake and negatively affects insect fitness. The effect of non-edible seed oils on probing behavior is graphically represented in Fig. 2, which clearly demonstrates the superior antibiosis effect of neem oil compared to other treatments.

Behavioral Response of *Nilaparvata lugens* to Essential Oils in Six-Arm Olfactometer:

Essential oils also significantly influenced the behavioral responses of *N. lugens* adults in the olfactometer assay (Table 3). Among the essential oils tested, eucalyptus oil was the least preferred, attracting only 5.0% of insects, followed by lemongrass (10.0%), citronella (12.5%), cedarwood (15.0%) and camphor oil (23.75%). The control recorded the highest attraction (33.7%).

The shortest approaching time was recorded in eucalyptus oil (17.4 min), indicating strong repellency. The reduced attraction toward eucalyptus-treated arms suggests interference with olfactory cues essential for host selection. The preference pattern of brown plant hopper adults toward essential oils is illustrated in Fig. 3, which clearly shows the strong repellent activity of eucalyptus oil. These findings are consistent with earlier reports on the repellency of aromatic plant oils against insect pests due to their volatile constituents.

Effect of Essential Oils on Probing Behaviour of *Nilaparvata lugens*:

Probing behavior of brown plant hopper females was significantly altered by essential oil treatments (Table 4). Eucalyptus oil recorded the highest number of probing marks (31.20), followed by lemongrass (28.00), citronella (27.20), cedarwood (23.50) and camphor oil (21.60). The untreated control recorded the lowest number of probing marks (15.60).

Higher probing activity on oil-treated seedlings indicates feeding deterrence, forcing insects to make repeated attempts to feed. This behavior reflects strong antifeedant and antibiosis effects of essential oils, particularly eucalyptus oil. The effect of essential oils on probing behavior is depicted in Fig. 4, which confirms the significant disruption of feeding behavior compared to the control.

Discussion: The present study demonstrated that both essential oils and non-edible seed oils significantly altered the behavioral and feeding responses of the brown plant hopper, *Nilaparvata lugens*. Neem oil and eucalyptus oil exhibited strong repellency in olfactometer assays, indicating disruption of host-finding behavior through interference with insect olfactory cues (Bruce *et al.*, 2005; Nerio *et al.*, 2010) [1, 6]. The increased number of probing marks on oil-treated seedlings suggests pronounced antifeedant and antibiosis effects, forcing repeated feeding

attempts without successful sap ingestion (Naito, 1964; Reddy *et al.*, 2005) [5, 8]. Similar repellency and feeding deterrence effects of botanical oils against insect pests have been reported earlier (Hori, 2003; Pavela, 2007) [4, 7]. The combined repellency and antibiosis action observed in this study is advantageous for suppressing pest populations while reducing selection pressure for resistance (Wu *et al.*, 2011) [12]. These findings support the potential use of plant-derived oils as eco-friendly components in integrated management of brown plant hopper in rice ecosystems.

Table 1: Olfactometer response of *Nilaparvata lugens* under to Non edible seed oils (Six arm olfactometer)

S.No	Treatment	No. of Insects Approached	Percent of Insects Approached (%)	Percent of Approaching Time (min) (%)
1	Neem oil	1.0 (4.9)	5.0 (11.0)	18.0 (30.3)
2	Jatropha	1.75 (7.5)	8.5 (17.0)	48.2 (40.1)
3	Pongamia	3.0 (9.9)	15.0 (22.6)	63.3 (38.0)
4	Mahua	3.0 (9.9)	15.0 (22.6)	50.0 (46.8)
5	Annona	4.7 (12.5)	23.5 (29.1)	54.9 (48.9)
6	Control	6.0 (14.1)	30.0 (34.6)	54.9 (48.9)
	SEm	0.92	2.1	4.8
	CD	2.76	6.30	14.95

Figures in the parentheses are square root transformed value.

Table 2: Effect of non edible seed oils on probing behaviour of *Nilaparvata lugens*

S.No	Treatment	Average No. of Probing Marks
1	Neem oil	35.40 (26.60)
2	Jatropha oil	26.60 (24.77)
3	Pongamia oil	24.80 (20.87)
4	Mahua oil	19.80 (17.25)
5	Annona oil	23.40 (21.47)
6	Control	14.80 (12.74)
	SEm	0.85
	CD	2.57

Table 3: Olfactory response of brown plant hopper (*Nilaparvata lugens*) to essential oils in six arms olfactometer

S.No	Treatment	No. of Insects Approached	Percent of Insects Attracted (%)	Percent of Approaching Time (%)
1	Eucalyptus oil	1.00 (4.9)	5.00 (6.7)	17.40 (18.6)
2	Lemon grass oil	2.00 (7.9)	10.00 (15.3)	46.60 (43.0)
3	Citronella oil	2.20 (9.0)	12.50 (17.9)	63.30 (52.7)
4	Cedar wood oil	3.00 (9.9)	15.00 (16.3)	56.30 (48.8)
5	Camphor oil	4.75 (12.5)	23.75 (16.3)	50.80 (45.9)
6	Control	6.75 (15.0)	33.70 (15.8)	49.90 (44.9)
	SEm	0.5	1.6	4.7
	CD	1.6	5.0	14.3

Figures in the parentheses are square root transformed value.

Table 4: Effect of non edible seed oils on probing behaviour of brown plant hopper (*Nilaparvata lugens*)

S.No	Treatment	Average No. of Probing Marks
1	Eucalyptus oil	31.20 (26.04)
2	Lemon grass oil	28.00 (24.42)
3	Citronella oil	27.20 (23.39)
4	Cedar wood oil	23.50 (21.60)
5	Camphor oil	21.60 (20.29)
6	Control	15.60 (16.50)
	SEm	0.78
	CD	2.35

Figures in the parentheses are square root transformed value.

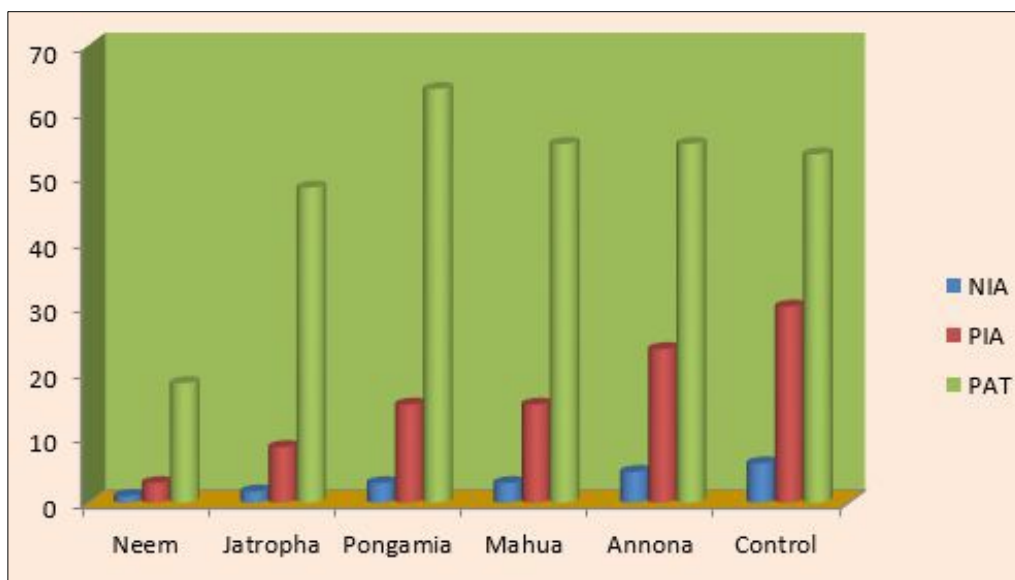


Fig 1: Preference of brown plant hopper to non edible seed oils in six arms olfactometer study

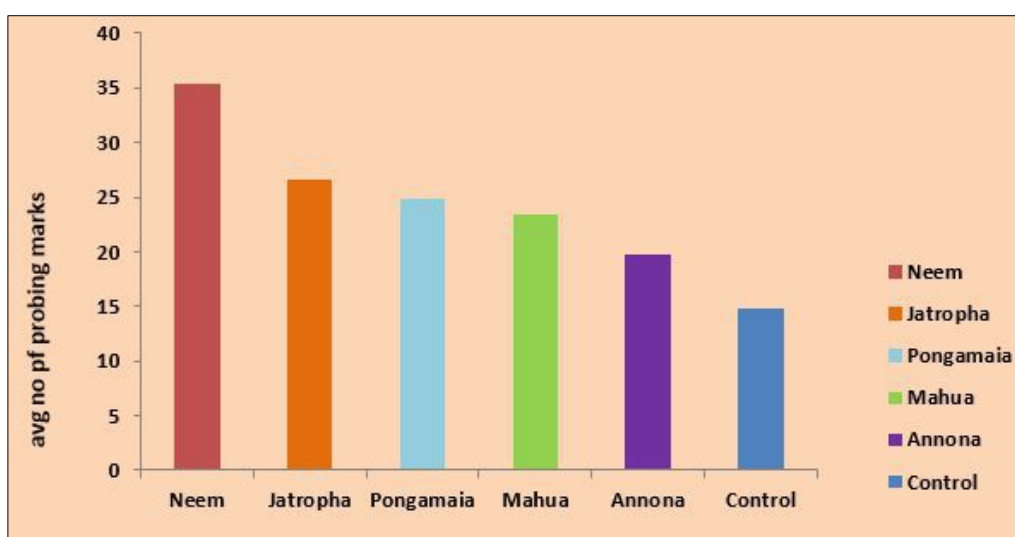


Fig 2: Effect of non edible seed oils on probing behavior of brown plant hopper

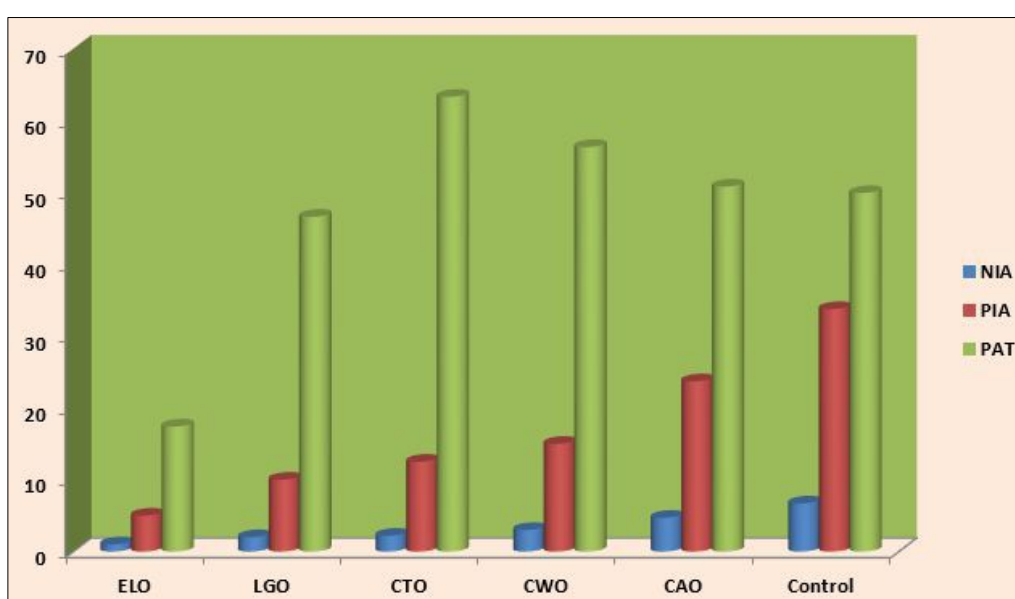


Fig 3: Preference of brown plant hopper to essential oils in six arms olfactometer study

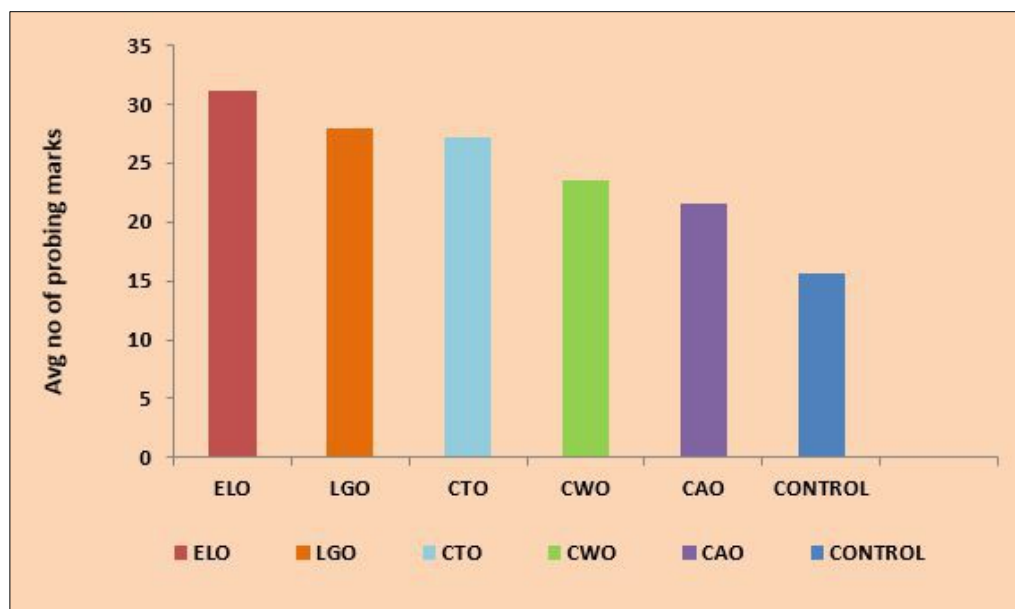


Fig 4: Effect of non edible seed oils on probing behavior of brown plant hopper

Conclusions

The present study clearly demonstrates that both essential oils and non-edible seed oils significantly affect the behavioral and feeding responses of brown plant hopper. Neem oil among non-edible seed oils and eucalyptus oil among essential oils exhibited strong repellent and antifeedant properties. These plant-derived oils disrupt host selection and feeding behavior of *N. lugens* and offer promising eco-friendly alternatives for incorporation into integrated pest management strategies in rice.

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