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Studies on the Biological Parameters of Brown Planthopper (*Nilaparvata lugens* Stal) on Oil-Treated Rice Plants

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Abstract

The brown planthopper (*Nilaparvata lugens* Stal) is a major sap-feeding pest of rice, responsible for severe yield losses and hopper burn symptoms. The present investigation was carried out to study the influence of selected plant oils on the biological parameters of *N. lugens* when exposed through treated rice plants. Four oils neem, jatropha, eucalyptus, and lemongrass were selected based on preliminary screening and evaluated on the susceptible rice variety TN1 under controlled conditions. The biological parameters studied included pre-oviposition period, incubation period, fecundity, nymphal instars and their duration, total nymphal period, nymphal survival, and adult longevity. Significant variations were observed among oil treatments and the untreated control. Neem oil exhibited the strongest antibiosis effect by significantly prolonging developmental periods, reducing fecundity and nymphal survival, and shortening adult longevity. The findings indicate that botanical oils, particularly neem oil, adversely affect the growth and reproduction of *N. lugens* and may be effectively utilized as eco-friendly components in integrated pest management strategies for rice.

Keywords: Brown planthopper, *Nilaparvata lugens*, rice, botanical oils, neem oil, biological parameters, antibiosis

Introduction

Rice (*Oryza sativa* L.) is one of the most important staple food crops in Asia, providing food security and livelihood to millions of people. Among the insect pests attacking rice, the brown planthopper, *Nilaparvata lugens* Stål, is considered one of the most destructive due to its high reproductive potential and phloem-feeding habit. Both nymphs and adults suck sap from the rice plant, leading to hopper burn symptoms such as yellowing, wilting and drying, and under severe infestations, complete crop failure (Heinrichs and Rapusas, 2009; Bottrell and Schoenly, 2012)^[2, 1]. In addition, *N. lugens* acts as a vector of viral diseases, further aggravating yield losses (Horgan *et al.*, 2015)^[3].

Management of brown planthopper has largely relied on chemical insecticides. However, prolonged and indiscriminate use of insecticides has resulted in the development of resistance, resurgence of pest populations, destruction of natural enemies, and serious environmental and health concerns (Nagata *et al.*, 2008; Bottrell and Schoenly, 2012)^[10, 1]. Resistance to several commonly used insecticides has been widely reported in *N. lugens* populations across Asia, highlighting the limitations of chemical-based control strategies (Matsumura *et al.*, 2009; Wang *et al.*, 2010)^[9, 17].

In this context, botanical oils and plant-derived products have received considerable attention as safer alternatives for pest management. Botanical oils are biodegradable, eco-friendly, and possess multiple modes of action including oviposition deterrence, feeding inhibition, growth regulation, and reduced survival (Isman, 2006; Regnault-Roger *et al.*, 2012)^[5, 13]. Neem-based products and essential oils have been shown to adversely affect development, reproduction and survival of several insect pests, including rice planthoppers (Senthil-Nathan, 2007; Hummelbrunner and Isman, 2011)^[14, 4].

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Although earlier studies have demonstrated the insecticidal and deterrent properties of botanical oils, comprehensive information on their effects on multiple biological parameters of *N. lugens* remains limited. Detailed evaluation of developmental, reproductive and survival parameters is essential to understand their antibiosis potential. Therefore, the present study was undertaken to assess the impact of selected plant oils (neem, jatropha, eucalyptus and lemongrass) on the biological performance of brown planthopper under controlled conditions.

Materials and Methods

Rearing of Brown Planthopper

A continuous supply of brown planthopper was maintained using the susceptible rice variety TN1. TN1 seeds were sown in tin trays used as seed beds at 15-day intervals. Twelve to fifteen-day-old seedlings were transplanted into pots at the rate of four hills per pot, with two seedlings per hill. The plants were allowed to grow for 30-40 days in a glasshouse.

Brown planthopper adults were collected using an aspirator and reared in a controlled temperature room maintained at 26 °C. The insects were introduced into medium-sized mylar cages containing potted TN1 plants. The cages were closed with fine nylon mesh and secured with rubber bands. Gravid females were periodically collected and transferred to fresh cages to maintain a uniform population for experimentation.

Description of Mylar Cage

The mylar cage consisted of a transparent plastic sheet encircling the potted rice plant. The upper opening was covered with a white nylon mesh to prevent insect escape, while an additional opening at the mid-region ensured proper ventilation. The cage allowed free movement of insects while facilitating easy observation and collection.

Experimental Design

Experiments were conducted to study the effect of plant oils on the biological parameters of brown planthopper. Forty-five-day-old TN1 rice plants grown in separate pots were used. A pair of newly emerged adults (one male and one female) was released onto each oil-treated plant for oviposition. After oviposition, females were removed carefully.

Pre-Oviposition Period

Freshly emerged adult pairs were released onto oil-treated plants. Pots were labeled with the date of release and observed daily for oviposition. Rust-colored marks on the stem confirmed egg laying. The period between adult release and the onset of oviposition was recorded as the pre-oviposition period.

Incubation Period

Egg-laid plants were observed daily for nymphal emergence. Newly emerged nymphs were removed and counted daily until no further emergence was observed. The duration between egg laying and nymphal emergence was considered as the incubation period.

Fecundity

Thirty-day-old plants were enclosed in mylar tubes with ventilating windows. One gravid female and one male were introduced into each cage. After five days (120 hours), adults were removed. The emerged nymphs were counted daily. After complete hatching, plants were dissected under a microscope to count unhatched eggs. Total fecundity was calculated as the sum of hatched nymphs and unhatched eggs.

Nymphal Instars and Duration

Nymphs emerging on oil-treated plants were observed daily for exuviae to identify instar changes. The number of nymphal instars and the duration of each instar were recorded.

Nymphal Survival

Ten first- and second-instar nymphs were released onto 30-day-old oil-treated rice plants enclosed in mylar cages. Observations were recorded daily until adult emergence. Nymphal survival percentage was calculated.

Adult Longevity

Freshly emerged adults were observed daily, and mortality of males and females was recorded separately. Longevity was calculated based on survival duration.

Statistical Analysis

All observations were recorded systematically and analyzed statistically using a completely randomized design (CRD) with appropriate data transformation wherever necessary.

Results and Discussion

Effect of Plant Oils on Pre-Oviposition Period and Incubation Period

Plant oil treatments significantly influenced the pre-oviposition and incubation periods of *Nilaparvata lugens* (Table 1). Among the treatments, neem oil recorded the longest pre-oviposition period (3.00 days), followed by eucalyptus oil (2.85 days), whereas the shortest pre-oviposition period was observed in the untreated control (2.00 days). The delay in oviposition indicates strong oviposition deterrent activity of neem oil.

Similarly, the incubation period was significantly prolonged under oil treatments. Neem oil resulted in the maximum incubation period (9.80 days), followed by eucalyptus (9.21 days), lemongrass (9.00 days), and jatropha oil (8.70 days). The control recorded the shortest incubation period (7.42 days). These results suggest that botanical oils interfere with embryonic development. The combined effect of oils on pre-oviposition and incubation periods is illustrated in (Fig. 1)

Effect of Plant Oils on Fecundity

Fecundity of *N. lugens* was significantly reduced in all oil-treated plants compared to the control (Table 1). The highest number of hatched eggs was recorded in the control (73.40 eggs/female), whereas neem oil treatment resulted in the lowest number of hatched eggs (29.20 eggs/female). Eucalyptus and lemongrass oils also caused considerable reduction in egg hatch. The number of unhatched eggs was highest in neem oil treatment, indicating ovicidal or embryotoxic effects. The impact of different oils on fecundity is clearly depicted in (Fig.2), which shows a marked reduction in reproductive potential under oil treatments.

Effect of Plant Oils on Nymphal Instars and Instar Duration

Five nymphal instars were observed in all treatments; however, the duration of each instar varied significantly among treatments (Table 1). Neem oil treatment significantly prolonged the duration of all five instars, resulting in delayed development. Eucalyptus oil also extended instar durations, though to a lesser extent.

In contrast, the control consistently recorded the shortest duration for all instars, indicating normal growth and development. The comparative effect of oils on nymphal instar duration is presented in (Fig. 3)

Effect of Plant Oils on Total Nymphal Duration

Total nymphal duration differed significantly among treatments (Table 1). Neem oil recorded the longest total nymphal period (16.13 days), followed by eucalyptus oil (14.55 days). Lemongrass and jatropha oils showed moderate effects, while the control recorded the shortest total nymphal duration (10.70 days). Prolongation of the nymphal period reflects growth-regulating and antibiosis effects of botanical oils.

Effect of Plant Oils on Nymphal Survival

Nymphal survival percentage was significantly reduced in oil-treated plants compared to the control (Table 1). Neem oil recorded the lowest survival rate (38.57%), followed by eucalyptus oil (45.28%). In contrast, the untreated control recorded the highest survival rate (77.71%). The reduction in survival indicates strong antibiosis effects exerted by plant oils, particularly neem oil. The effect of oils on nymphal survival is graphically represented in (Fig. 4).

Effect of Plant Oils on Adult Longevity

Adult longevity was significantly affected by oil treatments (Table 1). Female longevity was highest in the control (15.40 days) and lowest in neem oil treatment (9.71 days). Eucalyptus, lemongrass, and jatropha oils recorded intermediate values. The reduction in adult longevity further confirms the negative

physiological effects of botanical oils on *N. lugens*. The combined effects of oils on nymphal survival and adult longevity are depicted in (Fig. 4.)

Discussion

The present study clearly demonstrates that botanical oils significantly affect the development, reproduction and survival of *Nilaparvata lugens*, indicating strong antibiosis and growth-regulating effects. Neem oil was the most effective treatment, causing prolonged pre-oviposition and incubation periods, reduced fecundity, extended nymphal duration, and lower survival, which agrees with earlier reports on neem-induced physiological disruption in rice hoppers (Kareem *et al.*, 1988; Velusamy *et al.*, 1987) [6, 16]. Prolongation of developmental stages and reduced adult longevity suggest interference with hormonal regulation and nutrient utilization (Reddy *et al.*, 2005) [12]. Similar adverse effects of plant-derived oils on insect embryogenesis and nymphal development have been reported by Ramaraju and Sundarababu (1990) [11]. The reduction in fecundity and survival indicates cumulative sublethal stress imposed by oil treatments, ultimately suppressing population growth. These findings support the potential use of botanical oils, particularly neem oil, as eco-friendly components in integrated management of brown planthopper.

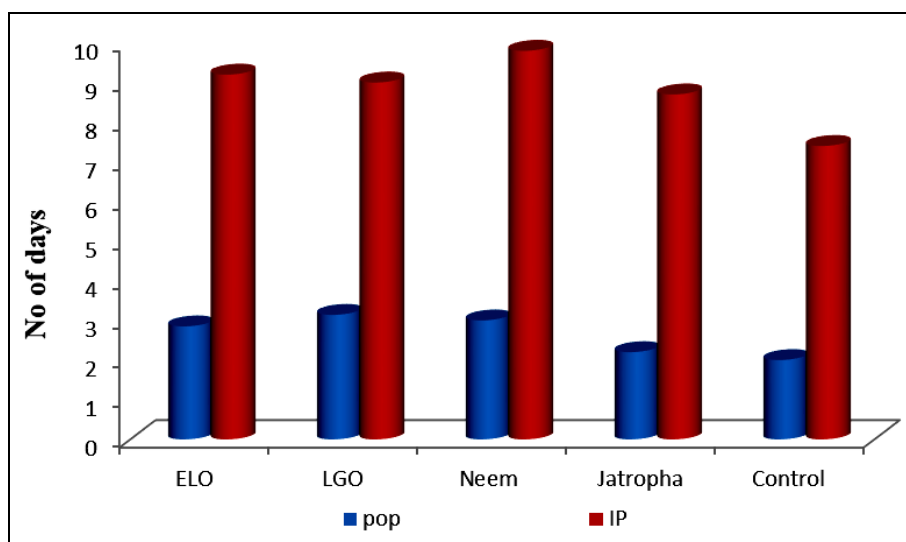


Fig 1: Effect of oils on pre-oviposition, Incubation period of brown planthopper

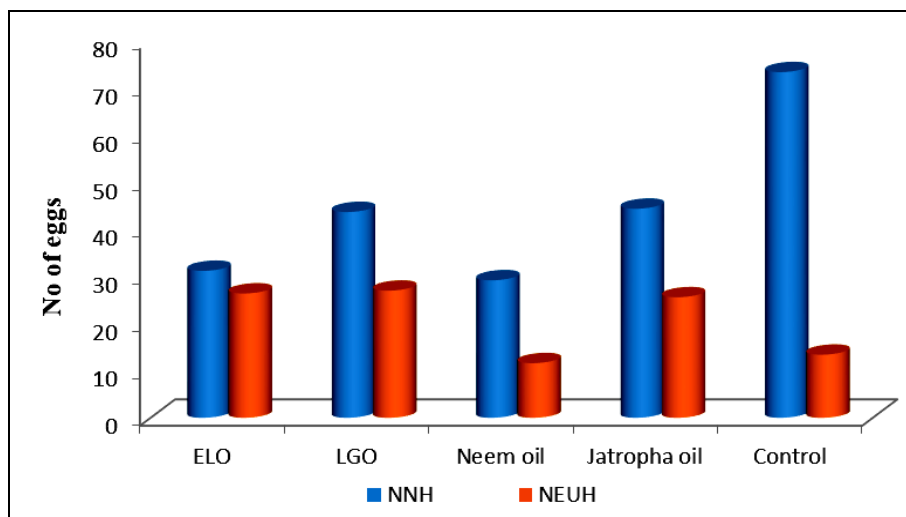


Fig 2: Effect of oils on fecundity of brown planthopper

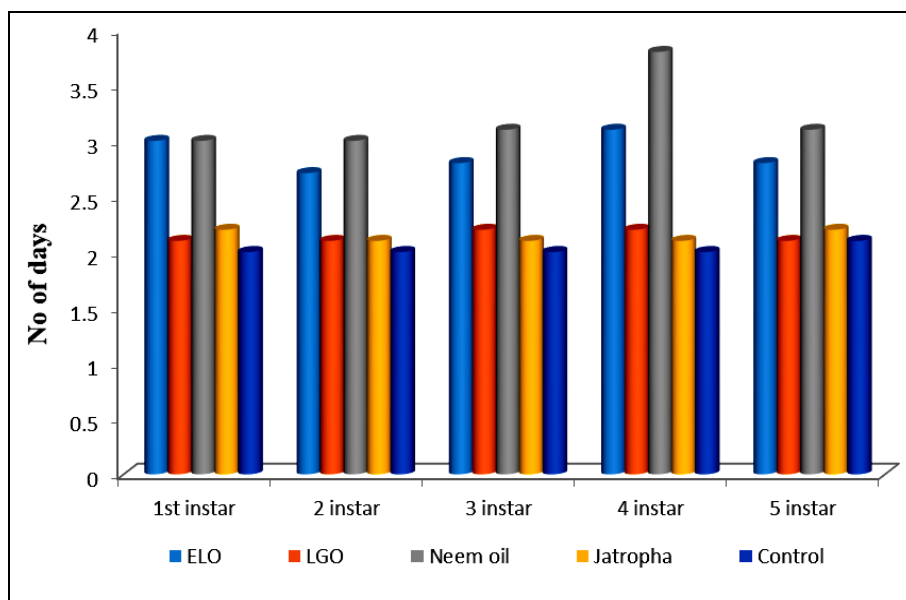


Fig 3: Effect of oils on nymphal instar of brown planthopper

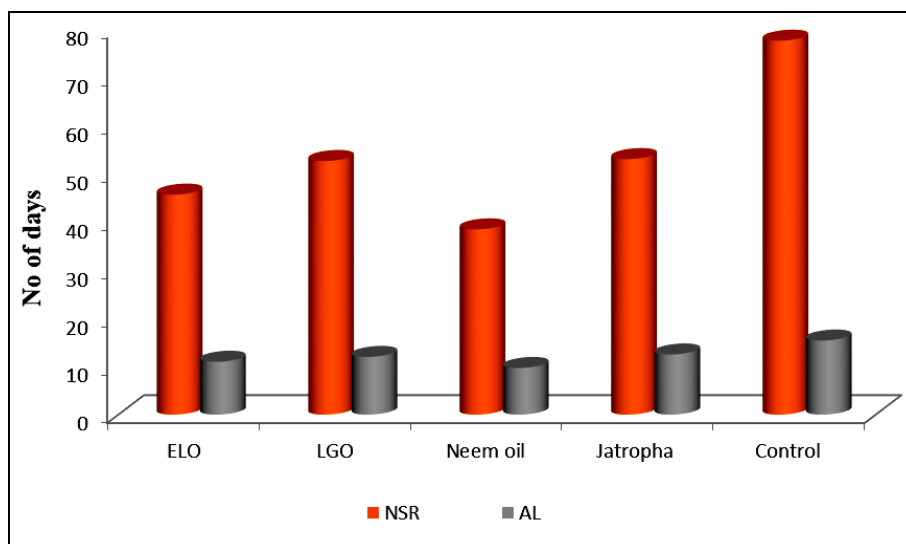


Fig 4: Effect of oil on nymphal survival and adult longevity of brown planthopper

Table 1: Effect of selected plant oils on the biological parameters of brown planthopper (*Nilaparvata lugens* Stal) on rice

S. No.	Treatment	Pre-oviposition period(Days)	Incubation period (Days)	No of eggs hatched	No of eggs un hatched	1 st instar	2 nd instar	3 rd instar	4 th instar	5 th instar	Total nymphal duration	Nymphal survival rate (percent)	Adult longevity (Days)
1	Eucalyptus oil	2.85	9.21	31.25 *(33.9)	26.42 (30.90)	3.00	2.71	2.85	3.14	2.85	14.55	45.28 *(42.71)	11.0
2	Lemon grass	2.14	9.00	43.75 (32.69)	27.00 (31.29)	2.14	2.14	2.28	2.28	2.14	10.98	52.71 (46.53)	12.0
3	Neem oil	3.00	9.80	29.20 (32.69)	31.61 (34.90)	3.00	3.00	3.14	3.85	3.14	16.13	38.57 (38.57)	9.71
4	Jatropa oil	2.28	8.70	44.41 (41.76)	25.60 (30.38)	2.28	2.14	2.14	2.10	2.28	10.98	53.10 (46.71)	12.50
5	Control	2.00	7.42	73.40 (58.92)	13.40 (21.4)	1.80	2.00	2.00	2.00	2.14	10.70	77.71 (61.80)	15.40
	S.Em	0.12	0.27	3.10	1.50	0.10	0.12	0.40	0.40	0.15	0.06	0.75	0.28
	CD	0.35	0.72	9.31	4.52	0.30	0.35	0.13	0.13	0.44	0.19	2.25	0.82

*Figures in the parentheses are arc sine transformed value.

Conclusion

The present study clearly demonstrates that botanical oils significantly influence the biological parameters of brown planthopper. Neem oil exhibited the strongest adverse effects on development, reproduction, survival, and longevity of *N. lugens*.

These results suggest that plant oils, particularly neem oil, possess strong antibiosis properties and can be effectively incorporated into integrated pest management strategies for sustainable rice cultivation.

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