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Bio-efficacy of Botanicals and Biopesticides against Rice Caseworm, *Parapoynx stagnalis* (Zeller)

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Abstract

The experiment was conducted in order to find the efficacy of eco-friendly insecticides against rice caseworm, *Parapoynx stagnalis*. The efficacy of three de-oiled botanical cakes *viz*., neem cake (2 and 3 %), mahua cake (2 and 3 %), and castor cake (2 and 3 %), as well as two biopesticides *viz*., *Bacillus thuringiensis* (1 ml L^{-1}) and *Beauveria bassiana* (20 ml L^{-1}) were evaluated under net house condition at Regional Agricultural Research Station, Pattambi during September 2023. The mortality and feeding were recorded at 1, 3, 5 and 7 days after treatment. The results showed that 100 per cent larval mortality was recorded on the 3rd day with mahua cake (3 %) treatment recorded followed by mahua cake (2 %) and *B. thuringiensis*. The treatments could also significantly reduce the feeding damage by 3rd day @ 7.73,13.67 and 13.27 % respectively. Neem cake showed significant larval mortality (90 %) of caseworm on the 7th day after treatment at a higher concentration (3%).

Keywords: *Parapoynx stagnalis*, *Bacillus thuringiensis*, mahua cake, castor cake, neem cake, botanicals, biopesticides, feeding deterrent

Introduction

India is the largest producer of rice after China, with an average production of 120 million tonnes. The productivity levels of paddy are significantly influenced by a myriad of biotic and abiotic factors, among which the contribution of insect pests accounts for approximately 25 per cent of total losses (Dhaliwal *et al*., 2010). The rice caseworm, *Parapoynx stagnalis* (Zeller) (Lepidoptera: Crambidae) in contrast to other lepidopteran pests that affect rice, possesses a larval stage that is aquatic in nature, that relies on dissolved oxygen present in the water contained within the case constructed out of paddy leaves (Nilamudeen *et al*., 2024). The rice crop during its seedling phase is vulnerable to pest infestation, which is notably prevalent in agricultural fields characterized by persistent standing water. The pest gets translocated from one field to another through drainage channels, and in the course of infestation, the affected plants will be reduced to mere stumps. Pandit *et al*., (2023) documented the damage level of 26 to 50 per cent due to the pest in susceptible varieties. The injury inflicted by larvae through foliar scraping results in white discoloration, leading to a diminution in yield of approximately 10 per cent in Philippines (Heinrichs and Vijante, 1987), and as much as 52 per cent reduction in Argentina (Trujillo, 1991).

Farmers rely on higher concentrations of insecticides than the recommended doses to manage the pest problem in rice fields. This practice heightens the potential for pesticide contamination of aquatic ecosystems, resurgence and adverse effects on natural enemies. The unique attributes of botanical and bio-insecticides, particularly their environmental safety and minimal impact on non-target organisms, render them formidable candidates for integration into pest management strategies. These botanical agents are highly biodegradable, and the likelihood of insects developing resistance to these compounds is minimal due to their diverse mode of action (Pedigo, 1999). Nevertheless, the pesticidal properties of botanicals and bio-insecticides against rice caseworms remain unexplored. Field experiments at multi-locations under the All India Coordinated Rice Improvement Programme (DRR, 1995-97) revealed that neem formulations *viz*., Achook, Nimbecidine, Neemax, Neemgold and Econeem at recommended concentrations (2% in oil based formulation) were moderately effective against stem borer (6.5 to 7.1% dead hearts-DH and 10.2 to 11.6% white ears-WE) and leaf folder (17.0 to 26.0 average damaged leaves - ADL per 10 hills) compared to standard insecticide check (5.4% DH, 8.0% WE and 19.2% ADL), but were significantly superior to control (11.3% DH, 14.8% WE and 42.4% ADL) (Katti, 2013).

Prior to the advent of synthetic insecticides, farmers relied on botanicals for pest management (Thacker, 2002). The application of oil cakes such as neem and karanj has been recognized as a potent strategy for mitigating pest prevalence, that reduced the incidence of *Scirpophaga incertulas* (Prasad, 2020). The study conducted by David (1986) concluded that the utilization of neem-coated urea led to a reduced incidence of whorl maggot and leaf folder. Employment of biopesticides that induce disease in insects plays an important role in mitigating the pest population. According to Nilamudeen and Sudharma (2020), the talc formulations of *Beauveria bassiana* significantly reduced the leaf folder damage. Aghaee and Godfrey (2015) documented that *Bacillus thuringiensis* could effectively manage rice water weevil and the results were comparable to the synthetic insecticide, λ cyhalothrin.

Considering the potential of botanicals and biopesticides in managing various pests, the present study evaluated the oil cakes and bio-pesticides against rice caseworm caterpillars under net house conditions.

Materials and Methods

The study was conducted in the net house of the Regional Agricultural Research Station (RARS), Pattambi, Kerala Agricultural University during September, 2023 with the weather conditions of maximum temperature: (32.1°C ± 1.40°C), minimum temperature: (23.1°C ± 0.69°C), and relative humidity: (84.33 ± 2.11%). The early instar larvae of *Parapoynx stagnalis* were collected from the rice fields of RARS Pattambi and mass multiplied under the net house.

Mass multiplication of rice caseworm

Mass multiplication of the caseworm was carried out under net house conditions in the rice seedlings (variety: Jyothi) grown in plastic trays kept in rearing cages. Larvae of *Parapoynx stagnalis* collected from the rice fields of RARS Pattambi were released on the surface of water in the plastic trays with three weeks old rice seedlings and allowed to pupate. The pupae were collected and placed in plastic cups at a rate of 10 pupae per cup in adult rearing cages. The newly emerged moths were collected using a glass tube and a pair (male and female) were released on potted rice plants maintained in a net house under a cage and were allowed to mate. The female moths were allowed to lay eggs on rice plants. The larvae emerged from the eggs were allowed to development into fourth instar larvae.

Evaluation of botanical cakes and biopesticides against rice caseworm

The experiment was laid out in a Completely Randomised Design (CRD) with nine treatments including untreated control and three replications. The treatments were selected based on the published literature on the efficacy of different oil cakes and bio-agents against leaf-feeding insects in rice. Each treatment had three replications. The botanicals evaluated includes neem cake (2 and 3 %), mahua cake (2 and 3 %) and castor cake (2 and 3 %). Among the bio-pesticides, granular formulations of *Bacillus thuringiensis* (1 g L^{-1}) and talc formulation of *Beauveria bassiana* (20 g L^{-1}). The oil cakes were weighed using an electronic weighing balance and quantified based on the requirement as per the volume of water in the pot. The test insects of ten numbers per pot of third/ fourth larval instars were released on the potted rice plants (20 cm diameter) (Jyothi) with three seedlings of 21 days old with a water level of 3-5 cm was maintained in the experimental pots. The weighed oil cakes were tied in a muslin cloth and immersed into the water filled in pots, while the microbial agents were given as a spray treatment along with jaggery to enhance feeding (0.5 g L^{-1}), and sticker solution (1 ml L^{-1}) using one litre plastic capacity sprayer. The mortality of the larvae was recorded at intervals of 1, 3, 5, and 7 days after treatment along with an assessment of foliar damage. The per cent mortality of larvae as well as the per cent leaf damage were assessed. Then data on mortality and leaf damage were then subjected to arcsine transformation after corrected mortality. The results obtained were statistically analyzed using the software GRAPES version 1.1.0. The mean values were compared using Duncan's Multiple Range Test (DMRT) to determine significant variation at $P<0.05$.

Results and Discussion

The findings derived from the current study of eco-friendly insecticides against rice caseworm larvae are delineated in **Tables 1 and 2**. Notably, a substantial variation was detected among the treatments on mortality rate and feeding. The efficacy of all administered treatments exhibited a notable enhancement from one day to seven days. The treatment with mahua cake at a concentration of 3 % was found to be most effective, followed by *B. thuringiensis* and mahua cake at 2%, with respect to feeding and mortality. On the 1st day after treatment with mahua cake (3%), 46.66 per cent mortality of the larvae was observed, whereas the leaf damage was 13.16 % (**Figures 1 and 2**). By 3rd day, the treatment recorded 100 per cent mortality of larva with leaf damage only 7.73 per cent. On 5th day of treatment, mahua cake (2%) and *B. thuringiensis* recorded 100 per cent mortality of larva with 14.27 and 15. 23 per cent leaf damage, respectively. Neem cake @ 2 and 3% was found to be effective with 79.26 and 76.66 per cent mortality respectively on the 5th day of treatment. During the 7th day of treatment neem cake at both the concentrations could cause significant mortality of larva (90 per cent). Castor cake was poor in efficacy with 69.26 and 86.30 per cent mortality of larva with the larval leaf damage of 23.37 and 23.83 % at the concentration of 3% at 5th and 7th day of treatment. The fungus, *B. bassiana* did not cause any significant effect on both the mortality of larvae and reduction in feeding damage, which was on par with untreated control.

Table 1: Efficacy of botanicals and bio-pesticides on mortality of *Parapoynx stagnalis*

Microbial agent/oil cake	concentration	Mortality of larvae (%)*			
		1 DAT	3 DAT	5 DAT	7 DAT
T1-Neem cake	2g / 100ml	10.00 (15.18)^{bc}	51.85 (46.06)^{cd}	76.66 (66.15)^{b}	90 (75.00)^{ab}
T2-Neem cake	3g / 100ml	23.33 (28.78)^{ab}	72.59 (58.69)^{bcd}	79.26 (63.41)^{b}	90 (75.00)^{ab}
T3-Castor cake	2g / 100ml	10.00 (15.18)^{bc}	57.78 (49.82)^{bcd}	61.11 (52.53)^{b}	75.19 (64.99)^{b}
T4-Castor cake	3g / 100ml	10.00 (15.18)^{bc}	45.18 (42.22)^{d}	69.26 (56.77)^{b}	86.30 (68.51)^{b}
T5-Mahua cake	2g / 100ml	26.66 (30.78)^{ab}	79.26 (62.91)^{bc}	100 (90.00)^{a}	100 (90.00)^{a}
T6-Mahua cake	3g / 100ml	46.66 (43.07)^{a}	100 (90.00)^{a}	100 (90.00)^{a}	100 (90.00)^{a}
T7-*Beauveria bassiana*	20g / litre	0 (0.551)^{c}	10.37 (15.52)^{e}	10.37 (15.35)^{c}	37.78 (37.82)^{c}
T8-*Bacillus thuringiensis*	1g / litre	13.33 (17.89)^{b}	78.52 (67.21)^{b}	100 (90.00)^{a}	100 (90.00)^{a}
T9-control	-	0 (0.55)^{c}	0 (0.55)^{e}	0 (0.55)^{c}	0 (0.55)^{d}
CD value (p=0.05)		17.188	17.527	19.685	17.319
CV		19.67	18.42	16.81	15.35

Figures in parenthesis are arcsine transformed values

*Corrected mortality, DAT – Days after treatment, CV – Coefficient of variation, Means followed by the same letter are not significantly different

Table 2: Impact of botanicals and bio-pesticides on the feeding of *Parapoynx stagnalis*

Microbial agent/oil cake	concentration	Percent leaf damaged			
		1 DAT	3 DAT	5 DAT	7 DAT
T1-Neem cake	2g / 100ml	12.47 (20.60)[d]	22.41 (28.23)[bc]	25.28 (30.17)[bc]	27.45 (31.59)[cd]
T2-Neem cake	3g / 100ml	10.49 (18.87)[d]	13.70 (21.71)[d]	14.37 (22.26)[d]	14.73 (22.55)[e]
T3-Castor cake	2g / 100ml	23.31 (28.86)[b]	26.77 (31.14)[b]	29.80 (33.05)[b]	32.20 (34.54)[c]
T4-Castor cake	3g / 100ml	17.48 (24.69)[c]	21.83 (27.85)[c]	23.37 (28.90)[c]	23.83 (29.22)[d]
T5-Mahua cake	2g / 100ml	11.80 (20.04)[d]	13.67 (21.65)[d]	14.27 (22.17)[d]	14.27 (22.17)[e]
T6-Mahua cake	3g / 100ml	5.19 (13.16)[e]	7.73 (15.99)[e]	7.73 (15.99)[e]	7.73 (15.99)[f]
T7-*Beauveria bassiana*	20g / litre	28.03 (31.96)[a]	42.19 (40.51)[a]	49.12 (44.49)[a]	54.28 (47.46)[b]
T8-*Bacillus thuringiensis*	1g / litre	10.01 (18.44)[d]	13.21 (21.23)[d]	15.23 (22.93)[d]	15.23 (22.93)[e]
T9-control	-	31.61 (34.21)[a]	42.18 (40.50)[a]	52.60 (46.49)[a]	68.69 (55.99)[a]
CD value (p=0.05)		2.546	3.127	3.307	3.553
CV		6.32	6.59	6.54	6.6

Figures in parenthesis are arcsine transformed values

DAT – Days after treatment, CV – Coefficient of variation, Means followed by the same letter are not significantly different

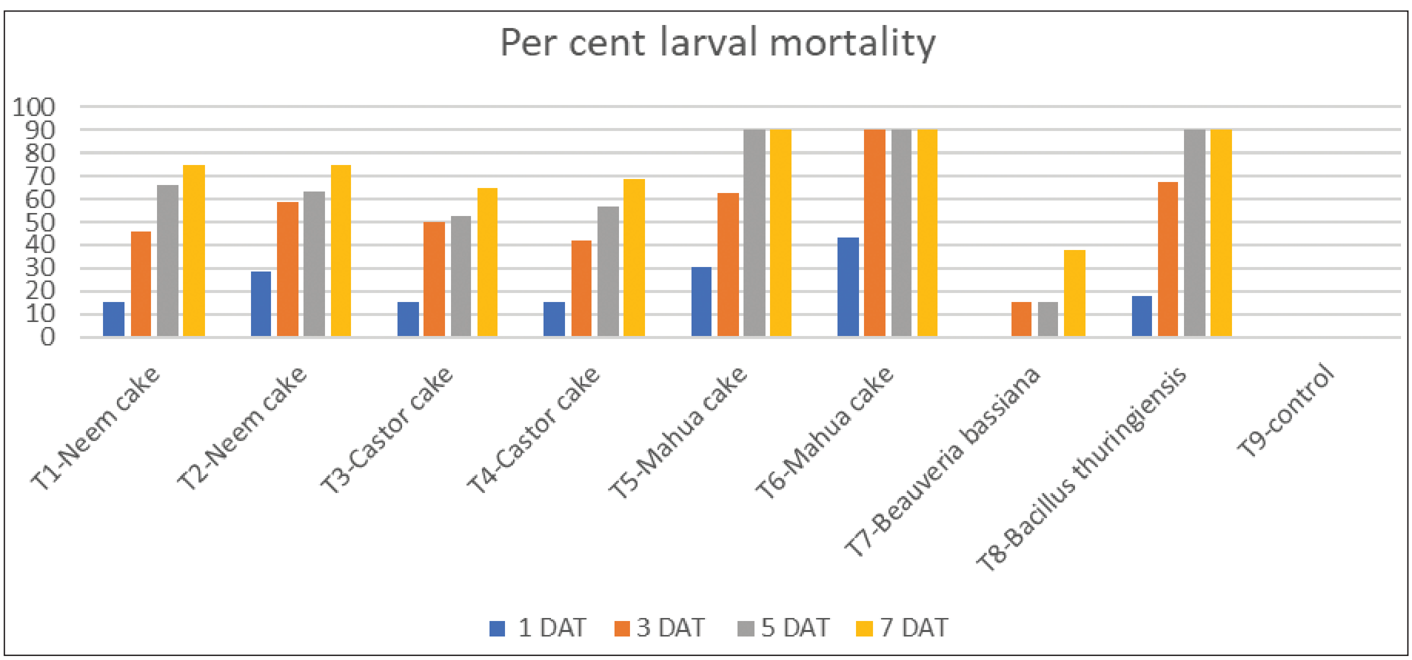

Figure 1: Efficacy of different treatments on the mortality of caseworm larvae

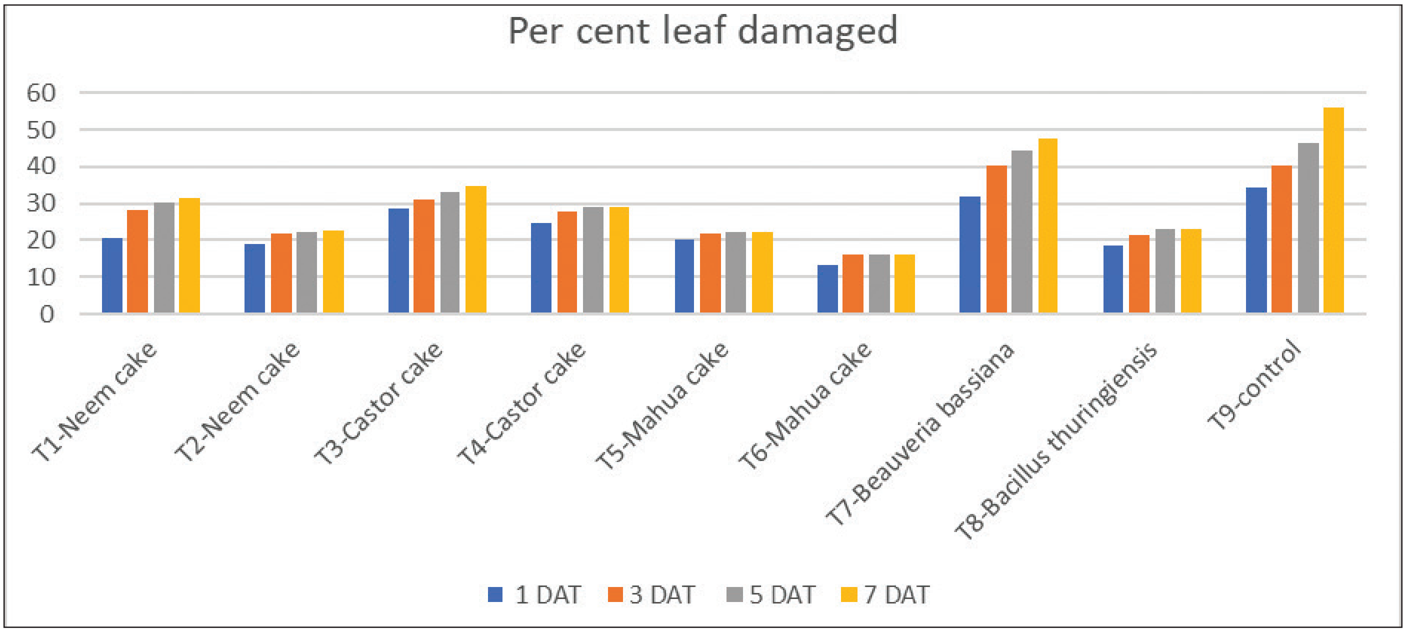

Figure 2: Effect of different treatments on leaf damage by caseworm larvae

Among the botanical cakes, mahua cake showed significant larval mortality and reduced leaf damage followed by neem cake, and castor cake, while in case of biopesticides, only *B.t* was found to be effective against larval mortality and leaf damage. In rice fields, application of mahua oil was reported to have reduced the damage caused by rice leaf folder, *Cnaphalocrocis medinalis* (Rajasekaran *et al*., 1987) and green leaf hopper, *Nephotettix virescens* (Mariappan *et al*., 1988). The saponin content present in *Madhuca indica* (mahua) was found responsible for the antifeedant principle, larval and adult growth inhibition of *Helicoverpa armigera* (Loganathan *et al*., 2006). Mordue and Blackwell (1993) documented the effects of azadirachtin on growth, molting and reproduction along with antifeedant action, even though antifeedant action varies with species of Lepidoptera. Similar results were obtained in this study, where reduced feeding damage by caseworm was found in neem cake applied treatment. Manendra (2016) recorded the least damage (0.80 %) on potato leaves when treated with neem cake, followed by mahua cake (1.2 %) against cutworms. The active compound azadirachtin extracted from neem cake has insecticidal, antibacterial, and antifungal properties (Harikrishnan *et al*., 2003).

Sanahuja *et al*. (2011) highlighted the potential value of *B. thuringiensis* toxin that kills the lepidopteran pest. Commercial formulations of *B. thuringiensis* and *Beauveria bassiana* have been shown to effectively manage *Helicoverpa armigera* populations (Kumar and Kaur, 2017). In the present study, *B. thuringiensis* produced comparable results, significantly increasing larval mortality and reducing feeding activity. In contrast, *B. bassiana* proved ineffective, possibly due to the protective casing of the larvae, which may have reduced fungal contact, or to the semiaquatic habit of the caseworm larvae, which could have washed away fungal spores. The primary mode of action of *B. thuringiensis* involves Cry proteins, which act on the alkaline midgut of lepidopteran insects to form pores (Aronson and Shai, 2001). According to Gould *et al*. (1991), feeding on *B. thuringiensis* - treated leaves by neonate larvae can lead to feeding cessation and gut paralysis. In the present study, although castor cake treatment caused noticeable feeding damage to rice plants, it also resulted in significant caseworm mortality from five days after application. Sousa *et al*., (2017) attributed the toxic effects of castor cake to the presence of ricinine. The insecticidal and insectistatic activities of castor seed extracts have been demonstrated against *Spodoptera litura* caterpillars

(Ramos-López *et al*., 2010), with castor oil and ricinine identified as the principal active compounds. Similarly, seed kernel extracts and oil emulsions of castor have been shown to cause significant mortality of *Plutella xylostella* under laboratory conditions (Kodjo *et al*., 2011). The results from the study showed a significant reduction in caseworm population and leaf damage to rice when treated with de-oiled cakes and bio-pesticides. This study also demonstrates the potential of de-oiled cakes and bio-pesticides as effective and environment-friendly alternatives for managing caseworm infestation in rice. These eco-friendly alternatives can lead to reduced reliance on chemical pesticides, and contribute to a healthier environment.

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Author Contribution Statement

Conceptualization, K.K.; methodology, K.K.; formal analysis, M.A.V., K.K., and H.B, investigation, M.A.V.; data curation, M.A.V., K.K. and H.B.; writing – original draft preparation, M.A.V. and K.K.; writing-review and editing, H.B. M.C. and S.V.M. All the authors have read and agreed to the published version of the manuscript.

Conflict of Interest

No conflict of interest

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