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Enhanced Efficacy of Combined Plant Extracts on Rice Leaf Folder, *Cnaphalocrocis medinalis* (Guenée)

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***Abstract*:** The rice leaf folder, *Cnaphalocrocis medinalis* (Guenée) (Lepidoptera: Crambidae), is a prominent and noxious pest in rice production, particularly in the Cauvery Delta region of Karaikal of Puducherry and Tamil Nadu, India, where rice is cultivated predominantly as a monocrop during the *Kharif* and *Rabi* seasons. Field experiments were conducted during *Kharif* and *Rabi* 2019-20 at PAJANCOA and RI, Karaikal, to evaluate the efficacy of plant extracts against leaf folder. Across both seasons, chemical insecticide treatments, Novaluron and Thiamethoxam resulted in 49.03% and 54.90% reduction in leaf folder damage, respectively. Among the botanical treatments, 5% garlic and chili extract consistently showed the lowest leaf damage, recording 6.27 and 6.49% in *Kharif* 2019 and *Rabi* 2019-2020, respectively. This represents a 40.40 and 40.02% reduction in damage compared to the untreated control. Thus, garlic and chili extract at 5% proved highly effective in minimizing leaf folder incidence under field conditions and offers a sustainable, eco-friendly alternative to chemical insecticides by reducing the risk of resistance development.

Keywords: Botanical extracts, Five leaf extract, Garlic and chilli extract, Leaf folder, Novaluron, Rice

The rice leaf folder, *Cnaphalocrocis medinalis* (Guenee) (Lepidoptera: Crambidae), has emerged as a major threat to rice cultivation in several Asian countries, particularly in tropical and subtropical Asia (SenthilNathan et al., 2006). Rice leaf folder is the most prevalent and economically significant of the eight reported species of rice leaf folders and is the only species capable of surviving by feeding on weeds. In the Puducherry region, stem borers, leaf folders, and leafhoppers are the most destructive pests of rice. Among these insect pests, the leaf folder is a regular and persistent pest in the Cauvery Delta region, where rice is cultivated as the main crop. The leaf folder causes yield losses of about 5–25% (Kulgod et al., 2011).

Chemical pest control using synthetic insecticides such as **o**rganophosphates (e.g., chlorpyrifos), carbamates, and pyrethroids is common in rice cultivation to manage pests like stem borers, brown planthopper, and leaf folder (Pasalu and Katti 2006). While effective initially, the indiscriminate use of these chemicals has led to pest resistance, secondary pest outbreaks, and environmental contamination. Residues of these chemicals accumulate in soil and water, posing health risks including neurotoxicity, carcinogenicity, and endocrine disruption (Aktar et al., 2009). Persistent organochlorines bioaccumulate through the food chain, resulting in long-term ecological hazards (Singh et al., 2018, Rajashekhar et al., 2021). Pesticide runoff further contaminates water bodies, harming aquatic ecosystems. Therefore, reducing chemical pesticide dependency and promoting botanical alternatives is crucial for sustainable rice production and for safeguarding human and environmental health.

Insecticide use can have negative effects on the ecosystem, eliminate beneficial insects, and leave residues in harvested produce; botanicals have long been marketed as substitutes for synthetic chemical insecticides in pest management (Echereobia et al., 2010). Plant-based insecticides derived from a combination of five leaf extracts *Azadirachta indica* (neem), *Vitex negundo* (Indian privet), *Lantana camara* (lantana), *Annona squamosa* (custard apple), and *Clerodendrum inerme* (wild jasmine) have shown promising results in controlling major rice pests such as the rice stem borer, rice leaf folder and brown planthopper. These extracts possess a variety of bioactive compounds, including alkaloids, flavonoids, and terpenoids, which exhibit insecticidal, antifeedant, and growth-regulating effects on pests (SenthilNathan et al., 2006). The foliar applications of these extracts significantly reduce pest infestation and improve rice yield without causing harm to beneficial insects (Kumar et al., 2015). Garlic (*Allium sativum*) and chilli (*Capsicum frutescens*) extracts have demonstrated significant bioefficacy against major rice pests. Garlic extract, rich in organosulfur compounds such as allicin, exhibits insecticidal, antifeedant, and repellent properties that disrupt the metabolic activities of pests, leading to reduced feeding and growth inhibition (Dougoud et al., 2019). Similarly, chilli extract contains capsaicinoids, which exhibit neurotoxic and antifeedant effects, impairing pest behavior and reducing insect proliferation in rice fields (Baidoo and Mochiah 2016). Combined application of garlic and chilli extracts enhances their insecticidal properties due to their synergistic effects, resulting in higher pest mortality and decreased pest infestation. Field trials have shown that foliar application of these extracts reduces pest incidence by up to 60 %,

improving overall rice yield and minimizing environmental contamination (Tuan et al., 2014). Considering the importance of eco-friendly pest management and the proven efficacy of plant extract mixtures in rice ecosystems, the present study aimed to evaluate the effectiveness of various botanical extracts against the rice leaf folder. The objective was to assess their potential as sustainable alternatives to chemical insecticides, focusing on their ability to reduce pest infestation while minimizing environmental impact and preserving beneficial organisms.

MATERIAL AND METHODS

Field experiments: To study the effect of botanical extracts, a supervised field experiment I and II was conducted during *Kharif* and *Rabi* 2019-20 (two seasons) on irrigated crop at the eastern farm of PAJANCOA and RI, Karaikal, UT of Puducherry, which lies between 10.95° N latitude and 79.78° E longitude with a height of 4 m above MSL.

The experiment was set up in a randomized block design with eight treatments of three replications. The crop was raised as per recommended agronomic procedures being followed except plant protection measures (Balaji et al., 2018). From each plot 10 plants were randomly selected were observed for insect damage symptoms at weekly intervals from 7 days after treatment (DAT), When pest incidence reached the economic threshold (ETL) of 10% damage, the treatments were imposed. Three foliar applications were given 24, 39 and 54 days after transplanting in experiment I and 27, 43 and 57 DAT in experiment II. Pre-treatment observations one day before application of treatment and post-treatment observations 1, 3, 5, 7, 10 and 14 DAT were recorded. The treatments include, T_1 -Five leaf extract @ 10%; T_2- Garlic and chilli extract @ 5 %; T_3 -Bitter apple leaf extract @ 10 %; T_4 - Ponneem 45% @ 3750 ml/ha; T_5 -Azadirachtin 0.03% @ 2000 ml/ha; T_6 -Thiamethoxam 25 WG @ 100 g/ha; T_7 - Novaluron 10 EC @ 1000 ml/ ha and T_8 -Untreated check

Preparation of the botanical extracts: Five leaf extracts were prepared by using plant materials *viz.* giant milkweed (*Calotropis gigantea* Linnaeus), leaves of neem (*Azadirachta indica*), jatropha (*Jatropha curcas* Linnaeus), chaste tree (*Vitex negundo*) and adhathoda (*Justicia adhatoda* Linnaeus) which were collected from the local area of Karaikal district (10.9221° N, 79.7547° E and 10.9166° N, 79.7548° E), U.T. of Puducherry, India. About 2 kg of fresh leaves from each plant were taken, washed with tap water and diced into small pieces. The diced leaves were macerated individually with an electric blender to form a paste, which was added to 12 litres of cow urine followed by the addition of 3 kg of cow dung and 100 g of turmeric powder. The mixture was then left to ferment for seven days. After fermentation, the solution was filtered through a double-layered muslin cloth, and the filtrate was used for spraying on the rice crop in the trial. For the garlic and chilli extract, the outer layers of garlic were peeled off, and mature green chillies was cleaned to make garlic and chilli extract. To prepare the extract, 200 g of each was combined with one litre of water and ground using an electric blender. An additional one litre of water was used to completely blend this juice. The mixture was then sieved to get a turbidity-free, homogeneous extract (Tuan et al., 2014). Bitter apple leaves, *Citrullus colocynthis* Schrad, were picked locally and rinsed with running tap water to eliminate debris before being cut into small pieces using a sharp knife. In a blender, 500 g of leaves were mixed into a fine paste with 500 ml of water. Before application, all the plant extracts were diluted to the required spray concentration from full-strength (100 %) solution. The total number of leaves and damaged leaves from 10 randomly chosen hills per plot were used to assess *C. medinalis* leaf damage. One day before spraying, pretreatment observations were made and posttreatment observations were taken at 1, 3, 5, 7, 10, and 14 days after spraying. The percentage of leaf damage was calculated.

Statistical Analysis: Statistical analysis of the data was carried out using one-way analysis of variance (SPSS version 22.0, IBM Corporation, New York, USA), and Duncan's multiple range test was used to determine the significant variation (P<0.05).

RESULTS AND DISCUSSION

Efficacy of botanical extracts*:* The efficacy of different botanical was evaluated across three foliar spray applications to assess their impact on the incidence of leaf folder in rice in *Kharif* 2019. The percentage of leaf folder incidence after the 1st, 2nd, and 3rd foliar sprays was recorded (Table 1). After the 1st foliar spray, significant differences were observed among the treatments. The botanical extracts, including garlic and chilli extract and five leaf extract, resulted in moderate leaf damage (7.72 and 8.12 %). Significant differences were recorded after the 2nd foliar spray, where all treatments demonstrated reduction in leaf folder incidence compared to the untreated control. Among the botanical extracts, the garlic and chilli extract showed reduction, in leaf folder incidence (6.64 %). Among the synthetic insecticides, Novaluron 10 EC recorded the lowest leaf damage (5.86 %). Further reduction in leaf folder incidence was observed after the 3rd foliar spray, with significant differences among treatments. Garlic and chilli extract showed superior efficacy among botanical treatments, reducing leaf damage to 4.45 %. Among the synthetic insecticides, Novaluron 10 EC

recorded the lowest incidence (3.41 %), The results indicated that novaluron 10 EC at 400 ml / ac superior among the treatments (49.05 % reduction) and garlic and chilli extract at 5 % (40.40 %) was superior among the botanicals compared to the untreated check.

In *Rabi* 2019-2020, leaf damage 1 day before the first spraying ranged from 10.47 to 11.37 %/hill with non-significant difference. Significant differences were recorded after the 1st spray, Novaluron 10 EC at 400ml/ac recorded the lowest leaf damage of 5.82%. Among the plants, garlic and chili extract was effective at 5 % with 7.74 % leaf damage, followed by five leaf extract at 10 % (8.61 %) compared to untreated controls (10.96 %). After the 2nd spray also significant differences were recorded, the lowest foliar damage of 5.24% was in Novaluron 10 EC at 1000 ml/ha and garlic and chilli extract at 5 % (6.73 %) compared to the untreated control (11.97 %). After the 3rd foliar application, a similar trend was observed as in the first and second foliar applications. Total leaf damage in Novaluron 10 EC at 1000ml/ha was 4.88 % with the highest percentage reduction of 54.90 and followed by garlic and chilli extract at 5 % (6.49 % leaf damage and 40.02 % reduction over control) (Table 2). The repeated foliar sprays significantly reduced leaf folder incidence in treated plots compared to the untreated control. The five-leaf extract and bitter apple leaf extract also contributed to pest suppression but were relatively less effective.

Ginger-garlic chili extract was 10% devoid of leaf folder larvae on the treated plants 6 hours after release and the percentage of leaf area fed was 13.03% 48 hours after release (Rani 2013). Similarly, karanj oil followed by chili-garlic solution proved to be the most effective treatment, (Niyati and Gajbhiye 2017). Tuan et al (2014) found that the combination of chili and garlic was effective against diamondback. Baidoo and Mochiah (2016) reported that garlic and hot pepper, *Capsicum frutescens*, control cabbage pests *P. xylostella*, *Hellula undalis* and *T. ni*, reducing mortality by 10.76 to 55.94%. The plant product garlic + green chili was most effective against the defoliants *Spodoptera litura* and *Chrysodeixis acuta* in soybeans (Kushram et al., 2017). Narayanasamy et al. (2009) shown that calotropis leaf extract combined with onion, garlic and chilli powder had the maximum mortality for the brinjal fruit and shoot borer, pumpkin caterpillar and tapioca whitefly. Biorationals treatments, ginger + garlic + green chilli extracts 5 % was effective against leafhopper, *Amrasca biguttula biguttula* in okra (Kanimozhi et al., 2020). The botanical treatments, garlic and chilli extract (5 %) proved to be the most effective against rice yellow stem borer (Nishanthini and Kandibane 2021). Ladji et al. (2011) observed that combination of garlic chilli aqueous (2 %) and garlic chilli kerosene (0.5 %) showed the highest percentage of larvae population decrease (46.85 %) against *H. armigera*. Rahman et al. (2022) observed that garlic and chilli extracts exhibited strong repellent and antifeedant properties against *Chilo suppressalis*. The effectiveness of vitex, pongamia, and calotropis extracts against rice planthoppers provided sustainable pest control while reducing the risk of pesticide resistance (Alam et al., 2019). Garlic and chilli extract showed over 50 % mortality of *Helicoverpa armigera* larvae in chickpea fields, supporting its role as an

Table 1. Efficacy of botanical extracts against the leaf folder, *C. medinalis* during *Kharif* 2019

Treatments	Conc. %/ml/g per hectare	Mean per cent leaf damage/hill during *Kharif* 2019				Overall mean	Percent reduction over control
		Pretreatment count	1st Foliar spray#	2nd Foliar spray#	3rd Foliar spray#		
Five leaf extract	10	10.81[a]	8.12d	7.15 (15.51)[d]	4.93 (12.84)[d]	6.74	35.93
Garlic and chilli extract	5	11.06[a]	7.72 (16.13)[c]	6.64 (14.94)[c]	4.45 (12.18)[c]	6.27	40.40
Bitter apple leaf extract	10	10.77[a]	9.27 (17.72)[g]	8.34 (16.79)[g]	6.02 (14.20)[g]	7.88	25.10
Ponneem 45%	3750	11.01[a]	8.67 (17.12)[e]	7.61 (16.01)[e]	5.29 (13.29)[e]	7.19	31.65
Azadirachtin 0.03%	2000	10.98[a]	9.02 (17.48)[f]	7.94 (16.37)[f]	5.65 (13.75)[f]	7.54	28.33
Thiamethoxam 25 WG	100	10.53[a]	7.08 (15.43)[b]	6.21 (14.43)[b]	3.75 (11.17)[b]	5.68	46.01
Novaluron 10 EC	1000	11.05[a]	6.81 (15.13)[a]	5.86 (14.00)[a]	3.41 (10.64)[a]	5.36	49.05
Untreated check	-	10.75[a]	11.40 (19.74)[h]	11.88 (20.16)[h]	8.27 (16.71)[h]	10.52	

- Observed on pretreatment, 1, 3, 5, 7, 10, and 14 days following treatment
In a column mean followed by a common letter not substantially different by DMRT (P<0.05)

Table 2. Efficacy of botanical extracts against the leaf folder, *C. medinalis* during *Rabi* 2019-2020

Treatments	Conc. %/ml/g per hectare	Mean per cent leaf damage/hill during *Rabi* 2019				Overall mean	Percent reduction over control
		Pretreatment count	1st Foliar spray#	2nd Foliar spray#	3rd Foliar spray#		
Five leaf extract	10	11.06[a]	8.61 (17.07)[d]	7.66 (16.07)[d]	5.75 (13.88)[d]	7.34	32.16
Garlic and chilli extract	5	10.97[a]	7.74 (16.16)[c]	6.73 (15.03)[c]	4.99 (12.91)[c]	6.49	40.02
Bitter apple leaf extract	10	11.37[a]	9.70 (18.14)[g]	9.10 (17.56)[g]	7.91 (16.33)[g]	8.91	17.65
Ponneem 45%	3750	10.62[a]	8.86 (17.31)[e]	8.16 (16.59)[e]	6.24 (14.46)[e]	7.76	28.28
Azadirachtin 0.03%	2000	10.47[a]	9.33 (17.78)[f]	8.60 (17.05)[f]	6.90 (15.23)[f]	8.28	23.48
Thiamethoxam 25 WG	100	11.15[a]	6.47 (14.74)[b]	5.98 (14.16)[b]	4.46 (12.20)[b]	5.64	47.87
Novaluron 10 EC	1000	10.72[a]	5.82 (13.96)[a]	5.24 (13.23)[a]	3.57 (10.90)[a]	4.88	54.90
Untreated check	-	10.90a	10.96 (19.33)[h]	11.97 (20.24)[h]	9.52 (17.97)[h]	10.82	32.16

- Observed on pretreatment, 1, 3, 5, 7, 10, and 14 days following treatment
In a column mean followed by a common letter not substantially different by DMRT ($P<0.05$)

eco-friendly alternative to synthetic insecticides (Borah et al., 2022). Similarly, combination of garlic and chilli extracts effectively suppressed populations of major rice pests, including leaf folders and planthoppers (Zhang et al., 2020).

CONCLUSION

The foliar application of botanical extracts resulted in lower leaf damage compared to the control, particularly, garlic + chilli extract (5%) combination, against the rice leaf folder was observed. Among the conventional insecticides, Novaluron 10 EC at 1000 ml/ha, recorded minimum leaf damage and maximum percent reduction, signifying its higher efficacy. The findings emphasize that botanical insecticides, particularly garlic and chilli extract, offer an eco-friendly and effective alternative for managing rice leaf folder, reducing dependence on synthetic chemicals, preserving natural enemies and supporting sustainable rice production.

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