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Efficacy of different chemistry of insecticides against rice leaf folder, *Cnaphalocrocis medinalis* (Guenee) and their effects on natural enemies in rice ecosystem

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Abstract
Rice leaf folder, *Cnaphalocrocis medinalis* (Guenee) considered an important pest among several insect species which were recorded as pests of rice, as it affects rice production in almost all of the rice-growing countries of Asia. Hence, keeping in mind field experiments were conducted during *Kharif* season, 2018-2019 with rice variety (MTU-7029) to determine the bioefficacy of certain newer insecticides against rice leaf folder, and experiment was laid out in a randomized block design with nine treatments and three replications. Results revealed that among all the insecticides after the first and second spray least percent incidence was observed in the Cartap hydrochloride 50 WP (T5) followed by Flubendamide 480 SC (T1) and Rynaxypyr 20 SC (T2) treated treatment i.e., 3.57%, 4%, and 4.67% respectively. The highest incidence was recorded in the neem treated plot was found to be (5.50%) followed by lamda cyhalothrin (5.27%). Population densities of natural enemies significantly reduce in treated plots as compared to untreated plots, the highest number of natural enemies were recorded in T5, whereas the lowest was in T6.

Keywords: Efficacy, different chemistry, insecticides, leaf folder, and natural enemies

Introduction

Rice crop one of the most important crops among the cereals, it is considered as life when comes to Asia. It is a staple food for nearly half of the global population (FAO, 2004) [2]. Even in India, it is the most consumed cereal covering about one-fourth of the total cropped area and providing food to about 50% of the Indian population. Insect pests menace is one among the many hurdles in reaching comprehensive rice grain productivity. The rice crop can be attacked by more than 100 species of insects, and 20 of them can cause serious economic loss (Pathak, 1977; Heinrichs *et al.*, 2017) [8]. The rice leaf folder, *Cnaphalocrocis medinalis* (Guenee) considered one of among several insect species which were recorded as pests of rice, as it affects rice production in almost all of the rice growing countries of Asia. Their symptoms start from feeding inside the folded leaf creating longitudinal white and transparent streaks on the blade; hinder the photosynthesis of the leaves resulting in the reduction of rice yield. Indiscriminate use nitrogenous fertilizers and mismanagement of insecticides have been attributed as the causes of this minor pest gaining major pest status (Dhaliwal *et al.*, 1979) [1]. Reports show that severe infestation of this pest leads to as high as 23.3 percent leaf damage (Seni *et al.*, 2017) and causes significant yield loss. Yield loss caused by leaf folders was reported to the extent of 5 to 25 percent (Kulgagod *et al.*, 2011). In rice crop, to lower the severity of insect-pest attacks chemical insecticides are still counted as an effective method. Though, most of the chemicals due to the development of insecticide resistance among the pest have failed to provide adequate control over these insects. To reduce the insecticide resistance judicious use of insecticides and alternation of chemicals with different modes of action are suggested (Seni and Naik, 2017). Many conventional insecticides though have been evaluated against this insect, yet, most of the chemicals have failed to provide adequate control. In addition to pests, many beneficial insects are present in rice fields. These beneficial faunas, collectively known as natural enemies, are categorized as predators and parasitoids. Conservation of predators, parasitoids and entomopathogens is an important component of modern integrated pest management (IPM) (Rahaman and Stout 2019) [10]. Pesticides that are less harmful to natural enemies can also be effective tools for IPM. Hence, new molecules are being added for their evaluation with an aim of least disruption of environmental quality.

In insecticide resistance management newer insecticide molecules with a diversified mode of action play significantly a vital role against these pests. Considering these conditions in view present study was focused on bio-efficacy of newer insecticide against rice leaf folder and their adverse effect on natural enemies and productivity in rice ecosystems.

Materials and methods

The experiment was conducted in the experimental farm of Bihar Agricultural University, Sabour, Bhagalpur, Bihar during *kharif* 2018-2019 with Randomized Block Design (RBD), having 9 treatments which were replicated thrice in a net experimental area of 6 m x 5 m each. The research farm, situated at [GPS: 25° 13' 33.6612" N (latitude), 87° 2' 56.184" E (longitude)]. Seedlings were transplanted at 21 days after sowing with inter and intra row spacing of 20 × 15 cm. All the agronomic practices were followed as per the recommended package of practices. The knapsack sprayer was used with a hollow cone nozzle to spray treatments twice in a season, once at a vegetative phase of the crop (45 days after transplanting (DAT)) and second time at a reproductive phase of the crop (70 DAT) and an untreated check was also maintained to compare the results. The observations for both natural enemies and efficacy were recorded similarly at one day before and 3rd, 7th and 14th days after imposition of treatments for each spray. The data thus obtained from all the observations were subjected to appropriate statistical analysis after suitable transformations. Economics of chemical applications were computed based on economic returns from grain yield and the cost of treatments. The observations were recorded by following the standard method for leaf folder (Anon., 2007). Data was recorded per plant damage in percentage by counting infected leaves/folded leaves/plant. With formula:

$$\frac{\text{Infested Leaves/plant} - \text{Total leaves X 100}}{\text{Total leaves/Plant}}$$

Incidences of natural enemies (predators) of rice pests were observed after applications of insecticides using the same plots that were used for the evaluation of insecticide efficacies. Visual observations were made to count the number of predators and parasitoids. Proper care was taken to not disturb natural enemies while observations were being made. Predators were identified with unaided sight, and parasitoid adults were identified using a magnifying glass. All data collection was made jointly by two persons.

Table 1: List of some selected insecticide for testing efficacy against rice leaf folder

Treatments	Insecticides	Mode of action	Manufacture company
T1	Flubendiamide 480 SC	Ryanodine receptor (RyR) modulators	Rallis India Ltd.
T2	Rynaxypyr 20 SC	Ryanodine receptor (RyR) modulators	DuPont
T3	Spinosad 45 SC	Nicotinic acetylcholine receptor (nAChR)	Bayer Crop Science
T4	Fipronil 5 SC	GABA-gated chloride channel antagonists	Kalyani Industries Pvt. Ltd.
T5	Cartap hydrochloride 50 WP	Nicotinic acetylcholine receptor (nAChR) antagonists	Kalyani Industries Pvt. Ltd.
T6	Lamda cyhalothrin 5EC	Sodium channel modulator	Syngenta Pvt. Ltd.
T7	Emamectin benzoate 5 SG	Sodium channel modulator	Syngenta Pvt. Ltd.
T8	Azadirachtin 3000 ppm	Ecdysone agonists	Ozone Biotech.
T9	Control	-	-

Results and Discussion

Efficacy of insecticides against *C. medinalis* after first spray

The result revealed that the per cent leaf damage ranged from 4.53% to 5.77% across the treatments one day before application of the first spray. After that we're all the treatment significantly effective in reducing the infestation of rice leaf folder as compared to the untreated plot (Table 2). At first, observation was taken, (3rd Day after spray) i.e., least per cent incidence was observed in the Cartap hydrochloride 50 WP (T5) followed by Flubendamide 480 SC (T1) and Rynaxypyr 20 SC (T2) treated treatment i.e., 3.57%, 4%, and 4.67% respectively. The least efficacy of the neem treated plot was found to be (5.50%) followed by lamda cyhalothrin (5.27%). Similar results were observed a week after spray means per cent incidence was found least in Cartap hydrochloride 50 WP (T5) followed by Flubendamide 480 SC (T1) and Rynaxypyr 20 SC (T2) treated treatment i.e., 3.23%, 3.67% and 4.43% respectively. Maximum incidence of leaf folder was found in Azadirachtin 3000 ppm i.e., 5.67%. Two weeks after spray Cartap hydrochloride remain effective overall insecticide, least per cent incidence was found in the Cartap hydrochloride 50 WP (T5) followed by Flubendamide 480 SC (T1) and Rynaxypyr 20 SC (T2) treated treatment i.e., 3.23%, 3.57% and 4.83% respectively. The highest numbers of leaf folder were found in Azadirachtin 3000 ppm (5.60%) treated plots. A similar, result was observed by (Padhan and Raghuraman 2018, Soomro *et al.*, 2020) [7, 11].

Table 2: Efficacy of newer molecules of insecticide against *C. medinalis* after (first spray)

Insecticides	Dosage (ml/g) per liter	PTC mean %/ hills	Mean % leaf damage/ hills (1st Spray)			
			3DAS	7DAS	14DAS	Overall mean
T1 - Flubendiamide 480 SC	0.3	4.47 (12.19)	4.00 (11.52)	3.67 (11.01)	3.57 (10.87)	3.74 (11.15)
T2 - Rynaxypyr 20 SC	0.25	5.13 (13.08)	4.67 (12.46)	4.43 (12.13)	4.83 (12.69)	4.64 (12.43)
T3 - Spinosad 45 SC	0.25	5.27 (13.25)	5.17 (13.13)	4.93 (12.82)	5.20 (13.17)	5.10 (13.04)
T4 - Fipronil 5 SC	0.75	5.53 (13.59)	5.20 (13.17)	5.13 (13.08)	5.23 (13.21)	5.19 (13.15)
T5 - Cartap hydrochloride 50 WP	2.0	4.53 (12.28)	3.57 (10.86)	3.23 (10.35)	3.23 (10.34)	3.34 (10.52)
T6 - Lamda cyhalothrin 5EC	1.0	5.77 (13.88)	5.27 (13.25)	5.13 (13.08)	5.43 (13.46)	5.28 (13.27)
T7 - Emamectin benzoate 5 SG	0.4	4.53 (12.28)	4.93 (12.82)	4.77 (12.59)	4.90 (12.78)	4.87 (12.73)
T8 - Azadirachtin 3000 ppm	3.0	5.73 (13.840)	5.50 (13.54)	5.67 (13.76)	5.60 (13.66)	5.59 (13.67)
Control		5.40 (13.42)	6.13 (14.33)	6.50 (14.76)	6.13 (14.33)	6.26 (14.47)
C.D. at (5%)		0.76	0.95	0.95	0.87	0.38
C.V.		3.35	4.27	4.35	3.94	1.73
SE(m) ±		0.25	0.31	0.31	0.29	0.12

*Mean of three replication, ** Figures of the parenthesis are angular transformed values,
PTC- Pretreatment count, DAS- Days after spray

Table 3: Efficacy of newer molecules of insecticide against *C. medinalis* after (second spray)

Insecticides	Dosage (ml/g) per liter	PTC mean %/ hills	Mean % leaf damage/ hills (2nd Spray)			
			3DAS	7DAS	14DAS	Overall mean
T1 - Flubendiamide 480 SC	0.3	6.90 (15.22)	6.77 (15.07)	6.53 (14.80)	6.83 (15.15)	6.71 (15.01)
T2 - Rynaxypyr 20 SC	0.25	7.50 (15.88)	7.17 (15.52)	6.87 (15.19)	7.10 (15.45)	7.04 (15.39)
T3 - Spinosad 45 SC	0.25	7.30 (15.66)	7.27 (15.63)	6.93 (15.26)	7.00 (15.34)	7.07 (15.41)
T4 - Fipronil 5 SC	0.75	6.80 (15.10)	6.77 (15.03)	6.80 (15.10)	7.17 (15.52)	6.92 (15.25)
T5 - Cartap hydrochloride 50 WP	2.0	6.70 (14.99)	6.50 (14.76)	6.42 (14.67)	6.32 (14.55)	6.41 (14.66)
T6 - Lamda cyhalothrin 5EC	1.0	7.60 (15.99)	7.37 (15.74)	7.00 (15.33)	6.93 (15.26)	7.10 (15.45)
T7 - Emamectin benzoate 5 SG	0.4	6.90 (15.21)	6.83 (15.14)	6.67 (14.96)	6.83 (15.15)	6.78 (15.08)
T8 - Azadirachtin 3000 ppm	3.0	7.67 (16.05)	7.43 (15.81)	7.20 (15.56)	7.37 (15.74)	7.33 (15.71)
Control		7.93 (16.34)	8.07 (16.49)	8.27 (16.70)	8.33 (16.77)	8.22 (16.66)
C.D. at (5%)		0.43	0.55	0.57	0.45	0.28
C.V.		0.14	0.18	0.19	0.15	0.09
SE(m) ±		1.58	2.02	2.13	1.67	1.03

*Mean of three replication, ** Figures of the parenthesis are angular transformed values,
PTC- Pretreatment count, DAS- Days after spray

Efficacy of insecticides against *C. medinalis* after second spray

The result revealed that the per cent leaf damage ranged from 6.70% to 7.93% across the treatments at one day before the application of second spray. After that we're all the treatment significantly effective to reduce the infestation of rice leaf folder as compared to the untreated plot (Table 3). At first observation taken, (3rd Day after spray) i.e., least per cent incidence was observed in the Cartap hydrochloride 50 WP (T5) followed by Flubendamide 480 SC (T1) and Fipronil 5 SC (T4) treated treatment i.e., 6.50%, 6.77%, and 6.77% respectively. Least efficacy of the neem treated plot was found to be (7.43%) followed by lamda cyhalothrin (7.37%). Similar results were observed a week after spray mean per cent incidence was found least in Cartap hydrochloride 50 WP (T5) followed by Flubendamide 480 SC (T1) and - Emamectin benzoate 5 SG (T7) treated treatment i.e., 6.42%, 6.53% and 6.67% respectively. Maximum incidence of leaf folder was found in Azadirachtin 3000 ppm i.e., 5.67%. Two weeks after spray Cartap hydrochloride remain effective overall insecticide, least per cent incidence was found in the Cartap hydrochloride 50 WP (T5) followed by Flubendamide 480 SC (T1) and Emamectin benzoate 5 SG (T7) treated treatment i.e., 6.41%, 6.71% and 6.78% respectively. The highest numbers of leaf folder infestations were found in Azadirachtin 3000 ppm (7.33%) treated plots. The newer insecticides were sprayed at 60 and 90 days after transplanting. Results revealed that all the insecticides were effective and least per cent leaf damage and higher grain yield (Girish *et al*., 2015) [3].

Natural enemies incidence after newer molecules insecticide application against *C. medinalis* in rice ecosystem

Population densities of natural enemies such as predators and other non-target arthropods (ladybird beetles, wolf spiders, carabid beetles, earwigs, green mired bugs) and damsel flies were all are abundantly present before spraying but, after application of insecticides significantly reduce their population densities. Patterns of abundance were similar for the different non-target organisms. The highest numbers of non-targets were found in the control (untreated) plots. Among the treated plots with insecticides, the highest numbers were in T5, whereas the lowest was in T6. Numbers in the other treatment were intermediate between T5 and T6, although differences were not always statistically significant. Reductions in abundances of non-targets were on average about twice as high in T5 than T6. The results justified with the previously reported by (Rahaman and Stout 2019) [10]. The reduction percentage of predator numbers in insecticide-treated plots relative to the control was lower than those in predator numbers. Thus, it appears that the natural enemies were more sensitive to insecticides than the target pests.

Conclusion

The rice leaf folder, *Cnaphalocrocis medinalis* (Guenee) considered an important pest among several insect species which were recorded as pests of rice, as it effects rice production in almost all of the rice growing countries of Asia. The present study suggests that all the tested chemicals were effective for rice folder management but among the newer insecticide molecules Cartap hydrochloride 50 WP @ 2g/l, followed by Flubendiamide 480 SC @ 0.3ml/l and Rynaxypyr 20 SC @0.25ml/l highly effective and rice leaf folder and also not harmful to the natural enemies.

Conflict of Interest

On behalf of all authors, the corresponding author states that there is no conflict of interest.

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