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EFFICACY AND ECONOMICS OF COMBINATION INSECTICIDES AGAINST YELLOW STEM BORER (*SCIRPOPHAGA INCERTULAS*) AND LEAF FOLDER (*CNAPHALOCROCIS MEDINALIS*) IN RICE

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ABSTRACT

Investigation was carried to evaluate combination insecticides against rice yellow stem borer and leaf folder. The most effective treatment after 1st and 2nd spray, was chlorantraniliprole 10% + Lambda cyhalothrin 5% ZC 250 mL ha⁻¹ (3.38% dead heart, 3.29% White ear; 3.52 % leaf damage hill⁻¹ and 3.30 % leaf damage hill⁻¹) and least effective was found treatment Triazophos 35% EC + Deltamethrin 1% EC 1000 mL ha⁻¹ (6.32% dead heart, 5.64% White ear; 6.13 % leaf damage hill⁻¹ and 6.78 % leaf damage hill⁻¹). The maximum yield was obtained in chlorantraniliprole 10% + Lambda Cyhalothrin 5% ZC 250 mL ha⁻¹ (40.25 q ha⁻¹); while the minimum in the treatment Triazophos 5%EC + Deltamethrin 1%EC (23.50 qha⁻¹). The highest incremental benefit: cost ratio was in the treatment Profenofos 40%+Cypermethrin 4% EC 1250 mL ha⁻¹ (1:13.82), while the least was in Imidacloprid 40% + Fipronil 40% WG 500 g ha⁻¹ (1:1.30).

Key words: Chlorantraniliprole, lambda cyhalothrin, dead heart, leaf damage, benefit: cost ratio

Introduction

In India, the rice crop covers an extensive area of approximately 43.79 million hectares, resulting in a total production of 116.42 million metric tons. The average productivity stands at 2659 kg/ha. Focusing specifically on Uttar Pradesh, rice cultivation spans over an area of about 5.74 million hectares, yielding a production of 12.47 million metric tons. The productivity in this state reaches 2704 kg/ha. Notably, Uttar Pradesh holds the second position in rice production across the country, trailing behind West Bengal (Dwivedi *et al.*, 2011).

Rice, a staple crop in India, thrives in tropical, sub-tropical, and humid climates. It is cultivated extensively across the country. Raw rice, rich in essential nutrients, contains approximately 6-9% protein and 77-84% carbohydrates. Additionally, it serves as an excellent source of thiamine (Vitamin B₁), riboflavin (Vitamin B₂), and niacin, encompassing all eight essential amino acids (Muralidharan and Pasalu, 2006).

Indian farmers grapple with substantial economic

losses in paddy cultivation year after year. These losses stem from a multitude of biotic stress including pests and diseases. Among these factors, pests play a pivotal role in limiting yield. In fact, pests are responsible for a 30% reduction in production across India (Sachan *et al.*, 2006; Dhaliwal *et al.*, 2010). Approximately 100 insect species have been documented as threats to rice crops in the country. Of these, 20 major pests stand out, including the Rice yellow stem borer, *Scirpophaga incertulas*, Rice leaf folder, *Cnaphalocrosis medinalis*, White-backed plant hopper, *Sogatella furcifera*, Brown plant hopper, *Nilaparvata lugens*, Gall midge, *Orseolia oryzae*, and the Rice Gundhi bug, *Leptocoris acuta*. These pests collectively cause 21% to 51% yield losses in diverse rice agroecosystems (Dhaliwal and Singh, 1996; Pathak and Khan, 1994).

Yellow stem borer (YSB), scientifically known as *Scirpophaga incertulas*, emerges as the most formidable pest of rice crops. Its devastating impact results in annual yield losses ranging from 10% to 60% (Panda *et al.*, 1976; Mahar *et al.*, 1985; Muralidharan and Pasalu,

2006). On a global scale, this insect single-handedly accounts for 10 million tons of yield reduction and is responsible for 50% of all insecticide usage in rice fields (Huesing and English, 2004).

The rice leaf folder, scientifically known as *Cnaphalocrocis medinalis*, holds significant importance as a pest in rice cultivation. Over the past few years, it has escalated to the status of an economic pest. Reports indicate that yield losses due to the leaf folder range from 18% to 60%. Researchers have closely studied this pest's impact, emphasizing the need for effective management strategies to mitigate its effects on rice production (Ramasamy and Jaliecksono, 1996; Alvi *et al.*, 2003).

Combination insecticides, also known as mixed or dual-action insecticides, are formulations that blend two or more active ingredients. These synergistic combinations aim to enhance pest control efficacy by targeting multiple aspects of the pest's biology or physiology. For instance, a combination might include an insect growth regulator to disrupt the pest's development alongside a neurotoxic insecticide for immediate knockdown. By utilizing different modes of action, combination insecticides reduce the risk of resistance development and provide more robust protection against pests in agricultural and horticultural settings. Considering the information provided, the recent research aimed to evaluate the bio-efficacy of a combination of insecticides against rice yellow stem borer and rice leaf folder by assessing the effectiveness, we sought to enhance pest management strategies and optimize rice production.

Materials and Methods

The assessment of bio-efficacy of certain Combination Insecticides *viz.*, Betacyfluthrin 8.49%+Imidacloprid 19.81%OD 400mL ha⁻¹ (T₁), Chlorantraniliprole 10%+Lambda Cyhalothrin 5% ZC 250mL ha⁻¹ (T₂), Chlorpyriphos 50%+Cypermethrin 5% EC 1000mL ha⁻¹ (T₃), Profenofos 40%+Cypermethrin 4% EC 1250mL ha⁻¹ (T₄), Imidacloprid 40%+Fipronil 40% WG 500g ha⁻¹ (T₅), Imidacloprid 40%+Ethiprole 40% WG 500g ha⁻¹ (T₆), Triazophos 35% EC + Deltamethrin 1% EC 1000mL ha⁻¹ (T₇) and Control (T₈) against rice yellow stem borer and rice leaf folder was carried out at Students' Instructional Farm (SIF), Acharya Narendra Deva University of Agriculture and Technology, Kumarganj, Ayodhya (U.P.). The unit plot size was kept at 5×3 m² with a 1m field border line to line spacing kept at 20cm and plant to plant spacing kept at 15cm. The experiment was laid out in Randomized Block Design (RBD) with 3 replications on rice variety NDR-2065. The observation

was recorded a day before the spray and again afterward 3rd, 7th and 15th day after each spraying in each treatment from 10 randomly selected hills. Rice stem borer counts were taken on no. of dead hearts/white ears and total numbers of tillers/panicles from 10 randomly selected hills. The percent incidence (dead heart/white ears) was calculated as follows.

$$\text{Percent incidence} = \frac{\text{No. of dead hearts / white ears}}{\text{Total no. of tillers / panicles}} \times 100$$

Leaf folder damaged leaf and total leaves from 10 randomly selected hills were observed in each plot & the percentage of leaf damage was calculated as follows.

$$\text{Percent incidence} = \frac{\text{No. of damaged leaves}}{\text{Total no. of leaves}} \times 100$$

In this context, we have closely monitored the yield for various treatments and then converted yield into quintals per hectare. To assess the financial implications, we factored in several components: the prevailing market price of the produce, the expenses incurred on insecticides, labor costs, and other inputs. Subsequently, calculated the incremental benefit-cost ratio for each treatment by comparing the additional returns (in rupees) over the control group with the cost of insecticide spray in each treatment. This comprehensive analysis allowed to evaluate the effectiveness and economic viability of different treatments.

Results and Discussion

Rice yellow stem borer (*S. incertulas*)

The damage of rice yellow stem borer was recorded a day before spray distributed homogenously throughout the experiment and ranged from 9.60-11.10% dead hearts. The mean damage percentage of 3, 7 and 15 DAS after first spray revealed that the smallest amount of dead hearts was found in the treatment Chlorantraniliprole 10% + Lambda cyhalothrin 5% ZC 250 mL ha⁻¹ (3.38% dead hearts) followed by Imidacloprid 40% + Fipronil 40% WG 500 g ha⁻¹ (3.92% dead hearts) while the highest per cent of dead heart was recorded in treatment Triazophos 35% EC + Deltamethrin 1% EC 1000 mL ha⁻¹ (6.32% dead hearts) followed by Chlorpyriphos 50% + Cypermethrin 5% EC 1000 mL ha⁻¹ (5.96% dead heart) as compared to Control (water spray) (10.65% dead heart).

The overall mean of data recorded 3, 7 and 15 after 2nd spray; the least damage was found in the treatment Chlorantraniliprole 10% + Lambda Cyhalothrin 5% ZC 250 mL ha⁻¹ (3.29% white ears) followed by Imidacloprid 40% + Fipronil 40% WG 500 g ha⁻¹ (3.69% white ears), while the most damage recorded in treatment Triazophos 35% EC + Deltamethrin 1% EC 1000 mL ha⁻¹ (5.64% white ears) followed by Chlorpyriphos 50% +

Table 1: Bio efficacy of certain combination insecticides against rice yellow stem borer during *Kharif*.

Treatments/ Dose ha ⁻¹	*Mean incidence of yellow stem borer									
	Dead heart (%)					White ear (%)				
	First Spray					Second Spray				
	DBS	3 DAS	7 DAS	15DAS	Mean	DBS	3 DAS	7 DAS	15DAS	Mean
Beta cyfluthrin 8.49% + Imidacloprid 19.81% OD/400mL	10.13 (18.56)	5.72 (13.83)	4.92 (12.81)	6.09 (14.19)	5.55 (13.62)	7.85 (16.27)	4.62 (12.41)	4.50 (12.25)	5.73 (13.85)	4.96 (12.86)
Chlorantraniliprole 10%+Lambda Cyhalothrin 5%ZC/ 250mL	11.07 (19.43)	2.80 (9.63)	2.40 (9.63)	3.73 (11.14)	3.38 (10.59)	7.44 (15.83)	2.97 (9.92)	2.92 (9.83)	4.00 (11.54)	3.29 (10.46)
Chlorpyriphos 50%+ Cypermethrin 5%EC/ 1000mL	10.08 (18.51)	6.02 (14.20)	5.40 (13.44)	6.47 (14.74)	5.96 (14.13)	7.88 (16.30)	5.11 (13.06)	4.82 (12.68)	6.05 (14.24)	5.32 (13.34)
Profenofos 40%+ Cypermethrin 4%EC/ 1250mL	10.18 (18.61)	4.94 (12.84)	4.20 (11.83)	5.43 (13.48)	4.86 (12.73)	7.48 (15.88)	4.29 (11.95)	4.02 (11.56)	5.37 (13.39)	4.56 (12.33)
Imidacloprid 40%+Fipronil 40%WG/ 500g	11.10 (19.46)	4.08 (11.66)	3.32 (10.49)	4.37 (12.06)	3.92 (11.42)	7.79 (16.21)	3.23 (10.36)	3.21 (10.32)	4.62 (12.41)	3.69 (11.07)
Imidacloprid 40%+ Ethiprole 40%Wg/ 500g	10.17 (18.59)	4.53 (12.29)	3.90 (11.39)	4.90 (12.79)	4.44 (12.17)	7.72 (16.13)	3.77 (11.19)	3.70 (11.09)	5.03 (12.96)	4.17 (11.78)
Triazophos 35%EC + Deltamethrin 1%EC/ 1000mL	10.90 (19.28)	6.38 (14.63)	5.82 (13.96)	6.76 (15.07)	6.32 (14.56)	7.84 (16.26)	5.37 (13.39)	5.20 (13.18)	6.35 (14.60)	5.64 (13.74)
Control (Water Spray)/ 500mL	9.60 (18.05)	10.65 (19.05)	10 (18.43)	11.30 (19.64)	10.65 (19.05)	7.35 (15.73)	9.30 (17.76)	9.42 (17.87)	10.10 (18.53)	9.61 (18.05)
CD @ 5%	(NS)	(0.57)	(0.84)	(0.07)	(0.24)	(NS)	(0.82)	(0.05)	(0.40)	(0.44)
S.Em. ±	-	(0.19)	(0.28)	(0.02)	(0.08)	-	(0.27)	(0.02)	(0.13)	(0.14)
Figures in the parentheses are angular transformed values, NS= Non-significant, DBS= Day before spray, DAS= Days after spray; *Mean of three replications										

Cypermethrin 5% EC 1000 mL ha⁻¹ (5.32% white ears) as compared to Control (water spray) (9.61% white ears).

The combination insecticide, Chlorantraniliprole 10% + Lambda-cyhalothrin 5% ZC, synergistically combines two active ingredients with distinct modes of action. Chlorantraniliprole disrupts the pest's growth and development, while Lambda-cyhalothrin acts as a neurotoxin, providing immediate knockdown of what. The two active ingredients act on different biological pathways, making it harder for pests to develop resistance. The findings are strongly supported by Kumar *et al.*, (2021) who reported that Chlorantraniliprole 10% + Lambda-cyhalothrin 5% ZC 250 mL ha⁻¹ was recorded the most effective against management of Tomato fruit borer. The findings are also agreement with Sen *et al.*, (2017) who found that Ampligo 150 ZC (Chlorantraniliprole 9.3% + Lambda-cyhalothrin 4.6% ZC) @ 35 g a.i./ha was recorded against shoot and fruit borer of Brinjal lowest percent shoot (1.26%) and fruit (2.49%) infestation. The present findings are in agreement with Bajya *et al.* (2015) who reported that Chlorantraniliprole 9.3% + Lambda-cyhalothrin 4.6% 150 ZC @ 37.5 g a.i./ha was found to be effective against cotton boll worm.

Rice leaf folder (*C. medinalis*)

The per cent leaf damage hill⁻¹ was observed one day before spray dispersed consistently during the

experiment and ranged from 9.00-9.80% per cent leaf damage hill⁻¹. The leaf damage caused by rice leaf folder recorded at 3, 7 and 15 DAS (mean value) after first spray; the most effective treatment was Chlorantraniliprole 10% + Lambda Cyhalothrin 5% ZC 250 mL ha⁻¹ (3.52% leaf damage hill⁻¹) followed by Imidacloprid 40% + Fipronil 40% WG 500g ha⁻¹ (3.93% leaf damage hill⁻¹) although the highest per cent damage leaf/hill was observed in the treatment Triazophos 35% EC + Deltamethrin 1% EC 1000 mL ha⁻¹ (6.13% leaf damage hill⁻¹) followed by Chlorpyriphos 50%+ Cypermethrin 5% EC 1000 mL ha⁻¹ (5.77% leaf damage hill⁻¹) as compared to Control (water spray) (10.65% leaf damage hill⁻¹).

The overall mean data of 3, 7 and 15 days after 2nd spray damage caused by the rice leaf folder was lowest in the treatment Chlorantraniliprole 10%+Lambda Cyhalothrin 5% ZC 250 mL ha⁻¹ (3.30% leaf damage hill⁻¹) followed by Imidacloprid 40% + Fipronil 40% WG 500g ha⁻¹ (3.54% leaf damage hill⁻¹) while the highest per cent leaf damage was recorded in the treatment Triazophos 35% EC + Deltamethrin 1% EC 1000 ml/ha (6.78% leaf damage hill⁻¹) followed by treatment Chlorpyriphos 50% + Cypermethrin 5% EC 1000 mL ha⁻¹ (6.02% leaf damage hill⁻¹) as compared to treatment Control (water spray) (8.66% leaf damage hill⁻¹).

Table 2: Bio efficacy of certain combination insecticides against Rice leaf folder during *Kharif* 2021.

Treatments/ Dose ha ⁻¹	*Mean percent leaf damage per hill									
	First Spray					Second Spray				
	DBS	3 DAS	7 DAS	15DAS	Mean	DBS	3 DAS	7 DAS	15DAS	Mean
Beta cyfluthrin 8.49% + Imidacloprid 19.81% OD/400mL	9.00 (17.46)	5.54 (13.62)	4.53 (12.29)	6.12 (14.32)	5.40 (13.41)	6.82 (15.14)	5.86 (14.00)	5.27 (13.27)	5.75 (13.87)	5.62 (13.71)
Chlorantraniliprole 10%+Lambda Cyhalothrin 5%ZC/ 250mL	9.69 (18.13)	3.60 (10.94)	2.90 (9.80)	4.05 (11.61)	3.52 (10.78)	6.92 (15.56)	3.61 (10.95)	2.78 (9.60)	3.52 (10.81)	3.30 (10.45)
Chlorpyriphos 50%+ Cypermethrin 5%EC/ 1000mL	9.72 (18.17)	6.02 (14.20)	4.80 (12.66)	6.48 (14.74)	5.77 (13.87)	7.02 (15.37)	6.34 (14.59)	5.71 (13.82)	6.00 (14.18)	6.02 (14.20)
Profenofos 40%+ Cypermethrin 4%EC/ 1250mL	9.80 (18.24)	5.13 (13.09)	4.05 (11.60)	5.66 (13.77)	4.95 (12.82)	7.07 (15.42)	5.18 (13.16)	4.63 (12.43)	4.77 (12.61)	4.86 (12.73)
Imidacloprid 40%+Fipronil 40%WG/ 500g	9.67 (18.12)	4.09 (11.66)	3.10 (10.15)	4.60 (12.38)	3.93 (11.40)	7.16 (15.52)	4.13 (11.72)	3.64 (10.21)	3.37 (10.57)	3.54 (10.83)
Imidacloprid 40%+ Ethiprole 40%Wg/ 500g	9.65 (18.10)	4.70 (12.52)	3.57 (10.89)	5.12 (13.08)	4.46 (12.16)	7.17 (15.53)	4.79 (12.64)	3.71 (11.11)	4.08 (11.66)	4.19 (11.80)
Triazophos 35%EC + Deltamethrin 1%EC/ 1000mL	9.60 (18.05)	6.44 (14.70)	5.08 (13.02)	6.86 (15.19)	6.13 (14.30)	7.03 (15.38)	6.82 (15.14)	6.27 (14.50)	7.26 (15.63)	6.78 (15.09)
Control (Water Spray)/ 500mL	9.64 (18.09)	10.06 (18.49)	10.38 (18.80)	10.65 (19.05)	10.36 (18.78)	7.69 (16.10)	8.26 (16.71)	8.83 (17.28)	8.66 (17.34)	8.66 (17.11)
CD @ 5%	NS	(0.50)	(1.01)	(0.43)	(0.67)	NS	(0.73)	(0.49)	(0.98)	(0.73)
S. Em. ±	—	(0.16)	(0.33)	(0.14)	(0.22)	—	(0.24)	(0.16)	(0.32)	(0.24)
Figures in the parentheses are angular transformed values, NS= Non-significant, DBS= Day before spray, DAS= Days after spray; *Mean of three replications										

The combination insecticide, Chlorantraniliprole 10% + Lambda-cyhalothrin 5% ZC, synergistically combines two active ingredients with distinct modes of action. Chlorantraniliprole disrupts the pest's growth and development, while Lambda-cyhalothrin acts as a neurotoxin, providing immediate knockdown. The two active ingredients act on different biological pathways, making it harder for pests to develop resistance. These findings are in agreement with Floret *et al.*, (2019) who reported that the Chlorantraniliprole 9.3% + Lambda-cyhalothrin 4.6% 150 ZC performed best against tomato fruit and shoot borer. The present findings are also in arrangement with Bajya *et al.*, (2015) who noticed that the Chlorantraniliprole 9.3% + Lambda- cyhalothrin 4.6% 150 ZC @ 37.5 g a.i/ha effective against cotton boll worm. The present findings also supported by Reddy and Paul

(2019) Lambda cyhalothrin 4.6% + Chlorantraniliprole 9.3% ZC @ 30 g a.i ha⁻¹, Thiamethoxam 12.6% + Lambda-cyhalothrin 9.5% ZC @ 27.5 g a.i ha⁻¹ and Chlorantraniliprole 8.8% + Thiamethoxam 17.5% SC @ 150 g a.i ha⁻¹ were found superior in the management of *M. vitrata* and *S. litura*

Effect of Certain Combination Insecticides on Yield of Rice

The study made on the effect certain combination insecticides on yield of Rice among all the treatment produces significantly higher yield as compared to the treatment control (water spray) (18.17 q ha⁻¹). In the present investigation maximum yield was obtained in the treatment Chlorantraniliprole 10% + Lambda Cyhalothrin 5% ZC 250 mL ha⁻¹ (40.25 q ha⁻¹) followed by treatment

Table 3: Economics of certain combination insecticides in Rice during *Kharif* 2021.

Treatments	Cost of spraying/ha	Yield (q/ha)	Additional yield (q/ha)	Net return (Rs./ha)	Incremental B:C ratio	Rank
Betacyfluthrin 8.49% + Imdacloprid 19.81% OD	Rs. 3900	30.00	11.83	Rs. 18050	4.62:1	IV
Chlorantraniliprole 10% + Lambda Cyhalothrin 5%ZC	Rs. 6280	40.25	22.08	Rs. 36555	5.82:1	III
Chlorpyriphos50% + Cypermethrin 5%EC	Rs. 2050	26.50	8.33	Rs. 14110	6.88:1	II
Profenofos 40% + Cypermethrin 4%EC	Rs. 1830	32.15	13.98	Rs. 25291	13.82:1	I
Imidacloprid 40% + Fipronil 40%WG	Rs. 16,300	37.50	19.33	Rs. 21200	1.30:1	VII
Imidacloprid 40% + Ethiprol 40%WG	Rs. 13,100	35.00	16.83	Rs. 19550	1.49:1	VI
Triazophos 5%EC + Deltamethrin 1%EC	Rs. 2900	23.50	5.33	Rs. 7440	2.56:1	V
Control (Water Spray)	-	18.17	-	-	-	VIII

Imidacloprid 40%+Fipronil 40% WG 500 g ha⁻¹ (37.50 q ha⁻¹), while the lower yield was recorded in the treatment Triazophos 35% EC + Deltamethrin 1% EC 1000 mL ha⁻¹ (23.50 q ha⁻¹) followed by Chlorpyrifos 50% + Cypermethrin 5% EC 1000 mL ha⁻¹ (26.50 q ha⁻¹). The present findings are similar agreement with the finding of Rana *et al.*, (2017) who observed that, the maximum yield (44.58 qha⁻¹) was recorded from Chlorantraniliprole 18.5 SC.

Economics of Certain Combination Insecticides in Rice

The data pertaining to economics various treatments are presented in Table 3 depicted that highest net return was recorded under the treatment Chlorantraniliprole 10% + Lambda Cyhalothrin 5% ZC 250 mL ha⁻¹ (Rs. 36555.20) followed by Profenofos 40% + Cypermethrin 4% EC 1250 mL ha⁻¹ (Rs. 25291.20), while the lowest net return was under the treatment Triazophos 35% EC + Deltamethrin 1% EC 1000 mL ha⁻¹ (Rs. 7440.20) followed by Chlorpyrifos 50%+Cypermethrin 5%EC (Rs. 14110.20). The highest incremental benefit: cost ratio of different insecticides revealed the treatment Profenofos 40% + Cypermethrin 4% EC 1250 mL ha⁻¹ (1:13.82) followed by Chlorpyrifos 50% + Cypermethrin 5% EC 1000 mL ha⁻¹ (1:6.88), while the lowest incremental benefit: cost ratio of different insecticides revealed the treatment Imidacloprid 40%+Fipronil 40% WG 500 g ha⁻¹ (1:1.30) followed by Imidacloprid 40% + Ethiprole 40% WG 500 g ha⁻¹ (1:1.49).

In Conclusion, the research findings underscore the efficacy of Chlorantraniliprole 10% + Lambda-cyhalothrin 5% ZC (250 mL ha⁻¹) in managing the Rice yellow stem borer (*Scirpophaga incertulas*) and rice leaf folder, *Cnaphalocrocis medinalis*. This dual-action insecticide not only targets the pest at various growth stages but also minimizes the risk of resistance development. The field trials demonstrate its ability to reduce larval populations, resulting in fewer dead hearts, white ears, and leaf damage per hill. Moreover, the treatment proves economically viable, yielding higher net returns. As we strive to enhance pest management practices and optimize crop production, this combination insecticide emerges as a valuable tool for sustainable agriculture.

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