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Bio-efficacy of insecticides against major insect pests of rice

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Abstract

A field experiment was conducted at the Research cum Instructional Farm, Shaheed Gundadhar College of Agriculture and Research Station, Jagdalpur, Bastar, Chhattisgarh during Kharif 2024 to evaluate the bio-efficacy of six insecticides against major insect pests of rice. The treatments comprised Chlorpyrifos 20% EC @ 1 ml/l, Chlorantraniliprole 18.5% SC @ 0.55 ml/l, Lambda-cyhalothrin 5% EC @ 1.6 ml/l, Carbosulfan 25% EC @ 1.2 ml/l, Tetraniliprole 18.18% SC @ 0.32 ml/l, Bifenthrin 10% EC @ 2.5 ml/l and untreated control, laid out in Randomized Block Design (RBD) with three replications. Three sprays were applied at 25, 45 and 60 days after transplanting (DAT). All insecticidal treatments significantly reduced the infestation of yellow stem borer, gall midge, leaf folder and whorl maggot compared to untreated control. Against stem borer, Carbosulfan 25% EC recorded the lowest overall mean dead heart incidence (1.73%) with maximum reduction over control (87.38%), while Chlorantraniliprole 18.5% SC recorded the lowest white ear head incidence at harvest (1.90%). Against gall midge, Bifenthrin 10% EC recorded the lowest overall mean silver shoot incidence (2.69%) with highest reduction over control (87.00%). Against leaf folder, Tetraniliprole 18.18% SC recorded the lowest mean leaf damage (5.67%) with highest reduction over control (75.45%). Against whorl maggot, Bifenthrin 10% EC recorded the lowest overall mean damage (3.43%) with highest reduction over control (84.38%). Grain yield was highest in Chlorantraniliprole 18.5% SC (52.71 q/ha) followed by Bifenthrin 10% EC (51.82 q/ha). Economic analysis revealed that Bifenthrin 10% EC recorded the highest ICBR of 1:3.43, making it the most economically viable treatment.

Keywords: Bio-efficacy, Insecticides, Rice, Stem borer, Gall midge, Leaf folder, Whorl maggot, ICBR

Introduction

Rice, *Oryza sativa* (Linnaeus) is one of the important cereal crops, being the staple food for more than 65 per cent of the world population (Mathur *et al.*, 1999)^[15]. Which provides 15% of the global calorie's intake and feeds about 45% of the world population and the area of rice cultivation in India is 45.5 million ha, with production of 1308.37 lakh tones and a productivity was 41q/ha About 24% of the world's total rice production is grown in India (Anonymous, 2022)^[1].

Rice and its cultivation are integral parts of humankind in and around the world. In efforts to end world hunger and malnutrition, rice is considered the most important crop with significant contributions to the world's primary food production (FAO,2022). More than half of the global rice production is shared by India and China. The primary challenge confronting rice scientists today is how to continually develop technologies that will eventually result in higher production to commensurate with the increasing population. India has surpassed China to become the world's most populous nation, with 142.86 crore inhabitants (UNFPA, 2023).

India has the largest area while china is the largest producer of rice in the world. The Year 2004 was declared as "International Year of Rice". Asian countries grow and eat around 85% of the world's rice. Due to its lack of fat and cholesterol, rice is a healthy cereal a good meal to include in a balanced diet is rice. It is a good source of fiber, calcium (0.3 g/mg), iron (38 ppm), protein (7.2%), carbohydrates (78%) and vitamins and minerals such thiamine (2.8 g/g), niacin (29.6 g/g) and riboflavin (0.5 g/g). There is not much sugar in it. Due to its gluten-free nature, rice is a need for diabetics and other patients with gluten-free dietary requirements (Laskowski *et al.*, 2019)^[14].

The state of Chhattisgarh is the 16th most populous and 10th largest in terms of area in India. It is also recognized as a major producer of rice 43 per cent of the state's total arable land is under cultivation, and about 70 per cent of the population works in agriculture. One of the main crops is paddy the geographical area is approximately 136 lakh ha, with 46.51 lakh ha of cultivable land and 60.76 lakh ha 2 of forest land (Jaiswal *et al.*, 2023) [8]. Rice is one of the vital crops in Chhattisgarh state and Chhattisgarh is the sixth largest producer of rice with the production of 8 million tons contributing 6 per cent of the rice production of the country and forth largest state in terms of rice area contributing 8 per cent area of the country (Jambhulkar *et al.*, 2024).

Chhattisgarh is a state in central India. It is known for rice cultivation and called "Rice Bowl of India" rice occupies average of 3.6 million hectare with the productivity of the state ranging between 1.2 to 1.6 tons per hectare depending upon the rainfall (Jaiswal and Soni 2024) [8]. It is cultivated in almost all the tropical, subtropical and temperate countries of the world. One of the major constraints of rice production and low productivity in India is the occurrence of insect pests at various stages of the crop growth. The rice crop is subject to attack by more than 100 species of insects and 20 of them can cause economic damage (Pathak and Khan, 1994) [18].

The rice crop is subject to attack by more than 100 species of insects, of which approximately 20 can cause significant economic damage (Pathak and Khan, 1994) [18]. Among the major pests, yellow stem borer *Scirpophaga incertulas* (Walker) causes 25-70% yield reduction; gall midge *Orseolia oryzae* (Wood-Mason) causes 15-60% loss; leaf folder *Cnaphalocrocis medinalis* (Guenée) accounts for 10% loss; and whorl maggot *Hydrellia sasakii* contributes to early-season crop damage. Together, these pests account for approximately 70% of the total insect-related yield losses in rice (Dhurwey and Deole, 2021) [4].

The present study was therefore undertaken to evaluate the comparative bio-efficacy of six insecticides representing different chemical groups and their economic viability against major insect pests of rice under Bastar Plateau conditions.

Material and Method

The field experiment was conducted at the Research cum Instructional Farm of Shaheed Gundadhar College of Agriculture and Research Station, Jagdalpur, Bastar (C.G.) - 494001 during Kharif 2024. The experiment was laid out in Randomized Block Design (RBD) with seven treatments and three replications. Each plot size was 25 m². The rice variety Swarna was used as the test crop, transplanted at 20 cm × 15 cm spacing. Six insecticides treatment were evaluated against an untreated control: T₁ - Chlorpyrifos 20% EC @ 1 ml/l; T₂ - Chlorantraniliprole 18.5% SC @ 0.55 ml/l; T₃ - Lambda-cyhalothrin 5% EC @ 1.6 ml/l; T₄ - Carbosulfan 25% EC @ 1.2 ml/l; T₅ - Tetraniliprole 18.18% SC @ 0.32 ml/l; T₆ - Bifenthrin 10% EC @ 2.5 ml/l; T₇ - Untreated control (water spray). Three sprays were applied at 25, 45 and 60 days after transplanting (DAT). Observations were recorded 3, 7 and 15 days after each spray. The per cent damage was calculated by using given formula:

For yellow stem borer per cent: The per cent incidence of yellow stem borer (*S. incertulas*) in term of dead heart and white ear head were recorded from 10 hills in each plot at tillering and panicle stages respectively.

$$\text{Percent dead heart} = \frac{\text{Number of dead heart or white ear}}{\text{Total number of tillers}} \times 100$$

For gall midge per cent: Total number of tillers and damaged tillers (onion shoots) was counted on 10 randomly selected plants (hills) to calculate percentage of silver shoots (SS%) i.e., gall midge incidence

$$\text{Percent silver shoot} = \frac{\text{Number of silver shoots}}{\text{Total number of tillers}} \times 100$$

For leaf folder per cent: The incidence of leaf folder (*C. medinalis*) was observed in terms of leaf damage and the per cent damage was recorded from at randomly selected 10 hills in each replication.

$$\text{Percent damage} = \frac{\text{Number of damaged leaves}}{\text{Total number of leaves}} \times 100$$

For whorl maggot per cent: The incidence of whorl maggot (*H. sasakii*) was observed in terms of leaf damage and the per cent damage was recorded from at randomly selected 10 hills in each replication.

$$\text{Percent damage} = \frac{\text{Number of damaged leaves}}{\text{Total number of tillers}} \times 100$$

Then, the pest intensity was scored as per standard evaluation system, International Rice Research Institute (IRRI)

Results and Discussion

Efficacy against Rice Stem Borer, *Scirpophaga incertulas* (Walker)

All insecticidal treatments significantly reduced dead heart (DH) percentage compared to the untreated control at all spray intervals (Table 1). Prior to treatment, the DH incidence ranged from 6.00 to 8.05% among plots, indicating a uniform pre-treatment pest population. After the first spray (25 DAT), the lowest DH incidence was recorded in Carbosulfan 25% EC (2.17%), which was at par with Chlorantraniliprole 18.5% SC (2.39%) and Lambda-cyhalothrin 5% EC (2.43%) (CD = 0.80). After the second spray (45 DAT), Carbosulfan 25% EC (2.89%) remained at par with Bifenthrin 10% EC (3.11%) and Chlorantraniliprole 18.5% SC (3.27%) (CD = 0.94). After the third spray (60 DAT), Bifenthrin 10% EC (0.04%) and Carbosulfan 25% EC (0.13%) recorded the lowest DH values, being at par with each other and significantly superior to all other treatments (CD = 0.36). The untreated control recorded progressively increasing DH (11.29%, 14.88% and 14.97% after 1st, 2nd and 3rd spray, respectively). The overall mean DH percentage was lowest in Carbosulfan 25% EC (1.73%) with the highest reduction over control (87.38%), followed by Bifenthrin 10% EC (2.15%, 84.32%) and Chlorantraniliprole 18.5% SC (2.22%, 83.80%). At harvest, Chlorantraniliprole 18.5% SC recorded the minimum white ear head (WEH) incidence (1.90%), followed by Carbosulfan 25% EC (2.37%), and was at par with Carbosulfan (CD = 0.22).

These results are in agreement with Bhagat *et al.* (2022) ^[2], who reported superior and consistent efficacy of newer chemical groups including chlorantraniliprole against rice stem borer. Jaglan *et al.* (2023) ^[7] also observed that Chlorantraniliprole at 50 g a.i./ha resulted in only 1.43% WEH compared to 7.21% in untreated plots. Mishra *et al.* (2024) ^[16] explained that diamide insecticides act as ryanodine receptor modulators causing rapid feeding cessation and prolonged muscle paralysis, justifying their strong field-level activity.

Efficacy against Rice Gall Midge, *Orseolia oryzae* (Wood-Mason)

All insecticidal treatments significantly suppressed silver shoot (SS) incidence compared to the untreated control at all observation intervals (Table 2). Pre-treatment SS incidence ranged from 13.27 to 17.64% across plots, confirming uniform infestation before spray imposition. After the first spray, Lambda-cyhalothrin 5% EC recorded the lowest SS incidence (4.15%), at par with Carbosulfan 25% EC (5.07%) and Bifenthrin 10% EC (5.73%) (CD = 1.10). After the second spray, Bifenthrin 10% EC (1.65%) was at par with Carbosulfan 25% EC (2.82%) (CD = 0.85). After the third spray, Bifenthrin 10% EC (0.70%) remained at par with Carbosulfan 25% EC (1.20%) and was significantly superior to all other treatments (CD = 0.21). The untreated control recorded 18.12%, 23.38% and 20.50% SS incidence after the three sprays, confirming sustained pest pressure. The overall mean SS percentage was lowest in Bifenthrin 10% EC (2.69%) with the highest reduction over control (87.00%), followed by Carbosulfan 25% EC (3.03%, 85.34%).

Suri (2011) ^[20] reported that repeated applications of pyrethroid insecticides, particularly bifenthrin, resulted in markedly lower SS incidence (2.5-5.6%) due to strong contact toxicity and rapid knockdown of newly hatched larvae. Kumar *et al.* (2023) ^[11] also confirmed that carbosulfan consistently recorded lower silver shoot incidence through its systemic and contact action targeting maggots feeding inside tillers.

Efficacy against Rice Leaf Folder, *Cnaphalocrocis medinalis* (Guenee)

All insecticidal treatments significantly reduced leaf folder (LF) damage compared to the untreated control throughout the spray schedule (Table 3). Pre-treatment LF incidence ranged from 9.05 to 15.05% among plots. After the first spray, Tetraniliprole 18.18% SC recorded the lowest LF incidence (7.35%), at par with Chlorantraniliprole 18.5% SC (7.85%) and Lambda-cyhalothrin 5% EC (8.10%) (CD = 0.74). After the second spray, Tetraniliprole 18.18% SC (5.75%) was at par with Chlorantraniliprole 18.5% SC (6.40%) and Lambda-cyhalothrin 5% EC (6.60%) (CD = 0.95). After the third spray, Tetraniliprole 18.18% SC (3.90%) was at par with Chlorantraniliprole 18.5% SC (4.30%) and Bifenthrin 10% EC (4.55%) (CD = 0.88). The untreated control recorded 21.80%, 22.90% and 24.60% LF incidence after the three sprays. The overall mean LF damage was lowest in Tetraniliprole 18.18% SC (5.67%) with the highest reduction over control (75.45%), followed by Chlorantraniliprole 18.5% SC (6.18%, 73.25%). Kumari *et al.* (2022) ^[12] reported superior control of rice leaf folder

by diamide insecticides; Patel *et al.* (2023) ^[17] explained that tetraniliprole causes prolonged muscle paralysis through ryanodine receptor activation, supporting its consistent performance in the present study. Jaglan *et al.* (2023) ^[7] observed that chlorantraniliprole-based formulations were highly effective against leaf folder with lower toxicity to non-target organisms.

Efficacy against Rice Whorl Maggot, *Hydrellia sasakii*

All insecticidal treatments significantly reduced whorl maggot (WM) leaf damage compared to untreated control at all observation intervals (Table 4). Pre-treatment WM damage ranged from 11.08 to 16.09% among plots. After the first spray, Bifenthrin 10% EC (3.50%) was at par with Carbosulfan 25% EC (4.50%) (CD = 0.53). After the second spray, Bifenthrin 10% EC (4.81%) remained at par with Carbosulfan 25% EC (7.36%) (CD = 0.88). After the third spray, Bifenthrin 10% EC (1.98%) was at par with Carbosulfan 25% EC (2.78%) and significantly superior to all remaining treatments (CD = 0.84). The untreated control showed an escalating trend of 18.20%, 23.30% and 24.34% damage after each spray. The overall mean WM damage was lowest in Bifenthrin 10% EC (3.43%) with the highest reduction over control (84.38%), followed by Carbosulfan 25% EC (4.88%, 77.77%) and Chlorantraniliprole 18.5% SC (7.24%, 67.02%). Kumar *et al.* (2022) ^[12] reported excellent control of rice whorl maggot by bifenthrin due to rapid knockdown effect and strong contact toxicity against adult flies and early larval stages. Singh *et al.* (2021) ^[19] also confirmed carbosulfan's effectiveness through systemic and contact action by inhibiting acetylcholinesterase activity.

Grain Yield

All insecticide-treated plots recorded significantly higher grain yield compared to the untreated control (46.00 q/ha) (Table 6). The highest grain yield was recorded in Chlorantraniliprole 18.5% SC (52.71 q/ha), followed by Bifenthrin 10% EC (51.82 q/ha) and Carbosulfan 25% EC (51.70 q/ha). The differences among treatments were statistically significant (CD = 3.20; SE(m)± = 1.04).

Economic Analysis

Economic analysis of insecticidal treatments (Table 6) revealed that Bifenthrin 10% EC recorded the highest ICBR of 3.43 with a net benefit of Rs 7,754 ha⁻¹, making it the most economically viable treatment. Carbosulfan 25% EC (ICBR: 1.90; net benefit: Rs 5,054 ha⁻¹) and Lambda-cyhalothrin 5% EC (ICBR: 2.00; net benefit: Rs 2,905 ha⁻¹) provided reasonable returns. Despite recording the highest grain yield, Chlorantraniliprole 18.5% SC recorded a moderate ICBR of 1:1.60 due to its higher cost of application. Tetraniliprole 18.18% SC recorded the lowest ICBR of 1:0.74, owing to its high market price relative to yield gains. These findings are in agreement with Hegde *et al.* (2015) ^[6], who reported higher profitability of pyrethroid-based insecticides due to their lower cost per application. Katel *et al.* (2023) ^[10] also confirmed that conventional insecticides like Lambda-cyhalothrin and Chlorpyrifos ensure reasonable economic returns, while certain newer molecules despite high efficacy may not yield favorable ICBR under field conditions (Devi *et al.*, 2021) ^[3].

Table 1: Bio-efficacy of insecticides against rice stem borer (Dead heart%)

Treatment	Pre-obs.	1st Spray	2nd Spray	3rd Spray	Overall Mean	ROC (%)
Chlorpyrifos 20% EC	6.02	3.45	4.01	1.43	2.96	78.41
Chlorantraniliprole 18.5% SC	8.05	2.39	3.27	1.02	2.22	83.80
Lambda-cyhalothrin 5% EC	2.93	2.43	4.83	3.21	3.49	74.55
Carbosulfan 25% EC	8.05	2.17	2.89	0.13	1.73	87.38
Tetraniliprole 18.18% SC	8.02	4.74	3.73	1.58	3.35	75.57
Bifenthrin 10% EC	6.04	3.31	3.11	0.04	2.15	84.32
Untreated Control	6.00	11.29	14.88	14.97	13.71	-
CD at 5%	N/S	0.80	0.94	0.36	0.70	-

Table 2: Bio-efficacy of insecticides against rice gall midge (Silver shoot%)

Treatment	Pre-obs.	1st Spray	2nd Spray	3rd Spray	Overall Mean	ROC (%)
Chlorpyrifos 20% EC	16.81	10.67	6.71	4.30	7.23	65.02
Chlorantraniliprole 18.5% SC	16.87	9.79	3.55	3.10	5.48	73.50
Lambda-cyhalothrin 5% EC	17.64	4.15	6.02	5.80	5.32	74.27
Carbosulfan 25% EC	17.07	5.07	2.82	1.20	3.03	85.34
Tetraniliprole 18.18% SC	16.84	6.79	4.97	4.80	5.52	73.29
Bifenthrin 10% EC	13.27	5.73	1.65	0.70	2.69	87.00
Untreated Control	15.61	18.12	23.38	20.50	20.67	-
CD at 5%	N/S	1.10	0.85	0.21	0.72	-

Table 3: Bio-efficacy of insecticides against rice leaf folder (Leaf folder%)

Treatment	Pre-obs.	1st Spray	2nd Spray	3rd Spray	Overall Mean	ROC (%)
Chlorpyrifos 20% EC	13.01	8.40	6.85	5.60	6.95	70.00
Chlorantraniliprole 18.5% SC	9.05	7.85	6.40	4.30	6.18	73.25
Lambda-cyhalothrin 5% EC	10.03	8.10	6.60	4.75	6.48	71.95
Carbosulfan 25% EC	15.05	9.10	7.20	5.35	7.22	68.74
Tetraniliprole 18.18% SC	12.02	7.35	5.75	3.90	5.67	75.45
Bifenthrin 10% EC	10.03	8.60	6.95	4.55	6.70	71.00
Untreated Control	13.00	21.80	22.90	24.60	23.10	-
CD at 5%	N/S	0.74	0.95	0.88	0.82	-

Table 4: Bio-efficacy of insecticides against rice whorl maggot (Damage%)

Treatment	Pre-obs.	1st Spray	2nd Spray	3rd Spray	Overall Mean	ROC (%)
Chlorpyrifos 20% EC	14.12	9.50	8.30	7.67	8.49	61.32
Chlorantraniliprole 18.5% SC	13.00	7.50	8.56	5.67	7.24	67.02
Lambda-cyhalothrin 5% EC	15.01	10.86	9.66	9.24	9.92	54.80
Carbosulfan 25% EC	12.34	4.50	7.36	2.78	4.88	77.77
Tetraniliprole 18.18% SC	16.09	9.83	10.52	8.00	9.45	56.96
Bifenthrin 10% EC	11.08	3.50	4.81	1.98	3.43	84.38
Untreated Control	13.10	18.20	23.30	24.34	21.95	-
CD at 5%	N/S	0.53	0.88	0.84	0.68	-

Table 5: Effect of insecticides on grain yield and economic analysis

Treatment	Yield (q/ha)	Plant prot. cost (Rs/ha)	Addl. yield (q/ha)	Value of addl. yield (Rs/ha)	Net benefit (Rs/ha)	ICBR
Chlorpyrifos 20% EC	49.81	3487	3.81	6287	2800	1.80
Chlorantraniliprole 18.5% SC	52.71	8139	6.71	13015	4870	1.60
Lambda-cyhalothrin 5% EC	49.60	2895	3.60	5800	2905	2.00
Carbosulfan 25% EC	51.70	5618	5.70	10672	5054	1.90
Tetraniliprole 18.18% SC	50.13	9476	4.13	7030	2446	0.74
Bifenthrin 10% EC	51.82	3196	5.82	10950	7754	3.43
Untreated Control	46.00	-	-	-	-	-
CD at 5%	3.20	-	-	-	-	-

Table 6: Effect of certain insecticides on cost and grain yield of rice

Trt	Insecticides	Dosage (formulation) ml/liter	Yield (Rs ha ⁻¹)	Additional Gain Yield Over Control		Avoidable Loss in Yield (%)	Value of Addition yield (Rs ha ⁻¹)	Cost of Insecticides and Labours (Rs ha ⁻¹)	Net Benefit (Rs ha ⁻¹)	Insecticides Cost Benefit Ratio (ICBR)
				q ha ⁻¹	(%)					
T ₁	Chlorpyriphos 20% EC	2.5	49.81	2.71	5.75	5.44	6287	3487	2800	1: 1.80
T ₂	Chlorantraniliprole 18.5% SC	0.32	52.71	5.61	11.91	10.63	13015	8139	4870	1: 1.60
T ₃	Lamda cyhalothrin 5% EC	1.2	49.60	2.50	5.31	5.04	5800	2895	2905	1: 2.00
T ₄	Carbosulfan 25% EC	1.6	51.70	4.60	9.77	8.87	10672	5618	5054	1: 1.90
T ₅	Tetraniliprole 18.18% SC	0.55	50.13	3.03	6.43	6.43	7030	9476	2446	1: 0.74
T ₆	Bifenthrin 10% EC	1	51.82	4.72	10.02	10.02	10950	3196	7754	1: 3.43
T ₇	Untreated	-	46.00	-	-	-	-	-	-	-

*Rice MSP as per C.G. Govt. - 2320 Rs q⁻¹ for 2024, Labour cost = 2 labours ha⁻¹ @ Rs 250.

Conclusion

The present investigation conclusively demonstrates that all evaluated insecticides significantly reduced infestation of yellow stem borer, gall midge, leaf folder and whorl maggot in rice compared to untreated control. Carbosulfan 25% EC and Bifenthrin 10% EC emerged as the most effective treatments against stem borer and whorl maggot, respectively, while Tetraniliprole 18.18% SC was most effective against leaf folder and Bifenthrin 10% EC against gall midge. Chlorantraniliprole 18.5% SC recorded the highest grain yield (52.71 q/ha). Economic analysis revealed Bifenthrin 10% EC as the most economically viable treatment with an ICBR of 1:3.43. Based on bio-efficacy and economic returns, Bifenthrin 10% EC @ 2.5 ml/l and Carbosulfan 25% EC @ 1.2 ml/l are recommended for inclusion in integrated pest management (IPM) programmes for rice insect pest management under Bastar Plateau conditions of Chhattisgarh.

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