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Bio efficacy of newer molecules against rice yellow stem borer in direct seeded rice

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Abstract
A field experiment was carried out during *kharif* 2025 at the College Farm, N.M.C.A., Navsari Agricultural University, Navsari, to evaluate the bio efficacy of eight insecticidal treatments against the rice yellow stem borer, *Scirpophaga incertulas* (Walker), in direct seeded rice. Among the treatments chlorantraniliprole 0.4 GR recorded the significantly lowest dead heart incidence (2.79%) and white ear incidence (2.95%), with the highest reduction over control of 77.91 and 78.15 per cent, respectively, and remained at par with chlorantraniliprole 9.3 + lambda cyhalothrin 4.6 ZC and fipronil 0.6 GR. Chlorantraniliprole 0.4 GR also recorded the highest grain yield (3.31 t/ha), an 88.38 per cent increase over the untreated control (1.84 t/ha). The results indicated that chlorantraniliprole-based formulations offer better and effective management for the yellow stem borer.

Keywords: Rice, yellow stem borer, *Scirpophaga incertulas*, Chlorantraniliprole, bio-efficacy, direct seeded rice

Introduction
Rice (Oryza sativa L.) is the staple food of more than sixty per cent of the world's population, of which nearly ninety-two per cent of total production and consumption of the world is contributed by Asia (Mangalarai and Mauria, 1999; FAO, 2023) [6, 14]. India has the largest area under rice cultivation in the world, covering about 47.83 million hectares (Anonymous, 2025a). In Gujarat, rice is cultivated over an area of approximately 0.96 million hectares, with an average productivity of 2.57 t/ha. Navsari is one of the important rice-growing districts of the state (Anonymous, 2025b). Still, there are several biotic and abiotic stresses that challenge both the yield and the grain quality of this crop in a given crop season (Rathee and Dalal, 2018; Savary *et al*., 2019) [25, 26], among which insect pests have the largest share as the rice agro-ecosystems provide an ideal habitat for most of the phytophagous species (Ali *et al*., 2021) [1].

Among the major insect pests associated with rice cultivation in South and South-East Asia, the yellow stem borer, Scirpophaga incertulas (Walker), is regarded as one of the most destructive pests, causing yield losses ranging from 25 to 87 per cent (Pallavi and Sharanabasappa, 2017; Krishnaiah and Mathur, 2004) [13, 19]. Following hatching, the larvae bore into the central shoot and feed internally during the vegetative stage, resulting in the characteristic dead heart symptom. Meanwhile, the tunneling is extended into the peduncle, thereby preventing any normal development of the panicle, and turning it into the so-called white ear during the reproductive stage (Viajante and Heinrichs, 1987) [30]. Because both symptoms translate directly into a loss of productive tillers and panicles, timely management of the pest is essential to safeguarding rice yield (Baskaran *et al*., 2019) [4].

Chemical control continues to be an important approach for managing yellow stem borer under field conditions (Rahaman and Stout, 2019) [22]. However, the repeated and indiscriminate use of conventional insecticides has contributed to the development of resistance to several major groups of insecticides (Matsumura and Sanada-Morimura, 2010). Rahaman and Stout (2019) [15, 22] reported that chlorantraniliprole 0.4 G was among the most effective treatments against yellow stem borer in Bangladesh, while Mehta *et al*. (2022) [17] also reported promising results with insecticidal treatments against the pest and Thorat et al. (2023) [28] similarly reported chlorantraniliprole formulations to outperform fipronil, spinosad and indoxacarb, and Meena and Kumar (2024) [16] recorded the combination product chlorantraniliprole 9.3 + lambda cyhalothrin 4.6 ZC to be highly effective at Puducherry (Udaybabu *et al*. 2025) [29].

Materials and Methods
1. Experimental site and crop
The field experiment was conducted during kharif 2025 at the College Farm, N.M. College of Agriculture, Navsari Agricultural University, Navsari, and Gujarat. Direct seeded rice of the variety GR-11 was sown with a seed rate of 50–60 kg/ha and a spacing of 30 × 10 cm. A basal dose of FYM at 10 t/ha and 80:30:0 kg NPK/ha was applied, and the crop was raised following the recommended package of practices for direct seeded rice, other than the insecticidal management schedule under evaluation.

2. Experimental design and treatments
Eight insecticidal treatments along with an untreated control were evaluated in a randomized complete block design (RCBD) with three replications. Each treatment was maintained in a gross plot size of 5.4 × 3.6 m, with a net plot size of 5.1 × 3.4 m. The details of the insecticides used, including their concentrations and application rates, are given in Table 1. All the treatments were applied twice during the crop season using a high-volume knapsack sprayer to ensure uniform application. The first spray was given when the pest appeared in the crop, followed by a second spray at 30 days after the first application.

Table 1: Details of the insecticidal treatments evaluated against the rice yellow stem borer

Sr. No.	Treatments	Conc. (%)	Dose a.i. (g/ha)	Dose (g or ml/10 L water)
1	Phenthoate 45% + Cypermethrin 6% EC	0.800	450.0	17.60
2	Imidacloprid 06% + Lambda-cyhalothrin 04% SL	0.006	18.0	3.60
3	Fipronil 15% + Flonicamid 15% WDG	0.024	60.0	4.00
4	Chlorantraniliprole 0.4% GR	0.004	40.0	10 kg/ha
5	Fipronil 0.6% GR	0.006	60.0	10 kg/ha
6	Chlorantraniliprole 9.3% + Lambda-cyhalothrin 4.6% ZC	0.007	28.0	5.00
7	Flubendiamide 20% WG	0.005	25.0	2.50
8	Cyclaniliprole 10% w/v DC	0.008	35.0	8.00
9	Control (Untreated)	–	–	–

3. Observations recorded

Dead heart incidence was recorded from 25 randomly selected hills per plot before spray and at 10 and 20 days after each spray, while white ear incidence was recorded at harvest. The per cent stem borer incidence was calculated using the formula of Chakraborty (2011) [5]:

$$\text{Per cent stem borer incidence} = \frac{\text{Number of dead heart/white ears}}{\text{Total number of tillers/panicles}} \times 100$$

Grain and straw yields were recorded plot-wise at harvest and expressed on a tonnes per hectare basis. The recorded percentage data were subjected to arcsine transformation prior to analysis of variance, and treatment means were compared using Duncan's New Multiple Range Test (DNMRT) at $p = 0.05$.

Results and Discussion

1. Effect of insecticidal treatments on dead heart incidence

Pre-spray dead heart incidence, recorded a day before the first spray, and ranged narrowly from 8.42 to 9.27 per cent across the treatments, with no significant difference among them (Table 2).

1.1 First spray

During the first spray the pooled 10 and 20 days dead heart incidence ranged from 3.06 to 12.23 per cent (Table 2). Chlorantraniliprole 0.4 GR recorded significantly lowest incidence (3.06%), which is on par with chlorantraniliprole 9.3 + lambda cyhalothrin 4.6 ZC (4.60%) and fipronil 0.6 GR (5.12%), while the untreated control recorded the highest incidence of dead heart (12.23%).

1.2 Second spray

After the second spray, a similar trend was noticed, with dead heart incidence ranging from 2.52 to 13.02 per cent (Table 2). Chlorantraniliprole 0.4 GR again proved as the most effective (2.52%), followed by chlorantraniliprole 9.3 + lambda cyhalothrin 4.6 ZC (4.00%) and fipronil 0.6 GR (4.52%), while the untreated control recorded the highest incidence of dead heart (13.02%).

1.3 Pooled over both sprays

Pooled over both the sprays (**Table 3** and fig.1), the dead heart incidence varied from 2.79 to 12.63 per cent, chlorantraniliprole 0.4 GR recorded the significantly lowest incidence (2.79%) and the highest reduction over control (77.91%), which was on par with the chlorantraniliprole 9.3 + lambda cyhalothrin 4.6 ZC (4.30%, 65.95%) and fipronil 0.6 GR (4.82%, 61.84%), followed by flubendiamide 20 WG, cyclaniliprole 10 w/v DC, fipronil 15 + flonicamid 15 WDG and phenthoate 45 + cypermethrin 6 EC, while imidacloprid 6 + lambda-cyhalothrin 4 SL (8.24%, 34.76%) was the least effective and the untreated control recorded the maximum incidence of dead heart (12.63%).

The present findings are in agreement with the findings of earlier workers. Omprakash *et al*. (2017) [18] demonstrated that chlorantraniliprole 0.4 GR recorded the least per cent dead hearts against yellow stem borer. Singh *et al*. (2017) [27] also reported that chlorantraniliprole 0.4 GR was one of the best granular insecticides for the management of stem borer second to fipronil 0.3 G. Singh *et al*. (2017) [27] results are in agreement with those of Rahaman and Stout (2019) and Mehta *et al*. (2022) [17, 22] who reported that chlorantraniliprole formulations had the least dead heart percentage and outperformed fipronil, spinosad and indoxacarb against yellow stem borer probably due to its mode of action as a ryanodine receptor activator which leads to rapid cessation of feeding and irreversible paralysis of lepidopteran larvae.

2. Effect of insecticidal treatments on white ear incidence at harvest

The white ear incidence recorded at harvest varied from 2.95 to 13.50 per cent among the treatments (**Table 3**). Among the treatments Chlorantraniliprole 0.4 GR treatment recorded the significantly lowest white ear incidence (2.95%) and the highest reduction over control (78.15%), which was on par with chlorantraniliprole 9.3 + lambda cyhalothrin 4.6 ZC (4.52%) and fipronil 0.6 GR (5.23%), while imidacloprid 6 + lambda-cyhalothrin 4 SL (8.34%) was the least effective treatment. The maximum white ear incidence (13.50%) was recorded in the untreated control.

3. Grain and straw yield

All the insecticide-treated plots produced significantly higher grain yield than the untreated control (Table 4 and fig. 2). The highest grain yield (3.31 t/ha, 88.38% increase over control) was recorded in chlorantraniliprole 0.4 GR, followed by fipronil 0.6 GR (2.94 t/ha) and chlorantraniliprole 9.3 + lambda cyhalothrin 4.6 ZC (3.05 t/ha), and the minimum grain yield (1.84 t/ha) was recorded in the untreated control. Straw yield did not vary significantly among treatments, ranging narrowly between 4.16 and 4.37 t/ha.

The present findings are in agreement with the findings of earlier workers. Rahaman and Stout (2019) [22] confirmed that chlorantraniliprole 0.4 G to recorded the highest grain yield among all the treatments evaluated against the yellow stem borer. Mehta *et al*. (2022) [17] revealed that the highest grain yield was recorded from plots treated with chlorantraniliprole 18.5 SC. The results were also in close association with Hurali *et al*. (2023) and Dhanapati *et al*.

(2024) [7, 10] who reported that chlorantraniliprole-based combination products gave the maximum grain yield over the untreated control, reflecting chlorantraniliprole's effective suppression of both dead heart and white ear damage, which together determine the panicle-bearing tiller population and grain-filling capacity of the crop.

Conclusion

Under direct-seeded rice conditions, chlorantraniliprole 0.4 GR was found to be the most effective treatment against yellow stem borer, as it recorded the lowest incidence of dead hearts and white ears and resulted in the highest grain yield. This was followed by chlorantraniliprole 9.3 + lambda-cyhalothrin 4.6 ZC and fipronil 0.6 GR. Based on these findings, chlorantraniliprole 0.4 GR can be recommended for the effective management of yellow stem borer and for obtaining higher grain yield under direct-seeded rice conditions. The results also indicate the potential of newer anthranilic diamide molecules and insecticide combinations as useful components for the insecticide rotation programmes, particularly when integrated with insecticides belonging to different chemical groups. Further evaluation across multiple locations and seasons would be useful to validate the present findings and to develop a more reliable resistance-management strategy for direct-seeded rice.

Table 2: Efficacy of different insecticides against rice yellow stem borer dead heart (%) incidence

Tr. No.	Treatments	Conc. (%)	First spray			Pooled	Second spray			Pooled
			Before spray	10 DAS	20 DAS		Before spray	10 DAS	20 DAS	
1	Phenthoate 45 + Cypermethrin 6 EC	0.800	8.72 (17.11)	7.92 (16.30)^{cd}	7.07 (15.40)^{cd}	7.50 (16.26)^{de}	8.91 (17.41)^{bc}	7.46 (15.82)^{cd}	6.52 (14.81)^{cd}	6.99 (15.32)^{d}
2	Imidacloprid 06 + Lambda-cyhalothrin 04 SL	0.006	9.13 (17.55)	9.07 (17.55)^{de}	8.12 (16.60)^{d}	8.60 (17.06)^{e}	9.60 (18.04)^{c}	8.28 (16.66)^{d}	7.48 (15.80)^{d}	7.88 (16.23)^{d}
3	Fipronil 15 + Flonicamid 15 WDG	0.024	8.92 (17.33)	7.63 (16.01)^{cd}	6.73 (15.03)^{cd}	7.18 (15.52)^{de}	8.56 (17.00)^{bc}	7.01 (15.37)^{cd}	6.16 (14.35)^{bc}	6.59 (14.86)^{d}
4	Chlorantraniliprole 0.4 GR	0.004	9.27 (17.63)	3.40 (10.55)^{a}	2.71 (9.43)^{a}	3.06 (9.99)^{a}	5.15 (13.09)^{a}	2.83 (9.61)^{a}	2.21 (8.46)^{a}	2.52 (9.03)^{a}
5	Fipronil 0.6 GR	0.006	8.42 (16.84)	5.50 (13.54)^{ab}	4.73 (12.52)^{ab}	5.12 (13.03)^{bc}	7.20 (15.53)^{ab}	4.90 (12.77)^{ab}	4.13 (11.73)^{ab}	4.52 (12.25)^{cb}
6	Chlorantraniliprole 9.3 + Lambda cyahalothrin 4.6 ZC	0.007	9.02 (17.37)	5.07 (12.97)^{ab}	4.12 (11.62)^{ab}	4.60 (12.30)^{ab}	5.83 (13.91)^{a}	4.26 (11.85)^{ab}	3.73 (11.10)^{ab}	4.00 (11.48)^{b}
7	Flubendiamide 20 WG	0.005	8.78 (17.22)	6.75 (15.05)^{bc}	5.69 (13.75)^{bc}	6.22 (14.40)^{bcd}	7.42 (15.81)^{ab}	5.87 (13.99)^{bc}	5.40 (13.42)^{bc}	5.64 (13.71)^{cd}
8	Cyclaniliprole 10 W/V DC	0.008	8.63 (17.08)	7.14 (15.50)^{bc}	6.50 (14.72)^{bc}	6.82 (15.11)^{cde}	8.17 (16.58)^{bc}	6.70 (14.97)^{cd}	6.21 (14.41)^{cd}	6.46 (14.69)^{d}
9	Control (Untreated)	-	8.67 (17.10)	11.10 (19.44)^{e}	13.37 (21.39)^{e}	12.23 (20.41)^{f}	14.80 (22.62)^{d}	13.87 (21.86)^{e}	12.17 (20.40)^{e}	13.02 (21.13)^{e}
S. Em ±			1.03	0.73	0.70	0.50	0.50	0.48	0.75	0.71
CD at 5%			NS	2.20	2.11	1.44	1.44	1.39	2.24	2.11
CV (%)			10.31	8.34	8.39	8.37	8.37	8.39	7.75	8.28

Note: DAS: Days after Spray; figures in parentheses are arcsine transformed values; means followed by same letter in a column do not differ significantly by DNMRT (p =0.05).

Table 3: Efficacy of different insecticides against rice yellow stem borer (pooled over sprays)

Tr. No	Treatments	Conc. (%)	Dead hearts (%)		Pooled over	ROC (%)	White ear (%) at harvest	ROC (%)
			First spray	Second spray				
1	Phenthoate 45 + Cypermethrin 6 EC	0.800	7.50 (16.26)^{de}	6.99 (15.32)^{d}	7.25 (15.79)^{de}	42.60	7.90 (16.29)^{cd}	41.48
2	Imidacloprid 06 + Lambda-cyhalothrin 04 SL	0.006	8.60 (17.06)^{e}	7.88 (16.23)^{d}	8.24 (16.64)^{e}	34.76	8.34 (16.72)^{d}	38.22
3	Fipronil 15 + Flonicamid 15 WDG	0.024	7.18 (15.52)^{de}	6.59 (14.86)^{d}	6.89 (15.19)^{de}	45.45	7.43 (15.80)^{cd}	44.96
4	Chlorantraniliprole 0.4 GR	0.004	3.06 (9.99)^{a}	2.52 (9.03)^{a}	2.79 (9.51)^{a}	77.91	2.95 (9.86)^{a}	78.15
5	Fipronil 0.6 GR	0.006	5.12 (13.03)^{bc}	4.52 (12.25)^{bc}	4.82 (12.64)^{bc}	61.84	5.23 (13.21)^{ab}	61.26
6	Chlorantraniliprole 9.3 + Lambda cyahalothrin 4.6 ZC	0.007	4.60 (12.30)^{ab}	4.00 (11.48)^{b}	4.30 (11.89)^{b}	65.95	4.52 (12.29)^{ab}	66.52
7	Flubendiamide 20 WG	0.005	6.22 (14.40)^{bcd}	5.64 (13.71)^{cd}	5.93 (14.05)^{cd}	53.05	6.17 (14.37)^{bc}	54.30
8	Cyclaniliprole 10 W/V DC	0.008	6.82 (15.11)^{cde}	6.46 (14.69)^{d}	6.64 (14.90)^{de}	47.43	7.16 (15.47)^{cd}	46.96
9	Control (Untreated)	-	12.23 (20.41)^{f}	13.02 (21.13)^{e}	12.63 (20.77)^{f}	-	13.50 (21.55)^{e}	-
S. Em ±			0.50	0.48	0.11	-	0.74	-
CD at 5%			1.44	1.39	0.31	-	2.21	-
CV (%)			8.37	8.39	8.05	-	8.46	-

Note: figures in parentheses are arcsine transformed values; means followed by same letter in a column do not differ significantly by DNMRT (p =0.05), ROC = Reduction over control.

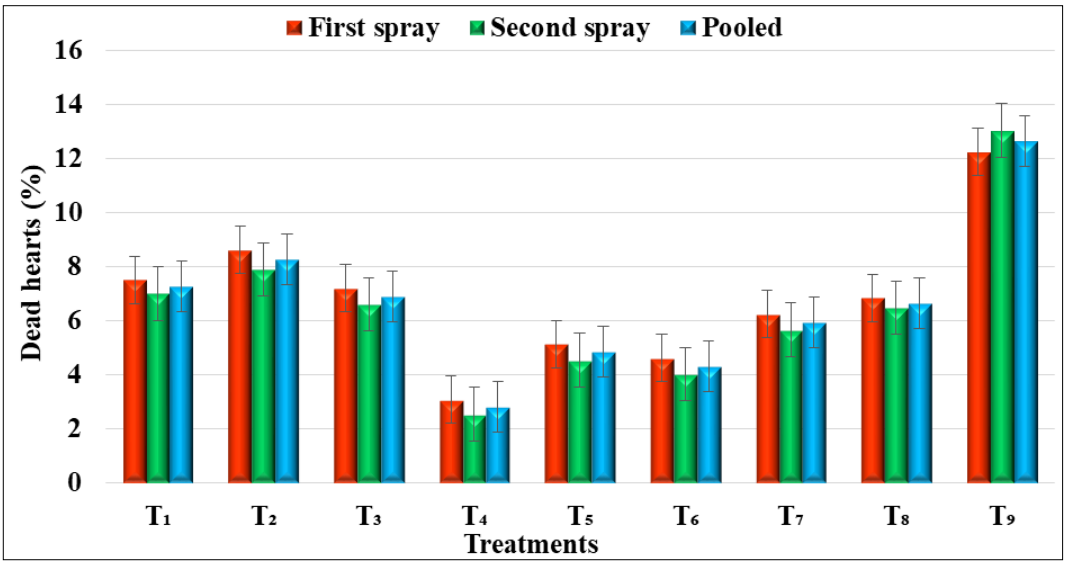

Fig 1: Dead heart incidence under different insecticidal treatments (pooled over both the sprays)

Table 4: Grain and straw yield of rice under different insecticidal treatments

Tr. No.	Treatments	Grain yield (t/ha)	Increase in grain yield over control (%)	Straw yield (t/ha)
1	Phenthoate 45% + Cypermethrin 6% EC	2.24^{de}	20.51	4.32
2	Imidacloprid 06% + Lambda-cyhalothrin 04% SL	2.13^{e}	13.39	4.20
3	Fipronil 15% + Flonicamid 15% WDG	2.32^{de}	28.55	4.28
4	Chlorantraniliprole 0.4% GR	3.31^{a}	88.38	4.37
5	Fipronil 0.6% GR	2.94^{b}	66.04	4.34
6	Chlorantraniliprole 9.3% + Lambda-cyhalothrin 4.6% ZC	3.05^{b}	65.13	4.35
7	Flubendiamide 20% WG	2.65^{c}	49.97	4.29
8	Cyclaniliprole 10% w/v DC	2.43^{cd}	37.49	4.36
9	Control (Untreated)	1.84^{f}	–	4.16
S.Em. ±		0.09	–	0.09
CD at 5%		0.27	–	NS
CV (%)		6.06	–	6.71

Note: Means followed by the same letter in the grain yield column do not differ significantly by DNMRT (p = 0.05); NS: non-significant

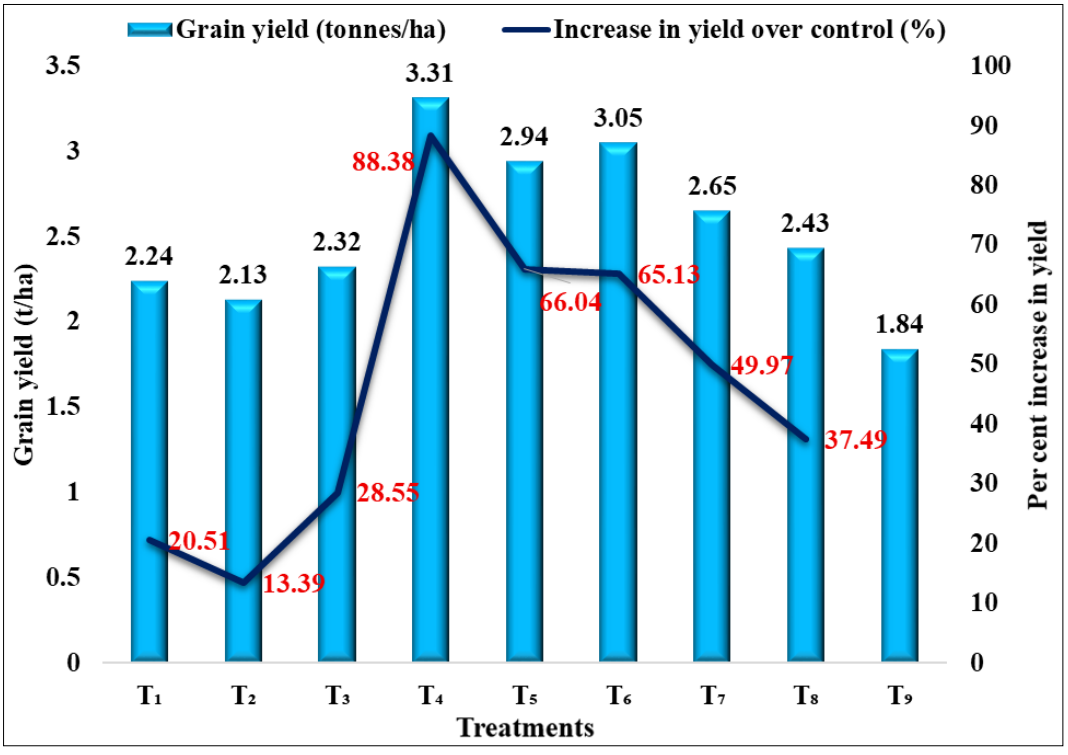

Fig 2: Grain yield of rice and per cent increase in grain yield over control in different treatments applied against the rice yellow stem borer

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