Journal of Agricultural Research Advances
ISSN: 2582-7227

Research Article
Open Access

Phytotoxic compatibility and bio-efficacy evaluation of pesticide combinations against brown planthopper and blast in rice

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Received on: 24/11/2025 Accepted on: 23/03/2026 Published on: 26/03/2026

ABSTRACT

Aim: Main purpose of the study was to assess the phytotoxic compatibility and bio-efficacy studies of insecticides and fungicides alone and in combinations against brown planthopper (BPH) and blast disease in rice.

Materials and Methods: The treatments were imidacloprid+ethiprole 80 WG @ 0.25 g/L; dinotefuran 20 SG @ 0.4 g/L; tricyclazole 75 WP @ 0.6 g/L and isoprothiolane 40 EC @ 1.5 ml/L and their tank mix combination and untreated control.

Results: During *rabi* 2012-13, imidacloprid+ethiprole 80 WG with isoprothiolane 40 EC (82.22%) and dinotefuran 20 SG in combination with isoprothiolane 40 EC (53.28%) recorded highest per cent reduction of BPH population and leaf blast incidence respectively. During rabi, 2013-14, both the insecticides, dinotefuran 20 SG and imidacloprid+ethiprole 80 WG with tricyclazole 75 WP recorded 73.70 and 70.66% reduction in BPH population over untreated control respectively. Whereas, imidacloprid+ethiprole 80 WG with tricyclazole 75 WP recorded 56.28% reduction in leaf blast incidence over untreated control. During rabi 2012-13, dinotefuran 20 SG (5447 kg/ha) and during rabi 2013-14, imidacloprid+ethiprole 80 WG (5196 kg/ha) recorded highest grain yields in combination with tricyclazole 75 WP. Overall mean results indicated that imidacloprid+ethiprole 80 WG in combination with tricyclazole proved to be the most effective recording the highest reduction in leaf blast incidence (48.72%) and severity (60.41%) along with the maximum yield increase over control (83.47%). Imidacloprid+ethiprole 80 WG in combination with isoprothiolane was the most effective against BPH, showing the highest reduction (75.14%).

Conclusion: It was concluded that tank mixing of imidacloprid+ethiprole 80 WG with tricyclazole 75 WP and dinotefuran 20 SG in combination with both the fungicides i.e. tricyclazole 75 WP and isoprothiolane 40 EC were compatible with each other and can be safely used as tank mix at the time of simultaneous occurrence of BPH and blast disease.

Keywords: Bio-efficacy, Brown planthopper, Pesticide combinations, Phytotoxic compatibility, Tank mixture.

How to cite this article: Vasanta BK and Mallikarjuna RN (2026). Phytotoxic compatibility and bio-efficacy evaluation of pesticide combinations against brown planthopper and blast in rice. J. Agri. Res. Adv., 08(01): 09-18.

Introduction

Rice (*Oryza sativa* L.) is critical for global food security, as it serves as the primary staple for over half the world's population, providing essential calories and nutrients, particularly in Asia (Zhao *et al*., 2020). Asia produces 90.6% of the global rice production, making it the world's largest producer (FAO, 2022). India is the second largest producer of rice next to China with a production of 120 Mt (USDA, 2022). India aims to increase its rice production to around 144.7 million tons by 2030-31, with the primary driver being increased yield per hectare, not expanded area (Kingsly *et al*., 2023).

However, rice cultivation is severely challenged by a wide range of insect pests and diseases that significantly reduce productivity, causing an estimated yield loss of 10–30% annually (Douglas, 2018; Savary *et al*., 2019). Among the major insect pests and diseases, the brown planthopper (BPH), *Nilaparvata lugens* (Pasalu *et al*., 2004) and blast (*Pyricularia oryzae*) (Deng *et al*., 2020) are of economic importance.

Pesticides remain an integral component of integrated pest management (IPM) strategies due to their effectiveness in reducing pest populations and disease incidence. The simultaneous occurrence of pests and diseases challenges farmers, leading them to use mixed pesticides to cut costs. While some pesticides are safe alone, they can be harmful in combination. However, inappropriate combinations of pesticide application often led to phytotoxicity, which manifests as leaf scorching, chlorosis, stunting, reduced tillering etc. and yield loss. Phytotoxic effects not only compromise plant health but also limit their effectiveness on insect pests and disease management (Peshney, 1990 and Kubendra *et al.*, 2009). Therefore, evaluating the phytotoxic compatibility and bio-efficacy of pesticides is essential to ensure that control measures against insect pests and diseases do not adversely affect rice physiology, growth, and productivity and are synergistic in action.

Compatibility studies provide insights into the safe use of chemical formulations, helping to optimize dosages, timing, and combinations for pest suppression while minimizing risks to the crop. Such evaluations are particularly important under intensive rice cultivation systems, where multiple pesticides are often applied either singly or in combination. Moreover, understanding the phytotoxic effects is vital for developing sustainable pest management practices that align with eco-friendly approaches, preserve yield potential, and reduce production costs (Sabita *et al.*, 2020). The present study was undertaken to assess the phytotoxic compatibility and bio-efficacy of selected pesticides used against major insect pest, brown planthopper (BPH) and disease, blast of rice alone and in combination.

Materials and Methods

Field experiments were conducted at Regional Agricultural Research Station, Maruteru, Andhra Pradesh, India to assess the phytotoxic compatibility and bio-efficacy of insecticides and fungicides alone and in combinations against brown planthopper and blast disease in rice during *rabi* 2012-13 and 2013-14. The experiment was laid out in a Randomized Block Design (RBD) with nine treatments and each treatment replicated thrice (Table 1).

Table 1. Pesticide treatments

Tr.No.	Treatment particulars	Dose (g or ml/L)
1	Imidacloprid+ethiprole 80 WG	0.25 g
2	Dinotefuran 20 SG	0.4 g
3	Tricyclazole 75 WP	0.6 g
4	Isoprothiolane 40 EC	1.5 ml
5	Imidacloprid+ethiprole + tricyclazole	0.25 +0.6 g
6	Imidacloprid+ethiprole + isoprothiolane	0.25 g + 1.5 ml
7	Dinotefuran +tricyclazole	0.4 g + 0.6 g
8	Dinotefuran + isoprothiolane	0.4 g+1.5 ml
9	Untreated control	-

The plot size of 20 m^2 were separated from each other so as to prevent water movement from one plot to another. Swarna (MTU 7029), a popular high yielding planthoppers and blast susceptible variety was used for the present study and crop was raised by duly following all recommended agronomic practices recommended for the area.

Evaluation of phytotoxicity on rice crop due to combination of insecticide and fungicide

Observations for phytotoxic symptoms such as injury to the leaf tip, yellowing, necrosis, wilting, vein clearing, hyponasty and epinasty were recorded at 1, 5 and 10 days after spray based on the phytotoxicity scale (Table 2) prescribed by Central Insecticide Board and Registration Committee (CIBRC). The per cent injury was calculated by using the formula mentioned below:

$$\text{Phytotoxicity injury (\%)} = \frac{\text{Total grade points}}{\text{Max. grade x No. of leaves observed}} \times 100$$

Table 2. Phytotoxicity scale of CIBRC

Scale	PHYTOTOXICITY	Scale	PHYTOTOXICITY
0	No Phytotoxicity	6	51 to 60%
1	1 to 10%	7	61 to 70%
2	11 to 20%	8	71 to 80%
3	21 to 30%	9	81 to 90%
4	31 to 40%	10	91 to 100%
5	41 to 50%		

Evaluation of efficacy of insecticides and fungicides against BPH and rice blast

The treatments were imposed twice at 45 and 65 days after transplanting (DAT) during both the seasons when the population of brown planthopper crossed the economic threshold level. A spray fluid of 500 L/ha was used to ensure thorough coverage of the crop canopy with a knapsack sprayer. Observation on both nymphs and adults of BPH and green leafhoppers (GLH) were recorded from 20 randomly selected hills per plot at one day before and ten days after each insecticide spray. At harvest the number of white ears were counted against productive bearing tillers. Similarly, the data on predators i.e. spiders and mirid bugs were also recorded.

The data on blast incidence was taken from five sampling units each of one square meter area in each plot at one day before and ten days after spray and disease severity was recorded at 10 days interval from the day of its appearance and terminal severity at heading stage following 0-9 scale (Table 3) as per the SES (Standard

Evaluation Scale) (IRRI, 2013) and the means were presented.

Table 3. Disease rating scale used for leaf blast disease

Scale	Description
0	Lesion are not present
1	Small brown specks of pin point size or larger brown specks without sporulating center
2	Small roundish to slightly elongated, necrotic gray spots, about 1-2 mm in diameter, with a distinct brown margin. Lesions are mostly found on the lower leaves
3	Lesions type is same as in scale 2, but a significant number of lesions on upper leaf area
4	Typical susceptible blast lesions, 3 mm or longer infecting less than 4 % of leaf area
5	Typical susceptible blast lesions infecting 4-10% of the leaf area
6	Typical susceptible blast lesions infecting 11 – 25% of the leaf area
7	Typical susceptible blast lesions infecting 26 - 50% of the leaf area
8	Typical susceptible blast lesions infecting 51-75% of the leaf area and many leaves are dead
9	More than 75% leaf area affected

Per cent disease index (PDI) of rice blast was calculated as per the formula mentioned below:

$$\text{PDI}=\frac{\text{Sum of all disease ratings}}{\text{Total number of ratings X maximum disease grade}} \times 100$$

The grain yields were recorded from each net plot at the time of harvest and presented as kilogram per hectare. The per cent increase in yield over control in various treatments was calculated by using the following formula.

$$\text{Per cent increase of yield in treatment over control} = \frac{\text{Yield in treatment-Yield in control}}{\text{Yield in control}} \times 100$$

Percent reduction of insect pests/ disease in a pesticide treatment compared to an untreated control is calculated based on the formula given below:

$$\text{Per cent insect Population reduction over control (Abbott's 1925)} = \frac{\text{population in control - population in treatment}}{\text{population in control}} \times 100$$

$$\text{Per cent reduction in disease over control} = \frac{\text{Disease incidence in control – Disease incidence in treatment}}{\text{Disease incidence in control}} \times 100$$

Data on BPH/GLH/mirid bug population were converted in to square root transformations and per cent white ears, disease severity to angular transformations, and analyzed using analysis of variance technique (ANOVA) (Gomez and Gomez, 1984). The treatment means were compared by least significant difference (LSD) method.

Results and Discussion

Phytotoxicity effect: The observations made on phytotoxic symptoms *viz*., leaf yellowing, tip necrosis, scorching, epinasty and hyponasty were recorded 1, 5 and 10 days after application of treatments and no phytotoxic symptoms were observed in any of the treatments in both the seasons.

Bio-efficacy of pesticides on insect pests: The differences in incidence of insect pests (BPH, GLH) before the pesticide treatments spray among the treatments were not significant in both the seasons.

Brown Planthopper

The data on efficacy of pesticides alone and in combination against BPH during both the seasons of *rabi* 2012-13 and 2013-14 were presented (Table 4 and 6). From the experimental result, it was observed that during both the seasons insecticides alone and in combination with fungicides were significantly superior over the fungicides alone and untreated control. During *rabi* 2012-13, the best treatment was imidacloprid+ethiprole + isoprothiolane @ 0.25 g + 1.5 ml /L, which recorded significantly lowest numbers of BPH /20 hills (205 No.s) and was on par with dinotefuran+isoprothiolane @ 0.4 g + 1.5 ml/L (387.00 No.s), imidacloprid+ethiprole + tricyclazole @ 0.25 g + 0.6 g/L (444.33 No.s), dinotefuran 20 SG @ 0.4 g/L (469.33 No.s), imidacloprid 80 WG @ 0.25 g/L (506.00 No.s) and dinotefuran +tricyclazole @ 0.4 g +0.6 g/L (630.67 No.s). However, the % population reduction over control was highest in imidacloprid+ethiprole + isoprothiolane @ 0.25 g + 1.5 ml /L (82.22%) and next best treatments in the order of efficacy were dinotefuran + isoprothiolane @ 0.4 g + 1.5 ml/L (66.43%), imidacloprid+ethiprole + tricyclazole @ 0.25 g + 0.6 g/L (61.45%), dinotefuran 20 SG @ 0.4 g/L (59.28%), imidacloprid+ethiprole 80 WG @ 0.25 g/L (56.10%) and dinotefuran +tricyclazole @ 0.4 g +0.6 g/L (45.29%). Likewise, the effectiveness of tricyclazole 75 WP @ 0.6 g/L (Singha and Dinesh, 2018, Anshu *et al*., 2024) and isoprothiolane 40 EC at 1.5 ml/ L (Pal and Mandal, 2021, Feng *et al*., 2023) in the reduction of rice blast was reported.

Table 4. Effect of pesticides alone and in combination on Incidence of insect pests, natural enemies and grain yield in rice during *Rabi* 2012-13

Tr. No.	Numbers/ 20 hills**		%ROC (GLH)	%ROC (BPH)	Natural enemies		% WE*	Grain yield (Kg/ha)	% YIOC
	GLH	BPH			Spiders	Mirid bugs			
1	15.67 (3.95)	506 (22.35)	66.66	56.10	11.74 (20.01)	73.67 (8.58)	11.74 (20.01)	4759	62.92
2	20.67 (4.53)	469.33 (20.16)	56.02	59.28	7.09 (15.40)	77.67 (8.04)	7.09 (15.40)	4330	48.24
3	42.67 (6.51)	1473.67 (37.63)	9.21	-27.85	8.89 (17.34)	133.67 (11.55)	8.89 (17.34)	3608	23.52
4	39.00 (6.16)	1107.67 (33.22)	17.02	3.90	5.78 (13.90)	117.00 (10.81)	5.78 (13.90)	3732	27.76
5	15.67 (3.93)	444.33 (18.94)	66.66	61.45	8.31 (16.71)	60.33 (7.17)	8.31 (16.71)	5323	82.23
6	19.00 (4.36)	205.00 (14.26)	59.57	82.22	8.40 (16.81)	48.67 (6.93)	8.40 (16.81)	5020	71.86
7	21.00 (4.55)	630.67 (24.27)	55.32	45.29	8.73 (17.18)	88.00 (9.32)	8.73 (17.18)	5447	86.48
8	14.00 (3.64)	387.00 (19.63)	70.21	66.43	5.86 (14.00)	71.33 (8.44)	5.86 (14.00)	5153	76.41
9	47.00 (6.85)	1152.67 (33.43)	-	-	7.71 (16.12)	143.33 (11.92)	7.71 (16.12)	2921	---
CD	1.23	10.33	-	-	1.95	3.22	1.95	458	
CV (%)	14.39	23.98	-	-	6.90	20.24	6.90	5.91	

*= Arc sine transformed values, **= square root transformed values, GLH= Green leafhopper, BPH= Brown planthopper, WE=white ears, ROC= reduction over untreated control

Table 5. Effect of pesticides alone and in combination on the Incidence of rice blast in rice during *Rabi* 2012-13

Tr. No.	% Leaf blast incidence*		%ROC	Leaf blast severity		%ROC	% Neck blast*	%ROC
	BS	10 DAS		BS	10 DAS			
1	5.39 (13.33)	17.17 (24.40)	26.40	3.13	3.92	21.13	20.29 (26.71)	8.23
2	4.37 (12.87)	17.81 (24.85)	23.66	2.07	2.77	44.27	30.77 (33.68)	-39.17
3	6.78 (14.98)	16.48 (23.92)	29.36	3.53	2.77	44.27	12.61 (20.78)	42.97
4	6.97 (15.33)	17.57 (24.52)	24.69	4.07	3.02	39.24	11.53 (19.82)	47.85
5	4.68 (12.32)	13.73 (21.66)	41.15	3.20	2.17	56.34	13.92 (21.81)	37.04
6	5.24 (13.01)	13.29 (21.28)	43.03	2.73	1.85	62.78	16.33 (23.70)	26.14
7	3.85 (11.22)	11.27 (19.61)	51.69	3.67	1.45	70.82	10.82 (19.16)	51.06
8	4.14 (10.95)	10.90 (19.25)	53.28	2.6	1.47	70.42	13.00 (21.11)	41.20
9	5.87 (13.53)	23.33 (28.61)	-	3.8	4.97	-	22.11 (27.92)	-
CD	---	5.45	-	---	1.79	-	4.46	-
CV (%)	15.37	13.63	-	29.58	38.22	-	10.80	-

*= Arc sine transformed values; Bs= Before spray, DAS= days after spray, ROC= reduction over untreated control

During *rabi* 2013-14, dinotefuran + isoprothiolane @ 0.4 g + 1.5 ml/L recorded significantly lowest numbers of BPH (60.67 No.s) and was on par with dinotefuran 20 SG @ 0.4 g/L (67.33 No.s), imidacloprid+ethiprole + tricyclazole @ 0.25 g + 0.6 g/L (67.67 No.s), imidacloprid+ethiprole + isoprothiolane @ 0.25 g + 1.5 ml /L (73.67 No.s), imidacloprid+ethiprole 80 WG @ 0.25 g/L (79.67 No.s) and dinotefuran + isoprothiolane @ 0.4 g + 1.5 ml/L (80.67 No.s). The % population reduction over control was highest in dinotefuran + isoprothiolane @ 0.4 g + 1.5 ml/L (73.70%), and next best treatments in the order of efficacy were dinotefuran 20 SG @ 0.4 g/L (70.81%), imidacloprid+ethiprole + tricyclazole @ 0.25 g + 0.6 g/L (70.66%), imidacloprid+ethiprole + isoprothiolane @ 0.25 g + 1.5 ml /L (68.06%), imidacloprid+ethiprole 80 WG @ 0.25 g/L (65.46%) and in dinotefuran + isoprothiolane @ 0.4 g + 1.5 ml/L (65.03%).

The data on mean percent reduction over control of BPH for two seasons (Table 8) indicated considerable variation among treatments. Among treatments, imidacloprid +ethiprole @ 0.25 g/L incombination with isoprothiolane @ 1.5 ml /L recorded the highest reduction of BPH (75.14%), followed by its combination with tricyclazole @ 0.25 g + 0.6 g/L (66.06%), dinotefuran + isoprothiolane @ 0.4 g + 1.5 ml/L (65.73%), dinotefuran 20 SG @ 0.4 g/L (65.05%), imidacloprid+ethiprole 80 WG @ 0.25 g/L (60.78%) and dinotefuran + tricyclazole @ 0.4 g +0.6 g/L (59.50%). Anand Kumar *et al*., 2023 also reported pymetrozine and triflumezopyrim in combination with tricyclazole and isoprothiolane were found effective against brown planthopper and blast and recorded higher grain yields.

Green leafhopper

The incidence of green leafhoppers was observed during *rabi* 2012-13 only and the data on efficacy of pesticides alone and in combination was presented (Table 4). From the data it was revealed that insecticides alone and their combination with fungicides recorded significantly lowest population of GLH than other treatments. Among those, dinotefuran + isoprothiolane @ 0.4 g + 1.5 ml/L recorded significantly lowest GLH population (14 No. s/20 hills) and was on par with imidacloprid+ethiprole 80 WG alone and in combination with tricyclazole (15.67 No. s each) and isoprothiolane (19.00 No. s), dinotefuran 20 WG alone (20.67 No. s) and in combination with tricyclazole (21.00 No. s). The per cent population reduction over untreated control was highest in dinotefuran + isoprothiolane @ 0.4 g + 1.5 ml/L (70.21%) and next best treatments in efficacy against GLH were imidacloprid+ethiprole 80 WG alone and in combination with tricyclazole (66.66% each), imidacloprid+ethiprole + isoprothiolane @ 0.25 g + 1.5 ml /L (59.57%), dinotefuran 20 SG @ 0.4 g/L (56.02%) and dinotefuran +tricyclazole @ 0.4 g +0.6 g/L (55.32%). Similarly, effectiveness of tricyclazole 75 WP @ 0.6 g/L (Singha and Dinesh, 2018, Anshu *et al*., 2024) and isoprothiolane 40 EC at 1.5 ml/ L (Pal and Mandal, 2021, Feng *et al*., 2023) in reduction of rice blast was reported.

Stem borer

The data on efficacy of pesticides alone and in combination for both seasons were presented (Tables 4 and 6). Data indicated that treatments were not showed much effectiveness in reducing infestation of rice yellow stem borer (YSB) and thus, reducing formation of white ears significantly as compared to control. However, during *rabi* 2012-13, significantly lowest per cent of white ears were observed in isoprothiolane alone @ 1.5 ml/L (5.78%) and its combination with dinotefuran @ 0.4 g/L (5.86%). These were on par with dinotefuran 20 SG @ 0.4 g/ L (7.09%). These were followed by untreated control (7.71%), imidacloprid+ethiprole + tricyclazole @ 0.25 g + 0.6 g/L (8.31%), imidacloprid+ethiprole + isoprothiolane @ 0.25 g + 1.5 ml /L (8.40%), dinotefuran +tricyclazole @ 0.4 g +0.6 g/L (8.73%) and tricyclazole @ 0.6 g/L (8.89%). Significantly highest per cent white ears were observed in imidacloprid+ethiprole 80 WG @ 0.25 g/L (11.74%).

During *rabi* 2013-14, significantly lowest per cent of white ears were observed in and its combination with dinotefuran + isoprothiolane @ 0.4 g +1.5 ml/L (7.77%) and was on par with imidacloprid+ethiprole + tricyclazole @ 0.25 g + 0.6 g/L (7.91%), dinotefuran 20 SG @ 0.4 g/ L (7.95%), dinotefuran +tricyclazole @ 0.4 g +0.6 g/L (7.96%), imidacloprid+ethiprole+ isoprothiolane @ 0.25 g + 1.5 ml /L (8.78%), isoprothiolane @ 1.5 ml/L (9.08%) and tricyclazole @ 0.6 g/L (9.75%). Significantly highest per cent white ears were observed in untreated control (10.10%) and imidacloprid+ethiprole 80 WG @ 0.25 g/L (10.50%).

Effect of pesticides on Predators:

Spiders: During *rabi* 2012-13, Data (Table 4) indicated that there were significant differences among treatments in spider numbers. Among those, highest number of spiders was observed in imidacloprid + ethiprole 80 WG @ 0.25 g/L (11.74 No. s) and was followed by tricyclazole 75 WP @ 0.6 g/L (8.89 No.s), dinotefuran +tricyclazole @ 0.4 g +0.6 g/L (8.73 No.s), imidacloprid+ethiprole+ isoprothiolane @ 0.25 g + 1.5 ml /L (8.40 No.s) imidacloprid+ethiprole + tricyclazole @ 0.25 g + 0.6 g/L (8.31 No.s) and untreated control (7.71 No.s).

Table 6. Effect of pesticides alone and in combination on Incidence of insect pests and natural enemies in rice during *Rabi* 2013-14

Tr. No.	BPH Numbers/ 20 hills**	%ROC	%WE	Natural enemies No. s/ 20 hills		Grain yield (Kg/ha)	% YIOC
				Spiders	Mirid bugs		
1	79.67 (8.74)	65.46	10.50 (18.90)	5.67	33.33 (5.76)	4594	63.31
2	67.33 (7.37)	70.81	7.95 (16.36)	5.00	29.67 (5.43)	4187	48.84
3	249.67 (15.72)	-8.24	9.75 (18.15)	9.00	48.67 (6.92)	3926	39.57
4	210.67 (14.42)	8.67	9.08 (17.53)	8.67	44.00 (6.59)	3949	40.38
5	67.67 (8.22)	70.66	7.91 (16.33)	5.67	25.67 (5.05)	5196	84.71
6	73.67 (8.49)	68.06	8.78 (17.22)	6.67	28.67 (5.34)	4672	66.09
7	60.67 (7.75)	73.70	7.96 (16.39)	8.67	34.33 (5.79)	4736	68.36
8	80.67 (8.95)	65.03	7.77 (16.18)	6.67	34.67 (5.85)	4863	72.88
9	230.67 (15.11)	-	10.10 (18.44)	7.00	56.33 (7.49)	2813	---
CD	3.09	-	2.04	-	0.92	528	
CV (%)	17.09	-	6.82	16.90	8.79	7.05	

*= Arc sine transformed values, **= square root transformed values, BPH= Brown planthopper, WE=white ears, ROC= reduction over untreated control; YIOC= yield increase over control

During *rabi* 2013-14, the differences among treatments were not significant (Table 6).

Mirid bugs: During *rabi* 2012-13, the data (Table 4) indicated that there were significant differences among the treatments in mirid bug numbers. Among those, highest number of mirid bug was observed in untreated control (143.33 No. s) and was at par with tricyclazole 75 WP @ 0.6 g/L (133.67 No. s), isoprothiolane @ 1.5 ml/L (117.00 No. s) and dinotefuran +tricyclazole @ 0.4 g +0.6 g/L (88.00 No. s). These were followed by other treatments. During *rabi* 2013-14, untreated control (56.33 No. s) and was at par with tricyclazole 75 WP @ 0.6 g/L (48.67 No. s), isoprothiolane @ 1.5 ml/L (44.00 No. s) recorded significantly highest number of mirid bugs.

Bio-efficacy of pesticides on rice blast

The differences in per cent leaf blast incidence and severity before the spray among the treatments were not significant in both the seasons. During *rabi* 2012-13, after ten days of spray the differences among the treatments were significant (Table 5). Per cent leaf blast incidence was ranged from 10.90% to 23.33%. Among the treatments, the fungicides alone and in combination with insecticides 80 WG recorded significantly lowest per cent of leaf blast incidence. Significantly lowest leaf blast incidence was observed in dinotefuran + isoprothiolane @ 0.4 g +1.5 ml/L (10.90%) and was on par with dinotefuran +tricyclazole @ 0.4 g +0.6 g/L (11.27%), imidacloprid+ethiprole+ isoprothiolane @ 0.25 g + 1.5 ml /L (13.29%), imidacloprid+ethiprole + tricyclazole @ 0.25 g + 0.6 g/L (13.73%), tricyclazole @ 0.6 g/L (16.48%) and isoprothiolane @ 1.5 ml/L (17.57%). The results indicated that both the fungicides were highly compatible with both the insecticides and showed some synergistic effect in managing leaf blast in rice. Similarly, the leaf blast severity was significantly lower in fungicides alone and their combination with insecticides. The per cent incidence of leaf blast (23.33%) and severity (4.97) was highest in untreated control.

The per cent neck blast incidence was significantly lower in dinotefuran +tricyclazole @ 0.4 g +0.6 g/L (10.82%) and was on par with isoprothiolane @ 1.5 ml/L (11.53%), tricyclazole @ 0.6 g/L (12.61%), dinotefuran + isoprothiolane @ 0.4 g +1.5 ml/L (13.00%) and imidacloprid+ethiprole + tricyclazole @ 0.25 g + 0.6 g/L (13.92%). Significantly highest per cent of neck blast was observed in dinotefuran 20 SG @ 0.4 g/L (30.77%). Dinotefuran 20 SG @ 0.4 g/L in combination with both the fungicides i.e. tricyclazole @ 0.6 g/L and isoprothiolane @ 1.5 ml/L recorded highest per cent reduction over control both leaf blast incidence (51.69 and

53.28% respectively) and severity (70.82 and 70.42 % respectively) over other treatments. Similarly, dinotefuran +tricyclazole @ 0.4 g +0.6 g/L (51.06%) and isoprothiolane @ 1.5 ml/L (47.85%) recorded highest per cent reduction of neck blast over untreated control. Anand Kumar *et al*. (2023) also reported pymetrozine and triflumezopyrim in combination with tricyclazole and isoprothiolane and found effective against brown plant hopper and blast and recorded higher grain yields.

During *rabi* 2013-14, after ten days of spray the differences among the treatments were significant. Per cent leaf blast incidence was ranged from 17.82% to 40.76%. Among the treatments, the tricyclazole alone (22.49%) and in combination with imidacloprid+ethiprole (17.82%) recorded significantly lowest per cent of leaf blast incidence and were at par with dinotefuran + isoprothiolane @ 0.4 g +1.5 ml/L (23.88%). These were followed by other treatments. Significantly highest per cent of leaf blast incidence was observed in untreated control (40.76%). Similarly, the leaf blast severity was significantly lower in fungicides alone and their combination with insecticides except imidacloprid+ethiprole+ isoprothiolane @ 0.25 g+1.5 ml/L. The per cent incidence of leaf blast (40.76%) and severity (7.32) was significantly highest in untreated control (Table 7). Similarly, the effectiveness of tricyclazole 75 WP @ 0.6 g/L (Singha and Dinesh, 2018, Anshu *et al*., 2024) and isoprothiolane 40 EC at 1.5 ml/ L (Pal and Mandal, 2021, Feng *et al*., 2023) in the reduction of rice blast was reported earlier.

The data on mean percent reduction over control of leaf blast incidence and leaf blast severity over two years (Table 8) indicated considerable variation among the treatments. With respect to leaf blast incidence, the highest reduction was observed in imidacloprid+ethiprole + tricyclazole @ 0.25 g + 0.6 g/L (48.72%), followed by dinotefuran + isoprothiolane @ 0.4 g +1.5 ml/L (47.35%), dinotefuran +tricyclazole @ 0.4 g +0.6 g/L (42.74%), tricyclazole @ 0.6 g/L (37.09%) and imidacloprid+ethiprole+ isoprothiolane @ 0.25 ml + 1.5 ml//L (36.52%). In the case of leaf blast severity, imidacloprid+ethiprole + tricyclazole @ 0.25 g + 0.6 g/L recorded the highest reduction (60.41%), followed by dinotefuran + isoprothiolane @ 0.4 g +1.5 ml/L (57.89%), dinotefuran +tricyclazole @ 0.4 g +0.6 g/L (56.93%), imidacloprid+ethiprole+ isoprothiolane @ 0.25 g+1.5 ml/L (48.61%), tricyclazole @ 0.6 g/L (44.61%) and isoprothiolane @ 1.5 ml/L (41.62%).

Grain Yield

The data (Table 4) indicated that during rabi 2012-13 the differences among the treatments in recording grain yield was significant. All the treatments recorded significantly higher grain yields than untreated control (2921 kg/ha). Among the treatments, significantly highest grain yield was observed in pesticide combinations i.e. dinotefuran +tricyclazole @ 0.4 g +0.6 g/L (5447 kg/ha), imidacloprid+ethiprole + tricyclazole @ 0.25 g + 0.6 g/L (5323 kg/ha), dinotefuran + isoprothiolane @ 0.4 g +1.5 ml/L (5153 kg/ha) and imidacloprid+ethiprole+ isoprothiolane (5020 kg/ha). These were followed by both the insecticides alone and fungicides alone. During *rabi* 2013-14 (Table 6) also the pesticide combinations *viz*., imidacloprid+ethiprole + tricyclazole @ 0.25 g + 0.6 g/L (5196 kg/ha), dinotefuran + isoprothiolane @ 0.4 g +1.5 ml/L (4863 kg/ha), dinotefuran +tricyclazole @ 0.4 g +0.6 g/L (4736 kg/ha) and imidacloprid+ethiprole+ isoprothiolane @ 0.25 g+1.5 ml/L (4672 kg/ha) recorded significantly highest grain yields than other treatments. The overall mean grain yields of both the seasons (Table 8) indicated that among the treatments, the pesticides in combination recorded highest per cent yield increase over untreated control and was highest in imidacloprid+ethiprole + tricyclazole @ 0.25 g + 0.6 g/L (83.45%). The next best treatments were dinotefuran +tricyclazole @ 0.4 g +0.6 g/L (77.59%), dinotefuran + isoprothiolane @ 0.4 g +1.5 ml/L (74.68%) and imidacloprid+ethiprole+ isoprothiolane @ 0.25 g +1.5 ml/L (69.03%) and were followed by insecticides and fungicides alone.

The data on mean percent yield increase over control over two years (Table 8) indicated that highest yield increase was recorded in imidacloprid+ethiprole + tricyclazole @ 0.25 g + 0.6 g/L (83.47%), followed by dinotefuran +tricyclazole @ 0.4 g +0.6 g/L (77.42%), dinotefuran + isoprothiolane @ 0.4 g +1.5 ml/L (74.64%), imidacloprid+ethiprole+ isoprothiolane @ 0.25 g+1.5 ml/L (68.97%), imidacloprid+ethiprole @ 0.25 g/L (63.12%), and dinotefuran @ 0.4 g/L (48.54%).

Table 7. Effect of pesticides alone and in combination on the Incidence of rice blast in rice *during Rabi* 2013-14

Tr. No.	% Leaf blast incidence*		%ROC	Leaf blast severity		%ROC
	BS	10 DAS		BS	10 DAS	
1	19.25 (25.96)	26.90 (30.90)	34.00	3.07	7.03	3.96
2	15.54 (23.21)	35.91 (36.81)	11.90	2.67	6.35	13.25
3	18.16 (25.10)	22.49 (28.24)	44.82	2.88	4.03	44.95
4	20.52 (26.93)	29.29 (32.68)	28.14	2.84	4.10	43.99
5	16.40 (23.88)	17.82 (24.96)	56.28	2.23	2.60	64.48
6	17.59 (24.69)	28.53 (32.23)	30.00	2.93	4.80	34.43
7	18.96 (25.79)	26.99 (31.24)	33.78	2.97	4.17	43.03
8	19.24 (26.01)	23.88 (29.20)	41.41	2.72	4.00	45.36
9	19.82 (26.43)	40.76 (39.65)	-	3.03	7.32	-
F test	NS	Sig	-	NS	Sig	-
CD	3.06	5.46	-	1.24	1.69	-
CV (%)	7.04	10.02	-	25.75	19.95	-

*= Arc sine transformed values; Bs= Before spray, DAS= days after spray, ROC= reduction over untreated control

Table 8. Pooled effect of pesticides alone and in combination on the reduction of rice blast and grain yield increase in rice during *Rabi* 2012-13 and 2013-14

Tr. No.	Mean % ROC of BPH	Mean % ROC of Leaf blast incidence	Mean % ROC of Leaf blast severity	% YIOC
1	60.78	30.20	12.55	63.12
2	65.05	17.78	28.76	48.54
3	-18.05	37.09	44.61	31.54
4	6.29	26.42	41.62	34.07
5	66.06	48.72	60.41	83.47
6	75.14	36.52	48.61	68.97
7	59.50	42.74	56.93	77.42
8	65.73	47.35	57.89	74.64

ROC= reduction over untreated control; YIOC= Yield increase over control

Fungicides alone i.e. isoprothiolane @ 1.5 ml/L (34.07%) and tricyclazole @ 0.6 g/L (31.54%) recorded relatively lower yield increases.

The results of the experiment on individual effectiveness of insecticides and fungicides were in agreement with the earlier findings of Jaglan *et al*. (2024). The effectiveness of insecticides against BPH *viz*., imidacloprid+ethiprole 80 WG @ 0.25 g/L (Vinothkumar *et al*. (2010), Dhaka *et al.* (2020), Bhanu *et al*. (2025)) and dinotefuran 20 SG @ 0.4 g/L (Ghosh *et al*., 2014, Kiran Kumar and Vijayachandra Reddy, 2022, Jaglan *et al*., 2024) in the present investigation have close proximity with the findings of earlier reports. Similarly, the effectiveness of tricyclazole 75 WP @ 0.6 g/L (Singha and Dinesh, 2018, Anshu *et al*., 2024) and isoprothiolane 40 EC at 1.5 ml/ L (Pal and Mandal, 2021, Feng *et al.*, 2023) in the reduction of rice blast was reported earlier. The compatibility of insecticides and fungicides in tank mixtures for the management of BPH and rice blast were reported earlier by Anand Kumar *et al*., 2023 who observed that pymetrozine and triflumezopyrim in combination with tricyclazole and isoprothiolane were found effective against brown plant hopper and blast and recorded higher grain yields.

Conclusions

It was concluded that tank mixing of imidacloprid+ethiprole 80 WG with tricyclazole 75 WP and dinotefuran 20 SG in combination with both the fungicides i.e. tricyclazole 75 WP and isoprothiolane 40 EC were compatible with each other and can be safely used as tank mix at the time of simultaneous occurrence of BPH and blast disease. All the combinations did not produce any phytotoxicity at their recommended dosages. By identifying effective and crop-safe pesticide combinations, this research contributed towards refining integrated management practices, ensuring both crop protection and sustainable rice production.

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