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Next-Generation Fungicides for Sustainable Management of Rice Blast: A Path towards Resilient Paddy Production

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Abstract

Rice blast caused by *Magnaporthe oryzae* is one of the most destructive diseases of rice, leading to heavy yield losses. The present study evaluated the efficacy of Azoxystrobin 16.7% + Tricyclazole 33.3% SC against rice blast under field conditions at three locations in Karnataka during *kharif* 2021-22. The trials were laid out in a randomized block design with ten treatments. Pooled results revealed that Azoxystrobin + Tricyclazole at 750 ml/ha recorded the lowest disease severity (10.57 PDI) with 71.25% reduction over control and the highest grain yield (36.90 q/ha) with a 65.25% increase over control. The same treatment also provided the highest net returns (₹44,386/ha) and benefit–cost ratio (2.63). The superior efficacy of this mixture is attributed to its dual mode of action, enhancing disease control and delaying resistance. Therefore, Azoxystrobin 16.7% + Tricyclazole 33.3% SC at 750 ml/ha can be recommended as an effective component in integrated management of rice blast.

Keywords: Rice blast, *Magnaporthe oryzae*, Azoxystrobin, Tricyclazole, Integrated disease management

Introduction

Rice (*Oryza sativa* L.) is the staple food for more than half of the world's population and contributes significantly to food and nutritional security in Asia, particularly in India. India is the second largest producer of rice after China, with an area of 43.46 million hectares and a production of 119.93 million tons during 2024–25 (DAC&FW 2024). Despite its importance, rice productivity is constrained by several biotic and abiotic stresses. Among the diseases, blast caused by the ascomycetous fungus *Magnaporthe oryzae* (*Pyricularia oryzae*) is considered as the most destructive disease of rice worldwide. It occurs in both tropical and temperate regions and is prevalent in all rice-growing states of India (Sharma *et al*., 2012). The disease was first reported from China in 1637 and later in India from Thanjavur district of Tamil Nadu in 1919 (Padmanabhan, 1965). Blast affects leaves, nodes and panicles leading to severe yield losses ranging from 30-50% under endemic conditions and in severe epidemics losses may reach up to 90% (Ou 1985, Nalley *et al*., 2016). The pathogen survives on infected crop residues, seeds and collateral hosts and its rapid spread is favored by congenial weather conditions such as high relative humidity, prolonged leaf wetness and moderate temperature (Bonman *et al*., 1992).

Several management strategies have been recommended to mitigate rice blast, including resistant cultivars, fungicides, cultural practices and bio-control agents but the breakdown of varietal resistance, fungicide resistance in pathogen populations and environmental concerns necessitate integrated and sustainable approaches (Skamnioti and Gurr, 2009). Although tricyclazole has long been a standard fungicide, its continuous use has reduced the sensitivity of *M. oryzae* in many regions (Srivatsava *et al*., 2017). Various fungicides have been used to control rice diseases, although systemic fungicides such as strobilurin, dithiocarbamate, triazole, and antibiotics have also drawn attention. Single-site fungicides have been shown to be very effective against several rice diseases, but have also been found to promote the development of fungicide resistance in pathogen populations (Deising *et al*., 2008, Ishii and Hollomon 2015). To address this, newer fungicide combinations such as Azoxystrobin 16.7% + Tricyclazole 33.3% SC with dual modes of action have been introduced, showing promise for improved disease suppression and resistance management (Rajashekhara *et al*., 2021). Field evaluation of these molecules across locations is essential to establish their efficacy and economic viability and hence the present investigation was undertaken to assess the effectiveness of the Azoxystrobin + Tricyclazole combination compared to other fungicides for managing blast disease of rice under farmers' field conditions.

Materials and Methods

Field experiments were conducted during *kharif* 2021-22 at three locations in Karnataka, the Agricultural Research Station (ARS) Hanagal, Agricultural Research Station (ARS) Mugad, and the Agricultural Extension Education Centre (AEEC) Belagavi. In addition, on-farm demonstrations were carried out during *kharif* 2022-23 at multiple farmer fields across Dharwad, Hanumanamatti, Sirsi, Belagavi and Hangal to validate the efficacy of treatments under real farming conditions. The region falls under the Northern Transitional Zone of Karnataka with average annual rainfall of 850–1100 mm. The trials were laid out in a Randomized Block Design (RBD) with three replications. Ten treatments comprising fungicide mixtures and solo applications were evaluated against an untreated control. HR -12 variety which is susceptible for the blast disease was used for the experiment. The treatment details are presented below

T_1: Azoxystrobin 16.7% + Tricyclazole 33.3% SC @ 500 ml/ha

T_2: Azoxystrobin 16.7% + Tricyclazole 33.3% SC @ 750 ml/ha

T_3: Tricyclazole 75 WP @ 400 g/ha

T_4: Validamycin 3% SL @ 500 ml/ha

T_5: Propiconazole 25 EC @ 500 ml/ha

T_6: Isoprothiolane 40 EC @ 750 ml/ha

T_7: Carbendazim 50 WP @ 500 g/ha

T_8: Azoxystrobin 23 SC @ 500 ml/ha

T_9: Tebuconazole + Trifloxystrobin 75 WG @ 200 g/ha

T_{10}: Untreated control

The fungicides were applied as foliar sprays at the first appearance of blast symptoms and repeated at 15-day intervals for second applications.

The incidence of leaf blast was assessed as per cent disease index (PDI) at 10 days after the final spray using the 0–9 scale proposed by IRRI (1996). Twenty-five of leaves were counted from each treatment to calculate the infection percentage. Grain yield from each plot 5 m X 5 m was recorded at harvest and expressed in kg/ha and later converted into q/ha. The per cent disease index was calculated following the formula suggested by Wheeler (1969).

$$\text{Per cent disease index (PDI)} = \frac{\text{Sum of individual disease ratings}}{\text{No. of leaves observed} \times \text{maximum disease grade}} \times 100$$

Grade	Symptoms
0	No lesions
1	Small lesion on leaf or secondary branches
3	Small roundish to oval lesion (1-2 mm) on leaf or on primary branches/panicle axis
5	Narrow lesion of 1-2 mm breadth and about 3 mm long on leaf, or around the base of uppermost internodes/lower part of panicle axis
7	Broad spindle-shaped lesion with yellow/brown/purple margin on leaf, completely around panicle base, with more than 30% filled grains
9	Complete lesion

The data on disease severity and yield were subjected to Analysis of Variance (ANOVA) using RBD design and treatment means were compared at 5% level of significance (CD at 5%). For economic analysis, pooled data from the three locations were considered to derive average profitability.

Results and Discussion

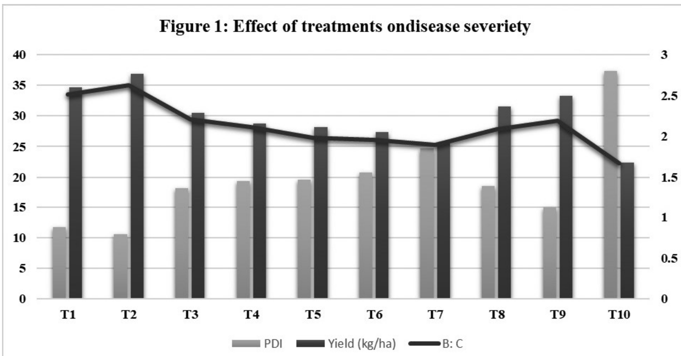
Pooled analysis across three locations during *kharif* 2021-22 (**Table 1**) revealed that fungicidal treatments significantly reduced blast severity and improved grain yield compared to the untreated control. The combination fungicide Azoxystrobin 16.7%+ Tricyclazole 33.3% SC @ 750 ml/ha was most effective, recording the lowest disease severity (10.57 PDI) with 71.25 per cent reduction over control and the highest grain yield (36.90 q/ha) with a 65.25 per cent increase over control (22.33 q/ha). The 500 ml/ha dose of the same fungicide was statistically comparable with 11.71 PDI (68.63% reduction) and 34.64 q/ha yield (55.13% increase). The enhanced performance of this mixture may be attributed to the complementary action of Tricyclazole, a melanin biosynthesis inhibitor highly specific to blast and Azoxystrobin, a Strobilurin fungicide with broad-spectrum activity targeting fungal respiration. Such dual action provides higher efficacy and delays fungicide resistance, which has been emphasized in earlier studies on rice and other crops. The superior performance of this fungicide combination can be attributed to its dual mode of action, ensuring both preventive and curative effects (Kumar *et al*., 2016; Goswami and Thind, 2018; Hegde *et al*., 2020 Mishra *et al*., 2025; Mohiddin *et al.,* 2021, Amoghavarsha *et al*., 2021, Kumar *et al*., 2013, Balol *et al*., 2022 and Magar *et al*., 2015. Similar results have been reported on other crops such as chickpea (Basamma *et al*., 2021; Sangeeta *et al.,* 2022), urdbean (Balol *et al.,* 2020), Onion (Shilpakumari *et al*., 2011), and Mango (Vamshika *et al*., 2023) efficacy of novel fungicides for the management of False smut of rice (Patil *et al.,* 2024), efficacy of fungicides on rice sheath blight and grain discolouration diseases in rice (Surendran *et al.,* 2023: Yadav *et al.,* 2022) and greengram (Rengima *et al.,* 2025).

Table 1: Management of blast of paddy by Azoxystrobin + Tricyclazole (pooled) 2021-22

Tr. No	Treatment details	PDI				% Reduction over control	Yield (q/ha)				% increase over control
		Hanagal	Mugad	Belagavi	pooled		Hanagal	Mugad	Belagavi	Pooled	
T_1	Azoxystrobin 16.7% + Tricyclazole 33.3% SC @ 500 ml/ha	13.54 (21.6)	12.29 (20.54)	9.30 (17.76)	11.71 (20.02)	68.63	37.07	31.61	35.25	34.64	55.13
T_2	Azoxystrobin 16.7% + Tricyclazole 33.3% SC @ 750 ml/ha	11.35 (19.7)	10.65 (19.05)	9.72 (18.18)	10.57 (18.98)	71.25	38.48	35.41	36.8	36.9	65.25
T_3	Tricyclazole 75 WP @ 400 g/ha	20.50 (26.94)	19.74 (26.39)	14.28 (22.21)	18.27 (25.32)	51.11	33.13	27.13	31.3	30.52	36.68
T_4	Validamycin 3% SL @ 500 ml/ha	21.55 (27.67)	20.22 (26.74)	16.45 (23.94)	19.41 (26.15)	47.67	31.37	25.45	29.6	28.81	29.02
T_5	Propiconazole 25 EC @ 500 ml/ha	22.25 (28.16)	20.49 (26.93)	16.15 (23.71)	19.63 (26.31)	47.23	31.02	24.37	29.3	28.23	26.42
T_6	Isoprothiolane 40 EC @ 750 ml/ha	22.65 (28.43)	21.67 (27.76)	18.09 (25.18)	20.80 (27.15)	43.75	30.4	22.97	28.6	27.32	22.35
T_7	Carbendazim 50 WP @ 500 g/ha	27.60 (31.71)	26.6 (31.06)	19.95 (26.54)	24.72 (29.83)	33.66	28.84	22.57	26.55	25.65	14.87
T_8	Azoxystrobin 23 SC @ 500 ml/ha	19.90 (26.51)	18.85 (25.75)	16.90 (24.29)	18.55 (25.52)	49.59	33.37	29.49	31.6	31.49	41.02
T_9	Tebuconazole + Trifloxystrobin 75 WG @ 200 g/ha	17.25 (24.55)	16.31 (23.83)	11.43 (19.77)	15.00 (22.8)	59.97	34.67	31.22	33.85	33.25	48.90
T_{10}	Untreated control	42.20 (40.53)	40.34 (39.45)	29.48 (32.9)	37.31 (37.67)		24.55	18.78	23.65	22.33	
	S Em ±	0.19	0.80	0.28	0.97					0.50	
	CD at 5%	0.56	2.37	0.84	2.88					1.49	

Tricyclazole 400 g/ha, the standard check, showed moderate performance with 18.27 PDI (51.11% reduction) and 30.52 q/ha yield (36.68% increase). The comparatively lower efficacy may be due to reduced sensitivity of *Magnaporthe oryzae* to tricyclazole, as reported from several rice-growing regions of India (Kumar *et al*., 2017). Another mixture, Tebuconazole + Trifloxystrobin @ 200 g/ha, also performed well with

15.00 PDI (59.97% reduction) and 33.25 q/ha yield (48.90% increase), supporting its role as a potential alternative in blast management programs **(Figure 1)**. Other fungicides such as Validamycin, Propiconazole and Isoprothiolane showed comparatively higher disease levels (19.41-20.80 PDI) and lower yields (27.32-28.81 q/ha), while Carbendazim was least effective (24.72 PDI; 25.65 q/ha yield).



Economic analysis of pooled data (**Table 2**) confirmed the advantage of Azoxystrobin + Tricyclazole. The 750 ml/ha dose resulted in the highest net returns (₹44,386/ha) and benefit-cost ratio (2.63), followed by the 500 ml/ha dose (₹40,402/ha; B:C ratio 2.51). Tricyclazole 400 g/ha also provided favourable returns (₹32,409/ha; B:C ratio 2.21). In contrast, Carbendazim recorded the lowest net returns (₹23,561/ha) and B:C ratio 1.90). These results agree with the findings of (Karthikeyan *et al*., 2010) and (Reddy *et al*., 2010) who emphasized the importance of both biological efficacy and economic viability in fungicide evaluation.

Table 2: Economics of management of blast of paddy by Azoxystrobin + Tricyclazole (pooled) 2021-22

	Treatment details	Yield (q/ha)	Gross returns (Rs)	Cost of cultivation (Rs)	Net returns (Rs)	B:C ratio
T_1	Azoxystrobin 16.7% + Tricyclazole 33.3% SC @ 500 ml/ha	34.64	67201.60	26800.00	40402.00	2.51
T_2	Azoxystrobin 16.7% + Tricyclazole 33.3% SC @ 750 ml/ha	36.90	71586.00	27200.00	44386.00	2.63
T_3	Tricyclazole 75 WP @ 400 g/ha	30.52	59208.80	26800.00	32409.00	2.21
T_4	Validamycin 3% SL @ 500 ml/ha	28.81	55891.40	26500.00	29391.00	2.11
T_5	Propiconazole 25 EC @ 500 ml/ha	28.23	54766.20	27600.00	27166.00	1.98
T_6	Isoprothiolane 40 EC @ 750 ml/ha	27.32	53000.80	27000.00	26001.00	1.96
T_7	Carbendazim 50 WP @ 500 g/ha	25.65	49761.00	26200.00	23561.00	1.90
T_8	Azoxystrobin 23 SC @ 500 ml/ha	31.49	61090.60	29300.00	31791.00	2.09
T_9	Tebuconazole + Trifloxystrobin 75 WG @ 200 g/ha	33.25	64505.00	29450.00	35055.00	2.19
T_{10}	Untreated control	22.33	43320.20	26000.00	17320.00	1.67
	S Em ±	0.50				
	CD at 5%	1.49				

Conclusion

Overall, results clearly establish that Azoxystrobin 16.7% + Tricyclazole 33.3% SC, particularly at 750 ml/ha, offers superior blast management, higher yield and greater profitability compared to single fungicides. The study demonstrates the effectiveness of tested fungicides in reducing rice blast severity under field conditions. Its consistent performance under experimental trials indicates its potential as a key

Azoxystrobin 16.7% + Tricyclazole 33.3% SC @ 750 ml/ha

Control

component of Integrated Disease Management (IDM) programs. However, reliance on fungicides alone may lead to resistance buildup. Hence, integration of this fungicide mixture with resistant varieties, cultural practices and bio-agents is essential for sustainable blast management.

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