Original Research Article

Evaluation of Novel Broad-Spectrum Fungicides for Management of Rice Blast and Sheath Blight Under *In-vitro* and Field Conditions

ABSTRACT

Thepresent study evaluated the efficacy of eight novel fungicidal treatments against *Magnaportheoryzae* (Blast) and *Rhizoctoniasolani* (Sheath blight) under both *in-vitro* and field conditions. *In-vitro* efficacy against *M.oryzae* revealed that, complete pathogen growth inhibition (100%) was exhibited by treatments T2 (Picoxystrobin 7% + Propiconazole 12% EC @ 2.0ml/L), T3 (Pyraclostrobin 100 g/L @ 2.0 ml/L), T4 (Flupyroxad 62.5 g/L + Epoxiconazole 62.5 g/L EC @ 1.5 ml/L), T6 (Propiconazole 20% EC @ 1.0 ml/L) and T7 (Isoprothiolane 40% EC @ 1.5 ml/L) at recommended doses. Whereas, at half-recommended doses, T2 and T3 still maintained high efficacy with inhibition rate of 91.8% and 90.7%. Similarly, for *R.solani*, treatments T2, T3, T4, T5 and T6 also showed complete inhibition at their recommended doses, while T1 and T7 achieved 82.6% and91.2% inhibition respectively.At half-recommended doses, T2, T3, T4 and T5 registeredthe cent per cent inhibition, while T1 and T7 showed 79.2% and 81.9%, respectively**.** In field trials conducted during *kharif*, 2020 to 2022revealed that, the treatment T1 notably reduced sheath blight severity to 36.1%, compared to 61.8% in untreated control and achieved the lowest neck blast severity (6.3%) and realised highest yield (7097 kg/ha) and ICBR (1:7.9), and significantly far surpassing the control yield (5144 kg/ha). The triazole-strobilurins combination demonstrated broad-spectrum efficacy, achieving 62.7% and 18.3% reduction in neck blast and sheath blightrespectively compared to standard fungicides.These findings underscore the potential of novel combination fungicides in enhancing disease management and yield while lowering the number of sprays and costs to the rice farmers.

Key Words: Rice, Magnaportheoryzae, Rhizoctoniasolani and combination fungicides

1. INTRODUCTION

Rice (*Oryza sativa* L.) is one of the most important staple food crops globally, feeding more than half of the world's population. It plays a pivotal role in ensuring the food security, particularly in Asia, where over 90% of the world's rice is produced and consumed. Rice cultivation is widespread across diverse agro-ecological zones, ranging from rainfed lowlands to irrigated fields (Rajeswari et al., 2024). Major rice-producing countries such as India, China, Indonesia and Bangladesh rely heavily on rice not only as a primary food source, but also as a major contributor to the agricultural economy. In India, Telangana State has witnessed a remarkable increase in the rice cultivation due to enhanced irrigation infrastructure and supportive pro-farmer policies implemented by the government. This expansion has positioned the Telangana as a potential rice bowl of the country(Aravind et al., 2022). However, despite the remarkable increase in the cultivated area, rice production is constrained by various biotic and abiotic stresses.

Among the major biotic constraints, fungal diseases like blast and sheath blight poses a serious threat to rice production, leading to substantial yield losses. These diseases affect rice crops at all growth stages, particularly in irrigated fields of both temperate and subtropical regions **(**Bonman et al., 1991**)**. Rice blast, caused by *Pyriculariaoryzae* (formerly *Pyriculariagrisea*Sacc., the anamorph of *Magnaporthegrisea* (Herbert) Yaegashi and Udagawa), is one of the most destructive and widespread diseases of rice (Hajano et al., 2012). Blast epidemics can lead to the complete destruction of seedlings in both nursery and field conditions (Chaudhary et al., 1994; Teng et al., 1991) resulting in yield reductions of up to 80% (Chaudhary, 1999; Koutroubas et al., 2009).Sheath blight, caused by *Rhizoctoniasolani* Kuhn, is a significant and destructive disease of rice, affecting rice-growing regions worldwide. In India, losses attributed to sheath blight have been estimated to reach as high as 54.3% (Ou, 1985; Rajan, 1987; Roy, 1993). The disease is especially problematic in intensive rice production systems, where the excessive use of nitrogenous fertilizers contributes to its severity (Savary and Mew, 1996).

The management of these fungal diseases is crucial for stabilizing rice yields and ensuring food security. While integrated disease management (IDM) practices, including the use of resistant cultivars, cultural practices and biological control agents are recommended, the application of fungicides remains a cornerstone in disease management strategies. Fungicides provide rapid and effective control of multiple diseases under field conditions, particularly in the conditions where resistant varieties are unavailable or disease pressure is high.

Over the past few decades, numerous fungicide molecules have been developed and deployed for rice disease management of blast and sheath blight diseases has proven successful at the field level in most cases (Filippi and Prabhu, 1997; Kandhari and Gupta, 2003; Kumar et al., 2013; Rao and Muralidharan, 1983; Variar et al., 1993).For blast management, traditional single-site fungicides such as Isoprothiolane, Probenazole, Pyroquilon and Tricyclazole (Varma and Menon, 1977), along with other fungicides like Benomyl, Carbendazim, Chloroneb, Captafol, Mancozeb, Zineb, Edifenphos, Iprobenphos, Thiophanate, Carboxin, Kitazin and Flutolanil, have been found effective under field conditions (Araki, 1985; Bag and Saha, 2009; Dash and Panda, 1984; Kannaiyan and Prasad, 1984; Singh and Sinha, 2004). Similarly, for sheath blight management, fungicides including Benomyl, Carbendazim, Chloroneb, Captafol, Mancozeb, Zineb, Edifenphos, Iprobenphos, Thiophanate and Carboxin have also shown efficacy in field settings (Bag and Saha, 2009; Kannaiyan and Prasad, 1984; Singh and Sinha, 2004).However, the continuous and widespread use of single-site fungicides has led to the emergence of resistant pathogen populations, necessitating the identification of novel fungicide combinations with broad-spectrum activity.

Recent advances in fungicide formulation have focused on combining molecules with different modes of action to enhance disease control efficacy, delay resistance development and provide broader protection against multiple pathogens. Several combination fungicides, such as Trifloxystrobin 25% + Tebuconazole 50% 75WG, Kasugamycin 5% + Copper Oxychloride 45% WP andKresoxim Methyl 40% + Hexaconazole 8% WG, have demonstrated effective control of both blast and sheath blight diseases under field conditions (Bag and Saha, 2009; Kumar et al., 2013; Kumar and Veerabhadraswamy, 2014). Despite the success of fungicides in controlling these diseases, the continuous development of fungicide resistance in fungal populations highlights the need for the identification of new fungicide groups with different modes of action. Therefore, this study was conducted to evaluate the field efficacy of combination fungicides against neck blast and sheath blight in rice.

2. Material and Methods

In-vitro evaluation of fungicides

The efficacy of different fungicides was evaluated under *in vitro* conditions using the poisoned food technique to assess their inhibitory activity against *M.oryzae* and *R.solani* (Table 1).

Table 1:Listof different new combination fungicides with recommended andhalf recommended doses against various pathogens in rice

S.No.	Chemicals	Dosage (g or ml/L of water)	
		Recommended dose	Half-recommended Dose
1	Azoxystrobin 18.2% w/w + Difenoconazole 11.4 % w/w SC	1.0 ml/L	0.5 ml/L
2	Picoxystrobin 7% + Propiconazole 12% EC	2.0 ml/L	1.0 ml/L
3	Pyraclostrobin 100 g/L CS	2.0 ml/L	1.0 ml/L
4	Flupyroxad 62.5 g/L + Epoxiconazole 62.5 g/L EC	1.5 ml/L	0.75 ml/L
5	Trifloxystrobin 50 % + Tebuconazole 25 % w/w (75 WG)	0.4 g/L	0.2 g/L
6	Propiconazole 25%EC	1.0 ml/L	0.5 ml/L
7	Isoprothiolane 40% EC	1.5 ml/L	0.75 ml/L

Efficacy of fungicides on the mycelialinhibition of *M. oryzae* and *R. solani*through poisoned food technique

The seven fungicides(Table 1)were evaluated for their inhibitory effects against *M.oryzae* and *R.solani* through poisoned food technique under *in- vitro* conditions.The fungicides were added to the 100ml sterilized PDA medium just before pouring. Control plates were prepared without fungicide. To prevent bacterial contamination, a pinch of streptomycin sulphate was added to the sterilized PDA medium. After solidification of the medium, 5 mm disc of pure cultures of *M.oryzae* and *R.solani*was placed at the center of each Petri dish. The plates were incubated at 28 ± 1°C and radial mycelial growth was recorded at 24-hour intervals until the control plates were fully covered by the mycelium (Hajano et al., 2012). Each treatment was replicated three times.

Per cent inhibition (I) = C-T/C × 100

Where, C = Radial growth of mycelium in fungicide un-amended medium (control)

T = Radial growth of mycelium in fungicide amended medium

Field evaluation of single and combined fungicides against Sheath blight and Neck Blastof rice

Field layoutand crop establishment:

A field experiment was conducted to evaluate the efficacy of combination fungicides against sheath blight and blast in rice under field condition over 3 *kharif* seasons during 2020 to 2022 at the Institute of Rice Research, ARI, Rajendranagar, Hyderabad. The popular rice variety BPT5204, known for its susceptibility to blast and sheath blight, was used as a test variety. Seeds were sown in the month of June and planted in July every *kharif* seasons. The trial was laid out in a randomized complete block design (RCBD) with eight treatments and four replications. Each plot had a gross area of 25 m² maintained. The seeds were soaked overnight in water, incubated in gunny bags for better sprouting and transplanted into the main field after 30 days of nursery growth. The land was prepared by puddling, followed by two ploughings after one week. Standard agronomic practices, including irrigation and fertilization, were followed throughout the crop growth period. A new combination formulation*viz.,* Azoxystrobin 18.2% w/w + Difenoconazole 11.4 % w/w SC@ 1.0 ml/L, Picoxystrobin 7% + Propiconazole 12% EC @ 2.0 ml/L, Flupyroxad 62.5 g/L + Epoxiconazole 62.5 g/L EC @ 1.5 ml/L, Trifloxystrobin 50 % + Tebuconazole 25 % w/w (75 WG) @ 0.4g/L, and standard check fungicides such as Pyraclostrobin 100 g/L @ 2.0 ml/L, Propiconazole @ 1.0 ml/L, Isoprothiolane @ 1.5 ml/L were included in thetreatments.Efficacy was evaluated by spraying all the test chemicals twice at 15 days interval starting from the initiation of the disease.

Artificial Inoculation

The efficacy of combination fungicideswas tested against sheath blight under artificial epiphytotic field condition. A pure culture of a virulent isolate of *R.solani* was multiplied on typha leaf bits. The artificial inoculation with *R. solani* was carried out at maximum tillering stage (Bhaktavatsalam et al., 1978). Thecolonized typha bits were placed between the tillers of 30 randomly selected plants in each replication / treatment at 5-10 cm above the water level. The treatments were imposed immediately after initiation of the sheath blight whereas, neck blastdisease was evaluated based on natural disease incidence among the treatments in comparison with untreated control.

Disease Assessment and Statistical Analysis

Disease assessment was carried out at 14 days post-treatment using Standard Evaluation System scale (0–9 rating scale) developed by IRRI, 2014 for sheath blight andneck blast. Further, the data was converted into per cent disease index (PDI) using formula given below. Data from *kharif,*2020,2021 and2022 seasons were pooled to get the average PDI and yield values. Subsequently, the data on disease severity and yield parameters were subjected to appropriatestatistical analysis.

PDI =[(Sum of the scores)**/(**Number of observations**×**Highest Number in Rating Scale)]**×** 100

3. RESULTS AND DISCUSSION

This study evaluated the *in-vitro* efficacy of various fungicides against *M.oryzae*, at recommended and half-recommended doses. Eight treatments including individual and combinations fungicides were tested. The results showed that at recommended doses, the treatments T2 (Picoxystrobin + Propiconazole), T3 (Pyraclostrobin), T4 (Flupyroxad + Epoxiconazole), T6 (Propiconazole) and T7 (Isoprothiolane) achieved complete inhibition of *M oryzae*, demonstrated the cent per-cent efficacy. Notably, T1 (Azoxystrobin + Difenoconazole) and T5 (Trifloxystrobin+Tebuconazole) also exhibited significant inhibition rates of 87.8% and 91.5%, respectively. At half-recommended doses, the majority of treatments were maintained effective inhibition of *M. oryzae*, with T2 and T3 showed growth inhibition rates of 91.8% and 90.7% respectively (Table 2).

Similarly,the efficacy of fungicides was evaluated against *R. solani*, at recommended and half-recommended doses revealed that, treatments T2 (Picoxystrobin + Propiconazole), T3 (Pyraclostrobin), T4 (Flupyroxad + Epoxiconazole), T5 (Trifloxystrobin + Tebuconazole) and T6 (Propiconazole) demonstrated cent per-cent inhibition of pathogen growth, whereas, the treatment T1 (Azoxystrobin + Difenconazole) exhibited significant inhibition at 82.6%, while T7 (Isoprothiolane) showed moderate efficacy with 91.2% inhibition at recommended dose. Further, the majority of the treatments (T2, T3, T4, T5 and T6)showed high effectiveness achieving 100% inhibition at half of the recommended dose. However, the efficacy of T1 decreased slightly to 79.2%, while T7 showed a reduction to 81.9%. These results suggested that most of the tested fungicides are highly effective against *R.solani* at both dosages (Table 3).

Pooled data of field efficacy studies conducted during the *Kharif*, 2020, 2021 and 2022 against sheath blight (ShB) and neck blast (NB) revealed that, among the treatments, T1*i.e.*Azoxystrobin 18.2% +Difenconazole 11.4% SC @ 1.0 ml/L demonstrated the lowest ShB severity of 36.1%, which significantly outperformed the untreated control (61.8%). Similarly, treatments T4 (Flupyroxad 62.5 g/L + Epoxiconazole 62.5 g/L EC @ 1.5 ml/L) and T5 (Trifloxystrobin 50% + Tebuconazole 25% (75 WG) @ 0.4 g/L) recorded ShB severity of 39.8% and 42.0%, respectively. A similar trend was observed with treatment T1 for neck blast, which demonstrated superior control, showing a severity of 6.3% compared to 29.3% in the untreated control. Additionally, the treatments T2 (Picoxystrobin 7% + Propiconazole 12% EC @ 2.0 ml/L), T3 (Pyraclostrobin 100 g/L @ 2.0 ml/L) also exhibited lower NB severity compared to the control (Table 4). The highest crop yield of 7097 kg/ha was recorded with foliar spraying of Azoxystrobin 18.2% + Difenconazole 11.4% SC @ 1.0 ml/L, which was significantly higher than the untreated control(5144 kg/ha). The next best treatmentsare T2 (Picoxystrobin 7% + Propiconazole 12% EC @ 2.0 ml/L) and T3 (Pyraclostrobin 100 g/L @ 2.0 ml/L) realized the yield of 6750 Kg/ha and 6860 Kg/ha, respectively, indicating a positive correlation betweendisease severity and yield (Table 5).The results in the present study clearly indicating that, the foliar spraying of Azoxystrobin 18.2% w/w + Difenconazole 11.4% SC @ 1.0 ml/L twiceat 15 days interval, was found effective against sheath blight and neck blast besides enhancing yield.

The superior efficacy of Azoxystrobin 18.2%+Difenconazole 11.4%SC, in controlling blast and sheath blight can be attributed to their broad-spectrum activity and dual modes of action against target pathogens. Further, Azoxystrobin, a QoI fungicide, inhibits mitochondrial respiration by blocking electron transport in fungal cells, thereby preventing energy production essential for pathogen growth. Whereas, Difenconazole, a triazole fungicide, acts by inhibiting ergosterol biosynthesis, which a key component of the fungal cell membrane.The combination of triazole and strobulin groups likely toprovided synergistic effects, resulting in high pathogen inhibition, even at lower doses.

Furthermore, the excellent performance of T2 (Picoxystrobin + Propiconazole) and T3 (Pyraclostrobin) can be attributed to the strobilurin group has strong preventive action and the triazole group's curative properties. The strobilurins ability to the inhibit spore germination and mycelial growth, combined with the triazoles interference in fungal sterol synthesis, ensures comprehensive control of both primary infection and subsequent pathogen spread.

The reduced disease severity observed in the field experiment aligns with the fungicides under *in-vitro* efficacy, suggesting their ability to suppress the pathogen inoculum effectively under natural conditions. Additionally, the observed increase in yield can be attributed to lower disease pressure, which minimized the damage to rice tillers and panicles, allowing for optimal grain filling and productivity. The treatments showingless severity of diseases also preserved the photosynthetically active leaf area, thereby contributing to better plant vigour and yield potential. These findings clearly suggesting that the importance of selecting fungicides with complementary mode of action for integrated disease management and to make more profitable rice cultivation to the farmers.

These findings are in alignment with previous research by Bhuvaneswari and Raju(2012)who reported that, the combination fungicide azoxystrobin 18.2% and difenoconazole 11.4% SC @ 1.25 ml/l and 1.0 ml/l was found effective against sheath blight recording least disease incidence of 9.36% and 16.43% respectively compared to standard recommended fungicides.Sharma et al.(2024) also reported that the combination fungicide Azoxystrobin 11% + Tebuconazole 18.3% w/w SC was highly effective in minimizing sheath blight severity, achieving the lowest PDI of 11.16% followed by Azoxystrobin 18.2% w/w + Difenoconazole 11.4% w/w SC effectively reduced disease severity to 11.90%. Biswas(2004) reported that, Azoxystrobin 25% SC applied at 1 ml/L effectively controlled sheath blight in rice, resulting in the lowest disease severity of 16.4% and achieving a maximum grain yield of 5225 kg/ha.

Similarly, Rajeswari et al.(2024) demonstrated that strobilurin-triazole combinations, including Azoxystrobin 18.2%+Difenconazole 11.4% SC, Metiram 55% + Pyraclostrobin 5% WG and Tebuconazole 50%+Trifloxystrobin 25% (75 WG), each applied at a constant dosage of 1.0 ml/L, significantly reduced the blast PDI to 26.66%, 20.63% and 14.6%, respectively, compared to 54.46% in untreated control.Goswami and Thind (2018) also reported that, the combination of Azoxystrobin and Difenoconazole exhibited superior efficacy in controlling rice blast at the seedling stage, aligning with the present study. Pak et al.(2017)further highlighted the higher efficiency of Azoxystrobin in managing rice blast during the early growth phase. These findings were also supported by Mohiddinet al.(2021), who reported the fungitoxic properties of Azoxystrobin, Difenoconazole + Propiconazole andFluopyram + Tebuconazole in effectively reducing blast disease.

Assessment of mean grain yield (q/ha) and Incremental Net Benefit-Cost(B:C) ratio of various treatments

An economic analysis of the treatments revealed that, T1 (Azoxystrobin+ Difenconazole @ 1.0 ml/L) and T6 (Propiconazole @ 1.0 ml/L) were found most effective in terms of mean grain yield and incremental Benefit-Cost Ratio (ICBR). The foliar application of Azoxystrobin+Difenconazole @ 1.0 ml/Lexhibited the highest mean grain yield (70.97 q/ha) and additional returns (Rs 39,841), coupled with a strong B:C ratio of 1:7.9, making the treatmenthighly effective and more profitable to the farming community (Table 5). The treatment T6 (Propiconazole @ 1.0 ml/L), despite recorded a slightly lower yield, demonstrated superior cost efficiency with the highest B:C ratio of 1:9.1, underscoring its economic viability but it is not having broad spectrum activity against multiple diseases of rice. The treatments *i.e.*T2 (Picoxystrobin + Propiconazole @ 1 ml/L) and T7 (Isoprothiolane @ 1.5 ml/L)were also performed well, which exhibited significant yield and returns, though their B:C ratios (6.8 and 8.8) respectively followed by T5(Trifloxystrobin+ Tebuconazole@ 0.4g/L)showing acceptable yield but incurs a higherinput cost (Rs. 4840), resulting in less favourable B:C ratio of 1:6.1. Among the treatments, T4 (Flupyroxad + Epoxiconazole)stands out with the lowest B:C ratio (1:5.4), suggesting it is the least cost-effective treatment.

4. CONCLUSION

Several previous studies have highlighted the role of fungicide applications in enhancing rice yield. In the present investigation, the combination fungicide *i.e.* Azoxystrobin 18.2% + Difenconazole 11.4% SC @ 1.0 ml/L emerged as the most effective treatment in reducing severity of sheath blight and neck blast, ultimately resulting in significantly higher grain yield. This combination demonstrated consistent performance across multiple years, suggesting its suitability for integrated disease management (IDM) strategies in rice cultivation. Given its high efficacy and favourable economic returns, this fungicide combination could be effectively utilized to manage the co-incidence of sheath blight and neck blast in rice, thereby reducing the number spraying and cost of cultivation andin-turn improving both productivity and profitability.

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Table 2. *In-vitro* evaluation of combination fungicides against *Magnaportheoryzae*

Trt. No.	Treatments details	Recommended dose		Half-recommended dose	
		Radial growth of the pathogen (mm)	Per cent Inhibition(%)	Radial growth of the pathogen (mm)	Per cent Inhibition(%)
T1	Azoxystrobin 18.2% +Difenconazole 11.4 % SC @ 1.0 ml/L	11.0 (19.3)[#]	87.8	12.3 (20.5)	86.3
T2	Picoxystrobin 7% + Propiconazole 12% EC @ 2.0 ml/L	0.0 (0.0)	100.0	7.3 (15.7)	91.8
T3	Pyraclostrobin 100 g/L @ 2.0 ml/L	0.0 (0.0)	100.0	8.3 (16.7)	90.7
T4	Flupyroxad 62.5 g/L + Epoxiconazole 62.5 g/L EC @ 1.5 ml/L	0.0 (0.0)	100.0	0.0 (0.0)	100.0
T5	Trifloxystrobin 50% + Tebuconazole 25% (75 WG) @ 0.4g/L	7.7 (16.0)	91.5	11.3 (19.6)	87.4
T6	Propiconazole 25% EC @ 1.0 ml/L	0.0 (0.0)	100.0	11.0 (19.4)	87.7
T7	Isoprothiolane 40% EC @ 1.5 ml/L	0.0 (0.0)	100.0	0.0 (0.0)	100.0
T8	Control	90.0 (71.5)	0.0	90.0 (71.5)	0.0
	CD @ 1%	0.3		1.2	
	SE (m)±	0.1		0.4	
	CV %	1.6		3.5	

[#]Figures are in parenthesis are angular transformed values.

Table 3. *In-vitro* evaluation of combination fungicides against *Rhizoctoniasolani*

Trt. No.	Treatment details	Recommended dosage		Half-Recommended dosage	
		Radial growth of the pathogen (mm)	Per cent Inhibition (%)	Radial growth of the pathogen (mm)	Per cent Inhibition (%)
T1	Azoxystrobin 18.2% + Difenconazole 11.4 % SC @ 1.0 ml/L	15.7 (23.3)[#]	82.6	18.7 (25.6)	79.2
T2	Picoxystrobin 7% + Propiconazole 12% EC @ 2.0 ml/L	0.0 (0.0)	100.0	0.0 (0.0)	100.0
T3	Pyraclostrobin 100 g/L @ 2.0 ml/L	3.4 (10.6)	96.2	6.0 (14.1)	93.3
T4	Flupyroxad 62.5 g/L + Epoxiconazole 62.5 g/L EC @ 1.5 ml/L	0.0 (0.0)	100.0	0.0 (0.0)	100.0
T5	Trifloxystrobin 50 % + Tebuconazole 25 % (75 WG) @ 0.4 g/L	0.0 (0.0)	100.0	0.0 (0.0)	100.0
T6	Propiconazole 25% EC @ 1.0 ml/L	0.0 (0.0)	100.0	0.0 (0.0)	100.0
T7	Isoprothiolane 40% EC @ 1.5 ml/L	7.9 (16.3)	91.2	16.3 (23.8)	81.9
T8	Control	90.0 (71.5)	0.0	90.0 (71.5)	0.0
	CD @ 1%	0.2		1.2	
	SE (m)±	0.09		0.4	
	CV %	1.1		4.3	

[#]Figures are in parenthesis are angular transformed values.

Table 4. Pooled analysis on evaluation of combination fungicides against majordiseases of rice during *kharif*, 2020 to 2022

Trt No.	Treatments	ShB severity (%) (*K*, 2020, 2021 & 2022)	NBSeverity(%) (*K*, 2020, 2021 & 2022)	Yield (Kg/ha)
T1	Azoxystrobin18.2% +Difenconazole 11.4 % SC @ 1.0 ml/L	**36.1[a] (36.9)**	**6.3[a] (14.5)**	7097[c]
T2	Picoxystrobin 7% + Propiconazole 12% EC @ 2.0ml/L	43.7[bc] (41.4)	13.8[b] (21.8)	6750[bc]
T3	Pyraclostrobin 100 g/L @ 2.0 ml/L	41.3[b] (40.0)	14.5[b] (22.3)	6860[bc]
T4	Flupyroxad62.5 g/L + Epoxiconazole 62.5 g/L EC @ 1.5 ml/L	39.8[ab] (39.1)	15.5[bc] (23.1)	6551[b]
T5	Trifloxystrobin 50 % + Tebuconazole 25 % (75 WG) @ 0.4 g/L	42.0[b] (40.4)	16.8[bc] (24.1)	6822[bc]
T6	Propiconazole 20% EC @ 1.0 ml/L	44.2[bc] (41.6)	18.8[c] (25.7)	6605[bc]
T7	Isoprothiolane 40% EC @ 1.5 ml/L	47.7[c] (43.6)	16.9[bc] (24.2)	6728[bc]
T8	Untreated Control (Water spray)	61.8[d] (51.8)	29.3[d] (32.8)	5144[a]
	CD @ 5%	4.6	3.3	471.5
	SEm±	1.6	1.1	160.3
	CV (%)	7.0	13.6	4.9

Figures in parenthesis are square root transformed values. *Dunccan multiple range test (DMRT). **NB**: Neck Blast; **ShB**: Sheath Blight

Table 5. Cost economics of various combination fungicides for management of key diseases of rice during *kharif*, 2020 to 2022 under field conditions

Trt No.	Mean grain yield (q/ha)	Additional yield over control (q/ha)	Additional cost of cultivation (Rs/ha)	Additional returns over control (Rs/ha)	Incremental net B:C ratio	Marginal Returns
T1	70.97	19.53	4453	39841	7.9	8.9
T2	67.50	16.06	4177	32762	6.8	7.8
T3	68.60	8.73	4000	17809	7.8	8.8
T4	65.51	14.07	4500	28703	5.4	6.4
T5	68.22	16.78	4840	34231	6.1	7.1
T6	66.05	14.61	2950	29804	9.1	10.1
T7	67.28	15.84	3301	32314	8.8	9.8
T8	51.44	-	-	-	-	-

Market price of Paddy (MSP): Rs. 2040/quintal.