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FIELD EVALUATION OF SYSTEMIC FUNGICIDES FOR THE MANAGEMENT OF BROWN LEAF SPOT CAUSED BY *HELMINTHOSPORIUM ORYZAE* (BREDA DE HAAN) IN BASMATI RICE (*ORYZA SATIVA* L.) AND ITS IMPACT ON GROWTH AND YIELD

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ABSTRACT

A field experiment was conducted at central research field, SHUATS, Prayagraj to evaluation of systemic fungicides for the management of brown leaf spot *Helminthosporium oryzae* (Breda de Haan) in basmati rice (*Oryza sativa* L.) *kharif* season 2023. The study evaluated the efficacy of various systemic chemical fungicides in controlling brown leaf spot disease and enhancing growth parameters of paddy at different stages of growth. Disease intensity (%) was significantly decreased in T_3 propiconazole 25% EC @1 ml/l 60 DAT (12.00), 75 DAT (15.00) and 90 DAT (18.70) followed by T_6 hexaconazole 5% EC @2 ml/l 60 DAT (12.85), 75 DAT (15.85) and 90 DAT (19.30). The plant height (cm) significantly increased in T_3 propiconazole 25% EC @1 ml/l 45 DAT (50.77), 60 DAT (73.54), 75 DAT (90.38) and 90 DAT (102.88). Number of tillers was significantly increased in T_3 propiconazole 25% EC @1 ml/l 45 DAT (20.96) and 75 DAT (25.23). Length of panicle (cm) was significantly increased in T_3 propiconazole 25% EC @1 ml/l (27.36). Yield (t/ha) was significantly increased in T_3 propiconazole 25% EC @1 ml/l (3.2 t/ha) followed by T_6 hexaconazole 5% EC @2 ml/l (3.0). C:B ratio was recorded with T_3 propiconazole 25% EC @1 ml/l (1:2.16) followed by T_6 hexaconazole 5% EC @2 ml/l (1:1.06). The results indicated that systemic fungicide applications not only reduced disease severity but also improved crop growth, leading to higher yields. The study concludes that propiconazole 25% EC (Tilt) at 1 ml/l is an effective fungicide for managing brown leaf spot disease and enhancing the productivity of paddy.

Key words : Systemic fungicides, Brown leaf spot, *Helminthosporium oryzae*, Basmati rice, Propiconazole, Crop growth and Yield.

Introduction

Rice (*Oryza sativa* L.) is a short-day monocotyledonous self-pollinated angiosperm within the genus Oryza of the family Poaceae. It is the principal nourishment for one-third of the total population and occupies nearly one-fifth of the total land area under cereals (Ren *et al.*, 2006). Rice is also considered as the “Queen of cereals” (Abbas *et al.*, 2011). In ayurveda, Basmati rice is pure, nourishing and easy to digest. The unique fragrance and flavour of basmati rice are due to the presence of a chemical compound called 2-acetyl-1-pyrroline, which makes it unmatched by any other aromatic rice in the world (Routary and Rayaguru, 2018). Basmati rice is characterized by extra-long, superfine, slender grains with a length to breadth ratio of more than 3.5, sweet taste, soft and fluffy texture, delicate curvature, superior aroma, unique flavour and significant elongation with minimal breadth-wise swelling when cooked (Bera and Anurag, 2020; Kumari *et al.*, 2022).

Breda de Haan first reported the brown leaf spot (BLS) pathogen as *Helminthosporium oryzae* in 1900. Ito and Kuribayashi reported the perfect stage as *Ophiobolus miyabeanus* in 1927. An unnamed report in 1934 placed the pathogen in the *Cochliobolus* genus. Dastur then formally transferred the pathogen into to the *Cochliobolus* genus in 1942. Shoemaker proposed the name *B. oryzae* in 1959. Subramanian and Jain reassigned the name to *Drechslera oryzae* in 1966. The currently accepted name, reflecting these changes is *Cochliobolus miyabeanus* (Palla, 2012). Maximum disease incidence has been reported in the Basmati super variety (51.43%) and the lowest in Basmati-38 (6.57%) (Choudhury *et al.*, 2019). This pathogen attacks plants, at both seedling and mature stages, mostly occurring in poor soil with fewer nutrients (Agarwal *et al.*, 1989; Mia and Safeeulla, 1998; Zadoks, 2002). In 1942, it became the source of the Bengal Famine, causing the death of two million people.

The pathogen enters through epidermal cells or stomata of the leaf (Ou, 1985). When fungal mycelium invades a cell, a brownish appearance occurs (Tullis, 1935). These brownish spots merge, forming larger chlorotic lesions with a halo around them. After 18 hours, entire leaf regions are observed with severe lesions. Ultimately, rice leaf blades are completely destroyed (Dallagnol *et al.*, 2009). After infection, the pathogen produces toxins that lead to the browning and death of parenchyma cells (Tullis, 1935). Pathogen infection also decreases the green pigment in leaves, which is essential for photosynthesis (AbdelFattha *et al.*, 2007; Shabana *et al.*, 2008). The infection and lesion formation reduce the photosynthetic area of leaves, resulting in fewer tillering nodes (Lee, 1992), lower grains weight and a reduced number of grains per panicles (Aluko, 1975). These toxins also increase electrolyte leakage in root cells (Tipton *et al.*, 1977).

Materials and Methods

The research was conducted during the Kharif season of 2023–24 at the Research Farm of the Department of Plant Pathology, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj, Uttar Pradesh, India. A Basmati rice variety was used under natural disease incidence. To evaluate the effectiveness of systemic fungicides against brown leaf spot caused by *Helminthosporium oryzae* (Breda de Haan), a field experiment was carried out using a randomized block design (RBD) with three replications (2m × 1m plots). Foliar application of seven different treatments was performed and the treatment details are provided in Table 1.

Table 1 : Treatments details of systemic fungicides.

S. no.	Treatments No.	Treatments name	Doses	Methods of applications
1	T_0	CONTROL	-	-
2	T_1	Propiconazole (Tilt) 25% EC	0.5 ml/l	Foliar spray
3	T_2	Propiconazole (Tilt) 25% EC	0.75 ml/l	Foliar spray
4	T_3	Propiconazole (Tilt) 25% EC	1 ml/l	Foliar spray
5	T_4	Hexaconazole (Contaf) 5% EC	1.5 ml/l	Foliar spray
6	T_5	Hexaconazole (Contaf) 5% EC	1.75 ml/l	Foliar spray
7	T_6	Hexaconazole (Contaf) 5% EC	2 ml/l	Foliar spray

Table 2 : Disease rating scale of brown leaf spot.

Disease rating/Grade	Leaf area cover	Reaction
0	No symptoms of disease on leaves	Immune
1	Small spots covering 1% or less leaf area	Highly resistant
3	Small spots (up to 5 mm in size) covering 1-10% of leaf area	Resistant
5	Enlarging spots covering 11-25% of leaf area	Moderately resistant
7	Spots coalesce to form big patches covering 26-50% of leaf area	Moderately susceptible
9	Big spots covering 51% or more of leaf area	Highly susceptible

Observations recorded

Disease intensity was calculated by randomly selecting five plants per replication to record observations on percent foliar infection using the percent disease intensity (PDI) formula given by Wheeler (1969):

$$\text{PDI} = \frac{\text{Sum of all disease rating}}{\text{Total number of rating} \times \text{Maximum disease grade}} \times 100$$

Disease intensity (%) was recorded at 45, 60 and 75 days after transplanting (DAT) for brown leaf spot. The severity of the disease was categorized based on the

Fig. 1 : Brown Leaf Spot symptoms on rice leaves based on Mayee and Datar (1986) disease rating scale.

disease intensity scale provided by Mayee and Datar (1986) as depicted in Table 2 and Fig. 1.

Observations were recorded on plant height (cm), number of tillers, panicle length (cm) and yield (t/ha) at different days of interval. Additionally, the cost-benefit ratio was calculated separately for different treatments on a per-hectare basis using the formula provided by Reddy and Reddi (1995).

$$\text{C:B ratio} = \frac{\text{Gross return}}{\text{Total cost of cultivation}}$$

Statistical analysis

The data collected from various experiments were statistically analyzed using Completely Randomized Design (CRD) and Randomized Block Design (RBD). The analysis was performed using OPSTAT and Microsoft Excel.

Results

Effect of Systemic Chemical Fungicides on Percent Disease Intensity (PDI) of Paddy at 60, 75 and 90 Days After Transplanting (DAT)

The effect of foliar spray of different systemic chemical fungicides on percent disease intensity (PDI) of paddy at 60, 75 and 90 days after transplanting (DAT) is presented in Table 3 and Fig. 2.

The results indicate significant differences in PDI at 60 DAT among the various systemic fungicides applied. The treatment T_3, Tilt 25% EC @1 ml/l, exhibited the lowest PDI (12.00%), followed by T_6, Contaf 5% EC @2 ml/l, with 12.85%, T_5, Contaf 5% EC @1.75 ml/l, with 14.31%, T_1, Tilt 25% EC @0.5 ml/l, with 15.40%, T_4, Contaf 5% EC @1.5 ml/l, with 14.59% and T_2, Tilt 25% EC @0.75 ml/l, with 14.73%. The highest disease intensity (21.40%) was recorded in the untreated control (T_0). Statistical analysis at the 5% level of significance (CD = 0.82) revealed that all treatments were significantly different from the control. However, treatments T_1, T_2, T_4 and T_5 were statistically non-significant among themselves.

A significant reduction in disease intensity was observed among the fungicide treatments at 75 DAT. The minimum PDI was recorded in T_3, Tilt 25% EC @1 ml/l, 15.00%, followed by T_6, Contaf 5% EC @2 ml/l, 15.85%, T_5, Contaf 5% EC @ 1.75 ml/l, 17.76%, T_1, Tilt 25% EC @0.5 ml/l, 22.19%, T_4, Contaf 5% EC @1.5 ml/l, 18.88% and T_2, Tilt 25% EC @0.75 ml/l, 19.36%. The maximum PDI (27.34%) was recorded in the control (T_0). Statistical analysis (CD = 0.81) confirmed significant differences between all treatments and the control. However, T_2 and T_4 were found to be statistically non-significant to each other.

At 90 DAT, a significant difference in disease intensity among the treatments was evident. The lowest PDI was observed in T_3, Tilt 25% EC @1 ml/l, 18.70%, followed by T_6, Contaf 5% EC @2 ml/l, 19.30%, T_5, Contaf 5% EC @1.75 ml/l, 20.35%, T_4, Contaf 5% EC @1.5 ml/l, 20.95% and T_2, Tilt 25% EC @0.75 ml/l, 21.02%. The highest PDI (41.23%) was recorded in the control (T_0). Statistical analysis (CD = 0.92) indicated that all treatments were significantly different from the control. However, treatments T_2, T_4 and T_5 were statistically non-significant among themselves.

Overall, T_3, Tilt 25% EC @1 ml/l (FS), consistently demonstrated the lowest PDI across all observation periods, suggesting its superior efficacy in managing disease intensity in paddy compared to other treatments.

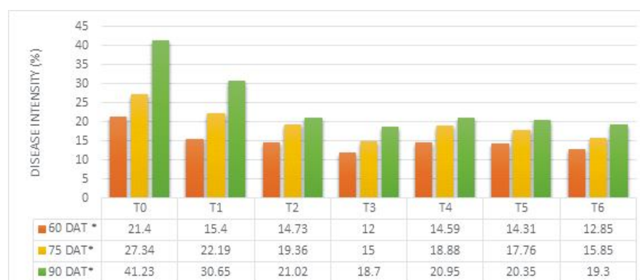

Fig. 2 : Disease intensity (%) of brown leaf spot of paddy at 60, 75 and 90 DAT as affected by treatments.

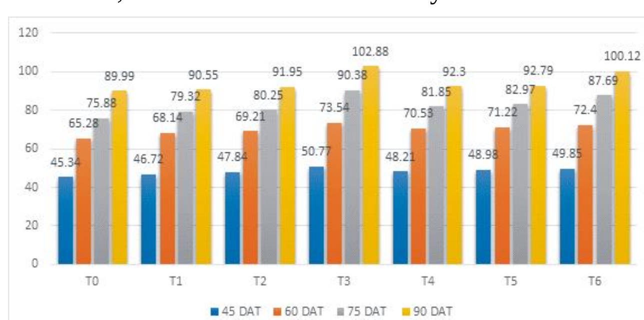

Fig. 3 : Plant height (cm) of paddy at 45, 60, 75 and 90 DAT as affected by treatments.

Table 3 : Effect of different systemic chemical fungicides on percent of disease intensity (PDI) of paddy at 60, 75 and 90 DAT.

Treatment	Treatments name	PDI (%)		
		60 DAT*	75 DAT*	90 DAT*
T_0	CONTROL	21.40	27.34	41.23
T_1	Tilt 25% EC @0.5 ml/l (F.S.)	15.40[a]	22.19	30.65
T_2	Tilt 25% EC @0.75 ml/l (F.S.)	14.73[ab]	19.36[a]	21.02[a]
T_3	Tilt 25% EC @1 ml/l (F.S.)	12.00	15.00	18.70
T_4	Contaf 5% EC @1.5ml/l (F.S.)	14.59[bc]	18.88[a]	20.95[ab]
T_5	Contaf 5% EC @1.75 ml/l (F.S.)	14.31[c]	17.76	20.35[b]
T_6	Contaf 5% EC @2 ml/l (F.S.)	12.85	15.85	19.30
	S.Em. (±)	0.25	0.32	0.56
	CD (5%)	0.82	0.81	0.92

F.S.- Foliar spray DAT- Day after transplanting
*Average of three replications
DATA followed by same alphabet in a column are non-significant to each other at 5% level.

Table 4 : Effect of different systemic chemical fungicides on plant height of paddy at 45, 60, 75 and 90 DAT.

Treatment	Treatments name	Plant height (cm)			
		45DAT*	60 DAT*	75 DAT*	90 DAT*
T_0	CONTROL	45.34	65.28	75.88	89.99
T_1	Tilt 25% EC @0.5 ml/l (F.S.)	46.72	68.14	79.32[a]	90.55
T_2	Tilt 25% EC @0.75 ml/l (F.S.)	47.84[a]	69.21	80.25[a]	91.95[a]
T_3	Tilt 25% EC @1 ml/l (F.S.)	50.77	73.54	90.38	102.88
T_4	Contaf 5% EC @1.5ml/l (F.S.)	48.21[ab]	70.53	81.85	92.30[ab]
T_5	Contaf 5% EC @1.75 ml/l (F.S.)	48.98[b]	71.22	82.97	92.79[b]
T_6	Contaf 5% EC @2 ml/l (F.S.)	49.85	72.40	87.69	100.12
	S.Em. (±)	0.37	0.20	0.46	0.31
	CD (5%)	0.80	0.50	0.99	0.67

F.S.- Foliar spray DAT- Day after transplanting *Mean of three replications
DATA followed by same alphabet in a column are non-significant to each other at 5% level.

@0.5 ml/l) at 46.72 cm, also showed significant improvements over the control (45.34 cm). Statistical analysis (CD = 0.80) confirmed significant differences among treatments, with T_1, T_2 and T_4 being non-significant among themselves.

At 60 DAT, plant height was significantly higher in treated plots than in the control (T_0, 65.28 cm). The highest plant height was observed in T_3 (Propiconazole 25% EC @1 ml/l) at 73.54 cm, followed by T_6 (Hexaconazole 5% EC @2 ml/l) at 72.40 cm and T_5 (Hexaconazole 5% EC @1.75 ml/l) at 71.22 cm. Other treatments, including T4

Effect of selected treatments on plant height (cm), number of tillers, panicle length (cm) yield (t/ha) and cost benefit ratio (C: B) of basmati rice at different days of interval

Plant height (cm)

The data presented in Table 4 and Fig. 3 indicate that all treatments significantly increased plant height compared to the untreated control (T_0) at 45 DAT, 60 DAT, 75 DAT and 90 DAT.

The maximum plant height at 45 DAT was recorded in T_3 (Propiconazole 25% EC @1 ml/l) at 50.77 cm, followed by T_6 (Hexaconazole 5% EC @2 ml/l) at 49.36 cm and T_5 (Hexaconazole 5% EC @1.75 ml/l) at 48.98 cm. Other treatments, including T_4 (Hexaconazole 5% EC @1.5 ml/l) at 48.21 cm, T_2 (Propiconazole 25% EC @0.75 ml/l) at 47.84 cm and T_1 (Propiconazole 25% EC

(Hexaconazole 5% EC @1.5 ml/l) at 70.53 cm, T_2 (Propiconazole 25% EC @0.75 ml/l) at 69.21 cm and T_1 (Propiconazole 25% EC @ 0.5 ml/l) at 68.14 cm, also showed significant improvements. Statistical analysis (CD = 0.50) indicated significant differences among treatments, with T_1 and T_2, T_5, T_4, T_5 and T_6 being statistically similar.

Significant differences in plant height were observed at 75 DAT. The highest plant height was recorded in T_3 (Propiconazole 25% EC @1 ml/l) at 90.38 cm, followed by T_6 (Hexaconazole 5% EC @2 ml/l) at 87.69 cm and T_5 (Hexaconazole 5% EC @1.75 ml/l) at 82.97 cm. Other treatments, including T_4 (Hexaconazole 5% EC @1.5 ml/l) at 81.85 cm, T_2 (Propiconazole 25% EC @0.75 ml/ l) at 80.25 cm and T_1 (Propiconazole 25% EC @0.5 ml/ l) at 79.32 cm, were also significantly better than the control (75.88 cm). Statistical analysis (CD = 0.99) showed that T_1, T_5, T_4 and T_5 were non-significant among themselves.

At 90 DAT, plant height remained significantly higher in treated plots than in the control (T_0, 89.99 cm). The maximum height was observed in T_3 (Propiconazole 25% EC @1 ml/l) at 102.88 cm, followed by T_6 (Hexaconazole 5% EC @2 ml/l) at 100.12 cm and T_5 (Hexaconazole 5% EC @1.75 ml/l) at 92.79 cm. Other treatments, including T_4 (Hexaconazole 5% EC @1.5 ml/l) at 92.30 cm, T_2 (Propiconazole 25% EC @0.75 ml/l) at 91.95 cm and T_1 (Propiconazole 25% EC @0.5 ml/l) at 90.55 cm, also demonstrated significant improvements. Statistical analysis (CD = 0.67) confirmed that T_1, T_5 and T_6 were significantly different from the other treatments, whereas T_2, T_5 and T_6 were statistically similar.

Overall, all fungicidal treatments significantly enhanced plant height compared to the untreated control, with Propiconazole 25% EC @1 ml/l (T_3) consistently showing the highest values at all time intervals.

Number of tillers

The data in Table 5 and Fig. 4 show that all treatments significantly improved the number of tillers compared to the untreated control (T_0).

Table 5 : Effect of different systemic chemical fungicides on numbers of tillers of paddy at 45 and 75 DAT.

Treatment	Treatments name	Numbers of tillers	
		45 DAT*	75 DAT*
T_0	CONTROL	13.52	19.66
T_1	Tilt 25% EC @0.5 ml/l (F.S.)	15.13	21.46[a]
T_2	Tilt 25% EC @0.75 ml/l (F.S.)	15.80	21.50[ab]
T_3	Tilt 25% EC @1 ml/l (F.S.)	20.96	25.23
T_4	Contaf 5% EC@1.5ml/l (F.S.)	17.00	22.00[bc]
T_5	Contaf 5% EC@1.75 ml/l (F.S.)	17.23	23.53[c]
T_6	Contaf 5% EC @2 ml/l (F.S.)	19.43	24.25
	S.Em. (±)	0.20	0.22
	CD (5%)	0.60	0.66

F.S.- Foliar spray DAT- Day after transplanting
*Mean of three replications
DATA followed by same alphabet in a column are non-significant to each other at 5% level.

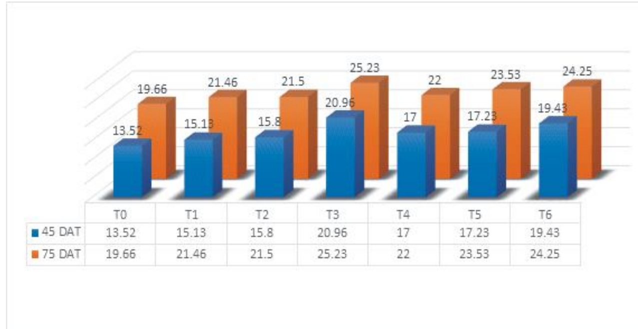

Fig. 4 : Numbers of tillers of paddy at 45 and 75 DAT as affected by treatments.

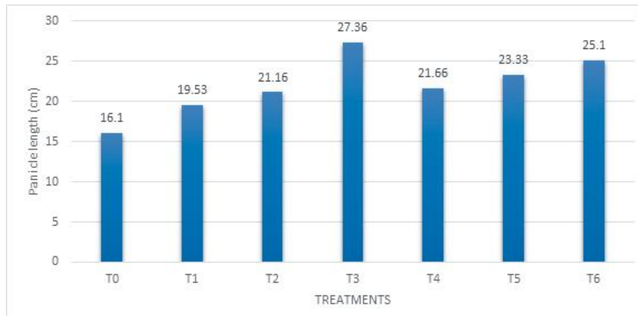

Fig. 5 : Panicle length of paddy at the time of harvest as affected by treatments.

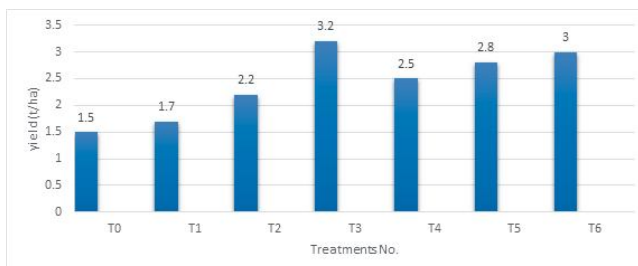

Fig. 6 : Yield of paddy as affected by treatments.

The highest number of tillers at 45 DAT was observed in T_3 (Propiconazole 25% EC @1 ml/L) with 20.96, followed by T_6 (Hexaconazole 5% EC @2 ml/L) with 19.43, T_5 (Hexaconazole 5% EC @1.75 ml/L) with 17.23 and T_4 (Hexaconazole 5% EC @1.5 ml/L) with 17.00. T_2 (Propiconazole 25% EC @0.75 ml/L) and T1 (Propiconazole 25% EC @0.5 ml/L) recorded 15.80 and 15.13 tillers, respectively, while the lowest number was found in the untreated control (T_0) with 13.52. With a critical difference (CD) of 0.60 at a 5% significance level, all treatments were significantly better than T_0. However, T_1 and T_2, as well as T_3 and T_6, showed no statistical difference from each other.

A significant increase in the number of tillers at 75 DAT due to fungicidal treatments. The maximum tillers were recorded in T_3 (Propiconazole 25% EC @1 ml/L) with 25.23, followed by T_6 (Hexaconazole 5% EC @2 ml/L) with 24.25, T_5 (Hexaconazole 5% EC @1.75 ml/L) with 23.53 and T_4 (Hexaconazole 5% EC @1.5 ml/L)

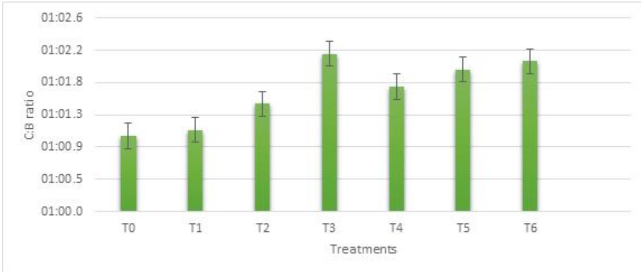

Fig. 7 : Cost benefit ratio (C: B) of paddy as affected by treatments.

Table 6 : Effect of different systemic chemical fungicides on Panicle length (cm) of paddy.

Treatment	Treatments name	Panicle length (cm)
T_0	CONTROL	16.10
T_1	Tilt 25% EC @0.5 ml/l (F.S.)	19.53
T_2	Tilt 25% EC @0.75 ml/l (F.S.)	21.16[a]
T_3	Tilt 25% EC @1 ml/l (F.S.)	27.36
T_4	Contaf 5% EC @1.5ml/l (F.S.)	21.66[ab]
T_5	Contaf 5% EC @1.75 ml/l (F.S.)	23.33[b]
T_6	Contaf 5% EC @2 ml/l (F.S.)	25.10
	S.Em. (±)	0.75
	CD (5%)	1.61

F.S.- Foliar spray DAT- Day after transplanting
Mean of three replications
DATA followed by same alphabet in a column are non-significant to each other at 5% level

Table 7 : Effect of different systemic chemical fungicides on yield tonne per hectare of paddy.

Treatment	Treatments name	Yield (t/ha) *
T_0	CONTROL	1.5
T_1	Tilt 25% EC @0.5 ml/l (F.S.)	1.7
T_2	Tilt 25% EC @0.75 ml/l (F.S.)	2.2
T_3	Tilt 25% EC @1 ml/l (F.S.)	3.2
T_4	Contaf 5% EC @1.5ml/l (F.S.)	2.5
T_5	Contaf 5% EC @1.75 ml/l (F.S.)	2.8
T_6	Contaf 5% EC @2 ml/l (F.S.)	3.0
	S.Em. (±)	0.08
	CD (5%)	0.17

F.S.- Foliar spray DAT- Day after transplanting
*Average of three replications.

with 22.00. T_2 (Propiconazole 25% EC @0.75 ml/L) and T_1 (Propiconazole 25% EC @0.5 ml/L) had 21.50 and 21.46 tillers, respectively, whereas the control (T_0) recorded the lowest number (19.66). With a CD value of 0.66 at a 5% significance level, all treatments were significantly superior to the control. However, T_5 and T_6 were statistically similar, as were T_1, T_2, T_4 and T_5.

Table 8 : Effect of different systemic chemical fungicides on cost benefit ratio of paddy.

	Treatments	Yield (t/ha)	Cost of yield (` /ha)	Total cost of yield (Gross retunes) (`)	Common cost of cultivation (`)	Cost of treatments (`)	Total cost of cultivation (`)	Net retunes (`)	C:B ratio
T_0	Control	1.5	22030	32677.83	30725	-	30725	1952.8	1:1.06
T_1	Tilt 25% EC @0.5 ml/l (F.S.)	1.7	22030	36349.50	30725	1094	31819	4530.5	1:1.14
T_2	Tilt 25% EC @0.75 ml/l (F.S.)	2.2	22030	47731.67	30725	1224	31949	15782	1:1.49
T_3	Tilt 25% EC @1 ml/l (F.S.)	3.2	22030	69761.67	30725	1585	32310	37451	1:2.16
T_4	Contaf 5% EC @1.5ml/l (F.S.)	2.5	22030	55075.00	30725	1220	31945	23130	1:1.72
T_5	Contaf 5% EC @1.75 ml/l (F.S.)	2.8	22030	62418.33	30725	1320	32045	30373	1:1.95
T_6	Contaf 5% EC @2 ml/l (F.S.)	3.0	22030	66099.00	30725	1430	32155	33935	1:2.06

Panicle length (cm)

The data in Table 6 and Fig. 5 indicate a significant improvement in panicle length of basmati rice compared to the untreated control (T_0). The longest panicle was recorded in T_3 (Propiconazole 25% EC @1 ml/L) at 27.36 cm, followed by T_6 (Hexaconazole 5% EC @2 ml/L) at 25.10 cm and T_5 (Hexaconazole 5% EC @1.75 ml/L) at 23.33 cm. Other treatments included T4 (Hexaconazole 5% EC @1.5 ml/L) at 21.66 cm, T_2 (Propiconazole 25% EC @0.75 ml/L) at 21.16 cm and T_1 (Propiconazole 25% EC @0.5 ml/L) at 19.53 cm, while the lowest was recorded in the untreated control (T_0) at 16.10 cm. With a critical difference (CD) value of 1.61 at a 5% significance level, all treatments were significantly superior to T_0. Among them, T_1, T_5 and T6 were statistically distinct, whereas T_3, T_4 and T_5 showed no significant difference from each other.

Yield (t/ha)

The impact of different treatments of systemic chemical fungicides on paddy yield (t/ha) is summarized in Table 7 and Fig. 6. Among the treatments, T_3 (Tilt 25% EC @1 ml/l) achieved the highest yield of 3.2 t/ha, followed by T_6 (Contaf 5% EC @2 ml/l) with 3.0 t/ha and T_5 (Contaf 5% EC @1.75 ml/l) with 2.8 t/ha. Other treatments included T1 (Tilt 25% EC @0.5 ml/l) with 1.7 t/ha, T_4 (Contaf 5% EC @1.5 ml/l) with 2.5 t/ha and T_2 (Tilt 25% EC @0.75 ml/l) with 2.2 t/ha. The control treatment (T_0) exhibited the lowest yield of 1.5 t/ha. When compared to the critical difference (CD) value at the 5% level of significance (0.17), all treatments were statistically significant compared to the control (T_0), but no significant differences were observed between the treatments themselves.

Cost benefit ratio

The data presented in Table 8 and Fig. 7 indicate that the highest cost-benefit ratio was recorded in T_5 - Hexaconazole 5% EC @ 1.75 ml/l (1:1.95), followed by T_4 - Hexaconazole 5% EC @ 1.5 ml/l (1:1.72), T_2 - Propiconazole 25% EC @ 0.75 ml/l (1:1.49) and T_1 - Propiconazole 25% EC @ 0.5 ml/l (1:1.14). Among the check treatments, T_6 - Propiconazole 25% EC @ 1 ml/l (1:2.16) and T_0 - Hexaconazole 5% EC @ 2 ml/l (1:2.06) exhibited higher cost-benefit ratios compared to the untreated control (T_0 - 1:1.06).

Discussion

The present study evaluated the efficacy of systemic fungicides, particularly propiconazole 25% EC and hexaconazole 5% EC, in managing brown leaf spot disease in Basmati rice and their impact on agronomic parameters. The results demonstrated that propiconazole 25% EC @ 1ml/l was the most effective treatment, recording the lowest disease intensity (18.70%) at 90 DAT, followed by hexaconazole 5% EC @ 2ml/l (19.71%). The observed reduction in disease intensity can be attributed to the systemic action of these fungicides, which interfere with essential biochemical processes in fungal cells, including cell membrane synthesis inhibition, respiration disruption and nucleic acid production interference. Additionally, systemic fungicides provide long-lasting protection within plant tissues, reducing the frequency of application and ensuring sustained disease control. These findings align with Gupta *et al*. (2013) and Kamei *et al*. (2020), who reported a significant reduction in disease severity and increased grain yield in the rice varieties following the application of propiconazole.

Furthermore, the study found that plant height was significantly improved under fungicide treatments, with propiconazole 25% EC @ 1ml/l recording the highest plant height (102.88 cm) at 90 DAT, followed by hexaconazole 5% EC @ 2ml/l (100.12 cm). This increase in plant height may be linked to the protection offered by fungicides against fungal pathogens, ensuring unhindered photosynthesis, nutrient uptake and overall plant vigor. Similar results were observed by Hossain *et al*. (2011) and Kamei and Simon (2018), who reported that the application of propiconazole and hexaconazole effectively inhibited the growth of *Helminthosporium oryzae*, resulting in improved plant height.

The study also recorded the maximum number of tillers at 75 DAT in propiconazole 25% EC @ 1ml/l (25.23), followed by hexaconazole 5% EC @ 2ml/l (24.25). The increase in tiller numbers could be attributed to the role of triazole-based fungicides in inhibiting gibberellin biosynthesis, thereby promoting stronger tiller development. These findings are consistent with those of Kamei and Simon (2018) and Takahashi *et al*. (2022), who reported that propiconazole and hexaconazole treatments resulted in a higher number of tillers due to their fungicidal efficacy against *H. oryzae*.

Similarly, the maximum panicle length at the time of harvest was recorded in propiconazole 25% EC @ 1ml/l (27.36 cm), followed by hexaconazole 5% EC @ 2ml/l (25.10 cm). This observation aligns with the findings of Hossain *et al*. (2011), who demonstrated that these fungicides significantly enhanced panicle length by effectively suppressing *H. oryzae* infections. Longer panicles contribute to an increased number of grains, ultimately improving yield potential.

Yield analysis revealed that the highest grain yield (3.2 t/ha) was obtained with propiconazole 25% EC @ 1ml/l, followed by hexaconazole 5% EC @ 2ml/l (3.0 t/ha). The improvement in yield can be attributed to effective disease control, enhanced plant health, improved photosynthesis efficiency and optimized nutrient absorption. The findings are in agreement with Shrestha *et al*. (2017), who observed that fungicidal application significantly increased yield by mitigating fungal infections. Additionally, Hossain (2011) reported that fungicides like Bion, Amistar and Tilt significantly enhanced grain yield by reducing disease incidence at critical growth stages.

The highest cost-benefit ratio (BCR) for controlling Brown Leaf Spot in Basmati rice was observed in treatment T_3 (Propiconazole 25% EC @1 ml/l) with a ratio of 1:2.16, followed by T_0 (Hexaconazole 5% EC @2 ml/l) at 1:2.06. These findings align with Kamei and Singh (2021), who reported the highest BCR for Propiconazole (1.72:1), followed by Propineb (1.47:1), Myclobutanil (1.45:1) and others. Propiconazole provided the best economic returns, generating a net profit of ¹ 2.72 per ¹ 2.10 investment, compared to other treatments like Propineb and Myclobutanil, which also offered favourable returns but were lower than Propiconazole. The control treatment had the lowest BCR (1.13:1), reinforcing the importance of fungicide application.

Overall, the study confirms that the application of systemic fungicides, particularly propiconazole 25% EC and hexaconazole 5% EC, not only effectively reduces brown leaf spot severity but also positively influences key agronomic traits, ultimately leading to improved yield in Basmati rice. These results reinforce the importance of timely and appropriate fungicide applications in integrated disease management strategies for sustainable rice production.

Conclusion

This research highlights the effectiveness of systemic chemical fungicides in managing paddy diseases and improving growth parameters, offering valuable insights into their role in modern agricultural practices. The findings demonstrate that the use of these fungicides significantly reduces disease intensity, enhances growth and leads to higher yields, thereby improving overall crop health and productivity. The potential benefits of this research extend beyond immediate disease management, including opportunities for future exploration in fungicide combinations, long-term environmental impacts and the integration of sustainable pest management practices. Additionally, the research paves the way for developing resistant crop varieties and applying precision agriculture technologies to improve fungicide efficacy while minimizing costs and environmental harm. By exploring alternative organic fungicides and assessing the economic feasibility of fungicide treatments, this research sets the stage for more sustainable and cost-effective agricultural practices. Ultimately, this study contributes to enhancing productivity in paddy cultivation while promoting environmentally responsible farming techniques for the future.

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