J.Mycopathol.Res. 63(2) : 399-404, 2025, ISSN : 0971-3719 (Print), 2583-6315 (Online) 10.57023/JMycR.63.2.2025.399

Evaluation of fungicides for the management of Leaf Blight Disease in Wheat (*Triticum aestivum* L.)

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Received : 01.01.2025 Accepted : 14.04.2025 Published : 30.06.2025

Leaf blight disease caused by *Bipolaris sorokiniana* and *Alternaria spp*. is an emerging threat to wheat production, as an increasing number of wheat fields are being affected by the disease. The pathogen significantly reduces crop health, leading to losses in yield and quality. New fungicide molecules are available in the market, and hence experiment was formulated to study their effectiveness in management of disease. In this study, the fungicides included were Copper oxychloride 50% WP + Mancozeb 75% WP, Propiconazole 25% EC, Tebuconazole 25.9% EC, Azoxystrobin 18.2% + Difenoconazole 11.4% SC, Carbendazim 50% WP + Mancozeb 75% WP and Kresoxim-methyl 44.3% SC having label claim for use in wheat crop against leaf blight and rust diseases. The experiment involved two foliar sprays, with the first application at the appearance of disease symptoms and the second 10 days later. Amongst the fungicides, Kresoxim methyl 44.3 SC was found the best fungicide for reducing leaf blight disease intensity, obtaining higher grain yield and monetary returns in wheat crop followed by Tebuconazole and Propiconazole.

Keywords : Disease management, fungicides, Kresoxim methyl, leaf blight, wheat

INTRODUCTION

As one of the most extensively grown cereal crops worldwide, wheat (*Triticum aestivum* L.) plays a crucial role in supplying vital calories and proteins to a large segment of the global population. With the increasing global demand for food, wheat production must keep pace with the growing population. Globally wheat is cultivated on an area of 222.88 MHa with annual production estimates of 788.95 MT. In India, during 2023-24 *Rabi* season, wheat was cultivated on 31.23 MHa, yielding a total production of 112.92 MT and achieving a national average productivity of 36.15 quintals per hectare (ICAR-IIWBR, 2024). Wheat productivity in the country is significantly hampered by both biotic and abiotic stresses. Biotic stresses include various diseases, pests, and weeds that directly affect crop health and yield. Diseases such as leaf blight, rust, and smuts are particularly detrimental, leading to substantial yield losses (Figueroa *et al*. 2018). Among the major foliar diseases, leaf blight caused by *Bipolaris sorokiniana* and *Alternaria spp*. is a persistent issue in many wheat-growing regions, particularly in areas with high humidity and moderate temperatures (Duveiller *et al*. 2007).

Leaf blight disease is one of the important disease of wheat crop after rusts causing significant losses in yield (Figueroa *et al*.2018). Due to dense planting and heavy irrigations, majority of the wheat fields are found infected with leaf blight. In early stages of infection, small, round necrotic areas become visible on the leaves, which enlarge further, coalesce and finally the leaves dries. The incidence of leaf blight in wheat is exacerbated by favorable environmental conditions such as high humidity, temperature fluctuations, and monocropping systems (Gupta *et al*. 2018). With the growing demand for wheat, effective management strategies for this disease are essential for sustaining productivity and food security.

Various management strategies, such as crop rotation, optimal planting times, and chemical control, are employed to address foliar diseases in wheat. While various cultural and biological controls are being explored, chemical fungicides

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remain the primary tool used to manage leaf blight due to their immediate and wide-ranging effectiveness (Oerke, 2006). Recent innovations in fungicide formulations and the introduction of new active ingredients have broadened the options available for managing foliar diseases in wheat. Modern fungicides, including strobilurins, triazoles, and Succinate Dehydrogenase Inhibitors (SDHIs), have demonstrated effective control of leaf blight (Poole and Arnaudin, 2014). Nevertheless, their efficacy may differ based on factors like geographic region, pathogen populations, and application timing (Thind, 2017). Additionally, studies have shown that combining fungicides with other management practices, such as resistant wheat varieties and improved agronomic techniques, can enhance disease control and reduce fungicide dependency (Simón *et al*. 2021).

This study aims to evaluate the efficacy of different fungicides in managing leaf blight on wheat, focusing on their ability to reduce disease incidence, severity and associated yield losses.

MATERIALS AND METHODS

The field experiment was conducted for three consecutive years 2019-20, 2020-21, and 2021-22, during *Rabi* season at Agricultural Research Station, Niphad (Maharashtra, India) under natural field condition. Wheat variety MACS 2846, known for its susceptibility to leaf blight, was selected for this experiment. The experiment was laid out in Randomized Block Design with seven treatments in three replications. The seed rate for the experiment was set at 100 kg/ha, with the plot dimensions measuring 5.00 m x 3.08 m for gross area and 4.0 m x 2.64 m for net area. Row spacing was maintained at 22 cm, and a recommended dose of fertilizer (RDF) was applied at a rate of 120:60:40 NPK (Kg ha^{-1}). All the recommended cultivation practices were followed.

Fungicide applications were initiated upon the first appearance of leaf blight symptoms in the experimental plots. The fungicidal treatments evaluated in the study comprised Copper oxychloride 50% WP @0.2% + Mancozeb 75% WP @0.2%, Propiconazole 25% EC @0.1%, Tebuconazole 25.9% EC @0.1%, Azoxystrobin 18.2% + Difenoconazole 11.4% SC @0.1%, Carbendazim 50% WP @0.1% + Mancozeb 75% WP @0.2%, Kresoxim methyl 44.3% SC @0.1%, and an untreated plot as a control. The methodology included two foliar sprays, with the first spray applied at disease onset and a second application given 10 days later. Intensity of leaf blight was recorded at hard dough stage, while thousand grain weight (g), and yield (q/ha) were recorded on harvest. Disease was allowed to develop from natural inoculum and epiphytotic conditions. Assessment of the disease intensity was done at dough stage using double-digit scale (00-99) developed as a modification of severity scale of Saari and Prescott (1975) to assess foliar diseases by visually scoring the percent diseased area on the flag (F) and penultimate (F-1) leaves. The two digits represent the percentage of leaf area damaged on flag leaf and penultimate leaf, respectively. Analysis of variance was performed using the statistical procedures outlined by Panse and Sukhatme (1967).

RESULTS AND DISCUSSION

Germination of wheat crop was satisfactory across all three crop seasons: *Rabi* 2019-20, 2020-21, and 2021-22. This ensured uniform growth and allowed for accurate assessment of fungicide efficacy on leaf blight disease, yield, and other agronomic traits over multiple seasons.

Leaf blight disease intensity

Statistically significant difference in leaf blight disease severity was observed among the fungicide treatments (Table 1). The lowest disease intensity was recorded with Kresoxim methyl 44.3% SC (10.02%), providing 85.96 per cent disease control compared to the untreated control which showed the highest disease intensity (71.38%). Tebuconazole 25.9% EC (17.13%) and Propiconazole 25% EC (19.02%) were also effective but less than Kresoxim methyl.

Kresoxim methyl exhibited the highest efficacy against leaf blight, which is consistent with findings from other studies that demonstrate the efficacy of strobilurin fungicides in managing foliar fungal diseases. Strobilurins, such as Kresoxim methyl, inhibit mitochondrial respiration in fungal

Table. 1: Effect of disease management on leaf blight disease intensity on wheat crop

Tr No	Treatment details	Average disease intensity (%) 2019-20	2020-21	2021-22	Pooled mean (%)	Per cent disease control
1	Copper oxychloride 50WP + Mancozeb 75WP	24.40 (29.54)	29.13 (32.66)	24.93 (29.93)	26.16 (30.71)	63.35
2	Propiconazole 25EC	14.73 (22.56)	21.80 (27.83)	20.53 (26.90)	19.02 (25.76)	73.35
3	Tebuconazole 25.9EC	13.13 (21.24)	19.80 (26.41)	18.47 (25.39)	17.13 (24.35)	76.00
4	Azoxystrobin 18.2 + Difenoconazole 11.4 SC	29.33 (32.79)	34.07 (35.71)	27.67 (31.72)	30.36 (33.41)	57.47
5	Carbendazim 50 WP + Mancozeb 75WP	26.27 (30.83)	31.27 (34.00)	33.93 (35.61)	30.49 (33.48)	57.28
6	Kresoxim methyl 44.3 SC	8.67 (17.10)	10.07 (18.47)	11.33 (19.61)	10.02 (18.39)	85.96
7	Untreated Control	72.53 (58.42)	72.07 (58.11)	69.53 (56.51)	71.38 (57.68)	--
	S.E. (m) ±	0.87	0.54	1.17	0.52	--
	C.D. at 5 %	2.69	1.68	3.61	1.48	--
	C.V.%	4.99	2.83	6.29	4.88	-

* Figures in parenthesis are arc sin transformed values

Table 2: Effect of disease management on thousand grain weight of wheat

Tr No	Treatment details	1000 grain weight (g) 2019-20	2020-21	2021-22	Pooled mean (g)	Per cent gain over control
1	Copper oxychloride 50WP + Mancozeb 75WP	50.32	33.83	44.63	42.93	14.48
2	Propiconazole 25EC	53.39	35.15	46.56	45.04	20.11
3	Tebuconazole 25.9EC	52.75	34.81	46.27	44.61	18.96
4	Azoxystrobin 18.2 + Difenoconazole 11.4 SC	48.98	31.57	43.67	41.41	10.43
5	Carbendazim 50 WP + Mancozeb 75WP	49.39	33.14	42.73	41.76	11.36
6	Kresoxim methyl 44.3 SC	54.67	36.58	48.86	46.70	24.53
7	Untreated Control	43.55	30.02	38.95	37.50	--
	S.E. (m) ±	0.85	0.99	1.40	0.64	--
	C.D. at 5 %	2.63	3.07	4.32	1.82	--
	C.V.%	2.93	5.14	5.45	4.48	--

pathogens, thereby preventing energy production and halting fungal growth (Bartlett *et al.* 2002; Lee and Kim, 2022). Similar reductions in disease severity were reported by Dimmock and Gooding (2002) in wheat treated with strobilurin fungicides, with significant control of foliar blights.

Triazoles, such as Tebuconazole and Propiconazole, also reduced disease intensity by inhibiting ergosterol biosynthesis, a key component of fungal cell membranes. These findings align with earlier research, where it was found that triazole fungicides were effective against a range of wheat diseases, including leaf blight. The untreated control plots with the highest disease incidence underscore the critical role of fungicide application in disease management.

Thousand grain weight

Statistically significant differences in thousand grain weight were observed across treatments (Table 2). Kresoxim methyl 44.3% SC had the highest grain weight (46.70 g), representing a

Table 3. Effect of disease management on wheat grain yield

Tr No	Treatment details	Grain yield (q/ha)			Pooled mean (q/ha)	Per cent gain over control
		2019-20	2020-21	2021-22		
1	Copper oxychloride 50WP + Mancozeb 75WP	45.19	32.17	38.05	38.47	18.95
2	Propiconazole 25EC	48.69	34.48	40.43	41.20	27.40
3	Tebuconazole 25.9EC	47.38	33.91	41.28	40.85	26.31
4	Azoxystrobin 18.2 + Difenoconazole 11.4 SC	42.48	29.08	37.10	36.22	12.00
5	Carbendazim 50 WP + Mancozeb 75WP	42.63	30.19	36.83	36.55	13.02
6	Kresoxim methyl 44.3 SC	50.35	37.46	44.26	44.02	36.12
7	Untreated Control	38.25	26.33	32.46	32.34	--
	S.E. (m) ±	1.97	1.49	1.83	1.03	--
	C.D. at 5 %	6.07	4.60	5.65	2.91	--
	C.V. (%)	7.58	8.09	8.22	7.99	--

Table 4: Effect of disease management on average grain yield and economics of wheat crop

Tr No	Treatment details	Average grain yield (q/ha)	Gross monetary returns (Rs./ha)	Total expendit-ure (Rs./ha)	Net returns (Rs./ha)	B:C ratio
1	Copper oxychloride 50WP + Mancozeb 75WP	38.47	84634	54034	30600	1.57
2	Propiconazole 25EC	41.20	90640	52634	38006	1.72
3	Tebuconazole 25.9EC	40.85	89870	53634	36236	1.68
4	Azoxystrobin 18.2 + Difenoconazole 11.4 SC	36.22	79684	55934	23750	1.42
5	Carbendazim 50 WP + Mancozeb 75WP	36.55	80410	53234	27176	1.51
6	Kresoxim methyl 44.3 SC	44.02	96844	55634	41210	1.74
7	Untreated Control	32.34	71148	50464	20684	1.41

♦ Average selling price of wheat grains (2019-20, 2020-21 & 2021-22): Rs.2200/q

♦ Average cost of cultivation (2019-20, 2020-21 & 2021-22) excluding cost of fungicide and spraying charges:Rs.50464/-

24.53% increase over the control (37.50 g). Propiconazole was at par with Kresoxim methyl (45.04g). The increased thousand grain weight observed in fungicide treated plots is likely due to the protection against leaf blight, which preserved the green leaf area and photosynthetic potential of the plants (Chowdhury *et al*. 2017). The effect of fungicides on improving grain weight has also been reported by Oerke *et al.* (2012), where the reduction in disease severity allowed plants to allocate more resources to grain filling, resulting in higher test weights. The untreated plots, with the lowest grain weight, reflect the detrimental impact of leaf blight on photosynthesis and resource allocation to grain development. Similar findings were reported by Kelley (2001) and Thind (2022), highlighting the positive impact of fungicide applications on grain weight.

Grain yield

The pooled data depicted in (Table 3) shows statistically significant grain yield differences between different treatments due to disease management. Significantly highest grain yield was recorded in treatment Kresoxim methyl 44.3% SC (44.02 q/ha) with 36.12% yield gain over the control, which was at par with treatment Propiconazole 25% EC (41.20 q/ha). Significantly lowest grain yield (32.34 q/ha) was recorded in untreated control plot.

Fungicidal treatments substantially increased grain yield, likely due to effective disease management. Kresoxim methyl not only controlled leaf blight but also provided a physiological benefit by enhancing crop stress tolerance and extending leaf functionality, as reported by Kelley (2001), Bartlett *et al*. (2002), Thind, (2017) and Lee and Kim (2022). The higher yields obtained with strobilurins are consistent with findings by Dimmock and Gooding (2002), who observed yield increases in wheat due to improved disease control and enhanced leaf health. Propiconazole, although slightly less effective than Kresoxim methyl, also increased yields significantly by reducing disease severity, a result echoed by Wegulo *et al*. (2009).

Net returns and B:C ratio

The data in Table 4 reveals that the highest gross monetary returns of Rs.96844 ha^{-1} were obtained in treatment with foliar sprays of Kresoxim methyl 44.3% SC followed by foliar sprays with Propiconazole 25% EC wherein gross monetary returns of Rs.90640 were obtained. Similarly, the highest net monetary returns of Rs.41210 ha^{-1} were received in treatment with foliar sprays of Kresoxim methyl 44.3% SC followed by foliar sprays with Propiconazole 25% EC (Rs.38006). Further, the highest B:C ratio of 1.74 was obtained in treatment with Kresoxim methyl 44.3% SC followed by foliar sprays with Propiconazole 25% EC (1.72).

The favorable economic returns from Kresoxim methyl and triazole treatments highlight the profitability of fungicide use for managing leaf blight (Kumar *et al*. 2023). Oerke *et al.* (2012) and Carmona *et al*.(2020) similarly reported that the cost of fungicide application is justified by the substantial yield increases and higher net returns, particularly in disease-prone environments. The higher B:C ratio in Kresoxim methyl treated plots suggests that, despite its cost, the fungicide is economically viable due to the significant yield and test weight improvements it provides.

CONCLUSION

Evaluation of fungicides for managing leaf blight in wheat demonstrated that Kresoxim methyl 44.3% SC @0.1% was the most effective treatment which significantly reduced disease intensity and improved both yield and economic returns. The study underscores the importance of timely fungicide applications in disease management strategies and emphasizes the need for integrating these practices with resistant varieties and sound agronomic techniques. Future research should focus on exploring the synergistic effects of fungicides with other management practices to enhance the sustainability of wheat production systems.

DECLARATION

Conflict of Interest. Authors declare no conflict of interest.

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