Original Research Article

Comparative efficacy of combi fungicides for management of leaf rust (*Puccinia triticina* Eriks.) in wheat

ABSTRACT

Wheat is attacked by a large number of pathogenic fungus, most destructive being rusts. Among three different rusts, leaf rust caused by *Puccinia triticina* Eriks is one of the devastating disease causing severe yield losses. The present investigation was conducted to gather the information of different combination fungicides in managing the leaf rust of wheat during rabi season of 2022-23. Nine different combi- fungicides were evaluated in completely randomized design and replicated thrice. The efficiency of different combi- fungicides for leaf rust management were analyzed by calculating disease severity and Area Under Disease Progress Curve (AUDPC). The evaluated data indicates that all combination fungicides were effective in controlling the leaf rust of wheat with respect to control. The combi fungicide Tebuconazole 50%+Trifloxystrobin 25% WG was found to be the most effective in terms of reducing the level of leaf rust and increasing grain yield exhibiting disease severity of 3.34%, percent disease control of 94.93, AUPDC of 49.16 with a grain yield of 47.65q/ha during rabi season of 2022-23. Therefore, the current findings demonstrate that combi-fungicides may play a significant role in effectively managing leaf rust of wheat.

Keywords: AUDPC, *Puccinia triticina*, leaf rust, combi-fungicides, wheat

INTRODUCTION

Wheat (*Triticum aestivum*) is one of the major cereal crops, mostly used as a staple food all across the world. Due to its high nutritive and calorific values, it is widely used as a source of dietary requirements **(1) (2).** Worldwide, it is grown in 224.05 million ha area with a production of 793.37 million tons **(3).** In India, wheat is grown under diverse climatic regions, ranging from mountainous regions of North India to semi-arid regions with mild to diverse winters with an estimated area of 31.82 million ha and production of 112.74 million tons during 2022-23 **(3).** Production of wheat is delimited largely by disease incidence, the most prevalent being rust of wheat in cool and wet regions **(4) (5).**

Rusts are considered as the most destructive diseases of wheat because they have the capacity to spread aerially and evolve into new pathotypes **(6).** It has emerged as one of the predominant disease in the North India, especially in the North Western Plain Zone and North Hill Zone including Uttarakhand. The three different rusts that affect the wheat crop are stem rust (*Puccinia graminis* f. sp. *tritici*), leaf rust (*Puccinia triticina*) and stripe rust (*Puccinia striiformis* f. sp. *tritici*). Among the three wheat rusts, brown rust (*P. triticina*) is most prevalent and widely distributed all across the country and cause severe economic losses **(7).** The prevalence of leaf rust all across different agroclimatic zones is mainly due to high diversity, constant emergence of new virulence profiles, high adaptability to a wide range of climatic conditions **(8)(9)(10).**

In order to effectively manage the incidence of leaf rust, commonly used strategy is application of fungicides or employment of resistant varieties. However, resistant varieties are short-lived and resistance is easily broken by mutating nature of pathogenic spores **(11).** Therefore, utilization of combination fungicides can play an important role in minimizing the adverse impact of leaf rust on yield parameters of wheat. Considering the potential advantages of chemical fungicides, the present study was conducted to evaluate the impact of combination fungicides on disease severity and yield of wheat crop during Rabi season of 2022-23.

MATERIAL AND METHODS

The field experiment was undertaken at Wheat Pathology Block, Norman E. Borlaug Research Centre of G.B.P.U.A &T, Pantnagar (Uttarakhand) during Rabi season of 2022-23 to assess the effectiveness of several combination fungicides against leaf rust of wheat. Susceptible wheat variety PBW 343 was used and experiment was conducted following the recommended agronomic practises under irrigated conditions in randomized block design with ten treatments replicated thrice (Table 1).

Fig. 1 Field evaluation of combi-fungicides for the management of wheat leaf rust during the Rabi season of 2022-23"

Artificial inoculation with spore suspension of uredospores of *Puccinia triticina* was done by spraying inoculum received from ICAR-IIWBR, Regional Station, Flowerdale, Shimla. Foliar sprays of fungicides (aqueous) *i.e.* Tebuconazole 50%+ Trifloxystrobin 25% WG, Azoxystrobin 18.2%+ Difenoconazole 11.4%, Pyraclostrobin 133g/l+Epoxiconaxole 50g/l SE, Azoxystrobin 11% + Tebuconazole 18.3% w/w SC, Azoxystrobin 18.2% w/w + Cyproconazole 7.3% w/w SC, Propiconazole, Tebuconazole, Bayleton and Mancozeb were applied after first appearance of disease symptoms (Table 1) Subsequent sprays were given after 10-15 days interval. Plots with no fungicide treatment were included as control.

Table1. List of combination fungicides used to manage Leaf Rust of Wheat during Rabi season of 2022-23.

S. No.	Chemical Name	Trade Name	Dose
1	Tebuconazole 50% + Trifloxystrobin 25% WG	Bayer Nativo 75 WG	0.06%
2	Azoxystrobin 18.2% + Difenoconazole 11.4% w/w SC	Azozole	0.10%
Q`1`` 3	Pyraclostrobin 133g/l + Epoxiconaxole 50g/l SE,	Opera	0.10%
4	Azoxystrobin 11% + Tebuconazole 18.3% w/w SC	Spectrum	0.10%
5	Azoxystrobin 18.2% w/w + Cyproconazole 7.3% w/w SC	Azoxy	0.10%
6	Propiconazole	Tilt	0.10%
7	Tebuconazole	Folicur	0.10%
8	Bayleton	Bayleton	0.10%
9	Mancozeb	Indofil	0.25%

The data on disease severity, per cent disease control, AUDPC and grain yield was calculated for each treatment.

Disease severity was scored visually from 25 randomly selected plants for each treatment using the modified Cobb's scale described by **Peterson (12).** The mean leaf rust terminal severity obtained from these plants of each plot was used for the analysis.

The per cent disease control was calculated as follows:

$$\text{Per cent disease Control (PDC \%)} = \frac{\text{Disease Severity in control plot} - \text{Disease Severity in treatment plot}}{\text{Disease severity in control plot}} \times 100 \quad \textbf{(1)}$$

Area under the disease progress curve (AUDPC), the development of disease on a whole plant or part of the plant, was assessed for each disease at different days after planting for each plot applying the following formula **(Wilcoxson et al 1975) (13).**

$$\sum \frac{1}{2}(X_i + 1 + X_i)d \quad \textbf{(2)}$$

Where,

X_i +1 = Rust severity on i+ 1th day

X_i = Rust severity on ith day

d = Days interval between two observations

Yield parameter such as grain yield was determined from each plot after harvesting of the crop and then converted to yield in terms of q/ha

DATA ANALYSIS

Data on disease severity, per cent disease control, AUDPC and grain yield were subjected to Analysis of Variance (ANOVA) for comparing the data for fungicide-applied and non-applied plots. Comparisons of means for the significantly different variables were made among treatments were analysed statistically by Duncan Multiple Range test at *P*=0.05 by using SPSS software (Version 23)

RESULTS AND DISCUSSION

In the present investigation, total nine treatments comprising combi-products of different fungicides were evaluated to manage the leaf rust in wheat. Data on the efficiency of combi-fungicides for the management of leaf rust are presented in the Table 2. The results of this study indicated that the fungicide application reduced disease severity, AUDPC, rate of disease progress and enhanced the grain yield as compared to unsprayed plots.

The results depicted that all the combination fungicide treatments significantly reduced disease severity, AUDPC and improved grain yield as compared to the untreated control during Rabi season of 2022-23. Among five different combination fungicides evaluated, the minimum disease severity (3.34%) was observed in the treatment including foliar spray of Tebuconazole 50%+Trifloxystrobin 25% WG @ 0.06% followed by Azoxystrobin 18.2% w/w + Cyproconazole 7.3% w/w SC @ 0.1% (4.41%) and Azoxystrobin 11%+ Tebuconazole 18.3% w/w SC (4.88%) @ 0.1% (Table 2). Maximum disease severity in case of combi- fungicides was observed in treatment of foliar spray having Pyraclostrobin 133 g/l + Epoxiconaxole 50 g/l SE 0.1% (5.96%) followed by Azoxystrobin 18.2%+ Difenoconazole 11.4% w/w SC @ 0.1% (5.10 %). The disease severity was significantly suppressed in treatments including combination fungicides as compared to treatments containing single fungicides. In case of treatments involving single fungicides, minimum disease severity was observed in treatment containing Tebuconazole @ 0.1% (6.42%) followed by Propiconazole @ 0.1% (6.54%) whereas, maximum disease severity was recorded in Bayleton @0.1% (6.84%) followed by Mancozeb @ 0.25% (6.59%). In all the various treatments, the incidence of disease severity were at par as compared to the disease severity of control plots.

Table2. Effect of combi-fungicides on leaf rust severity, per cent disease control, AUDPC and yield in wheat

		Doses (%)	Disease Severity (%)	Per cent Disease Control (%)	AUDPC value	Yield (q/ha)
1	**Tebuconazole 50% + Trifloxystrobin 25% WG**	0.06%	3.34±0.45^{d}	94.93±0.67^{a}	49.16±0.42^{g}	47.65±0.65^{a}
2	**Azoxystrobin 18.2% + Difenoconazole 11.4% w/w SC**	0.10%	5.10±0.19^{bc}*	92.273±0.34^{bc}	79.45±1.37^{f}	47.30±0.47^{ab}
3	**Pyraclostrobin 133g/l + Epoxiconazole 50g/l SE**	0.10%	5.96±0.15^{ab}	90.97±0.31^{cd}	131.46±0.46^{cd}	46.55±0.46^{abc}
4	**Azoxystrobin 11% + Tebuconazole 18.3% w/w SC**	0.10%	4.88±0.11^{bc}	92.60±0.18^{bc}	99.70±1.91^{e}	47.30±0.47^{ab}
5	**Azoxystrobin 18.2% w/w + Cyproconazole 7.3% w/w SC**	0.10%	4.41±0.63^{cd}	93.33±0.91^{ab}	99.64±1.26^{e}	46.60±0.34^{abc}
6	**Propiconazole**	0.10%	6.54±0.28^{a}	90.29±0.91^{d}	121.03±1.13^{d}	45.05±0.89^{cd}
7	**Tebuconazole**	0.10%	6.42±0.65^{a}	90.03±0.53^{d}	141.70±0.13^{bc}	45.75±0.56^{bcd}
8	**Bayleton**	0.10%	6.84±0.22^{a}	89.64±0.29^{d}	157.02±0.93^{a}	42.23±0.26^{e}
9	**Mancozeb**	0.25%	6.59±0.25^{a}	90.02±0.34^{d}	145.23±1.85^{ab}	44.17±0.62^{d}
10	**Control**		66.09±0.59^{e}	66.09±0.59^{e}	1679.05±12.17^{h}	30.04±0.34^{f}
	CD (*P*=0.05)		1.17	1.76	12.02	1.62

*Values are of mean of three replicates ±S.E. Significant difference at *P* =0.05 were calculated by One way ANOVA. Values followed by the same letter within a column are not significantly different and different letters with in column are significantly different (Duncan's multiple range post hoc test

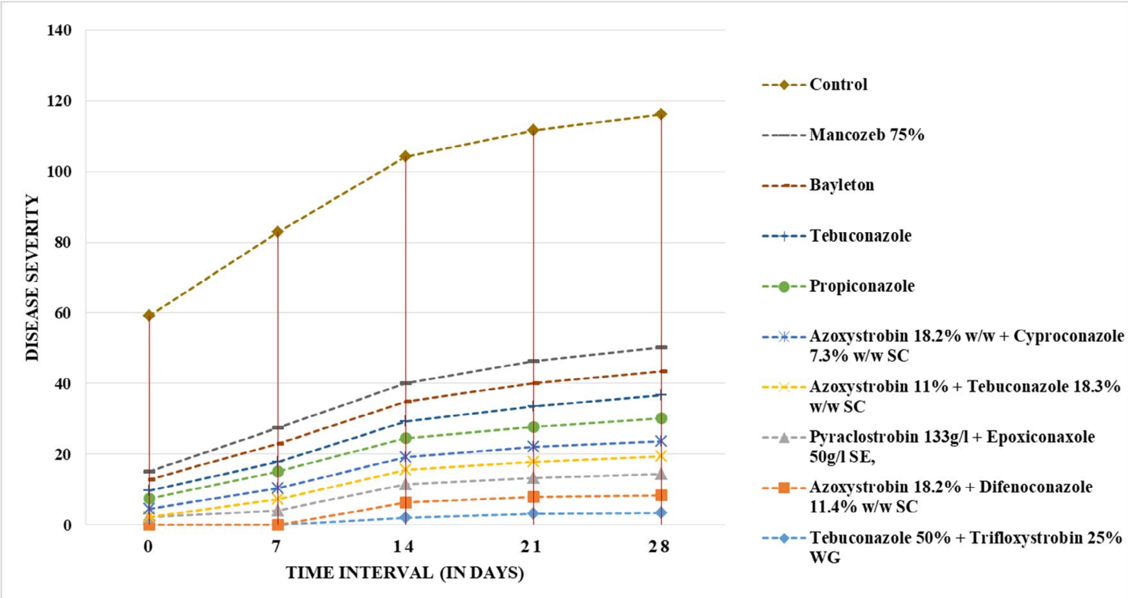

Fig.2 Disease progress in different treatments employed for management of leaf rust in wheat

In terms of per cent disease control, treatment (Tebuconazole 50%+ Trifloxystrobin 25% WG) exhibited maximum per cent disease control of 94.93 followed by 93.33 % in Azoxystrobin 18.2%+ Cyproconazole 7.3% whereas, minimum percent disease control of 92.27% was observed in Azoxystrobin 18.2%+Difenoconazole 11.4% followed by 90.97% in Pyraclostrobin + Epoxiconaxole. Whereas, it was noteworthy that the percent disease control of combi-fungicides was found to be significantly different as compared to the single fungicides. Among treatments involving single fungicide, minimum percent disease control was observed in treatment Bayleton (89.64) followed by Mancozeb (90.02) whereas, maximum percent disease control was reported in treatment Tebuconazole (90.03) and Propiconazole (90.29). Therefore, the above results indicated that the combination fungicide Tebuconazole 50%+Trifloxystrobin 25% proved to be effective in minimizing the leaf rust disease as compared to other combination fungicides.

Area under Disease Progress Curve (AUPDC) was calculated for all the treatments to determine the disease progress over a period of time in each treatment. The results demonstrated that treatment containing Tebuconazole 50%+Trifloxystrobin 25% recorded minimum AUPDC of 49.16. This was followed by treatment Azoxystrobin 18.2%+ Difenoconazole 11.4% w/w SC with a AUDPC value of 79.45, and Azoxystrobin 18.2% + Cyproconazole 7.3% with a value of 99.64 (Fig. 3). Bayleton (157.02) has the highest recorded AUDPC value among the various single fungicides, followed by Mancozeb (145.23) and Tebuconazole (141.70). According to the study, rate of disease progress was lower in all the combination and were reported to be significantly at par with respect to check plot.

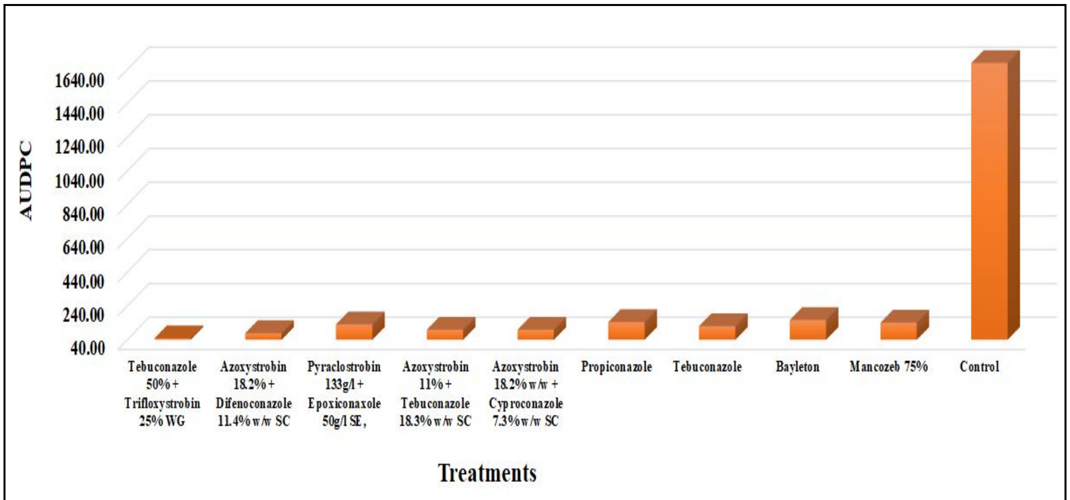

Fig. 3 Area under Disease Progress Curve (AUDPC) values across various treatments applied for leaf rust management in wheat

The maximum grain yield (47.65 q/ha) was obtained from foliar application of Tebuconazole 50% + Trifloxystrobin 25%, followed by Azoxystrobin 11% + Tebuconazole 18.3% (47.30 q/ha) and Azoxystrobin 18.2% + Difenoconazole 11.4% (47.30 q/ha). In comparison to the grain yield obtained from single fungicide treatments, the yield obtained from treatments including combi-fungicides increased significantly. Regarding individual fungicides, the highest yield was achieved with Tebuconazole treatment (45.75 q/ha) succeeded by Propiconazole treatment (45.05 q/ha). On the other hand, the lowest yield was associated with Bayleton foliar spray treatment (42.23 q/ha) following Mancozeb treatment (44.17 q/ha).

Many researchers reported that the application of fungicides against various wheat diseases significantly reduced the severity of disease and increased the yield parameters over control plots **(14).** A study was conducted where negative correlation between various yield parameters and disease severity was reported **(15) (16) (17)**. According to the current study, the combi-fungicides was successful in suppressing the leaf rust pathogen, minimizing the disease severity, and ultimately increasing the grain production due to the active substances incorporated in the product formulation. These fungicides reduced AUDPC for leaf rust much more below the unsprayed and single fungicide sprayed plots; they seem to be more effective and feasibly acceptable for rust management. This can be attributed to the mechanism that the combination of strobilurin and triazole makes them more potent in suppressing the disease. Triazole group interferes with biosynthesis of sterols and strobilurin interferes with Electron Transfer Cycle in Mitochondria, which disrupts the metabolism and thus inhibit the respiratory chain. A mixture of Strobilurin (Trifloxystrobin) and Triazole (Tebuconazole) were reported to be more efficient in controlling the infestation of leaf rust in combi formulation as compared to single formulation **(18)**. The present results are in agreement with the findings of **(19)** and **(20)** who recommended that combination of Triazoles and Strobilurin are more efficient in controlling the infestation of leaf rust**.** Similar findings were also reported that combi fungicides were effective in controlling the leaf rust of wheat **(21) (22)**. Present findings are in accordance with the previous works and suggested that to lower the subsequent disease progress on the wheat, fungicides should be applied at the time of disease appearance in order to get effective results in disease pressure reductions **(23) (24).**

Area under disease progress (AUDPC value) is one of the useful method which gives quantitative summary of disease intensity over time which can be used for comparison of disease progress across various time spans, locations and management tactics. The AUDPC values in current investigation were reported to be comparatively lower in treatments comprising various combinations of fungicides. The results are in compliance with the findings of various research workers who reported that highest value of AUDPC along with high rate of disease development were obtained in plots where different combination of fungicides were applied as compared to no application in control plot **(25) (26) (27).** In present study**,** the application of fungicides in various treatment plots largely increased the grain yield of wheat crop as compared to control plots. The findings are in line with previous findings wherein, they reported that application of fungicides largely increased the yield parameters of the crop **(28) (29)**.

CONCLUSION

The management of leaf rust by employment of genetic resistance is of utmost importance. Due to epiphytotic conditions, it is necessary to scrutinize the multiplication and spread of inoculum by incorporating fungicides which can rapid and easy management of such dreadful obligate pathogen. In the present study, in search of better alternative to existing fungicide to manage the incidence of brown rust, a study was attempted with nine different combination fungicides against brown rust of wheat. The investigation revealed that leaf rust of wheat can cause drastic reduction in yield of wheat. Therefore, application of combi- fungicides can be viable option to safeguard the economic losses. The combi- fungicides such as Tebuconazole 50%+ Trifloxystrobin 25%, Azoxystrobin 11%Tebuconazole 18.3% and Azoxystrobin 18.2% + Cyproconazole 7.3% were found effective in managing the leaf rust of wheat and could be suggested to the farmers in the study areas and elsewhere with similar agro-ecological conditions for efficient management and optimization of the grain yield.

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