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## *In vivo* Efficacy of fungicides, bioagents, and botanicals in managing wheat leaf rust caused by *Puccinia triticina* Eriks

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### Abstract

The field experiment was conducted during *rabi* season at Agriculture Research Station, Kundewadi, Niphad to evaluate the efficacy of fungicides, bioagents, and botanicals against wheat leaf rust caused by *Puccinia triticina* Eriks under field conditions. Eight treatments comprising three fungicides, two bioagents, two botanicals, and an untreated control were evaluated in a randomized block design. Per cent disease intensity was recorded before spraying and at 45 and 60 days after spraying, along with grain yield and per cent disease control. The treatments differed significantly in reducing leaf rust intensity and improving grain yield. Among the fungicides, Tebuconazole 50% + Trifloxystrobin 25% w/w 75 WG @ 0.05% proved to be the most effective, recording the lowest disease intensity, highest disease control (84.33%), and maximum grain yield (31.12 q/ha), followed by Azoxystrobin 18.2% + Difenconazole 11.4% w/w SC @ 0.1% and Hexaconazole 5% SC @ 0.1%. Among the bioagents, *Bacillus subtilis* @ 5% performed better than *Trichoderma harzianum* @ 5%, although both were less effective than the fungicidal treatments. The botanical treatments, Neem oil @ 5% and Pongamia oil @ 1%, were comparatively less effective in suppressing leaf rust and enhancing grain yield. The findings indicate that Tebuconazole + Trifloxystrobin @ 0.05% is the most effective treatment for the management of wheat leaf rust and for improving grain yield under field conditions, while *Bacillus subtilis* offers a promising eco-friendly alternative for integrated disease management.

**Keywords:** *Puccinia triticina*, wheat, *in vivo*, fungicides

### Introduction

Wheat (*Triticum aestivum* L.) is one of the most important cereal crops worldwide and serves as a staple food for a large proportion of the global population. In India, wheat is the second most important food crop after rice, contributing significantly to national food security and the agricultural economy. However, wheat productivity is constrained by several biotic stresses, among which rust diseases are considered the most destructive (Singh *et al.*, 2016) [9].

Leaf rust, caused by *Puccinia triticina* Eriks, is the most widespread and frequently occurring rust disease of wheat. The disease is characterized by the development of orange-brown uredinial pustules on leaves, resulting in premature leaf senescence, reduced photosynthetic efficiency, poor grain filling, and significant yield losses. Depending on the susceptibility of the cultivar, environmental conditions, and the stage of crop growth, leaf rust may cause yield losses ranging from 10 to 40%, and under severe epidemics, losses may exceed 50% (Roelfs *et al.*, 1992; Huerta-Espino *et al.*, 2011) [8, 5].

The management of wheat leaf rust primarily depends on the cultivation of resistant cultivars and the timely application of fungicides. However, the emergence of new pathogen races often overcomes host resistance, necessitating the use of effective fungicides for disease management (Kolmer, 2013) [7]. Triazole and strobilurin fungicides, either alone or in combination, have been reported to provide effective control of leaf rust while improving grain yield through prolonged green leaf area and enhanced physiological activity (Chen, 2005) [3]. In recent years, increasing concern regarding environmental sustainability has stimulated interest in eco-friendly alternatives such as biological control agents and plant-derived botanicals. Bioagents, including *Trichoderma*

*harzianum* and *Bacillus subtilis*, have shown potential in inducing systemic resistance and suppressing plant pathogens, whereas botanical products such as neem and pongamia oil are considered safer alternatives with minimal environmental impact (Harman *et al.*, 2004; Kloepper *et al.*, 2004) <sup>[4, 6]</sup>.

Although numerous disease management strategies have been developed, comparative information on the efficacy of fungicides, bioagents, and botanicals against wheat leaf rust under field conditions remains limited. Therefore, the present investigation was undertaken to evaluate the comparative efficacy of selected fungicides, bioagents, and botanicals in reducing leaf rust intensity and improving grain yield of wheat under field conditions.

## Materials and Methods

### *In-vivo* management of wheat leaf rust disease

A field experiment was conducted during the *Rabi* season at the Agriculture Research Station, Kundewadi, Niphad, to evaluate the efficacy of fungicides, bioagents, and botanicals against wheat leaf rust under natural epiphytotic conditions. The experiment was laid out in a Randomized Block Design (RBD) with eight treatments and three replications.

The wheat variety Lok-1, which is susceptible to leaf rust, was used for the study. The total experimental area measured 18.20 ×

18.80 m, with each treatment plot measuring 2.4 × 5.0 m. The crop was sown with a row spacing of 22.5 cm following the recommended agronomic practices. Three fungicides belonging to different chemical groups, two bioagents, and two botanicals were evaluated for their effectiveness in managing wheat leaf rust caused by *Puccinia triticina* Eriks. The fungicides were procured from the Department of Plant Pathology and Microbiology and stored in a dark place at 25 ± 2 °C until use to maintain their biocidal activity. Bioagents and botanicals were prepared and applied according to the recommended concentrations and methods.

The first foliar spray of the respective treatments was applied immediately after the appearance of the initial symptoms of leaf rust in the experimental plots. A second spray was administered 15 days after the first application. Untreated control plots were maintained for comparison.

Observations on disease intensity were recorded at regular intervals after treatment application using the appropriate disease rating scale. The efficacy of different treatments was assessed based on the reduction in disease severity compared with the untreated control.

## Results and Discussion

**Table 1:** Management of wheat leaf rust disease under *in vivo* condition by using different fungicides, bioagents and botanicals (Niphad 2023-24)

| Tr. No.        | Treatment                                                | PDI Before 1 <sup>st</sup> Spray | PDI           |               | Yield q/ha | PDC   |
|----------------|----------------------------------------------------------|----------------------------------|---------------|---------------|------------|-------|
|                |                                                          |                                  | 45 DAS        | 60 DAS        |            |       |
| T <sub>1</sub> | <i>Trichoderma harzianum</i> @ 5%                        | 6.62 (14.90)                     | 35.22 (36.40) | 42.97 (39.04) | 23.65      | 32.94 |
| T <sub>2</sub> | <i>Bacillus subtilis</i> @ 5%                            | 4.20 (11.78)                     | 32.55 (34.78) | 39.69 (40.96) | 25.94      | 37.92 |
| T <sub>3</sub> | Neem oil @ 5%                                            | 6.01 (14.18)                     | 37.78 (37.93) | 49.01 (44.43) | 21.48      | 23.34 |
| T <sub>4</sub> | Pongamia oil @ 1%                                        | 4.72 (12.53)                     | 40.35 (39.43) | 52.26 (46.29) | 19.30      | 18.25 |
| T <sub>5</sub> | Tebuconazole 50% + Trifloxystrobin 25% w/w 75 WG (0.05%) | 5.06 (12.86)                     | 8.2 (16.56)   | 10.07 (18.38) | 31.12      | 84.33 |
| T <sub>6</sub> | Azoxystrobin 18.2% + Difenconazole 11.4% w/w SC (0.1%)   | 5.33 (13.35)                     | 9.72 (18.17)  | 11.07 (19.38) | 30.96      | 82.76 |
| T <sub>7</sub> | Hexaconazole 5% SC (0.1%)                                | 4.10 (11.63)                     | 12.34 (20.55) | 14.27 (22.16) | 28.73      | 77.84 |
| T <sub>8</sub> | Control (Water spray)                                    | 5.54 (13.40)                     | 43.08 (41.02) | 63.93 (53.09) | 16.67      | -     |
|                | SEm ±                                                    | 0.71                             | 0.84          | 1.06          | 0.72       | -     |
|                | CD at 5%                                                 | NS                               | 2.53          | 3.21          | 2.17       | -     |

### *In vivo* disease management of wheat leaf rust during 2023-24 at Niphad

The results of the management trial conducted during 2023–24, as presented in Table 3, and Fig. 1, indicated that there was no significant difference among the treatments before the first spray. The initial leaf rust disease intensity varied from 4.10 to 6.62% across all treatments. Following two foliar applications, the lowest leaf rust disease intensity was observed in T<sub>5</sub> (Tebuconazole 50% + Trifloxystrobin 25% w/w 75 WG @ 0.05%), which recorded only 10.07% disease intensity and achieved 84.33% disease control over the untreated control. This treatment was statistically at par with T<sub>6</sub> (Azoxystrobin 18.2% + Difenconazole 11.4% SC @ 0.1%), which resulted in 11.07% disease intensity with 82.76% disease control. Among the biological treatments, T<sub>2</sub> (*Bacillus subtilis* @ 5%) proved more effective by recording 39.69% disease intensity, followed by T<sub>1</sub> (*Trichoderma harzianum* @ 5%) with 42.97% disease intensity. In the botanical treatments, T<sub>3</sub> (Neem oil @ 5%) and T<sub>4</sub> (Pongamia oil @ 1%) recorded disease intensity of 49.01% and 52.26%, respectively. Overall, disease intensity among the treated plots ranged from 10.07 to 52.26%, whereas the untreated control exhibited the highest disease intensity of 63.93% at the final observation.

Grain yield also differed significantly among the treatments. The highest grain yield (31.12 q/ha) was obtained with Tebuconazole

50% + Trifloxystrobin 25% w/w 75 WG @ 0.05% (T<sub>5</sub>), which was statistically comparable to Azoxystrobin 18.2% + Difenconazole 11.4% SC @ 0.1% (T<sub>6</sub>), yielding 30.96 q/ha.

The present findings are consistent with those reported by Basandrai *et al.* (2020) <sup>[1]</sup>, who assessed the efficacy of eleven fungicides over two consecutive years at RWRC, Malan, for the management of yellow rust in wheat. Among the fungicides evaluated, Tebuconazole 25% EC @ 0.1% was the most effective, reducing disease intensity to 1.84% and providing 99.64% disease control. Other fungicides, including Nativo 75 WG, Amistar SC, Propiconazole, and Amistar Top 325 SC, also demonstrated excellent disease suppression, resulting in higher grain yield and improved economic returns.

Similarly, Bajoriya *et al.* (2023) <sup>[2]</sup> evaluated the performance of four recently introduced fungicides against stem rust of wheat on two susceptible cultivars. Their study revealed that Tebuconazole 50% EC exhibited the greatest curative efficacy, reducing disease incidence by 45.62% at 7 days and 74.92% at 14 days after fungicide application. In addition, it lowered disease severity to 1.67%, which was significantly superior to the untreated control. Propiconazole 25% EC was the second most effective treatment and performed statistically similar to Tebuconazole. The observations recorded in the present investigation closely corroborate the findings of these earlier studies.

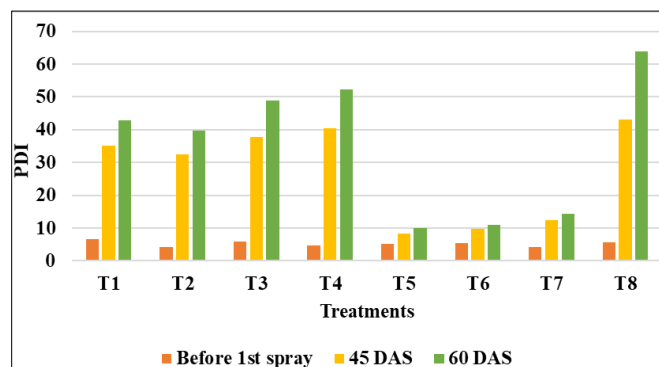


**Fig 1:** Graphical presentation of *in vivo* management of wheat leaf rust disease during Rabi 2023-24 at Niphad

### Treatments

T<sub>1</sub> *Trichoderma harzianum* @ 5%

T<sub>2</sub> *Bacillus subtilis* @ 5%

T<sub>3</sub> Neem oil @ 5%

T<sub>4</sub> Pongamia oil @ 1%

T<sub>5</sub> Tebuconazole 50% + Trifloxystrobin 25% w/w 75 WG @ 0.05%

T<sub>6</sub> Azoxystrobin 18.2% + Difenconazole 11.4% w/w SC @ 0.1%

T<sub>7</sub> Hexaconazole 5% SC @ 0.1%

T<sub>8</sub> Control (Water spray)

### Conclusion

Among the evaluated treatments, Tebuconazole 5% + Trifloxystrobin 25% WG @ 0.05% was the most effective in reducing disease intensity, recording the lowest PDI, highest disease control (84.33%), and maximum yield (31.12 q/ha). It was closely followed by Azoxystrobin 18.2% + Difenconazole 11.4% SC @ 0.1%. Among the eco-friendly treatments, *Bacillus subtilis* @ 5% performed best by significantly reducing disease and improving yield compared with other biological and botanical treatments. These findings suggest that Tebuconazole + Trifloxystrobin is an effective option for disease management, while *Bacillus subtilis* offers a promising eco-friendly alternative.

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