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Management of white rust (*Albugo candida*) of mustard through chemical measures

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ABSTRACT

Field studies were conducted during rabi 2022-23 and 2023-24 for the evaluation of different fungicides, namely copper oxychloride 50% WP (1.25%), mancozeb 75% WP (0.25%), metalaxyl 8% + mancozeb 64% WP (0.2%), propineb 70% WP (0.2%), and propiconazole 25% EC (0.1%) as a single spray treatment at 45 and 60 days after sowing, along with a control with no treatment. The susceptible variety Varuna was used as planting material for evaluation during both years. All the fungicides reduced disease severity, incidence, and staghead formation compared to the control. The plots sprayed with metalaxyl 8% + mancozeb 64% recorded minimum disease severity (7.71% and 8.61%), incidence (25.56% and 26.70%), and staghead formation (9.61% and 8.33%) at 60 DAS, followed by mancozeb 75% WP, copper oxychloride 50% WP, and propiconazole 25% EC. The yield was also highest in plots sprayed with metalaxyl 8% + mancozeb 64% (30.03 and 30.16 q/ha), followed by mancozeb 75% WP (29.33 and 29.6 q/ha), copper oxychloride 50% WP (28.33 and 28.63 q/ha), and propiconazole 25% EC (26.03 and 26.1 q/ha). The least effective fungicide was propineb 70% WP compared to all other treatments. As the limited effectiveness of conventional methods like cultural and mechanical practices for disease control, which often fail to provide adequate protection under severe disease pressure. Hence the study demonstrated that fungicidal treatments, particularly metalaxyl 8% + mancozeb 64% WP, offered effective disease control and improved yields. This research provides valuable insights and practical recommendations for enhancing disease management strategies in mustard crop, helping farmers adopt more reliable and sustainable solutions.

Keywords: *Susceptible, Fungicides, disease severity, disease incidence, stag head.*

1. Introduction

Indian mustard (*Brassica juncea* L. Czern & Coss.) is a major oilseed crop cultivated extensively in India and globally. As the second most significant edible oilseed in India, it is widely grown both as a monocrop and intercrop in marginal and sub-marginal soils, particularly in the eastern, northern, and northwestern states. The cool, moist winter climate in these regions supports vigorous growth and high productivity in mustard. Despite progress in yield and production, there remains a notable gap between mustard's potential yield and actual farm-level yield, largely due to biotic and abiotic stresses. Among biotic stresses, white rust is one of the most pervasive and destructive fungal diseases affecting rapeseed-mustard worldwide. Its incidence has increased significantly since the 1970s, emerging as a primary threat to mustard production in India. In states such as Haryana, Rajasthan, Uttarakhand, Punjab, Delhi, and Jammu & Kashmir, the cold winter climate accelerates the spread of white rust, particularly in late-sown crops. The disease typically manifests during flowering, with shiny white to creamy yellow raised pustules on the undersides of leaves. In severe cases, white pustules may also appear on the stem, inflorescence, and pods, with systemic infections leading to the characteristic "staghead" formation [6]. White rust, caused by the biotrophic oomycete pathogen *Albugo candidal* (Pers. ex. Lev), can cause significant yield losses up to 89.8% in India due to foliar infection and hypertrophy of flowers and pods [5]. Another studies report losses ranging from 17 to 34% [10]. Conventional cultural methods often provide insufficient disease control, and resistant varieties may lack agronomic acceptance or market preference. Thus, fungicides are frequently used as an effective and economical approach for disease management. Early chemical control efforts focused on copper-based fungicides for the leaf phase, with Bordeaux mixture recommended by Vasudeva (1958) [8] for managing white rust in crucifers. The advent of dithiocarbamates allowed further control with repeated applications of protectant fungicides. Recently, systemic fungicides specifically targeting peronosporales pathogens have been developed, offering enhanced white rust control. Hence the following studies were undertaken during *rabi* 2022-23 and 2023-24 to evaluate the efficacy of selected fungicides against white rust.

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2. Material and methods

A field experiment was laid at the research farm of Division of Plant pathology (SKUAST- Jammu) in randomized block design (RBD) for two consecutive years i.e. *rabi* 2022 and 2023 with six treatments and three replications. The susceptible mustard cultivar "Varuna" was sown in the second week of November in both years, ensuring that the foliage and flowering stages aligned with the peak period of disease development under favorable weather conditions.

The crop was sown in 2×2m^2 plot size and the data was recorded at 15 days interval. The following five chemicals were evaluated, T1: Copper oxychloride 50% WP, T2: Mancozeb 75% WP, T3: Metalaxyl 8%+ Mancozeb 64% WP, T4: Propineb 70% WP, T5: Propiconazole 25% EC and T6: Control.

The first spray was applied at 45 days after sowing (DAS), at the onset of disease, followed by a second spray 15 days later (60 DAS), using a knapsack sprayer with 1000 liters of spray solution per hectare. Plots treated with water spray served as controls. White rust severity on foliage was assessed 15 days after the second spray (75 DAS). Fifteen plants were randomly sampled from each plot, and white rust severity was evaluated based on the percentage of leaf area covered by pustules, using the revised rating scale (0-6) from Conn *et al.* (1990): 0 = No symptoms; 1 = 0-5%; 2 = 5-10%; 3 = 10-20%; 4 = 20-35%; 5 = 35-50%; and 6 = more than 50% of the leaf area covered. The percent disease index (PDI) was calculated using Wheeler's (1969) formula [9]:

$$\text{Per cent disease severity} = \frac{\text{Sum of Numerical ratings}}{\text{Total no of leaves examined} \times \text{Maximum grade}} \times 100$$

Disease incidence was also calculated using formula:

$$\text{Per cent disease incidence} = \frac{\text{No of infected plants}}{\text{Total no. of plants observed}} \times 100$$

Staghead incidence was also observed 15 days before harvest by counting the total number of plants in each plot and the number showing staghead symptoms, then calculating the percentage. The crop was harvested at maturity, each treatment plot was threshed separately, and individual plot yields were recorded. The analysis of data was done using R studio.

3. Results and Discussion

The data presented in Tables 1 and 2 and Figures 1 and 2 clearly show that all tested fungicides significantly reduced the severity and incidence of white rust on mustard variety Varuna under field conditions. Fungicides were applied after the onset of the disease, with the combination of metalaxyl 18% + mancozeb 64% WP (0.2%) proving the most effective in minimizing disease severity and incidence. This treatment was closely followed by mancozeb 75% (0.25%), propiconazole 25% EC, and copper oxychloride. Among the tested fungicides, propineb 70 WP (0.2%) was the least effective, although it still performed better than the untreated control.

In addition to controlling white rust, fungicide applications reduced staghead formation a characteristic symptom of the disease. Metalaxyl + mancozeb treatment resulted in the lowest staghead formation, followed by mancozeb, copper oxychloride, and propiconazole, while propineb demonstrated comparatively less effectiveness. These results remained consistent over both rabi seasons, highlighting the sustained efficacy of metalaxyl + mancozeb as a disease management strategy.

Moreover, the use of fungicides enhanced yield significantly compared to untreated plots. The highest yield was recorded in plots treated with metalaxyl + mancozeb, followed by those treated with mancozeb alone. This yield improvement underscores the dual benefits of effective white rust management and enhanced productivity, making metalaxyl + mancozeb a promising choice for managing white rust in mustard cultivation.

The study clearly demonstrated that single-spray fungicide treatments were less effective than combination sprays in managing white rust on crucifers.

While single sprays provided some level of disease control during the initial stages of growth, they failed to suppress the disease throughout the crop cycle. This decline in efficacy could be linked to the natural growth of the plant, which leads to an increased tissue volume that dilutes the concentration of the fungicide. Consequently, disease symptoms reappeared at later stages, indicating that single-spray applications were inadequate for long-term management. Among the single sprays tested, metalaxyl + mancozeb (0.2%) emerged as the most effective, achieving substantial reductions in disease severity at both the leaf and staghead phases while significantly improving seed yield compared to untreated controls.

The yield data further supported the superior efficacy of the metalaxyl + mancozeb treatment. With a seed yield of 30.03q/ha (2022-23) and 30.16q/ha (2023-24), this treatment outperformed others, showcasing the critical role of effective disease management in enhancing productivity. Single applications of mancozeb, though less effective than combination sprays, still reduced disease severity to a certain extent. However, their impact on yield improvement was relatively modest, reinforcing the need for more robust strategies like combination sprays to maximize both disease control and crop output.

Historical data corroborate the results of this study, as numerous researchers have validated the efficacy of combination sprays in managing white rust. Mehta *et al*. (1996) [7] documented the effectiveness of three sprays of Ridomil MZ (metalaxyl + mancozeb) at a 0.25% concentration applied at 20-day intervals starting at 40 DAS, achieving superior control of white rust. In contrast, their findings indicated that even multiple sprays of mancozeb alone could only achieve 42% disease control. Similarly, Yadav (2003) [11] demonstrated that two sprays of Ridomil MZ, applied at 60 and 80 DAS, reduced disease indices from 62.7% to 17.1% and significantly boosted yield. Meena *et al*. (2014) also highlighted the effectiveness of metalaxyl + mancozeb in reducing white rust intensity, further validating its role as a critical tool in disease management. The findings of Bhargava *et al*. (1997) [2] provide valuable insights into the management of white rust in the susceptible mustard cultivar Varuna through seed treatment and foliar sprays. Their study evaluated the efficacy of seed treatments with mancozeb or metalaxyl, combined with subsequent foliar applications of mancozeb, metalaxyl + mancozeb, and chlorothalonil applied one, two, or three times post-planting. Across all treatments, significant reductions in leaf infection were observed, underscoring the potential of these fungicides in disease management. Kapoor and Suhag (1995) [4] conducted experiments in 1989 and 1990 to evaluate the efficacy of various fungicides in controlling white rust caused by *Albugo candidal* on Indian mustard. Their study included a range of fungicides such as Aliette (fosetyl), chlorothalonil, Ridomil MZ (metalaxyl + mancozeb), Galben R-4-33 (benalaxyl + copper oxychloride), Galben M-8-65 (benalaxyl + mancozeb), SAN 506, SAN 518, Blitox (copper oxychloride), and Dithane M-45. The research aimed to identify the most effective treatments for suppressing white rust and minimizing its impact on crop health and yield. Yadav (2007) [12] reported that applying two sprays of Metalaxyl 8% + Mancozeb 64% (Ridomil MZ 72 WP) at a concentration of 0.25%, administered at 70 and 85 days after planting, effectively reduced disease severity and staghead incidence in mustard crops. This treatment also resulted in a seed yield of 1708 kg/ha, highlighting its effectiveness in managing the disease while enhancing crop productivity.

Asif *et al*. (2017) [1] evaluated the efficacy of eight different fungicides at concentrations of 0.25% and 0.50% against white rust in mustard crops, with applications made at weekly intervals for each fungicide. Among the tested treatments, Swing 72% (Metalaxyl 8% + Mancozeb 64%) was found to be the most effective in controlling the disease, demonstrating superior performance compared to the other fungicides.
The results of this study highlight the limitations of single-spray strategies and emphasize the importance of adopting combination sprays for effective white rust control. The significant reduction in disease severity and increase in yield observed with metalaxyl + mancozeb underscores its practical value for mustard growers. Combination treatments not only provide prolonged protection but also ensure higher returns by reducing disease-induced losses. This finding is particularly relevant for mustard cultivation, where white rust poses a major challenge to productivity.

4. Future scope: The integration of combination fungicide sprays like metalaxyl + mancozeb into mustard crop management practices offers a reliable and efficient approach to combating white rust. The enhanced efficacy of such treatments over single sprays suggests that growers should prioritize combination fungicides to optimize disease control and maximize yields. Further research could explore the cost-effectiveness and environmental impacts of these treatments to develop more sustainable and scalable solutions for mustard farming.

5. Conflict of interest: I Sakshi Sharma, declare that I have no conflicts of interest that could have influenced the research, authorship, and/or publication of this article.

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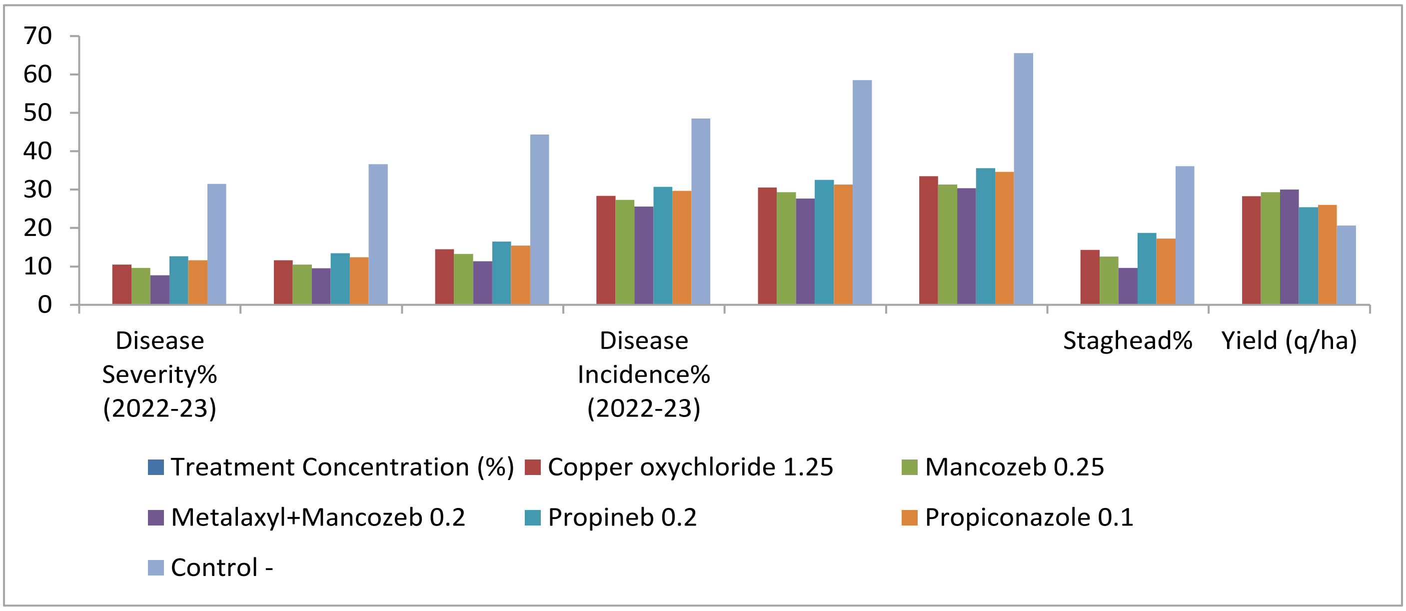

Figure 1: Effect of different fungicides on disease severity, incidence, stag head and yield index of white rust in mustard during 2022-23

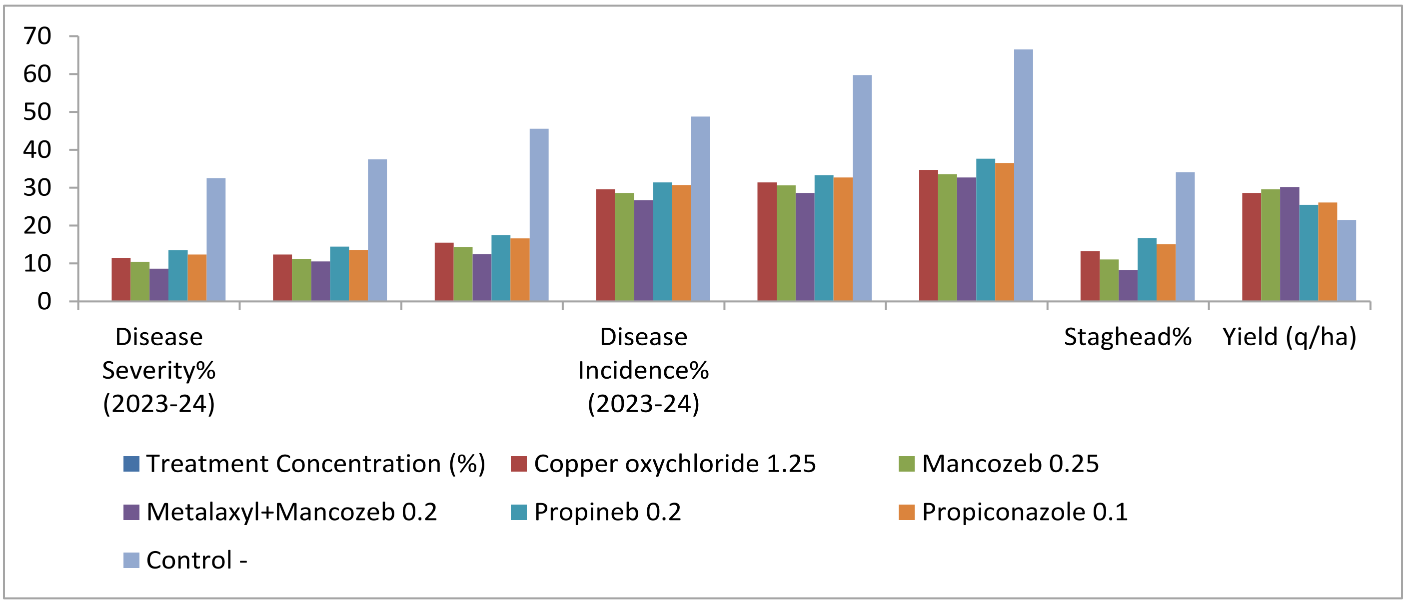

Figure 2: Effect of different fungicides on disease severity, incidence, stag head and yield index of white rust in mustard during 2023-24

Table 1. Effect of different fungicides on white rust of mustard during 2022-23

Treatment	Concentration (%)	Disease Severity% (2022-23)			Disease Incidence% (2022-23)			Staghead%	Yield (q/ha)
		60DAS	75DAS	90DAS	60DAS	75DAS	90DAS		
Copper oxychloride	1.25	10.47^{d}	11.61^{d}	14.5^{d}	28.36^{d}	30.58^{d}	33.47^{d}	14.33^{d}	28.33^{c}
Mancozeb	0.25	9.58^{e}	10.5^{e}	13.28^{e}	27.31^{e}	29.31^{e}	31.36^{e}	12.53^{e}	29.33^{b}
Metalaxyl+Mancozeb	0.2	7.71^{f}	9.52^{f}	11.36^{f}	25.56^{f}	27.64^{f}	30.41^{f}	9.61^{f}	30.03^{a}
Propineb	0.2	12.61^{b}	13.45^{b}	16.47^{b}	30.69^{b}	32.51^{b}	35.61^{b}	18.71^{b}	25.4^{e}
Propiconazole	0.1	11.59^{c}	12.39^{c}	15.44^{c}	29.67^{c}	31.36^{c}	34.62^{c}	17.24^{c}	26.03^{d}
Control	-	31.48^{a}	36.67^{a}	44.34^{a}	48.5^{a}	58.53^{a}	65.58^{a}	36.11^{a}	20.66^{f}

Table 2. Effect of different fungicides on white rust of mustard during 2023-24

Treatment	Concentration (%)	Disease Severity% (2023-24)			Disease Incidence% (2023-24)			Staghead%	Yield (q/ha)
		60DAS	75DAS	90DAS	60DAS	75DAS	90DAS		
Copper oxychloride	1.25	11.54^{d}	12.39^{d}	15.47^{d}	29.56^{d}	31.43^{d}	34.7^{d}	13.28^{d}	28.63^{c}
Mancozeb	0.25	10.45^{e}	11.26^{e}	14.34^{e}	28.59^{e}	30.67^{e}	33.59^{e}	11.05^{e}	29.6^{b}
Metalaxyl+Mancozeb	0.2	8.61^{f}	10.59^{f}	12.47^{f}	26.7^{f}	28.62^{f}	32.7^{f}	8.33^{f}	30.16^{a}
Propineb	0.2	13.55^{b}	14.51^{b}	17.53^{b}	31.37^{b}	33.34^{b}	37.7^{b}	16.73^{b}	25.5^{e}
Propiconazole	0.1	12.39^{c}	13.59^{c}	16.62^{c}	30.72^{c}	32.67^{c}	36.55^{c}	15.11^{c}	26.1^{d}
Control	-	32.53^{a}	37.53^{a}	45.54^{a}	48.78^{a}	59.76^{a}	66.53^{a}	34.08^{a}	21.53^{f}

DAS: Days after sowing

Different alphabetical letters on the superscript among the column indicate significant differences between the treatments according to Duncan's multiple range tests at $p \leq 0.05$.

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