**Efficacy of Various Seed Treatments in the Management of White Rust (*Albugo candida*) in Mustard (*Brassica juncea*)**

**Abstract**

The present investigation was conducted during *Rabi* 2024 at the Organic Research Farm, Bundelkhand University, Jhansi, to evaluate the efficacy of seed bio-priming with chemicals and biocontrol agents against white rust of mustard caused by Albugo candida. The experiment, laid out in a Randomised Block Design with nine treatments and three replications, assessed disease incidence at 30, 45 and 60 DAS. Among all treatments, Mancozeb @ 3 kg-1 seed showed the lowest mean disease incidence (16.80%), followed by Carbendazim (17.80%). Biocontrol agents like Trichoderma harzianum also provided effective disease suppression (19.04%), while botanical extracts showed moderate control. Overall, seed treatment with fungicides and bioagents significantly reduced disease incidence compared to the untreated control, highlighting its importance in integrated disease management strategies for sustainable mustard production.

**Keyword:** Mustard, White rust, Albugo candida, Seed treatment, Bio-priming, Fungicides, Biocontrol agents.

**Introduction**

Mustard (Brassica juncea) is an important oilseed crop grown extensively in India, especially in Rajasthan, Uttar Pradesh, and Madhya Pradesh (Indiastat, 2024). It is an important winter (*Rabi*) season oilseed crop. Among the seven edible oilseeds cultivated in India, mustard is the second-most important oilseed crop in India, next only to soybean, with almost one-fourth share in both area and production (Kumar & Tiwari, 2024). Its productivity is significantly affected by **white rust**, a disease caused by Albugo candida, which leads to white pustules on leaves and stag head formation in inflorescences, resulting in yield losses up to 60% (Sran *et al*., 2024). With the increase in area under mustard cultivation, the intensity and severity of white rust have increased gradually throughout the mustard-growing areas of tropical and subtropical India. White rust disease in Indian mustard is favoured when low temperature (15–20 °C) and high humidity (>65%) with intermittent rainfalls occur from the cotyledonary to the complete flowering stage (Chand *et al*., 2022; Tiwari *et al*., 2025). Conventional foliar fungicides offer temporary relief but may cause environmental hazards and resistance buildup (Meena and Rai, 2023). **Seed treatment** has emerged as a promising pre-sowing strategy to protect seedlings during early growth stages. Fungicides like Carbendazim and Mancozeb, and biological agents like Trichoderma harzianum and Pseudomonas fluorescens have shown potential in reducing disease incidence (Gupta *et al*., 2018; Bisen *et al*., 2020). Moreover, seed treatment with *Trichoderma viride* followed by spray of *T. viride* gave good results for the management of white rust in Indian mustard. Seed treatment with *T. viride* and foliar spray of copper oxychloride was found to control white rust disease and also increase the grain yield (Sran *et al*., 2024). Integrated seed treatments can provide sustainable disease control. Therefore, the present study was undertaken to evaluate the **efficacy of different seed treatments** in managing white rust of mustard in an eco-friendly manner.

**Materials and Methods**

The present investigation was conducted during the *Rabi* season of 2024 at the Organic Research Farm, Karguan Ji, Institute of Agricultural Sciences, Department of Plant Pathology, Bundelkhand University, Jhansi (Uttar Pradesh). The experiment was laid out in a Randomised Block Design (RBD) with nine treatments and three replications, comprising a total of 27 plots. Each plot measured 2.5 × 2.5 meters, with row-to-plant spacing maintained at 30 cm × 10 cm, and the overall field size was approximately 27.7 × 10.3 meters. The mustard variety PM-30 was sown on 24th November 2024, and harvesting was done on 24th March 2025. Standard agronomic practices were followed throughout the growing period. Fertilizers were applied as per the recommended doses, and a light irrigation was given immediately after sowing to ensure proper germination. Thinning was carried out at 15 days after sowing (DAS), followed by necessary intercultural operations to maintain plant health and growth. To assess the impact of seed bio-priming treatments on white rust disease, caused by *Albugo candida*, a fungicide spraying schedule was implemented. The first spray was applied immediately after the appearance of initial disease symptoms, followed by the second and third sprays at 15-day intervals. Disease incidence data were recorded on four occasions: Day Before Spray (DBS), 30, 45 and 60 DAS. In each plot, ten plants were randomly selected and permanently tagged for consistent monitoring. For disease assessment, any plant showing at least one characteristic symptom-such as white pustules or blister-like lesions on leaves or stems-was considered infected. The disease incidence (%) was calculated using the following formula:

#### $$Per cent disease incidence=\frac{No. of plant affected}{Total number of plants observed}×100$$

The mean disease incidence for each treatment was calculated for all observation intervals. These values were used to analyze the effectiveness of the different seed treatments in reducing white rust disease and managing its progression under field conditions.

**Results**

The data presented in Table (1) reveal the impact of various seed treatments on the incidence of white rust disease in mustard at different stages of crop growth, specifically at 30, 45, and 60 days after sowing (DAS). The experiment consisted of nine treatments, including fungicides, bioagents, botanicals, and a control. The results indicate significant variation among the treatments in their ability to suppress white rust disease progression, with a clear distinction between treated and untreated plots.

**Disease Incidence (%)**

Disease incidence was observed before and after spray applications (DBS, 30, 45 and 60 DAS). The observations were based on the number of infected plants out of 10 tagged plants per plot (Table 1)

**Day Before Spray (DBS)**

The initial disease incidence recorded at DBS ranged between 5.7% (T7) and 6.2% (T0), showing no significant difference, confirming uniform initial infection level across treatments. This validated the effectiveness of randomization and experimental setup (Table 1).

**Disease Incidence at 30 DAS**

At 30 DAS, disease incidence varied from 10.00 to 17.60% across treatments. The lowest incidence was recorded in T1 (Mancozeb at 3 kg-1 seed) with 10.00%, followed closely by T2 (Carbendazim at 2 kg-1) at 10.30% (Table 1). These treatments were significantly superior to the control (T0), which recorded the highest incidence at 17.60%, demonstrating the early protective effect of fungicidal seed treatments. Among the bio-control agents, *T. harzianum* (T4)and *T. asperellum* (T5) recorded 11.50 and 12.50% incidence, respectively, suggesting moderate effectiveness. Botanical extracts, such as neem leaf extract (T6) and garlic bulb extract (T7), were comparatively less effective, showing incidences of 13.60 and 13.50%, respectively. However, these treatments still outperformed the control, reflecting some protective efficacy in the early crop stage.

**Disease Incidence at 45 DAS**

As the crop advanced, disease incidence increased across all treatments. At 45 DAS, the trend remained similar, with (T1) continuing to perform best, showing a disease incidence of 16.40%, followed by (T2) with 17.50% (Table 1). The combined fungicide treatment, Carbendazim 12% + Mancozeb 63% (T3), showed incidence at 17.50%, possibly due to the slow release and interaction of its dual components. The bioagents again showed intermediate efficacy with (T4) at 18.30% and (T5) at 20.20%. The neem leaf extract and garlic bulb extract recorded disease incidences of 23.10% (T6) and 18.50% (T7), respectively. It is noteworthy that *P. fluorescens* (T8) also showed considerable control with 21.50% incidence, indicating its antagonistic effect against the pathogen. The control (T0), lacking any treatment, reported the highest disease incidence at 27.10%, reaffirming the necessity of seed treatment to suppress white rust development.

**Disease Incidence at 60 DAS**

Table (1) shows that at 60 DAS, white rust incidence reached its peak, reflecting the cumulative impact of disease progression under favourable environmental conditions. Again, Mancozeb (T1) emerged as the most effective treatment with 24.00% incidence, followed by Carbendazim (T2) at 25.60%. Carbendazim 12% + Mancozeb 63% (T3) also recorded a similar value of 25.60%, suggesting its consistent performance across growth stages. (T4) and (T5) treatments showed moderately higher incidence levels of 27.33%, while Neem leaf extract (T6) showed a sharp increase, recording 31.10%, the highest among all treatments. This suggests that while botanical extracts may offer early-stage protection, their efficacy diminishes over time due to degradation and reduced residual activity. The control plot (T0) reported a significantly higher incidence of 39.27%, confirming the rapid spread and severity of the disease in the absence of any management intervention.

**Mean Disease Incidence Across All Stages**

The mean disease incidence (averaged across 30, 45, and 60 DAS) ranged from 16.80 (T1) to 27.99% (T0). The results demonstrate that Mancozeb (T1) was the most effective seed treatment in minimizing white rust incidence, followed by Carbendazim (T2) with a mean of 17.80% (Table 1). Among the biological and botanical options, T4 (*T. harzianum*) recorded the lowest mean disease incidence of 19.04%, making it a promising eco-friendly alternative. The combined fungicide formulation (T3) and bioagents (T5, T8) showed moderate control with mean incidences between 18.41 and 20.01, 21.17%, whereas botanical treatments (T6 and T7) were less consistent, especially at later growth stages. Despite this, all treatments significantly reduced disease incidence compared to the untreated control.

**Table 1: Percentages of white rust disease incidence after different days**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Tr. No.** | **Treatments** | **DBS\* (%)** | **Disease incidence (DAS)\*\*** | **Mean (%)** |
| **30**  | **45**  | **60**  |
| T1 | Mancozeb (3 g kg-1) | 6.10 | 10.00 | 16.40 | 24.00 | 16.80 |
| T2 | Carbendazim (2 g kg-1) | 5.90 | 10.30 | 17.50 | 25.60 | 17.80 |
| T3 | Carbendazim 12% + Mancozeb 63% (6 g kg-1) | 5.90 | 12.15 | 17.50 | 25.60 | 18.41 |
| T4 | *T. harzianum* (10 g kg-1) | 6.00 | 11.50 | 18.30 | 27.33 | 19.04 |
| T5 | *T. asperellum* (10 g kg-1) | 5.80 | 12.50 | 20.20 | 27.33 | 20.01 |
| T6 | Neem Leaf Extract (10%) | 6.10 | 13.60 | 23.10 | 31.10 | 22.60 |
| T7 | Garlic Bulb Extract (10%) | 5.70 | 13.50 | 18.50 | 28.60 | 20.20 |
| T8 | *P. fluorescens* (10 ml kg-1) | 5.90 | 12.70 | 21.50 | 29.33 | 21.17 |
| T0 | Control (water spray) | 6.20 | 17.60 | 27.10 | 39.27 | 27.99 |
| **S. Em ±** | **—** | **0.35** | **0.42** | **0.56** | **—** |
| **C.D. at 5%** | **—** | **1.05** | **1.25** | **1.66** | **—** |

**DISCUSSION**

The data indicate that seed treatment plays a vital role in the suppression of white rust disease and enhancement of yield in mustard. Fungicides such as Mancozeb, Carbendazim, and Carbendazim 12% + Mancozeb 63% effectively reduced both incidence and severity, which may be attributed to their protective and systemic actions (Patel *et al*., 2018).

Biocontrol agents like *Trichoderma* spp. Exhibited promising results through mechanisms such as competition, antibiosis, mycoparasitism, and induction of host resistance (Singh and Kapoor, 2021). These agents not only suppressed *A. candida* effectively but also promoted plant vigour, contributing to yield improvement.

### **CONCLUSION**

The findings of this study clearly demonstrate that **seed treatment is an effective strategy** for the management of **white rust disease in mustard**. Among the tested treatments:

**Chemical fungicides**, particularly **Mancozeb**, **Carbendazim**, and **Carbendazim 12% + Mancozeb 63%**, provided **superior disease suppression** and significantly enhanced yield parameters. **Biocontrol agents** like ***Trichoderma* spp.** Emerged as **promising eco-friendly alternatives**, offering notable disease control and yield benefits without harmful environmental effects. **Botanical extracts** showed moderate effects and may be considered as part of **organic or low-input disease management systems**.

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