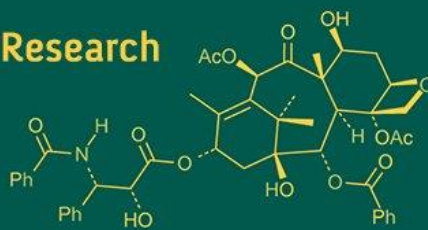


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Antagonistic effect of *Trichoderma* isolates on management of sheath blight (*Rhizoctonia solani*) disease of rice

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Abstract

Rice (*Oryza sativa* L.) is one of the most important staple food crops worldwide; however, its productivity is severely constrained by sheath blight caused by *Rhizoctonia solani* Kühn, resulting in considerable yield losses. The present study was undertaken to evaluate the efficacy of native *Trichoderma* isolates for the management of sheath blight and their influence on the growth of rice and incidence of sheath blight disease under field condition. Nine native *Trichoderma* isolates were applied as soil treatments @ 20 g m⁻² along with an untreated control. Significant differences among treatments were observed for both plant growth and disease suppression. Among all the isolates, *Trichoderma* isolate-9 (T9) proved to be the most effective, recorded the highest shoot length of 26.39, 56.67, and 91.11 cm at 30, 60, and 90 days after transplanting (DAT), respectively, compared with the untreated control. The same isolate also exhibited the lowest sheath blight incidence, with 7.74% and 9.06% disease incidence at 60 and 90 DAT, respectively, whereas the untreated control recorded 16.57% and 20.08% disease incidence. Other isolates, particularly T7, T8, and T6, also showed promising performance in enhancing plant growth and reducing disease severity. The findings demonstrate that native *Trichoderma* isolates possess strong biocontrol potential against *R. solani* while simultaneously promoting rice growth. The study suggests that *Trichoderma* isolate-9 can be effectively incorporated into integrated disease management programmes as an eco-friendly and sustainable alternative to chemical fungicides for improving rice health and productivity.

Keywords: Rice, *Rhizoctonia solani*, *Trichoderma*, disease incidence and management

Introduction

Rice is a monocotyledonous annual grass belonging to the family Gramineae and the genus *Oryza*. It includes 20 wild species and two cultivated species: *Oryza sativa* (grown throughout the world) and *Oryza glaberrima* (grown only in Africa) (Khush, 1997; Yadav *et al.* 2019) [7, 14]. India is the second-largest producer of rice (24%) in the world after China (30%), with greater than 11% of the world production along with the share of the other country like, Bangladesh (7%), Indonesia (7%), Vietnam (5%) and Thailand (4%). In India, rice cultivation encompasses an expansive 47.82 million hectares, resulting in an annual production of 137.82 MMT and achieving a productivity rate of 2882 kg per hectare (Anonymous 2025) [1]. West Bengal, Uttar Pradesh, Andhra Pradesh, Punjab, Tamil Nadu, Odisha, and Bihar are the major rice producing states in India. The state-wise area, total production, and productivity (i.e., average yield) of rice India's agricultural performance varies significantly across different states, reflecting regional disparities in land use, production, and productivity. Uttar Pradesh emerges as the leading state in terms of cultivated area, utilizing 5.93 million hectares of land and contributing 13.6% to the country's total agricultural production. Despite this extensive cultivation, its yield is moderate, averaging 1,960 kilograms per hectare (Ashok *et al.* 2021) [2].

Rice is one of the major kharif crops of the state of Himachal Pradesh being cultivated on an area of 73.7 thousand hectare with the production and productivity of 129.9 tonnes and 17.6 q ha, respectively (Department of Economics and Statistics, 2022). Major Rice growing districts of Himachal Pradesh viz., Kangra, Mandi, Una, Sirmour and Chamba were surveyed during kharif 2010 to 2015 under Production Oriented Survey (POS) programme of All India Coordinated Rice Improvement Project (Upmanyu, 2016) [13].

The Chailchowk valley in Himachal Pradesh is known for rice cultivation due to its suitable agro-climatic conditions, including fertile soil, moderate rainfall, and temperatures conducive to rice growth. The prevalence of rice farming here is driven by its integration into local diets and farming traditions, coupled with efforts to preserve traditional rice varieties (Yumnam et al. 2017) [16]. Diseases are very important constraints for rice production. As a result an average yield loss of 25-30 per cent per annum due to diseases is a regular feature in India. Among all the diseases of rice, the most common and severe diseases are blast and sheath blight (Jha et al. 2012) [5]. Sheath blight, also known as 'oriental sheath and leaf blight' of rice caused by *Rhizoctonia solani* Kuhn [Teleomorph: *Thanatephorus cucumeris* (Frank) Donk] was first reported in Japan by Miyake (1910) as *Sclerotium irregulare* was the causal organism of the disease. Subsequently, its occurrence was recorded throughout the temperate and tropical rice growing areas including Africa, Bangladesh, Brazil, Burma, Colombia, China, Cuba, Germany, Fiji, Formosa, India, Indonesia, Iran, Korea, Liberia, Madagascar, Malaya, Malaysia, Netherland, Nigeria, Papua New Guinea, Philippines, Russia, Senegal, Sri Lanka, Surinam, Taiwan, Thailand, Trinidad, Tobago, UK, USA, Venezuela and Vietnam (Singh et al. 2016) [10]. In India, Butler (1918) first noticed the sheath blight disease, with symptoms similar to those of banded sclerotial disease of sugarcane. Later, Paracer and Chahal (1963) [8] reported the presence of this disease from Gurdaspur district in Punjab. They described the disease as sheath blight of rice caused by *Rhizoctonia solani*. *R. solani* is a soil borne necrotrophic pathogen and it survives either as sclerotia or mycelia in the debris of host plants. The sclerotia float to the surface of flooding water in the rice fields and germinate on rice sheaths forming infection cushions or appressoria during the infection process (Richa et al. 2016) [9]. The disease was named as 'Sheath blight' because of its primary infection on leaf sheath. The most critical stage for the infection to occur was at maximum tillering stage, while leaf sheath becomes discoloured at or above water level. Initially the disease appears on leaf sheath as elliptical or oval to irregular, 1-3 cm long, greenish gray spots with brown margin at or above the water line. Presence of many such spots on the leaf sheath gives the appearance of snake skin (Singh et al. 2016) [11]. The yield loss due to sheath blight ranges between 20-50 per cent depending on the severity of infection (Rao, 1995). The estimation of losses due to sheath blight of rice in India has been reported to be up to 14.3 to 39.7% yield loss to rice (Ahmad and Khan 2023) [19].

The study focuses on the biocontrol potential of *Trichoderma* spp., a promising bio-agent known for its antagonistic activity against plant pathogens. *Trichoderma* spp. offers multiple benefits, including nutrient competition, mycoparasitism, antifungal metabolite production, and plant growth promotion, making it a viable alternative to chemical fungicides. Previous research has demonstrated its efficacy in reducing disease severity and enhancing plant growth under controlled conditions, yet its large-scale application and optimization remain underexplored (Rubayet and Hossain, 2024) [20].

Materials and Methods

The materials used and techniques adopted in accomplishing the objectives of the present investigations entitled "Studies

on management of sheath blight (*Rhizoctonia solani*) disease of rice through bio-agent (*Trichoderma* spp.) are mentioned in this chapter.

Experimental Site

The research was conducted during the year 2023 cropping season at Research Farm School of Agriculture, Abhilashi, University, Chailchowk, Mandi, Himachal Pradesh. The study aimed at investigating the antagonistic effects of *Trichoderma* spp. isolates against sheath blight (*Rhizoctonia solani*) disease of rice.

Cleaning and sterilization of glasswares

The glass wares used during experiments were cleaned by overnight dipping in the water and then washed with detergent under running tap water and dried. The air dried glass wares were sterilized in hot air oven at temperature 160 °C for 2 hours. The forceps and other metallic instruments were sterilized by dipping them in ethanol and heating over the flame of spirit lamp during inoculation and purification.

Culture medium and their preparation

During the study, fungal *Trichoderma* spp. bioagents were used. For cultivation of *Trichoderma* spp. potato dextrose agar medium was used.

Composition of Potato dextrose Agar (PDA) Medium

- **Peeled Potato:** 200 g
- **Agar-agar:** 20 g
- **Dextrose:** 20 g
- **Distilled water:** 1000 ml

PDA preparation procedure

The required quantity of peeled potatoes were cut into small pieces and boiled in 500 ml of distilled water till the pieces became soft. The potato extract was filtered through muslin cloth and the filtrate was collected in the beaker. Rest of the 500 ml water was made warm and 20 g agar and 20 g dextrose was added properly by stirring through glass rod. Both solutions were mixed together in a beaker and volume was maintained up to 1000 ml by adding required amount of distilled water. 200 ml of this solution was dispensed in each conical flask of 250 ml capacity. Flasks were plugged with non-absorbent cotton plugs and wrapped with silver foil. Flasks containing medium were sterilized at 121 °C at 15 lbs pressure/inch² for 15 minutes in an autoclave. Medium was allowed to cool up to 40-45 °C before pouring into petriplates.

Collection of *Trichoderma* spp.

The samples of *Trichoderma* spp. were collected from Plant Pathology Laboratory, Abhilashi University, Chailchowk, Mandi H.P., and further used in study.

Mass multiplication of *Trichoderma* spp.

Wheat grains were used for mass multiplication of different *Trichoderma* isolates. The grains were soaked overnight in water for 12 hours and then spread on blotter paper to remove the excess water. Dextrose was added to the seeds @ 20 g/kg of seed and then 150 g of wheat grains were taken in each 250 ml conical flasks. Flasks filled with grains were plugged with non-absorbent cotton and wrapped in aluminum foil and sterilized in autoclave at 121°C

temperature at 15 lbs pressure/inch² for 15 minutes. Flasks were taken out from autoclave and were allowed to cool. After cooling, each conical flask which contained sterilized seeds were inoculated with 5 disks of *Trichoderma* isolate punched from the cork borer (5 mm). The disks were punched from the periphery of actively growing 5 days old culture of *Trichoderma* isolate. All inoculated conical flasks were incubated in a BOD at 26±2 °C. *Trichoderma* isolate were allowed to grow with periodic shaking of the flasks to ensure that the surface of all seeds were colonized with the growth of *Trichoderma* isolates properly. When all the seeds were completely covered with mycelial growth, the colonized seeds were taken out from the flasks and shade dried in clean and sterilized place. After proper drying, powder of selected *Trichoderma* isolate was prepared with the help of mixer-cum grinder.

Experimental details

- **Crop:** Rice
- **Design:** Randomized Block Design (RBD)
- **Number of treatments:** 9 + 1 (Control)
- **Replications:** 3
- **Total number of plots:** 30
- **Net plot size:** 1 m²
- **Spacing:** 20 × 15 cm
- **Variety:** PAC 807+
- **Seed rate:** 15-20 kg/ha

Treatment details

- T₁-soil application of *Trichoderma* isolate-1 @20g/m²
- T₂- soil application of *Trichoderma* isolate-2 @20g/m²
- T₃- soil application of *Trichoderma* isolate-3 @20g/m²
- T₄-soil application of *Trichoderma* isolate-4 @20g/m²
- T₅- soil application of *Trichoderma* isolate-5 @20g/ m²
- T₆- soil application of *Trichoderma* isolate-6 @20g/m²
- T₇- soil application of *Trichoderma* isolate-7 @20g/m²
- T₈-soil application of *Trichoderma* isolate-8 @20g/m²
- T₉- soil application of *Trichoderma* isolate-9 @20g/m²
- T₁₀- control

Observations

Growth Parameters

Plant growth parameters were recorded at 30, 60, and 90 days after transplanting:

Plant Height: Measurements were taken from the base to the tip of the tallest leaf, and the average height was recorded.

Disease incidence

Data on number of sheath blight (*Rhizoctonia solani*) infected plants were recorded in each pot at 60 and 90 days after transplanting. The per cent disease incidence was calculated according to the following formula given by (Teng and James, 2001; Zainudin *et al.*, 2008)^[12, 17].

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

Statistical Analysis

The data collected on disease incidence, tiller count, and plant height were analysed statistically using the OPSTAT software developed by CCSHAU, Haryana. Analysis of

variance (ANOVA) was employed to determine the significance of treatment effects.

Results and Discussion

Effect of native isolates of *Trichoderma* spp. treatment on plant growth parameters

The growth of rice plants were studied in terms of shoot length at 30, 60 and 90 days after transplanting. It is evident from the data of Table 4.1, significantly increased growth parameters were observed in field with soil application of *Trichoderma* isolates viz; *Trichoderma* isolate-1 to *Trichoderma* isolate-9, and one treatment maintained as control (T₁₀).

Effect of *Trichoderma* isolates on shoot length of rice at 30 days of transplanting (DAT)

The results presented in Table 4.1 and Figure 4.1 revealed that soil application of *Trichoderma* spp. showed statistically significant impact on rice plant height at 30 DAT. The maximum plant height 26.39 cm, was recorded in T₉ *Trichoderma* isolate-9 @ 20 g/m² followed by 23.11, 22.67 and 20.39 cm in T₇ (23.11) T₈ (22.67) and T₆ (20.39) at 30 DAT, respectively. Whereas, minimum shoot length 15.89 cm was recorded in T₂-*Trichoderma* isolate-2 @20 g/m². As compared to other treatments, average 14.00 cm shoot length was observed in untreated control at 30 days after tram planting DAT.

Effect of *Trichoderma* isolates on shoot length of rice at 60 days of transplanting (DAT)

The results presented in Table 4.1 and Figure 4.1 revealed that soil application of *Trichoderma* spp. showed statistically significant impact on rice plant height at 60 DAT. The maximum shoot length 56.67cm was rewarded in T₉ *Trichoderma* isolate-9 @20 g/m² followed by 54.90, 52.00 and 46.22 cm in T₇ (54.90), T₈ (52.00) and T₆ (46.22) at 60 DAT, respectively. Whereas, minimum shoot length 41.33 cm was recorded in T₁. As compare to other treatment, average 40.78 cm shoot length was recoded in untreated control at 60 DAT.

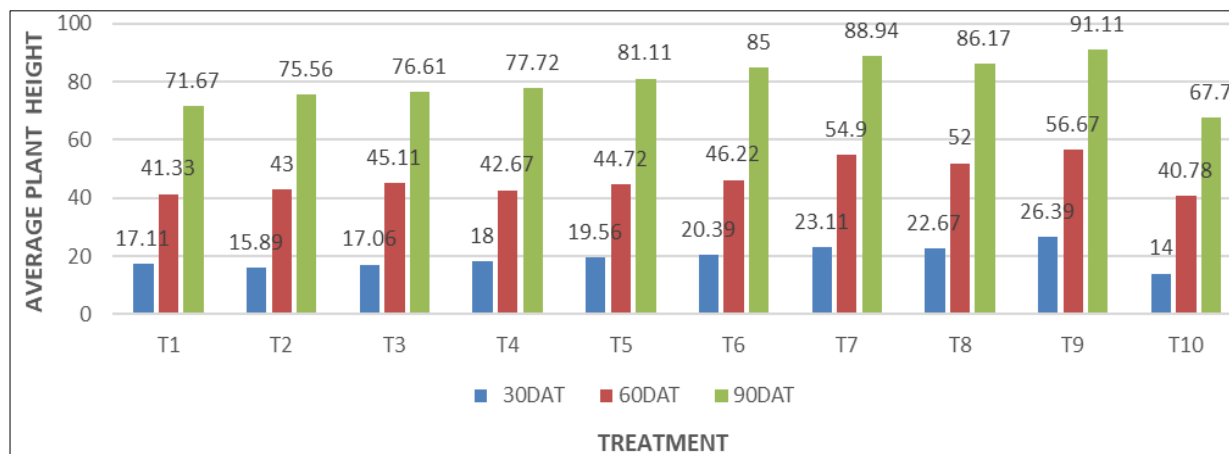
Effect of *Trichoderma* isolates on shoot length of rice at 90 days of transplanting (DAT)

The results presented in Table 4.1 and Figure 4.1 revealed that soil application of *Trichoderma* spp. showed statistically significant impact on rice plant height at 30 DAT. The maximum plant height 91.11 cm was observed in T₉ -followed by T₇ (88.94), T₈ (86.17) and T₆ (85.00) at 90 DAT, respectively. Whereas, minimum shoot length 71.67cm was recorded in T₁. As compare to other treatment, average shoot length 67.70 cm was recorded in untreated control. Similar research conducted by Kabitarani *et al.* checked the effect of *Trichoderma viride* and *T. harzianum* against sheath blight disease of rice. They observed maximum plant height (75.6 cm) in case of treatment with *Trichoderma viride* and *T. harzianum* as compared to control.

Yadav *et al.* (2024)^[15] also revealed that *Trichoderma* isolates also significantly enhanced the growth of rice plants. Plants treated with the isolates RN-10 (66.25 cm, mean of 4 varieties) and RN-1 (65.74 cm) had significantly highest plant height. Similarly, isolate RN-10 recorded maximum flag leaf length (22.65 cm), number of tillers (21.16), and root length (26.02 cm).

Table 1: Plant height at 30, 60 and 90 DAT after transplanting

Treatment	Plant Height (cm)		
	30 DAT	60 DAT	90 DAT
T ₁ - <i>Trichoderma</i> isolate @20g/m ²	17.11	41.33	71.67
T ₂ - <i>Trichoderma</i> isolate @20 g/m ²	15.89	43.00	75.56
T ₃ - <i>Trichoderma</i> isolate @20 g/m ²	17.06	45.11	76.61
T ₄ - <i>Trichoderma</i> isolate @20 g/m ²	18.00	42.67	77.72
T ₅ - <i>Trichoderma</i> isolate @20 g/m ²	19.56	44.72	81.11
T ₆ - <i>Trichoderma</i> isolate @20 g/m ²	20.39	46.22	85.00
T ₇ - <i>Trichoderma</i> isolate @20 g/m ²	23.11	54.90	88.94
T ₈ - <i>Trichoderma</i> isolate @20 g/m ²	22.67	52.00	86.17
T ₉ - <i>Trichoderma</i> isolate @20 g/m ²	26.39	56.67	91.11
T ₁₀ -Control (without treatment)	14.00	40.78	67.70
SE(m) ±	0.24	1.77	0.48
C.D. (P=0.05)	0.71	5.31	1.46

**Fig 4.1:** Plant height at 30, 60 and 90 DAT

Effect of soil application of *Trichoderma* isolates on disease incidence of Sheath blight (*R. solani*)

The results presented in Table 4.2 and Figure 4.2 revealed that soil application of *Trichoderma* spp. showed statistically significant impact on disease incidence of Sheath blight (*R. solani*) at 60 and 90 DAT.

Disease incidence at 60 DAT

The minimum disease incidence (7.74%) was recorded in T₉- *Trichoderma* isolated-9 @ 20 g/m² of soil followed by 9.32, 10.62 and 11.06% in T₇ (54.90), T₈ (52.00) and T₆ (46.22) respectively. Whereas, maximum disease incidence 16.37% was recorded in T₄. As compared to other treatments average 16.57% disease incidence was recorded in untreated control at 60 DAT.

Disease incidence at 90 DAT

Data presented Table 4.2 and Fig.4.2 revealed that minimum disease incidence 9.06% was recorded in T₉- *Trichoderma* isolated-9 @ 20 g/m² of soil followed by 11.17, 11.66 and 13.36% in T₇ (88.94), T₈ (86.17) and T₆ (85.00)

respectively. Whereas, maximum disease incidence 19.23% was recorded in T₃. As compared to other treatments average 20.08% disease incidence was recorded in untreated control at 90 DAT. Similar studies were conducted by Chaudhary *et al.* (2020) [3] revealed that among the *T. harzianum* treatments, bio-agents SVPRT-THLi06 and SVPP-8 recorded highest value of disease reduction from soil treatment + seedling root dip + foliar spray (75.1% and 69.8%) as compared to fungicide propiconazole 25EC @ 0.1% which showed disease reduction of 83.9%. Moreover, *T. atroviride* isolate (SVPRT-TVir01) showed disease reduction over disease severity (63.0%), when applied with soil treatment and foliar spray. No significant difference in disease severity was recorded between soil treatment + foliar spray and seedling root dip + foliar spray with all the treatments. However, among different treatments, maximum and significant higher disease severity (34.5%) and incidence (59.4%) were recorded with soil treatment + foliar spray of the bioagent SVPRT-TL10. Kannaiyan and Prasad (1978) [6] reported reduced disease incidence (85.87%) in *Trichoderma* treated plants and lowest in untreated plants.

Table 2: Disease incidence at 60 Days and 90 Days

Treatment	Disease Incidence (%)	
	60 DAT	90 DAT
T ₁ - <i>Trichoderma</i> isolate @20g/m ²	15.67	17.71
T ₂ - <i>Trichoderma</i> isolate @20 g/m ²	16.29	18.88
T ₃ - <i>Trichoderma</i> isolate @20 g/m ²	15.33	19.23
T ₄ - <i>Trichoderma</i> isolate @20 g/m ²	16.37	19.17
T ₅ - <i>Trichoderma</i> isolate @20 g/m ²	14.44	17.67
T ₆ - <i>Trichoderma</i> isolate @20 g/m ²	11.06	13.36
T ₇ - <i>Trichoderma</i> isolate @20 g/m ²	9.32	11.17

T ₈ - <i>Trichoderma</i> isolate @20 g/m ²	10.62	11.66
T ₉ - <i>Trichoderma</i> isolate @20 g/m ²	7.74	9.06
T ₁₀ -Control (without treatment)	16.57	20.08
SE(m) ±	1.46	0.58
C.D. (P=0.05)	3.71	1.76

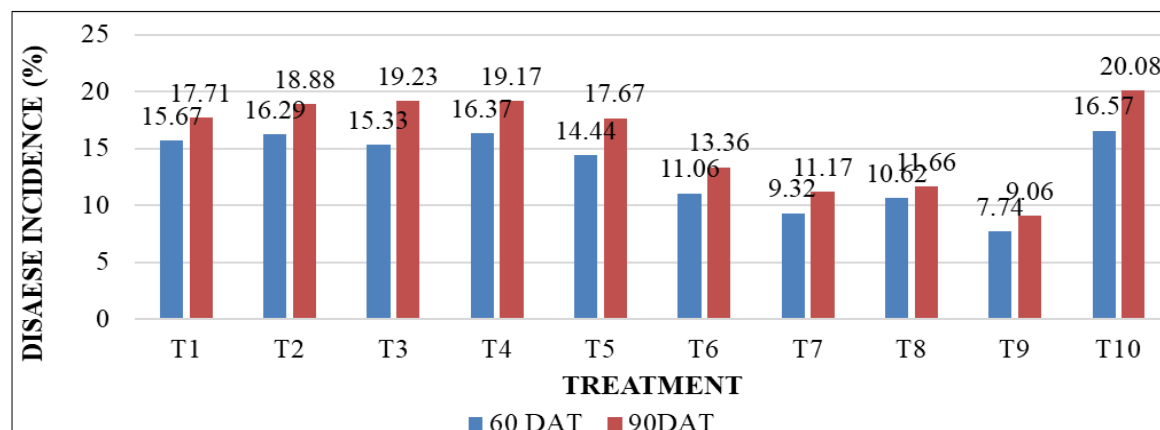


Fig 4.2: Disease incidence 60 and 90 DAT

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