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In vitro and *in vivo* evaluation against sheath blight disease of rice (*Rhizoctonia solani*) through the fungicides

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Abstract
Rice is a monocotyledonous annual grass, and belongs to the family *Poaceae*. Sheath blight of rice is one of the major limiting factors in rice production. The causal agent of disease is *Rhizoctonia solani*. Seven fungicides were tested to know their efficacy against the pathogen under *in-vitro* and *in-vivo*. Among seven fungicides Hexaconazole 5% EC at 500 ppm was found to be highly effective followed by Captan + Hexaconazole under *in-vitro* condition which inhibit the fungal mycelium up to 93.66% and 89.77% respectively. Under *in-vivo* condition the maximum disease suppression was found in Hexaconazole treated plot followed by Captan + Hexaconazole.

Keywords: Sheath blight, disease of rice, *Rhizoctonia solani*, through the fungicides

Introduction
Rice is a monocotyledonous annual grass, and belongs to the family Poaceae and the genus *Oryza*. Globally, more than 3 billion people have rice as staple food and it accounts for 50 to 80 per cent of their daily calorie intake. In India it is cultivated under varied agro-ecological situations. Globally, rice covers an area of about 166 million hectares with a production level of about 750 million tones and productivity of 4.5 tons per hectare. Globally, India ranks first in area (43 million hectares) and second in production (170 million tons) with a productivity of 3.9 tons per hectare (Pathak *et al*. 2020) [6]. Rice is the primary source of energy for over half of the world's people. Depending on the varieties it may differ in amounts of fiber, protein, vitamin B, iron and manganese. This means it can play a vital role against malnutrition. But sheath blight of rice caused by *R. solani* is one of the major limiting factors in rice production. It was first reported in Japan in 1910 and subsequently spread around the world. In India, the disease was first reported from Gurdaspur, Punjab by Paracer and Chahal (1963) [7].
R. solani is an ubiquitous soil-borne fungus. The pathogen survives in unfavorable conditions by forming sclerotia or dormant mycelia. Sclerotia in soil can survive for 2 years (Sumner, 1996) [8]. The characteristic symptoms of sheath blight disease can be observe in both nursery and transplanted crop. Early symptoms usually develop on the leaf sheaths at or just above the water level as circular to oval or ellipsoid, water- soaked spots which are greenish gray in colour. As the disease progresses, the infection spreads rapidly to upper leaf sheaths and leaf blades of the same or adjacent tillers. According to Chahal *et al.* (2003) [2] the estimation of losses due to sheath blight of rice in India has been reported up to 54.3 per cent. It has been reported that earlier recommended fungicides did not provide satisfactory disease control. In the present study the investigation was carried out to evaluate the fungicides under *in-vitro* and *in-vivo* conditions against sheath blight disease of rice.

Material and methods
In vitro evaluation of fungicides
Laboratory experiment in this study was performed in the Department of Plant Pathology, while field experiment was conducted at Krishi Nagar Farm, College of Agriculture, JNKVV Jabalpur (M.P.).
To test the *in-vitro* efficacy of fungicides *R.solani* was isolated from the infected sheath of a rice plant and cultured on Potato dextrose Agar (PDA) medium. The relative efficacy of seven fungicides *viz.* Propiconazole 13%+ Difenoconazole 13.9% SC, Propiconazole 25% EC, Tebuconazole 50% + Trifloxystrobin 25% WG, Azoxystrobin 23% SC, Captan 70% +

Hexaconazole 5% WP, Hexaconazole 5% EC and Carbendazim 12% + Mancozeb 63% were evaluate under field conditions by using Randomized block design and three replications were maintained for each treatment with plot size 9.5 m x 2.40 m. Two spray were taken, first at initiation of disease and second at the interval of 15 days after first spray. Disease severity and per cent disease suppression were recorded by using following formula:

$$\text{Disease severity} = \frac{\text{Lesion length}}{\text{Tiller length}} \text{X } 100$$

$$\text{Per cent disease control} = \frac{\text{PDI in control plot} - \text{PDI in treated plot}}{\text{PDI in control plot}} \times 100$$

Result and discussion

Evaluation of fungicides against sheath blight of rice under *in-vitro* and in-*vivo* Conditions

In-vitro evaluation of fungicides

Relative efficacy of seven fungicides checked against *R. solani* at 100 ppm, 200 ppm and 500 ppm concentrations under *in-vitro* conditions and per cent growth inhibition was calculated over control.

The radial growth of *R. solani* and per cent growth inhibition over control under *in vitro* condition depicted in table 1. The data shows that maximum mycelial growth (90 mm) was recorded in control after 96 hrs. The result revealed that the all fungicides tested under laboratory conditions exhibited the inhibition in growth and colony diameter. Maximum inhibition 79.77, 86.74, 93.66 per cent was recorded in Hexaconazole (100, 200, 500 ppm) where the colony diameter was 18.20, 11.93, 5.70 as compared to 90 mm in control, where no fungicide was added to the medium. In Captan + Hexaconazole (100, 200, 500 ppm) only 22.75, 18.38, 9.20 mm growth was recorded with 74.72, 79.57 and 89.77 per cent inhibition in the growth of fungal mycelium followed by Azoxystrobin, Propiconazole + Difenoconazole, Tebuconazole + Trifloxystrobin and Propiconazole, whereas, Carbendazim + Mancozeb found least effective among all the fungicides with the growth inhibition of 54.81, 64.16 and 77.15 per cent.

All the seven fungicides tested at different concentrations inhibit the growth of fungal mycelium among them Hexaconazole was found most effective fungicide at all the three concentrations, at 500 ppm it was found highly effective which inhibits 93.66 per cent fungal mycelial growth followed by Captan + Hexaconazole, whereas Carbendazim + Mancozeb found the least effective which shown minimum inhibition of fungal mycelium. Similar results were also reported by Sudhakar *et al*. (2005) [9] and Thamarai *et al*. (2019) [11].

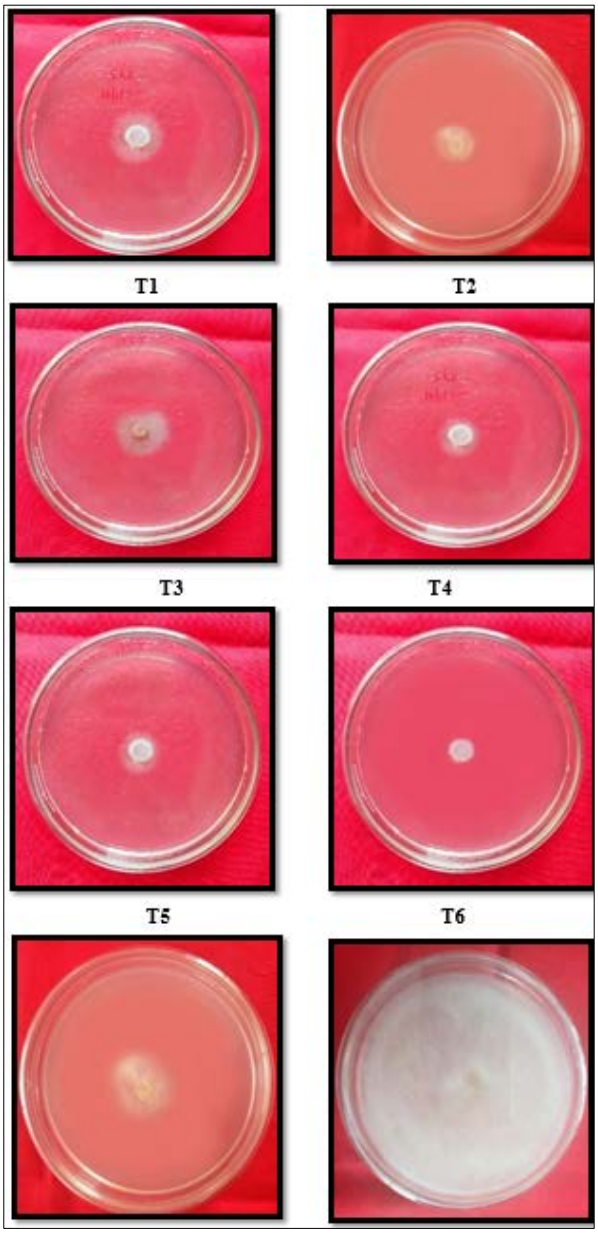

Plate 1: Efficacy of fungicides (500 ppm) on mycelial growth of *R. solani*

Table 1: Effect of fungicides on mycelial growth of *R. solani*

Treatments	Fungicides	Radial growth (mm)			Percent inhibition (%)		
		100 ppm	200 ppm	500 ppm	100 ppm	200 ppm	500 ppm
T1	Propiconazole13.9%+ Difenoconazole13.9% SC	29.46	22.20	13.70	67.26	75.33	84.77
T2	Propiconazole 25% EC	39.68	28.19	17.20	55.91	68.67	80.88
T3	Tebuconazole 50%+ Trifloxystrobin 25% WG	33.50	24.18	16.70	62.77	73.13	81.44
T4	Azoxystrobin 23% SC	25.76	20.27	9.70	71.37	77.47	89.22
T5	Captan 70% +Hexaconazole 5% WP	22.75	18.38	9.20	74.72	79.57	89.77
T6	Hexaconazole 5% EC	18.20	11.93	5.70	79.77	86.74	93.66
T7	Carbendazim12%+ Mancozeb 63% WP	40.67	32.25	20.56	54.81	64.16	77.15
T8	Control	90	90	90	0.00	0.00	0.00
	SE±m	1.210	1.379	0.710			
	CD at 5%	3.659	4.171	2.147			

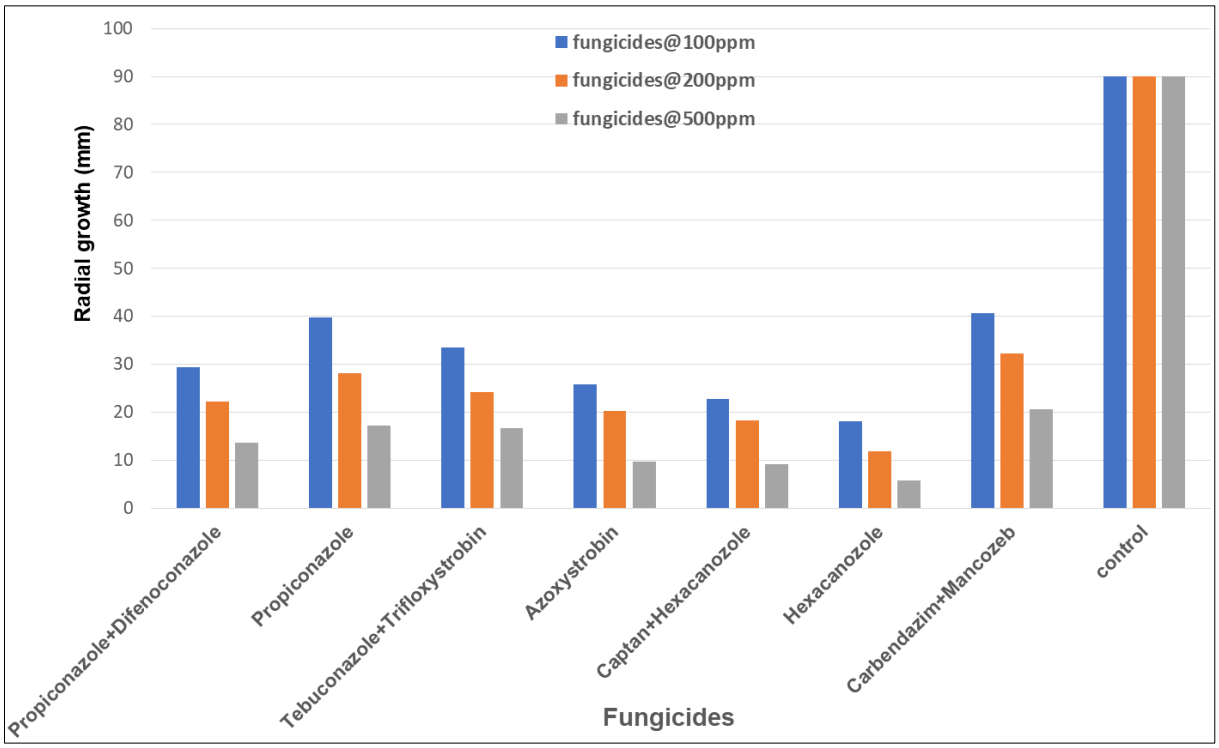

Fig 1: Effect of various fungicides on radial growth of *R. solani*

***In vivo* evaluation of fungicides**

The field experiment was conducted to evaluate the fungicides against sheath blight of rice during *Kharif* season 2021-22. Two sprays were scheduled, first spray at initiation of disease and second spray at the interval of 15 days after first spray. At pre-treatment there was no significant difference in per cent disease index among the treatment plots and it was ranged from 32.65 to 33.89.

Data on table 2, fig.2 revealed all the fungicides reduced sheath blight severity over control. The minimum disease severity was recorded in Hexaconazole (T6) treated plot and it was 28.25 and 15.92 per cent after 12 days of first and second spray respectively. Plots treated with Captan + Hexaconazole exhibits the diseases severity 31.28 and 22.82 per cent, it was followed by Azoxystrobin, Propiconazole + Difenoconazole, Tebuconazole + Trifloxystrobin and Propiconazole, whereas, Carbendazim + Mancozeb found least effective in reducing sheath blight severity and it was 32.80 and 31.42 per cent in both the spray scheduled. The maximum disease severity was recorded in control plot and it was 49.46 and 50.68 per cent.

The per cent disease suppression was also recorded after 12 days of second spray and it was found maximum (69.57%) in Hexaconazole treated plot followed by 54.97 percent in Captan + Hexaconazole treated plot and the minimum disease suppression (38%) was recorded in Carbendazim + Mancozeb treated plot.

Therefore, among all the treatments Hexaconazole 5% EC was most effective in suppressing the disease at field level.

Data revealed that after 12 days of each spray all fungicides reduced sheath blight severity over control. The per cent disease suppression over control was calculated for all the treatments and it was maximum with Hexaconazole which suppressed 69.57 per cent disease over control followed by Captan + Hexaconazole which suppressed 54.97 per cent disease and the lowest disease suppression was recorded with Carbendazim + Mancozeb. Similar findings were also reported by Dubey and Toppo (1997) [3] and Tiohuat (1997) [10], Akter *et al*. (2001) [1] and Naik *et al*. (2017) [5].

Table 2: Effect of fungicides on sheath blight of rice in field condition

Treatments	Fungicides	Per cent disease index			Disease suppression over control (%) (12 days after second spray)
		Pre-treatment	12 days after first spray	12 days after second spray	
T1	Propiconazole 13% + Difenconazole 13.9% SC	32.65	30.45	26.57	47.57
T2	Propiconazole 25% EC	33.20	32.48	30.74	39.34
T3	Tebuconazole 50% + Trifloxystrobin 25% WG	33.23	30.96	27.82	45.10
T4	Azoxystrobin 23% SC	32.80	29.60	25.45	49.78
T5	Captan 70% + Hexaconazole 5% WP	33.35	31.28	22.82	54.97
T6	Hexaconazole 5% EC	33.50	28.25	15.42	69.57
T7	Carbendazim 12% + Mancozeb 63% WP	33.89	32.90	31.42	38.0
T8	Control	32.75	49.46	50.68	0.00
	S.Em (±)	0.08	0.572	0.835	
	CD at 5%	0.23	1.753	2.556	

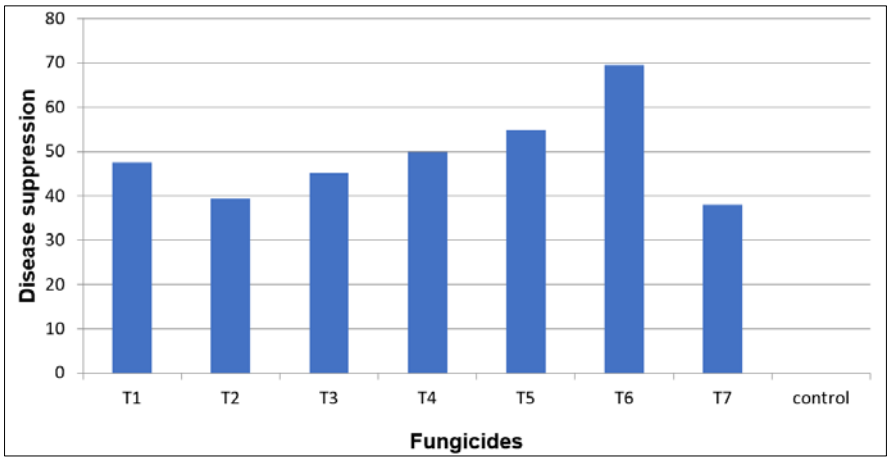

Fig 2: Per cent disease suppression over control (12 days after second spray)

Conclusion

The present investigation on evaluation of fungicides under *in-vitro* and *in-vivo* conditions revealed that Hexaconazole 5% EC was found most effective against *R. solani* which inhibit the fungal mycelium 93.66 per cent under *in-vitro* condition and suppressed the disease 69.57 per cent under field condition so it can be concluded that Hexaconazole may be used for effective management of sheath blight of rice.

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