J.Mycopathol.Res. 63(1) : 95-100, 2024, ISSN : 0971-3719 (Print), 2583-6315 (Online) 10.57023/JMycR.63.1.2025.095

Evaluation of effective chemicals for the management of sheath blight disease in rice

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Received : 07.10.2024 Accepted : 01.02.2025 Published : 31.03.2025

Sheath blight, a fungal disease caused by *Rhizoctonia solani* Kuhn has now become serious threat for rice cultivation in India. Due to non-availability of resistant varieties, chemical management is the most effective method for managing the disease till date. Therefore, a number of chemicals were evaluated for their efficacy against the sheath blight pathogen both *in vitro* and under field condition by AICRP on Rice, RRTTS, Chiplima. Out of seven chemicals tested, thifluzamide 24 SC @ 0.8 ml/l was found to be the most effective in reducing sheath blight disease severity (PDI 12.96) and increasing the yield (51.2 q/ha) followed by propineb 70% WP @ 3g/l and difenoconazole 25% EC @ 0.5 ml/l recording 20.49 and 20.99 PDI respectively. Fungicide thifluzamide was also effective *in vitro* in completely inhibiting the mycelial growth of *R.solani* at both 200 and 500 ppm. It resulted 66.8 % disease reduction and 29.6 % yield increase over control with a highest B:C ratio of 1.53 and proved to be the best among all the chemicals tested.

Keywords: Chemicals, management, Rice, Sheath blight

INTRODUCTION

Rice is the staple food for human beings in the most parts of the world. It is grown in more than hundred countries covering 158 million hectares of land and producing more than 700 million tonnes annually (FAO 2022). India is the second largest producer and consumer of rice globally. But its production is limited by several biotic and abiotic stresses. Among different biotic stresses, sheath blight disease of rice caused by *Rhizoctonia solani* Kuhn [teleomorph: *Thanatephorus cucumeris* (Frank) Donk] is recently considered as one of the most serious threats for rice production. Yield loss due to this disease may be as high as 50 percent under high humid conditions and fertility production system (Anonymous 2008). The pathogen is soil borne and has a wide host range, often infecting legumes grown in rotation with rice crop (Zou *et al*. 2000). Management of sheath blight is difficult due to its wide host range, soil borne nature of the pathogen, prolonged survival of its sclerotia and lack of resistant rice germplasms against the disease (Srinivasachary *et al.* 2011).

Till now chemical management is the most effective means of managing the disease but many chemical fungicides which were earlier recommended for the disease are now banned or have become less effective against the disease. This might be due to the fact that the pathogen has developed resistance against those chemicals due to their repeated use (Deising *et al*. 2008). Systematic evaluation of effective chemicals from time to time is essential for new recommendations against important diseases of crops so that the farmers can choose the most effective one based on efficacy and cost. So, evaluation of effective chemicals must be a continuous process. In view to this, the present experiment was conducted with an objective to evaluate some effective chemicals under laboratory and field conditions to find out the best one against the disease.

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MATERIALS AND METHODS

Evaluation of effective chemicals under field condition

Field experiments were conducted during three consecutive kharif seasons, from 2020 to 2022 at All India Coordinated Research Project on Rice, Regional Research and Technology Transfer Station, Chiplima, Sambalpur, Odisha. The list of different chemicals used in the experiment along with theiractive ingredients, formulation type and dose are presented in Table 1. The experiment was laid following randomized block design(RBD) with 3 replications. Each plot measured 15 m^2 with a planting spacing of 15 X 15 cm with bunds all around the plots. Replications were separated with a gap of 1 meter for irrigation channels. The susceptible rice variety Swarna (MTU 7029) was planted with recommended package of practices except plant protection measures. Recommended doses of NPK @ 80: 40: 40 kg/ ha was applied in the form of Urea, DAP and MOP in three split doses at basal, active tillering stage and at panicle initiation stage. For artificial inoculation of the crop, the pathogen was isolated from sheath blight infected plants and was multiplied under laboratory conditions. The pure culture of *R. solani* was multiplied on autoclaved rice culm bits (5–7 cm) medium and incubated at 25 ±2°C for 15 days. The crop was inoculated artificially at tillering stage 40days after transplanting by placing the inoculum between the tillers just above the water line. Two foliar sprays of fungicides were given at 15 days interval using 500 l of water per ha. First spray was given just after initiation of disease symptoms in the experimental plots about 15 days after inoculation. Only water was sprayed for the untreated check. Weeds were controlled by hand picking. The data on disease severity was recorded 15 days after the last spray. From each treatment, 10 hills were selected randomly, and the plants were assessed for vertical spread of the disease individually using Standard Evaluation Scale (SES 0–9 scale) (IRRI 2014). The disease severity was recorded as Percent Disease Severity (PDS) and was averaged. The Percent Disease Index was calculated by using the following formulae :

$$\text{PDI} = \frac{\text{Sum of al the numerical rating}}{\text{Number of observation x Max rating}} \times 100$$

The grain yield was recorded on plot basis and converted to kg/ ha. Per cent increase in grain yield was calculated using following formula:
AYL = [(Yp -Yu/Yu] × 100

where, Yp = Yield under protected condition and Yu = Yield under unprotected condition (Nagaraja *et al.* 2012). The data obtained were subjected to statistical analysis and were tested at 5% level of significance to interpret the treatment differences following Gomez and Gomez (1984).

In vitro evaluation of chemicals against Rhizoctonia solani

Seven chemicals were tested at different concentrations under *in vitro* condition against the sheath blight pathogen, *Rhizoctonia solani* using poisoned food technique (Vincent 1969). The culture of *Rhizoctonia solani* was isolated from the leaf sheath of diseased rice plants and incubated at 28±2 ^{0}C. The culture was maintained on Potato Dextrose Agar (PDA) medium. Stock solution of each fungicide formulation was prepared by mixing required quantity of fungicides in sterilized distilled water. Required amount of stock solution was poured in sterilized melted PDA to get a series of concentration of 100, 200 and 500 ppm of fungicides in the medium. After thorough mixing of fungicides, the poisoned PDA medium of each flask was poured in three sterilized petri plates of 90 mm diameter @ 20 ml/ plate. The petri plates poured with PDA having no fungicide served as control. After solidification, the petri plates were inoculated aseptically with 5 mm mycelia disc taken from actively growing colonies of six days old culture of *Rhizoctonia solani* at the centre on agar surface with their mycelia side down and incubated at 28±2 ^{0}C. The experiment was laid in complete randomized design with three replications for each test concentration. After 48 hours of incubation, when control plates were full of fungal growth, the radial colony growth was measured in each plate and growth inhibition of the test pathogen over control was calculated by using the standard formulae:

$$\text{Percent Growth Inhibition (PGI)} = \frac{C-T}{C} \times 100$$

Where C = Radial growth in check plate and T = Radial growth in treated plate.

RESULTS AND DISCUSSION

Efficacy of different chemicals under field condition

The effect of different chemical treatments showed consistent trends in efficacy during the three years of testing. All the seven chemicals were significantly effective in reducing sheath blight disease severity compared to control treatment. Among the treatments, two spraying with thifluzamide @ 0.8 ml/ l resulted in lowest disease severity of 14.07, 13.33 and 11.48 in terms of PDI during all the three years of experiment respectively (Table 2). In pooled data analysis, it was found that thifluzamide resulted in maximum reduction in disease severity (79%) compared to control plots where no chemical was applied and was statistically superior to all the chemicals tested. It was followed by propineb @ 3g/l which was at par with thifluzamide during the first year of experiment and was the next best treatment in three years pooled analysis recording 66.8 % disease reduction over the control plots. However, propineb was statistically at par with difenoconazole @ 0.5 ml/l during all the three years of experiment and resulted in 66 % reduction in sheath blight disease severity over control. Azoxystrobin @ 1 ml/l showed good result during second year of experiment and was statistically at par with the best treatment thifluzamide. It provided 62.8 % disease reduction over the control plot during pooled data analysis. No phytotoxicity symptoms like necrosis, epinasty, hyponasty, chlorosis, leaf tip injury, stunting or wilting was recorded within seven days of each spray of the chemicals tested during the three years of experiment and hence the chemicals may be considered as safe for use in rice crop.

Due to lack of resistant donor lines, many researchers worked on the chemical management of sheath blight disease of rice and found variable results. Naik *et al*. (2017) found hexaconazole and propiconazole both at 0.1% effective against the disease. Combination fungicides were also found effective by many workers. Kumar *et al*. (2018) and Pal and Mandal (2023) reported that (azoxystrobin+ difenoconazole) @ 1ml/l was most effective to control sheath blight disease. Shahid *et al*. (2014) and Pal *et al*. (2017)found (trifloxystrobin + tebuconazole) @ 0.4g/l as the best fungicide against the disease. The present finding is supported by the work of Surendran *et al*. (2023) who revealed that the plots treated with fungicide thifluzamide recorded lower sheath blight severity during *kharif* 2020. The present experiment was a multilocational trial designed by ICAR- IIRR, Hyderabad conducted over ten locations across the country and thifluzamide 24% SC gave good result and was found most effective against sheath blight disease in both Maruteru and Pantnagar centres as well (Anonymous 2023).

Efficacy of different chemicals in vitro

All the seven chemicals at three concentrations (viz, 100, 200 and 500 ppm) inhibited the mycelial growth of *Rhizoctonia solani* except control (Table 3). Maximum growth inhibition (100%) was observed in thifluzamide at both 200 and 500 ppm followed by propineb and difenoconazole both at 500 ppm only. Thifluzamide was significantly superior to all other treatments in inhibiting the radial growth of the fungi. However, comparatively less growth inhibition was noticed in case of tebuconazole and azoxystrobin treatments recording 97.8 % and 96.6 % growth inhibition of *Rhizoctonia solani* respectively at 500 ppm only. Several previous workers also studied the *in vitro* efficacy of different fungicides against sheath blight pathogen. Pal *et al*. (2017) found (trifloxystrobin + tebuconazole) as the best fungicide to control *Rhizoctonia solani in vitro* whereas similar result to the present study was obtained by Kumar *et al.* (2018) who reported complete inhibition of sclerotia formation of *Rhizoctonia solani* using thifluzamide 23.9 % SC at different concentrations *in vitro*.

Effect of chemical spray on yield of rice

The treatment thifluzamide @ 0.8 ml/ l resulted in maximum yield (47.6, 47.7 and 58.2 q/ha) during the three years of experiment respectively (Table 4). It provided the highest yield increase of 29.6 % over control during pooled yield data analysis with the highest BC ratio of 1.53. It was

Table 1 :. List of chemicals evaluated against *Rhizoctonia solani*

Treatment	Active ingredients	Formulation type	Dose	
			Formulation	g ai/ ha
T_1	Difenoconazole 25%	EC	0.5 ml/l	12.5
T_2	Isoprothiolane 40%	EC	1.5 ml/l	300
T_3	Kasugamycin 3%	SL	2.0 ml/l	30-50
T_4	Azoxystrobin 23%	SC	1.0 ml/l	125
T_5	Propineb 70%	WP	3.0 g/l	1050- 1400
T_6	Tebuconazole 25.9%	EC	1.5 ml/l	187.5
T_7	Thifluzamide 24%	SC	0.8 ml/l	90

Table 2: Effect of different chemicals on sheath blight disease severity of rice under field condition (*Kharif* 2020, 2021 and 2022)

Treatment No.	Treatment Details	Dose	ShBl Severity% (PDI)			Pooled PDI	Disease Control (%)
			2020	2021	2022		
T_1	Difenoconazole 25%EC	0.5 ml/l	21.11* (27.3)	21.85 (27.83)	20.00 (26.6)	20.99 (27.23)	66.0
T_2	Isoprothiolane 40% EC	1.5 ml/l	34.45 (35.9)	37.41 (37.64)	37.04 (37.5)	36.30 (37.03)	41.2
T_3	Kasugamycin 3% SL	2.0 ml/l	43.70 (41.3)	35.56 (36.57)	38.52 (38.4)	39.26 (38.77)	36.4
T_4	Azoxystrobin 23% SC	1.0 ml/l	23.70 (29.1)	18.15 (25.17)	27.04 (31.3)	22.96 (28.62)	62.8
T_5	Propineb 70% WP	3.0 g/l	19.63 (26.2)	21.11 (27.15)	20.74 (27.1)	20.49 (26.77)	66.8
T_6	Tebuconazole 25.9% EC	1.5 ml/l	22.59 (28.3)	26.67 (31.04)	26.29 (30.8)	25.18 (30.12)	59.2
T_7	Thifluzamide 24% SC	0.8 ml/l	14.07 (22.0)	13.33 (21.27)	11.48 (19.8)	12.96 (21.08)	79.0
T_8	Control (No spraying of fungicides)		63.33 (52.7)	57.78 (49.48)	64.07 (53.2)	61.73 (51.77)	-
	CD(0.05)	-	5.7	5.62	3.7	3.28	

*Figures in the parenthesis are transformed values

Table 3: Effect of different chemicals on mean mycelial growth and % growth inhibition of *Rhizoctonia solani* under *in vitro* condition

Treatment	Mean radial growth (mm)*			Growth Inhibition (%)		
	100 ppm	200 ppm	500 ppm	100 ppm	200 ppm	500 ppm
T_1	18.5	4.5	0.0	58.97	89.93	100
				(50.2) **	(71.6)	(90.0)
T_2	27.3	10.5	5.5	39.23	76.67	86.30
				(38.7)	(61.2)	(68.4)
T_3	27.5	12.0	7.5	38.90	73.23	83.37
				(38.5)	(58.8)	(66.0)
T_4	21.5	6.3	1.5	52.20	85.93	96.60
				(46.3)	(68.1)	(79.5)
T_5	18.0	3.3	0.0	60.00	92.57	100
				(50.8)	(74.3)	(90.0)
T_6	21.7	4.8	1.0	51.73	89.27	97.80
				(46.0)	(70.9)	(81.4)
T_7	12.0	0.0	0.0	73.27	100	100
				(58.9)	(90.0)	(90.0)
T_8 (Control)	45.0	45.0	45.0	0	0	0
CD (0.05)	4.54	2.30	1.36	5.94	4.11	2.93

*Average of three replications
**Figures in the parenthesis are angular transformed values.

Table 4 : Effect of different chemical fungicides on yield components of rice under field condition (*kharif* 2020, 2021 and 2022)

Treatment No.	Treatment Details	Dose	Grain Yield (q/ha)			Pooled Yield	Yield increase over control (%)	BC Ratio
			2020	2021	2022			
T_1	Difenoconazole 25%EC	0.5 ml/l	43.5	45.1	57.1	48.57	23.1	1.40
T_2	Isoprothiolane 40% EC	1.5 ml/l	37.6	40.9	51.7	43.41	10.0	1.29
T_3	Kasugamycin 3% SL	2.0 ml/l	35.3	41.6	52.7	43.22	9.5	1.21
T_4	Azoxystrobin 23% SC	1.0 ml/l	42.2	45.4	54.3	47.32	19.9	1.36
T_5	Propineb 70% WP	3.0 g/l	46.4	44.7	55.5	48.89	23.9	1.47
T_6	Tebuconazole 25.9% EC	1.5 ml/l	44.1	43.5	54.6	47.41	20.1	1.38
T_7	Thifluzamide 24% SC	0.8 ml/l	47.6	47.7	58.2	51.16	29.6	1.53
T_8	Control (No spraying of fungicides)	-	32.7	37.0	48.7	39.47	-	-
	CD(0.05)		4.2	3.6	1.57	1.93		

followed by propineb and difenoconazole recording 48.89 and 48.57 q/ha pooled yield respectively and both were statistically at par with each other.

After considering the efficacy of different treatments against sheath blight disease of rice over a period of three consecutive years, two spraying of thifluzamide 24% SC @ 0.8 ml/l at 15 days interval starting from the initiation of the disease is found best for management of sheath blight disease with highest yield potential.

ACKNOWLEDGEMENTS

The authors are grateful to the ICAR-IIRR, Hyderabad for providing the financial assistance through All India Coordinated Research Project on Rice.

DECLARATION

Conflict of interest: The authors declare no conflict of interest.

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