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A unique organic and biocontrol amendment to manage sheath blight disease of rice

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Among the important fungal diseases of rice, sheath blight isone of the important disease during the recent years and is responsible for significant yield losses.Rice growers are mainly dependent on chemical fungicides for the management of the disease. But the major problems of excessive and indiscriminate use of chemical fungicides include residue accumulation, resistance build up and toxicity to non-target microflora. Considering the importance of the disease, a study was undertaken at Regional Research and Technology Transfer Station (RRTTS), Chiplima, Sambalpur, Odisha for developing a management strategy against the disease in an organic way.The present experiment was carried out during kharif 2020 and 2021 for the management of sheath blight disease using organic amendment and biocontrol agents. It was observed that all the treatments were effective to reduce the severity of the disease. Among the different organic and biocontrol treatments tested against the disease, soil application of neem cake @ 5q/ha + soil application of mixed formulation of *Pseudomonas fluorescens* and *Trichoderma viride* @ 2.5kg/ha + spraying of mixed formulation of *P. fluorescens* and *T. viride* @ 15g/l of water thrice at 10 days interval starting from 35 days after transplanting (DAT) showed least disease severity (12.78%), highest grain yield (50.5q/ha) and maximum B:C ratio (1.58). The same organic treatment enhanced soil microbial status in respect of fungal and bacterial population which ultimately improved soil health through increased biological activity.

Keywords : Biocontrol agents, neem cake, rice, sheath blight

INTRODUCTION

Due to lack of effective resistant cultivars, rice growers are dependent on chemical fungicides, which are widely used for combating rice sheath blight pathogen (Pal *et al*. 2017). Chemical pesticides have been found to be hazardous to humans, animals, fishes, and other non-target beneficial organisms as their toxic substances and byproducts can create pollution to the environment (Wan *et al*. 2025; Pathak *et al.* 2022).

Thus, application of organic amendment and biocontrol agents for sheath blight disease management seems to be an alternative way (Nuryanto *et al*. 2023; Kannan *et al*. 2019) as it is economical, long lasting and decrease the burden of excessive and harmful use of chemical pesticides. The use of organic amendments is not only the best preventive practice for management of soil borne pathogen but also improve the soil's physical, chemical, and microbial characteristics (Naghmen *et al.* 2023). Non chemical approach,by using combined application of bio agents like *Trichoderma* and *Pseudomonas*can manage the sheath blight disease in a sustainable way (Kabdwal *et al*. 2023).

Hence, the present study was undertaken to evaluate suitable biological methods for management of sheath blight disease and to enhance the yield component and soil health status in order to achieve maximum production in rice.

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MATERIALS AND METHODS

The present field experiments were carried out during kharif, 2020 and 2021 at the research farm of RRTTS, Chiplima, Sambalpur, Odisha. The experiment was laid out in a plot size 5 m x 3 m following randomized block design (RBD) with three replications. Seven biocontrol treatments along with organic amendment, chemical treatment and an untreated control constituted a total of nine different treatments of the experiment. The details of different treatments that are used in the present experiment are as follows: T_1=Soil application of *Pseudomonas fluorescens* @ 2.5 kg/ha; T_2=Soil application of *Trichoderma viride* @ 2.5 kg/ha; T_3=Soil application of neem cake @ 5q/ha; T_4=Soil application of mixed formulation of *P. fluorescens* and *T. viride* @ 2.5kg/ha; T_5=T_1 + T_3 + three spraying of *P. fluorescens* @ 10g/l of water; T_6=T_2 + T_3 + three spraying of *T. viride* @10g/lof water; T_7=T_3+T_4 + three spraying of mixed formulation of *P. fluorescens* and *T. viride* @ 15 g/l water; T_8=Three spraying of validamycin @ 2ml/l of water; T_9=Untreated control.

The susceptible rice variety MTU 7029 was transplanted in a spacing of 15×15 cm with recommended package of practices (NPK @80:40:40 kg/ha) except plant protection measures. *Pseudomonas fluorescens*, *Trichoderma viride* and neemcake were applied at the time of final land preparation in respective treatment with their respective doses. The formulations of biocontrol agents were obtained from Multiplex Bio-Tech Pvt. Ltd., Bangaluru, India. 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) (Anonymous, 2014). The percent disease index was calculated by using the following formulae by McKinny(1923):

$$\text{Percent Disease Index (PDI)} = \frac{\text{Sum of all numerical ratings}}{\text{No.of observations} \times \text{Maxmimum rating}} \times 100$$

From each treatment 10 hills were collected randomly at the time of harvesting for recording yield attributes data like number of panicle per hill, panicle length, grain per panicle and test weight. From each plot, grain yield was calculated and converted to q/ha. Straw yield was also recorded by subtracting grain yield from total biomass yield. Net return was calculated on the basis of grain and straw yield, their prevailing market prices and cost of cultivation. Benefit cost ratio was calculated by dividing the net returns by total cost of cultivation. The data obtained were subjected to statistical analysis and were tested at five per cent level of significance to interpret the treatment differences following Gomez and Gomez (1984).

Percent yield increase in protected plots over the unprotected (control) was worked out by using the following formula given by Kumar (2020).

$$\text{Increase in grain yield (\%)} = \left[\frac{Yt-Yc}{Yc}\right] x\ 100$$

Where, Yt = yield in treated (protected) plots,Yc = yield in control (untreated) plots.

The total fungal and bacterial populations of the experimental soil were enumerated in Plant Pathology laboratory, RRTTS, Chiplima, Sambalpur, Odisha. The soil fungal and bacterial population were studied by standard serial dilution and plate count method (Vance *et al.* 1987). Rose bengal agar medium and nutrient agar medium were used to enumerate fungal and bacterial colonies respectively. Observations on soil fungal and bacterial population (CFU/g dry soil) were recorded before final land preparation (initial) and at harvesting stage.

RESULTS AND DISCUSSION

Effect on disease severity

The pooled percent disease index data presented in Table 1 revealed that all the treatments were significantly superior to control and the percent disease index varied from 8.89 to 46.11. Among the different treatment schedules tested against sheath blight of rice, the fungicidal treatment T_8 (chemical check) i.e., three spraying of validamycin @ 2ml/l of water gave the least PDI (8.89) and maximum disease control (80.7%). Among the biocontrol treatments which were taken for the study in the experiment, the best treatment was T_7 i.e., soil application of neem

Table 1 : Effect of different treatment on sheath blight disease incidence and yield components of rice (pooled of kharif, 2020 and 2021)

Treatments	Percent Disease Index (PDI)	Disease control (%)	Grain yield (q/ha)	Yield increase (%)	Straw yield (q/ha)	B:C ratio
T_1	35.37 *(36.48)	23.3	41.57	15.1	51.22	1.45
T_2	30.74 (33.64)	33.3	42.21	16.9	52.90	1.48
T_3	27.22 (31.42)	41.0	42.99	19.0	54.65	1.47
T_4	23.34 (28.85)	49.4	44.34	22.8	57.37	1.55
T_5	20.56 (26.93)	55.4	45.67	26.4	60.0	1.41
T_6	17.78 (24.92)	61.4	47.12	30.5	62.45	1.48
T_7	12.78 (20.86)	72.3	50.55	40.0	66.88	1.58
T_8	8.89 (17.34)	80.7	53.12	47.1	65.32	1.85
T_9	46.11 (42.75)	-	36.12	-	46.68	1.25
CD (0.05)	2.96	-	3.93	-	6.20	-
SEm(±)	0.98	-	1.30	-	2.05	-

*Figures in the parentheses are angular transformed values

T_1:Soil application of *Pseudomonas fluorescens* @ 2.5 kg/ha; T_2:Soil application of *Trichoderma viride* @ 2.5 kg/ha; T_3:Soil application of neem cake @ 5q/ha; T_4:Soil application of mixed formulation of *P. fluorescens* and *T. viride* @ 2.5kg/ha; T_5:T_1 + T_3 + three spraying of *P. fluorescens* @ 10g/l of water; T_6:T_2+T_3+three spraying of *T. viride* @10g/lof water; T_7:T_3+T_4+three spraying of mixed formulation of *P. fluorescens* and *T. viride* @ 15 g/l water; T_8:Three spraying of validamycin @ 2ml/l of water; T_9: Control.

cake @ 5q/ha + soil application of mixed formulation of *P. fluorescens* and *T. viride* @ 2.5kg/ha + three spraying of mixed formulation of *P. fluorescens* and *T. viride* @ 15g/l of water and recorded least PDI (12.78) and highest percentage disease control (72.3%).

Application of *P. fluorescens* on seed and soil level for control of *Rhizoctonia solani* through induced systemic resistance (ISR) in rice plant has been reported earlier.. *Trichoderma* sp is also found to be very effective antagonist against rice sheath blight pathogen (Pal *et al*. 2015; Naeimi *et al*. 2010; Doni *et al.* 2023). Seed treatment, soil drenching and three foliar sprays with the combination of *T. harzianum*, *P. fluorescens* and herbal kunapjala was found very effective in reducing the sheath blight disease severity and increasing rice grain yield (Kabdwal *et al.* 2023). Similar type of observation is also recorded by Mishra *et al*.(2009) who found that application of Neem cake + *T. harzianum* was most effective in reducing the sheath blight disease incidence by up to 57.27% and disease severity by 54.77%. Pant and Mukhopadhyay (2001) reported that the genus *Pseudomonas* and *Trichoderma* were very important potential antagonistic microorganisms to reduce plant diseases caused by fungal pathogens.

Effect on grain yield

Pooled analysis of two-year grain yield data (Table 1) revealed that all the treatments were effective in increasing grain yield over control. Among the organic treatment schedule in the experiment, the

Table 2: Effect of different treatment on yield attributes of rice (pooled of kharif, 2020 and 2021)

Treatments	Plant height (cm)	No. of panicle/hill	Panicle length (cm)	Grain/panicle	1000 grain weight (g)
T_1	102.3	7.25	23.18	172.02	19.67
T_2	104.8	7.88	24.17	178.05	19.85
T_3	104.0	7.57	23.90	175.07	19.15
T_4	106.1	8.55	24.65	182.03	20.70
T_5	107.6	8.42	24.42	187.35	20.37
T_6	108.5	8.62	24.85	192.67	20.57
T_7	111.1	9.25	25.27	204.92	22.37
T_8	105.4	8.43	24.80	193.78	21.70
T_9	97.8	6.71	20.97	167.82	18.27
CD (0.05)	N.S	1.07	1.50	11.96	1.72
SEm(±)	2.40	0.36	0.50	3.96	0.57

T_1:Soil application of *Pseudomonas fluorescens* @ 2.5 kg/ha; T_2:Soil application of *Trichoderma viride* @ 2.5 kg/ha; T_3:Soil application of neem cake @ 5q/ha; T_4:Soil application of mixed formulation of *P. fluorescens* and *T. viride* @ 2.5kg/ha; T_5:T_1 + T_3 + three spraying of *P. fluorescens* @ 10g/l of water; T_6:T_2+T_3+three spraying of *T. viride* @10g/lof water; T_7:T_3+T_4+three spraying of mixed formulation of *P. fluorescens* and *T. viride* @ 15 g/l water; T_8:Three spraying of validamycin @ 2ml/l of water; T_9: Control.

Table 3. Effect of different treatment on soil microbial population of rice (pooled of kharif, 2020 and 2021)

Treatments	Fungal population ($\times 10^3$ CFU/g dry soil)		Bacterial population ($\times 10^4$ CFU/g/dry soil)	
	Initial	Harvesting stage	Initial	Harvesting stage
T_1	4.67 (0.66)*	22.33 (1.35)	15.0 (1.18)	43.0 (1.63)
T_2	5.83 (0.76)	23.0 (1.36)	15.83 (1.20)	42.0 (1.62)
T_3	6.33 (0.80)	23.67 (1.37)	16.33 (1.21)	43.83 (1.64)
T_4	5.5 (0.74)	24.0 (1.38)	15.5 (1.19)	44.17 (1.64)
T_5	5.5 (0.73)	26.0 (1.41)	15.67 (1.19)	46.83 (1.67)
T_6	5.17 (0.71)	27.0 (1.43)	15.67 (1.18)	45.67 (1.66)
T_7	6.17 (0.79)	29.33 (1.46)	16.17 (1.21)	49.67 (1.70)
T_8	7.17 (0.85)	18.67 (1.26)	17.0 (1.23)	38.83 (1.59)
T_9	6.0 (0.77)	18.0 (1.25)	16.0 (1.20)	38.17 (1.58)
CD (0.05)	NS	0.13	NS	0.06
SEm(±)	0.05	0.04	0.02	0.02

*Figures in parentheses are log transformed values, N.S= Non significant

T_1:Soil application of *Pseudomonas fluorescens* @ 2.5 kg/ha; T_2:Soil application of *Trichoderma viride* @ 2.5 kg/ha; T_3:Soil application of neem cake @ 5q/ha; T_4:Soil application of mixed formulation of *P. fluorescens* and *T. viride* @ 2.5kg/ha; T_5:T_1 + T_3 + three spraying of *P. fluorescens* @ 10g/l of water; T_6:T_2+T_3+three spraying of *T. viride* @10g/lof water; T_7:T_3+T_4+three spraying of mixed formulation of *P. fluorescens* and *T. viride* @ 15 g/l water; T_8:Three spraying of validamycin @ 2ml/l of water; T_9: Control.

highest grain yield (50.55q/ha) was recorded by T_7 treatment i.e., soil application of neem cake @ 5q/ha + Soil application of mixed formulation of *P. fluorescens* and *T. viride* @ 2.5kg/ha + three spraying of mixed formulation of *P. fluorescens* and *T. viride* @ 15g/l of water which was statistically at par with T_8 i.e., fungicidal check plot. The treatment T_7 gave 40.0% increase in grain yield over control and a maximum straw yield (66.88q/ha) was also recorded by T_7 treatment. Among the organic treatments taken in the experiment, highest B:C ratio (1.58) was obtained by the same treatment (T_7).

Chakrabarti *et al*. (2018) also reported highest rice grain yield by application of *P. fluorescens* and *T. viride* @ 2.5 kg/ha. The present results are in agreement with Mathivanan *et al.* (2005) who reported that combined application of *T. viride* and *P. flourescens* was most effective in reducing rice sheath blight diseaseand also increased number of productive tillerswith higher straw and grain yields. A number of previous scientists (Kumar *et al.* 2012; Singh *et al*. 2013) also observed that application of combination of two or more biocontrol agents was more effective in reducing sheath blight disease as compared to single method of application.

Effect on yield attributes

Effect of different treatments on plant height, no. of panicle per hill, panicle length, grain per panicle and 1000-grain weight were studied for two consecutive years and pooled data is presented in Table 2. There was no significant difference in plant height in all the treatments. The maximum plant height (111.1cm) was recorded by T_7 treatment. The lowest plant height (97.8cm) was recorded in control plots (T_9). Maximum number of panicles/hill (9.25) was recorded in treatment T_7. The lowest number of panicles/hill (6.71) was recorded in control plots (T_9) where no biocontrol input was given to crop. Panicle length (cm) of rice was influenced due to application of different biocontrol inputs to the crops. The highest panicle length (25.27cm) was observed by T_7 treatment which was at par with fungicide treated check plot. Significantly lowest panicle length (20.97cm) was observed in control plots (T_9). The highest grain per panicle (204.92) was recorded in T_7 treatment i.e., soil application of neem cake @ 5q/ha + soil application of mixed formulation of *P. fluorescens* and *T. viride* @ 2.5kg/ha + three spraying of mixed formulation of *P. fluorescens* and *T. viride* @ 15g/l of water which was at par with fungicide treated check plots. The lowest grain per panicle was noticed by the control plot (T_9 treatment).

The mean 1000-grain weight (g) data (Table 2) was found to be influenced by the application of different organic inputs to the crops. The highest 1000-grain weight of rice (22.37 g) was recorded in treatment T_7which was at par with fungicide treated plots. Minimum 1000-grain weight (18.27 g) was found in control plot (T_9) where none of the biocontrol inputs was given to crop.

Mishra *et al.* (2009) reported that maximum increase in grain yield (39.44%) and 1000–grain weight (26.37%) of rice was observed with the treatment neem cake + *T. harzianum*. The present experimental findings were also supported by the findings of Mohandas *et al.* (2008) who observed that continuous supply of nutrients through enriched organics produced higher tiller, increased panicle length and filled grain of rice. Prasad and Reddi (2011) reported that the bio-agents not only effectively manage the disease under field condition but also improve plant growth characters and thus better alternative to chemical pesticides application. Though chemical fungicides control the disease incidence, they do not improve plant growth to that extent. However, introduction of biocontrol agents enhanced plant growth while also having potential to significantly increase the grain yield. Besides, bioagents produce different metabolites and antibiotics that enhance plant growth directly or indirectly.

Effect on soil microbial population

Soil microbial population (fungal and bacterial) of rice were studied in two stages i.e., before final land preparation, and at harvesting stage and presented in Table 3. Two years pooled data revealed that maximum fungal population was found at harvesting stage (29.33×10^3 CFU/g dry soil) in T_7 treatment. But initial population i.e., before application of any treatments fungal population among different treatments was non-significant.

In case of bacterial population also, initial population i.e., before application of any treatments the data did not differ significantly. The lowest bacterial population was found in control plots. Maximum bacterial population i.e., 49.67×10^4 CFU/g dry soil at harvesting stage was found in treatment T_7 i.e., soil application of neem cake @ 5q/ha + soil application of mixed formulation of *P. fluorescens* and *T. viride* @ 2.5 kg/ha + three spraying of mixed formulation of *P. fluorescens* and *T. viride* @ 15g/l of water.

Similar findings have been reported by Sarkar *et al*. (2021) where the dual inoculation of *Trichoderma sp.* and *P. fluorescens* had a positive impact on root length, as it increased the microbial activity in the soil. The addition of organic inputs can result in favorable microbial activity, increased soil microbial biomass, including the total bacterial population because of the proper supply of organic carbon and better physical qualities of the soil.

Indiscriminate use of chemicals for the management of plant diseases has caused huge health hazards in animals and humans due to residual toxicity and hamper the ecological balance of the cropping system. Many pathogenic microorganisms have developed resistance against chemical pesticides. Considering the deleterious effects of chemical pesticides, there is an urgent need of alternative methods for the management of plant diseases.

So, considering the overall observation of the organic and biocontrol treatments, soil application of neem cake @ 5q/ha + soil application of mixed formulation of *P. fluorescens* and *T. viride* @ 2.5kg/ha + three spraying of mixed formulation of *P. fluorescens* and *T. viride* @ 15g/l of water at 10 days interval starting from 35DAT may be recommended for better management of sheath blight disease of rice, obtaining higher yield of rice crop and also for improving the biological activity of soil.

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