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Evaluation of Consortium of Fungal and Bacterial Bio-control agents for Management of Rice Sheath Blight caused by *Rhizoctonia solani*

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ABSTRACT: Rice is one of the most important and staple food crop of world. India occupies an important place in the world and shares about 21% of global rice production. In spite of all the efforts of breeding for disease resistance, this crop is found prone to many diseases caused by fungi, bacteria, viruses, and nematodes have been reported out of them Sheath blight of rice caused by *Rhizoctonia solani* causes heavy losses ranges between 4-50%. To overcome the problem different management strategies are applied. Due to the side effects of chemical pesticides, sustainable crop production through eco-friendly management is essentially required in the current scenario. In biological control, genus *Trichoderma* and *Pseudomonas* serves as one of the best bioagents, which is found to be effective against a wide range of soil-borne, the present investigation has carried out to study the combining effect of fungal and bacterial biocontrol agents' consortia as well as chemicals for reduction of rice sheath blight. Current study reveals that consortium is almost effective as carbendazim in sheath blight disease reduction as well as it promotes plant growth.

Keywords: Rice, Consortium, Sheath Blight, bioagents

INTRODUCTION

Rice (*Oryza sativa*) belongs to the genus *Oryza* (Family: Poaceae) which includes two cultivated and more than 25 wild species. Rice (*Oryza sativa* L.) is one of the most important cereal crops for 70% of the world population. Over 90% of world's rice is produced and consumed in the Asian region (Yadav and Singh 2006). India is the second largest producer and consumer of rice in the world and India shares around 21 per cent of global rice production from about 28 per cent of rice area. The area under rice cultivation in India accounts for 437.89 lakh hectare with an average production 112.91 MT and productivity of 2578 kg ha^{-1} (Department of Agriculture, Cooperation & Farmers Welfare 2017-18). In Uttarakhand, the annual rice production is around 5.5 lakh tonnes from an area of about 2.80 lakh hectares. Rice is cultivated in all the 13 districts of the Uttarakhand. Among the 13 districts, Udham Singh Nagar has maximum area (33%) and production about 48% of the total rice produced annually in the state (Rice knowledge Management Portal, D. R. R, 2013).

Diseases are the major factors for reduction in crop yield of rice, among them sheath blight disease is major concern and it causes considerable losses in rice field. The estimation of losses due to sheath blight of rice in India has been reported to be up to 54.3% (Chahal *et al.*, 2003). However, the yield losses ranging from 4-50% have been reported depending on the crop stage at the time of infection, severity of the disease and environmental conditions (Singh *et al.* 2004; Zheng *et al.* 2013; Bhukal *et al.* 2015). Richa *et al.* (2016) also reported that up to 50% of rice yield reduction was done by the sheath blight pathogen during favourable environmental condition. Different management strategies are applied for reduction of the sheath blight disease and among all strategies chemical control still performs better in disease reduction, but chemical control of sheath blight is expensive and non-sustainable. In the absence of suitable and effective management through chemicals, bio control agents may be exploited for the management of rice sheath blight. Disease management through eco-friendly fungal and bacterial antagonists are the need of today. In the present study, two bio control agents fungal and bacterial namely, *Trichoderma* spp. and *Pseudomonas* spp. which were earlier proved to be very effective to manage the disease in different parts of the country, were tested under field condition as soil and seed treatment with foliar spray and simultaneously compared with the effective chemicals to manage sheath blight disease.

MATERIAL AND METHODS

To find out the effectiveness of consortium of biocontrol agents against sheath blight of rice, this experiment was conducted at Crop Research Centre (NEB-CRC) of G.B. Pant University of Agriculture and Technology, Pantnagar during 2019-2020. In this experiments, susceptible rice variety against sheath blight of rice Pant Dhan 4 was sown in randomized

block design (RBD) with eleven treatments and three replications**.** The crop was raised in plots of 3 × 2 m^2 area, keeping row to row and plant-to-plant distance of 30 cm × 10 cm.

The field experiment was conducted to evaluate the effect of four potential biocontrol agents in single and in consortium along with one standard check PBAT3 and one fungicide carbendazim in field condition. Formulation of *Trichoderma asperellum* and *Pseudomonas fluorescence* were applied in field in single and in consortium to study the effect of potential fungal and bacterial antagonist against the sheath blight disease of rice. The Field experiment was conducted with following treatments to test the efficacy of these treatments against rice sheath blight.

Treatments	
T1	Th-17 + Psf-173
T2	Th-17+ Psf-2
T3	Th-17 + Th-14
T4	Th-14+ Psf-2
T5	Th-17 (Positive control)
T6	Th-14 (Positive control)
T7	Psf-2 (Positive control)
T8	Psf-173 (Positive control)
T9	PBAT-3 (Standard check)
T10	Carbendazim (Chemical check)
T11	Control (Negative control)

Mode of application of biocontrol agent isolates in single and in consortium was applied according to treatment in field. The different mode of application was: 1) Seed treatment with biocontrol agents in single and in consortium was done by mixing 10gm of biocontrol agents in 1kg of seeds before 24 hours of seed sowing 2) soil was treated with the biocontrol agents
@10gm were mixed with vermicompost @100gm applied in each plot before15 days of transplanting soil, 3) In Seedling dip method the freshly uprooted seedlings were dipped in biocontrol agent suspension @ 10gm in 1 litre of water before 20-30 minutes of transplanting. 4) Foliar spray of biocontrol agents was done at three times; first spray of biocontrol agent was done at 30 days after sowing; the 2nd and 3rd spray was done at 45 days of interval.

In context to treated seeds with biocontrol agent in field conditions observation was recorded in term of both growth promotion and disease reduction. The disease severity and disease reduction percentage, increase in Plant vigor and Yield were recorded in field condition at 90-120 days after sowing.

The disease severity and disease reduction percentage were measured by given formula:

$$\text{Disease severity} = \frac{\text{Lesion height}}{\text{Total plant height}} \times 100$$

$$\text{Disease reduction } \% = \frac{\text{Disease severity in control} - \text{Disease severity in treatment}}{\text{Disease severity in control}} \times 100$$

The statistical study of field experiment data was examined by RBD (randomized block design) with the help of OPSTAT software. The data found by OPSTAT were compared by means of critical difference at 5% level of significance.

RESULT AND DISCUSSION

The present investigations were carried out on sheath blight disease of rice to test the effect of fungal and bacterial biocontrol agent formulations against sheath blight in rice, the experiment was conducted under field conditions at Crop Research Centre (CRC), Pantnagar. To test these biocontrol agents formulations, randomly block design RBD) was implemented in field condition on the area of 6 square meter (Plate 1). Total number of 11 treatments and each treatment having 3 replications were used in RBD. The rice variety Pant Dhan 4 which was suceptible for the disease was used to know the effect of consortium of biocontrol agents on disease reduction and plant growth promotion.

In recent years, similar attempts were also made to use a consortium of biological control of plant pathogens by Chakrabarti *et al*. (2018); Mishra *et al*. (2011); Singh *et. al.* (2010).

Rice Nursery View at Crop Research Centre, Pantnagar

Transplanted Rice in field

Root Dip Treatment of Rice Seedlings

Foliar spray of bioagent

Plate 1: View of Field Experiment.

Effect of biocontrol agents consortia on rice plant vigour. As these natural antagonist helps in disease management as well as plant growth promotion. The observation of the field experiment shows that the different biocontrol agents of fungal and bacterial isolates were effective in increasing number of tillers per plant and plant height.As the result shows that among all the treatments, biocontrol agents which were used in combination/consortia were more effective than the control and carbendazim. The experiment showed that the height of plant after 90 days of transplanting were maximum in case of consortia of PBAT3 (63.20cm), followed by Th17 + Psf173 (63.06cm), Th17 + Psf2 (63.00cm) and Th14 + Psf2 (61.95cm) which were significantly better than carbendazim (59.80cm) and control (57.94cm) (Table 1). Maximum number of tillers per plant after 90 days of transplanting was observed in the treatment of PBAT3 (18.66 tillers/hill), followed by Th17 + Psf173 (17.66 tillers/hill), Th17 + Psf2 (16.86 tillers/hill) and Th14 + Psf2 (16.86 tillers/hill) which were better than carbendazim (15.33 tillers/hill) and control (14.66 tillers/hill) (Table 1). Roy *et al.* (2015) also conducted a field experiment to assess the integrated management of *M. phaseolina* by application of three bioagents through seed treatment or soil application either single or in consortium with seed treating fungicide and found the similar results in context to increase in yield and reduction of disaese.

Effect of biocontrol agents consortia on yield parameter of rice plant. Sheath blight is important disease as it reduces the yield of rice and also affects the quality of the grain. The experiment was conducted to know the effect of consortium of biocontrol agents on yield parameters. The observations showed in the (Table 2), the maximum yield per hactare was found in the PBAT3 (53.83q/ha), followed by Th17 + Psf173 (53.50q/ha), Th17 + Psf2 (53.33q/ha) and Th14 + Psf2 (53.33q/ha) which were significantly better than the carbendazim (50.00q/hac) and control (41q/hac)**.** Biocontrol agents were also helpful for increasing test weight of the grain (1000grain weight). In the field experiment, data has been taken on test weight of grain and the maximum test weight was found in consortium of PBAT3 (28.51g), followed by Th17 + Psf173 (28.50g), Th17 + Psf2 (28.41g) and Th14 + Psf2 (28.29) which were significantly superior than the carbendazim (25.93g) and control (21.41g) (Table 2). The results of the consortium of biocontrol agents showed better performance over control and carbendazim.

Table 1: Effect of consortium of fungal and bacterial bioagents on rice plant vigour in field condition.

Treatment	Plant height (90 DAT) (cm)	Tillers/hill (90 DAT) (no.)
Th17 + Psf173	63.06	17.66
Th17 + Psf2	63.00	16.86
Th17 + Th14	61.33	15.66
Th14 + Psf2	61.95	16.86
Th-17	61.44	15.33
Th-14	60.73	16.33
Psf-2	60.86	16.33
Psf-173	60.01	15.66
PBAT-3	63.20	18.66
Carbendazim	59.80	15.33
Control	57.94	14.66
C.D.	1.29	2.10
C.V.	1.23	7.55

Table 2: Effect of consortium of fungal and bacterial bioagents on rice plant yield in field condition.

Treatment	Yield			
	Yield / plot (6 m^2) (kg)	Yield (q/ha)	Increase in yield (%)	Test wt (g) (1000 no)
Th17 + Psf173	3.21	53.50	30.48	28.50
Th17 + Psf2	3.20	53.33	30.07	28.41
Th17 + Th14	3.10	51.66	26.00	28.18
Th14 + Psf2	3.20	53.33	30.07	28.29
Th-17	3.03	50.50	23.17	27.80
Th-14	3.03	50.50	23.17	28.03
Psf-2	3.10	51.66	26.00	27.35
Psf-173	3.11	51.83	26.41	28.13
PBAT-3	3.23	53.83	31.29	28.51
Carbendazim	3.00	50.00	21.95	25.93
Control	2.46	41.00		21.41
C.D.	0.15			1.14
C.V.	2.90			2.44

This result is close confirmity with Khan and Sinha, (2007). The optimum dose of the bioagent was found to enhance the qualitative parameters such as number of tillers, plant hieght and grain yield reported by Doni *et al.* (2014); Khan and Sinha (2007); (Mathivanan *et al.* (2005).

Effect of biocontrol agents consortia in single or in combination on disease severity and disease reduction percentage of rice plant. During the rice season the disease sheath blight was the major problem in rice field (Plate 1). The effect of the fungal and bacterial biocontrol agents on disease reduction percentage and disease severity percentage is showed in Table 3. The minimum disease severity percentage was recorded in the fungicide carbendazim (30.30%), followed by the consortium of PBAT3 (30.58%), Th17 + Psf173 (31.00%) and Th17 + Psf2 (31.29%) and Th14 + Psf2 (32.95%) which were significantly better than control (37.30%). The result of the disease reduction percentage was maximum in the fungicide carbendazim (18.76%), followed by the consortium of PBAT3 (18.00%), Th17 + Psf173 (16.89%), Th17 + Psf2 (16.11%) and Th14 + Psf2 (11.66). However, all the treatments were found superior as compared to control. The result showed that the fungal or bacterial isolates used in consortium or in alone were found as effective as carbendazim. Singh *et al*. (2010); Chakrabarti *et al*. (2018); Mathivanan *et al.* (2006) have also observed the similar finding earlier.

Table 3: Effect of consortium of fungal and bacterial biocontrol agents on sheath blight disease severity and disease reduction percentage in field condition.

Treatment	Disease severity (%)	Disease reduction percentage (%)
Th17 + Psf173	31.00	16.89
Th17 + Psf2	31.29	16.11
Th17 + Th14	34.17	8.39
Th14 + Psf2	32.95	11.66
Th-17	34.69	6.99
Th-14	34.78	6.75
Psf-2	33.57	10.00
Psf-173	33.61	9.89
PBAT-3	30.58	18.00
Carbendazim	30.30	18.76
Control	37.30	
C.D.	1.33	
C.V.	2.35	

CONCLUSION

The intensive investigation of field studies using potential fungal and bacterial biocontrol agents revealed that performance of consortia of (*Trichoderma asperellum*) + (*Pseudomonas fluorescence*) is better over using single isolate of biocontrol agent. Further, the studies also revealed that when the results were compared with the fungicide carbendazim which is being used by the farmers for the control of sheath blight, Consortium of biocontrol agents gave better performance in regard of plant vigour and yield or they were significantly at par with each other.

The experiment concluded that soil application, seed treatment, foliar spray, seedling dip all were effective in field condition. Application of the biocontrol agents by these methods proved that the maximum plant growth promotion and minimum disease severity percentage was observed in consortium. Therefore, it can be recommended that the use of potential consortia of biocontrol agents against sheath blight can be practiced at farmer's field successfully. It is very important that the use of biocontrol agents is only successful when the product is having viable counts of spores as per recommendation and application methods are followed properly. Further, future studies can be taken up for the use of consortium of more than two isolates of fungal and bacterial biocontrol agents.

Conflict of Interest. None.

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