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Biological and chemical management of sheath rot disease in rice (*Oryza sativa* L.)

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Abstract
The biocontrol agents and fungicides were evaluated in the field, against sheath rot disease of rice in kharif 2022 at RRS, Moncompu. Management of disease before panicle emergence is very much essential. Prophylactic application of talc-based formulation of *Bacillus* sp. B15, *Bacillus* sp. B17, *Bacillus* sp. B33, *Bacillus* sp., B42 B 15+ B 17+ B 33+ B 42 consortium and *Pseudomonas fluorescens* (PN026) as seed treatment (10g kg^{-1}) + soil application (1kg/acre) + foliar spray (20g L^{-1} of water at booting) for the management of sheath rot disease of rice and thereby improving the yield. Among all the bioagent treatments, the application of B 15+ B 17+ B 33+ B 42 consortium shows more efficacy for the management of sheath rot disease of rice and improving the yield.
Four commercial fungicides *viz.*, Copper hydroxide 77 WP @ 2 g L^{-1}, Trifloxystrobin 25%+Tebuconazole 50% 75 WG @ 0.4 g L^{-1}, Propineb 50 WP @ 2.5 g L^{-1} and Hexaconazole 5 EC@2 ml L^{-1} were given as foliar spraying at booting stage. Among the all the fungicides tested in the field, Trifloxystrobin 25%+Tebuconazole 50% 75 WG @ 0.4 g L^{-1} and Hexaconazole 5 EC@ 2 ml L^{-1} applied as foliar spraying were found significantly superior in reducing the disease and increasing the yield followed by Propineb 50 WP @ 2.5 g L^{-1} and Copper hydroxide 77 WP @ 2 g L^{-1}. Benefit cost ratio is also more in case of B 15+ B 17+ B 33+ B 42 consortium and Trifloxystrobin 25%+Tebuconazole 50% 75 WG @ 0.4 g L^{-1}.

Keywords: Sheath rot pathogen, chemical management, biological management, crop yield

Introduction
Rice (*Oryza sativa* L.), a cereal grain is the most widely consumed staple food that belongs to genus *Oryza* of family *Gramineae*. Among the different cultivars of rice *viz*. Asian rice (*Oryza sativa*). African rice (*Qryza glabherima*) and wild rice (*Zizania* sp.), Asian rice is widely known with its sub species Indica being more popular in India. Owing to its major role as global staple food, rice is grown in more than hundred countries with an approximate annual production of 700 million tons. Even though, efforts have been made for intensifying agricultural production through high yielding varieties and adequate production inputs, there is a sharp decline in cereal yields (Ray *et al.*, 2013) [2] in recent years. The rising demand of rice due to population growth and urbanization highlight the need for intensifying the production in future.
Many countries have cut down the use of fungicides & pesticides due to higher price and resistant pathogenic fungal strains (Rahman 2013) [1]. Use of chemical pesticides is the most common practice followed for plant protection. However, application of fungicides for disease management is neither economical nor environmentally safe and there is the possibility of development of enhanced pathogen population which are resistant to fungicides. Hence, farmers prefer integrated strategies for management of the diseases. In recent days, the heterotrophic rhizobacteria *Pseudomonas* spp. has been practically used as seed inoculants for biological control of several plant pathogens. *P. fluorescens* strains useful for controlling sheath rot (Sh-R) of rice (*Oryza sativa* L.).

Materials and Methods
Methods of application of biocontrol agents are
A. Seed treatment with Pseudomonas fluorescens and Bacillus spp.
The seeds of the variety Uma were treated with *P. fluorescens* and *Bacillus* separately. Wet seed treatment was done with liquid formulation of the biocontrol agents at the rate of 10g kg^{-1} seed. Ten grams formulation of *P. fluorescens* and *Bacillus* was mixed separately with one liter of water and one kg seed was soaked in it for 12 hours.

Then drained and kept for germination in gunny bags. For control plots seeds were soaked in water alone. Water was sprinkled over the gunny bags thrice a day. Sprouted seeds were sown in the nursery field on third day. The 25 days old seedlings were transplanted into the main field at a spacing of 15 x 15 cm. The crop was raised at RRS Moncompu, as per the package of practices recommendation of Kerala Agricultural University.

B. Soil application of *Pseudomonas fluorescens* and *Bacillus* spp.

The soil application of *P. fluorescens* was done at 35 days after planting (DAP) at the rate of 1kg/acre. The required quantity of formulation for 10 m^2 was taken and mixed with one kg of cow dung and then broadcasted in the field.

C. Foliar spray of *Pseudomonas fluorescens* and *Bacillus* sp.

The bio control agents *viz*., *Pseudomonas fluorescens* and *Bacillus* spp. were applied as foliar spray (20g L^{-1} of water) at booting stage.

Preparation of Fungicide Solution:

Required quantity of fungicidal solution for foliar spray of each fungicide under the study were prepared on the basis of active ingredient available in the formulation. The fungicidal solution was prepared by using following formula.

$$\text{Quantity of fungicide required (ml or per lit)} = \frac{\text{Conc.of fungicide in per cent} \times \text{Quantity of spray vol.}}{\text{Per cent a.i.in fungicide}}$$

Two sprayings of each treatment were made, first spray at the appearance of the disease and second after 10 days of first spray.

Results

Evaluation of bioagents for the management of sheath rot of rice

Grain yield recorded in all the treatments were significantly higher than the yield recorded in control plot. Highest yield of 5515 kg ha^{-1} was recorded in T5: B 15+ B 17+ B 33+ B 42 consortium as Soil Treatment (35 DAP) + Seed Treatment (35 DAP) + Foliar Spraying at booting. The yield recorded in other treatments of T1: *Bacillus* sp. (B 15) as Soil Treatment (35 DAP) + Seed Treatment (35 DAP) + Foliar Spraying (At booting stage) (4786 kg ha^{-1}) and T2 *Bacillus* sp. (B 17) Soil Treatment (35 DAP) + Seed Treatment (35 DAP) + Foliar Spraying(At booting stage) (4627 kg ha^{-1}) and T_3 *Bacillus* sp. (B 33) Soil Treatment (35 DAP) + Seed Treatment(35 DAP) + Foliar Spraying(At booting stage) (4823 kg ha^{-1}), T4 *Bacillus* sp. (B 42) T5 B 15+ B 17+ B 33+ B 42 consortium Soil Treatment (35 DAP) + Seed Treatment (35 DAP) + Foliar Spraying(At booting stage) (3578 kg ha^{-1}). The yield recorded in standard check - Hexaconazole 5 EC (POP KAU) @ 2 ml L^{-1} treated plot was 5578 kg ha^{-1} which was statistically on par with T5.

Straw yield recorded in all the treatments were significantly higher than the yield recorded in control plot (Table 11). Highest yield of 6480 kg ha^{-1} was recorded in T5: B 15+ B 17+ B 33+ B 42 consortium as Soil Treatment (35 DAP) + Seed Treatment (35 DAP) + Foliar Spraying at booting. The yield recorded in other treatments of T1: *Bacillus* sp. (B 15) as Soil Treatment (35 DAP) + Seed Treatment (35 DAP) + Foliar Spraying (At booting stage) (5315 kg ha^{-1}) and T2 *Bacillus* sp. (B 17) Soil Treatment (35 DAP) + Seed Treatment (35 DAP) + Foliar Spraying(At booting stage) (5344 kg ha^{-1}) and T_3 *Bacillus* sp. (B 33) Soil Treatment (35 DAP) + Seed Treatment(35 DAP) + Foliar Spraying(At booting stage) (5714 kg ha^{-1}), T4 *Bacillus* sp. (B 42) T5 B 15+ B 17+ B 33+ B 42 consortium Soil Treatment (35 DAP) + Seed Treatment (35 DAP) + Foliar Spraying(At booting stage) (4679 kg ha^{-1}). The yield recorded in standard check - Hexaconazole 5 EC (POP KAU) @ 2 ml L^{-1} treated plot was 6460 kg ha^{-1} which was statistically on par with T5.

Evaluation of fungicides for the management of sheath rot of rice

The highest Grain yield (5578 kg ha^{-1}) was recorded in in standard check - Hexaconazole 5 EC (POP KAU) @ 2 ml L^{-1} (T10), this was followed by Propineb 50 WP @ 2.5 g L^{-1} (5310 kg ha^{-1}), Trifloxystrobin 25%+Tebuconazole 50% 75 WG @ 0.4 g L^{-1} (T8) treated plots (5173 kg ha^{-1}), then in copper hydroxide 77 WP @ 2 g L^{-1} (4337 kg ha^{-1}).

The highest Straw yield (6460 kg ha^{-1}) was recorded in in standard check - Hexaconazole 5 EC (POP KAU) @ 2 ml L^{-1} (T10), this was followed by Trifloxystrobin 25%+Tebuconazole 50% 75 WG @ 0.4 g L^{-1} (T8) treated plots (6308 kg ha^{-1}), Propineb 50 WP @ 2.5 g L^{-1} (6177 kg ha^{-1}), then in copper hydroxide 77 WP @ 2 g L^{-1} (4925 kg ha^{-1}).

Conclusions

Thus, the study concluded that the consortium of *Bacillus* sp. biocontrol agent, since these bioagents have specific antagonistic actions and enhances the beneficial microbial growth in soil which leads to increase the fertility of soil and also having high B:C ratio and fungicides like triazole (Hexaconazole 5 EC) and strobilurin in combination (Trifloxystrobin 25%+Tebuconazole 50% 75 WG) were highly effective against sheath rot disease of rice. Since theses fungicides have site specific action and efficacy at lower doses with high B:C ratio, it could be used as a better alternative to the conventionally using fungicides.

References

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