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Studies on biological control of sheath blight disease in rice

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Abstract
Sheath blight disease management focuses mostly on combining cultural measures with chemical control. Disease prevention through biological means is cost-effective, long-lasting, and free from lingering adverse effects. A number of studies have shown that strobilurin-based compounds, including as azoxystrobin, trifloxystrobin, and metominostrobin, are more effective and environmentally friendly at managing the disease than other fungicides that are sold commercially. This study aims to identify successful disease management strategies using Cultural and Biological management. Findings from this research emphasize the importance of adopting an integrated disease management approach for sustainable and productive rice cultivation. Employing a combination of cultural, biological, and chemical methods can effectively mitigate disease severity, reduce reliance on singular control measures, and minimize environmental impacts.

Keywords: sheath blight, disease, control, chemical, biological, cultural

1. Introduction
Due to the widespread consumption of rice (*Oryza sativa* L.) as a source of energy around the world, it is regarded as one of the primary crops. More than two billion people in Asia and more than 70% of Indians eat this crop as a staple diet. On an area of 44.6 mha, rice is grown all year round in one or more regions of India, with an average productivity of 2.96 t/ha. India has to increase its milled rice production by no less than 2.5 million tons annually to maintain its level of increasing self-sufficiency at the current rate of population growth (Pasalu, *et al*., 2007) [11]. But in order to reach this goal, the crop must wage an ongoing war. The rice crop is susceptible to numerous bacterial, viral, and fungal infections, as well as a variety of physiological abnormalities, which results in an annual loss of 12–25% of the total rice yield. Sheath blight, a fungal disease produced by *Rhizoctonia solani*, is one of several that affect rice. The second most prevalent disease in the world after blast disease is Kuhn. Miyake made the initial discovery of the illness in Japan in 1910. From Gurdaspur in Punjab, it was initially documented in India. Sheath blight, which has become common on many improved types farmed in India and is a significant barrier to the profitable production of rice, particularly in intensive production systems.

Sheath blight disease mostly affects rice at the seedling, tillering, booting, and flowering phases. According to Vanitha *et al*. (1996) [16], the plants were more sensitive to infection throughout the booting and flowering stages, and with increasing plant age, both the average percentage of infected tillers and the average disease severity rose. While long grain, semi-dwarf cultivars are thought to be the most susceptible in commercial fields, all recently created rice cultivars and hybrids are proven to be susceptible under favorable conditions for sheath blight development (Groth, 2005; Groth and Bond, 2006) [6, 7]. When weeds, self-sown rice, or regrowth from stubbles occur during the fallow period preceding a rice crop, secondary hosts can play a critical role in triggering disease epidemics, especially in tropical environments. However, a quantitative analysis of the relative significance of these many primary inoculum sources has not been done. Both the mobilization of initial inoculums and the propagation of the disease are significantly impacted by the architecture of crop canopy and associated microclimate (Castilla *et al*., 1996) [2]. The morphology of the rice genotype and crop establishment methods, as well as fertilizer input (Cu *et al*., 1996) [3], are additional elements that affect canopy architecture (Tan *et al*., 1995) [14].

The secondary spread of the disease, which has been variously referred to as the vertical and horizontal spread of the disease (Hashiba *et al*., 1982) [8] is primarily dependent on running hyphae that develop from the initial lesions of the lower part of the crop towards the upper parts, *i.e*., along the tillers and leaves and across the adjacent plant units.

Fungicidal resistance by the pathogens arose as a new restriction as the use of fungicides skyrocketed with the forward march of the dial hour. The need for crop protection agents with low use rates, a benign environmental profile, and minimal toxicity to humans and other animals was developing, and this combined with that demand provided the search for new fungicide molecules with unique modes of action a boost. One of the worst diseases in the eastern portion of India is the sheath blight of rice, which is caused by the bacterium *Rhizoctonia solani* Kuhn. There have been numerous attempts to create sheath blight-resistant cultivars, but none have been made public as of yet. The most typical method of treating the illness is to employ fungicides in conjunction with a variety of cultural treatments. The development of resistance recombinant of *R. solani* may be the cause of repeated use of the same fungicides in the same field becoming less or ineffective. A number of studies have shown that strobilurin-based compounds, including as azoxystrobin, trifloxystrobin, and metominostrobin, are more effective and environmentally friendly at managing the disease than other fungicides that are sold commercially (Bag *et al*., 2016) [1]. Keeping this in mind, the following study was conducted to identify successful disease management strategies using disease control measures.

2. Materials and Methods

2.1 Collection of sheath blight disease samples in rice

A field survey was conducted during 2023 in Ten villages of Dehradun (Harrawala, Miyawala, Prem nagar, Doiwala, Raipur, Kuanwala, Nanda ki Chowki, Dakpathar, Sahaspur and Vikasnagar) for the collection of early blight disease infected samples from a tomato field.

2.2 Pathogen's isolation

The infected paddy leaves were surface sterilized with a 0.5% sodium hypochloride solution for two minutes, and then rinsed in sterile distilled water. Using PDA media, the fungus from the infected paddy leaves was isolated.

2.3 Pathogen identification

The fungus isolated from paddy plants affected by the sheath blight disease was identified based on physical and cultural characteristics. This was accomplished by using a sterile cork borer to remove a mycelial disc of 5 mm in diameter from the edge of an active culture that had been developing for 7 days. After being inoculated on PDA plates and cultured for 7 days at room temperature (25 °C), its colony properties were evaluated. It was proven that the pathogenicity followed Koch's postulates.The fungi were identified using a manual of soil fungus, the Dematiaceous Hyphomycetes, More Dematiaceous Hyphomycetes, and Hyphomycetes, as well as the Raper and Fennell Manual of Aspergillus and the Raper and Thom Manual of Penicillia.

2.4 Maintenance of fungal culture

The pathogen was maintained in Potato Dextrose Agar (PDA) medium, the composition of which is as follows: Potato 200 g, Dextrose 20 g, Agar 20 g, Distilled water 1000 ml.

2.5 Disease Management

2.5.1 Cultural management

2.5.1.1 Adjustment of date of sowing

Each plot had a uniform plant population and was 50 m^2 in size, with two replications spaced 20 cm apart from one another. The advised agronomic procedures were all followed. Following the raised bed approach, the crop was directly sowed 15 days apart at three different times: early (30 June), mid (15 July), and late (30 July). Ten plants were chosen at random from each sampling unit, and each plot's sheath blight severity was noted.

2.5.2 Management of Sheath blight of rice by biocontrol agent

The field experiment was carried out during 2022-23 at the experimental site of Dev Bhoomi Uttarakhand University during the kharif season.

The Percent Disease Index was calculated by using the following formulae

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

3. Result and Discussion

3.1 Collection of diseased samples and isolation of pathogen

The data pertaining to observations of the leaves of rice plant showing the typical early blight symptoms were collected from the farmer's fields which is located in the ten villages of Dehradun.

3.2 Test of pathogenicity of *R. Solani* isolates

All the ten isolates of *R. Solani* were tested for pathogenicity by the following Koch's postulate method. These isolates were subjected to the pathogenicity tests on the susceptible under *in vitro* conditions by detached leaf technique showed typical early blight symptoms. All isolates of *R. Solani* were able to produce characteristics of early blight symptoms like angular, oval, or circular-shaped spots on the leaves.

3.3 Cultural management

3.3.1 Adjustment of date of sowing

The experiment was designed to find out more about how the timing of planting impacted how severe the sheath blight illness was. In both plots, the sickness developed over time and grew worse as they matured. An early-planted crop had a low disease severity throughout the early growth stages, but this severity swiftly increased during the flowering or grain-filling stages and peaked as the crop matured.

3.4 Management of Sheath blight of rice by bio control agent

The effectiveness of various bio control agents and the method of application for treating the rice sheath blight disease were assessed in a field experiment. Without hurting the ecosystem, this was accomplished. The most effective bio control strategy for treating the rice sheath blight disease, outperforming pesticides while leaving no residual harm on the soil or plant, was seed treatment followed by three sprayings of *Trichoderma viride*, it was determined after examining all of the bio control methods. The treatment increased plant vigor, was easy to apply in the field, and subsequently increased rice crop production. According to research by Dennis and Webster (1971) [5], *Trichoderma viride* significantly reduced sheath blight infection and increased grain production in rice.

The outcomes unmistakably shown that seed treatment plus spraying outperformed just seed treatment with a particular bio agent. The fungicide propiconazole (T7), which recorded a pooled PDI of 9.82% in the current trial, and the seed treatment plus three sprays of *Trichoderma viride* (T5) produced the lowest pooled PDI value (10.93%) among the bio control treatments. The best-performing medication overall, validamycin (6.67% pooled PDI), considerably outperformed all other therapies. Numerous past studies have found that combining two or more bio agent application strategies was more effective than using only one strategy in lowering the sheath blight disease (Surulirajan and Kandhari, 2003; Kumar *et al*., 2009; Singh *et al*., 2013) [13, 9, 12].

The successful and economical management of plant diseases relies on the integration and timely implementation of various disease control methods. Daroga Singh *et al*. (2007) [4] conducted a field experiment and reported that a combination of *T. Viride* @ 5 Kg/ha (a biocontrol agent) and Validmycin @ 2l/ha (a chemical agent) was highly effective in controlling sheath blight and sheath rot diseases in rice. Moreover, this integrated approach resulted in enhanced crop yields.

Similarly, Panday *et al*. (2005) [10] suggested that employing need-based plant protection measures as part of a management program proved to be cost-effective and led to higher economic yields compared to relying solely on chemical methods. Furthermore, this approach contributed to less environmental pollution, highlighting the importance of sustainable and environmentally friendly disease management practices.

The findings from both studies indicate that integrating different disease management practices, including biological control agents, chemical treatments, and other control methods, results in reduced disease incidence and increased crop yields. Each method contributes to compensating for the deficiencies of others, leading to a more comprehensive and effective disease management strategy.

4. Conclusion

The findings from this field trial emphasize the importance of adopting an integrated disease management approach for sustainable and productive rice cultivation. Employing a combination of cultural, biological, and chemical methods can effectively mitigate disease severity, reduce reliance on singular control measures, and minimize environmental impacts. Implementing such integrated disease management strategies is pivotal for ensuring successful plant protection and supporting sustainable rice production in the face of sheath blight disease challenges.

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