Chapter

Management of False Smut Disease of Rice: A Review

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Abstract

Rice (*Oryza sativa* L.) is the most important food crop of the developing world. Among the biotic stresses of false smut is an emerging disease caused by *Ustilaginoidea virens*. The disease reduces both the quality and quantity of rice. The pathogen produces mycotoxins that are harmful to animals and humans. The disease is severe when favorable environmental conditions like high humidity (more than 80%) and temperature ranging from 25 to 30°C, late sowing and high soil fertility as well as using high amount of nitrogen. It has gained the status of a major disease of rice and causing varying yield loss depending on the weather conditions during the crop-growing period and the genotypes. Therefore, the primary concern of the farmers is the disease management methods, which are effective, simple and practical. Since, there is no single effective management strategy for false smut, we have discussed about the potential management options available depending upon the economic status and adoption capacity of the farmers. In the Plant Pathologists point of view, eco-friendly methods of disease management like cultural, biological and use of resistant variety should be advocated for sustainability of agriculture and human being.

Keywords: Management, false smut, rice, disease, *Ustilaginoidea virens*

1. Introduction

Rice is one the most important food crop of India. It is cultivated in all states from North to South and East to West. India is the second largest producer of rice in the world after China. In 2018–2019 India produced 116.47 million tonnes of rice with an average productivity of 2638 kg/hectare (Indiastat.com). However, rice is constantly attacked by biotic stresses namely pathogens, insects and weeds etc. False smut of rice is a destructive inflorescence disease caused by *Ustilaginoidea virens* (Cooke) Takahashi (teleomorph: *Villosiclava virens*). It was a minor disease with sporadic occurrences. However, it has recently become emerging disease in the majority of rice-growing areas of the world due to planting of high-yielding varieties and hybrids and climate change [1, 2]. The disease caused yield losses of rice by 2.8–81% depending on the disease intensity and genotypes [3, 4]. The disease caused grain quality reduction and mycotoxins produced by the pathogen is poisonous to livestock and humans [5]. The pathogen converts individual grains of the rice panicle into greenish spore balls (false smut balls) of a velvety appearance [6], the surface of which are covered by powdery dark-green chlamydospores during maturity (**Figure 1**).

Figure 1.
Rice panicle infected with false smut.

The chlamydospores survive the winter in the soil and act as primary source of infection in the succeeding rice plants. Therefore, the pathogen is primarily soil and air-borne. The pathogen is a slow-growing fungus that forms abundant conidia in cultures which are globose in shape and echinulated under scanning electron microscope [7, 8]. False smut of rice can be managed using appropriate fungicides, cultural practices, bio-agents, plant extracts, resistant cultivar and integrated disease management techniques which are briefly discussed.

2. Management through fungicides

The most common method of plant disease management is by use of chemical pesticides. It is popular with farmers probably due to easy availability and quick action. The control of rice false smut is mostly relied on fungicides. However, they are harmful to environment and increase the cost of cultivation and hence are highly discouraged whenever possible. Therefore, it should be used judiciously as prevention but not as curative measure. The timing and dose of application of fungicides are also important to control the disease. Crop loss is common where fungicide application timing is incorrect or an inadequate concentration of the material is applied [9, 10]. Therefore, need based applications are highly advisable for their usage.

Various fungicides such as Wenquning (a suspension of *Bacillus subtilis* in a solution of validamycin), copper oxychloride, cuproxat, simeconazole, tebuconazole, copper hydroxide, difenoconazole and hexaconazole have been reported for the control over 70% of rice false smut disease [11–16]. Field tests were conducted [17], to determine the effect of fungicide applications to flooded paddy water to control false smut. The results showed that the application of simeconazole granules to the paddy water two to five weeks prior to the heading stage of rice was highly effective against false smut and the fungicide application at three weeks was the most effective. Application of prochloraz + carbendazim followed by chlorothalonil were efficacious in controlling the false smut of rice [18]. There is a report that propiconazole 25EC (0.1%) recorded lowest disease severity than other treatments, followed by trifloxistrobin + tebuconazole 75 WG when sprayed at booting or 50% panicle emergence [19]. Higher yields were obtained when propiconazole 25 EC was sprayed at booting stage and also trifloxystrobin + tebuconazole 75 WG at booting. Spray of propiconazole and hexaconazole were effective in managing the rice false smut [20].

The eventual goal of reducing fungicide use in rice production will be accomplished by using different broad-spectrum, bio-rational fungicides in rotations with traditional fungicides as preventive or need based applications. Further studies are desirable to explore the best fungicide that is specific and effective against *U. virens*, their use as potential, economical phytochemical molecule against false smut of rice.

3. Management through cultural practices

Cultural practices prevent the disease through disease avoidance, escape or protection because they disrupt the favorable interactions of the pathogen, host and environment. Cultural practices like cleaning of bunds and fields reduce the incidence as the disease has been reported on some of the weeds [21]. Date of planting and maturity time of different genotypes have significant effects on the incidence and severity of the false smut [22]. Water management and fertilization affected false smut incidence [23]. The late-maturing varieties exhibited higher rates of infection even though three different sowing dates with an interval of 14 days were set for each variety under examination [24]. Furthermore, early maturing rice varieties escaped from false smut infection, while the late maturing ones did not. Disease avoidance by changing date of sowing/planting is an established fact and very economical and practical for marginal farmers in managing plant disease. Therefore, changing sowing time is a preventive control strategy that can be opted by the marginal farmers when the disease is endemic in a location with a susceptible cultivar.

4. Management through bio-agents

Biological control is the use of living organism to inhibit/kill the other target living organism (**Figure 2**). It is the most eco-friendly and economical method of plant disease management when there is no resistant variety available. The major mechanisms of biological control are follows;

1. Predation/Hyperparasitism
2. Production of Antibiotics
3. Production of Lytic enzymes
4. Production of Unregulated waste products like Ammonia, Hydrogen cyanide etc.
5. Competition for food, space, Siderophore scavenging
6. Induction of host resistance

The management of the rice false smut disease is not well documented, as its striking epidemiological features under field conditions are still uncertain. Therefore, integrated management of the false smut using fungicide applications, cultural practices and deployment of resistant cultivars if available, have been tried before to a certain extent with average results [25].

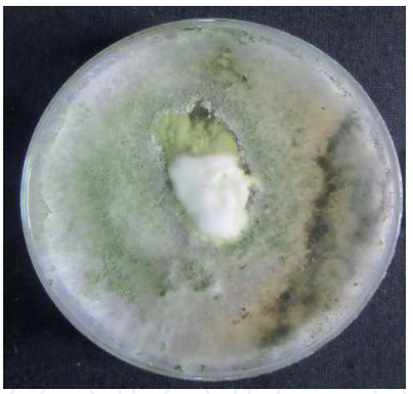

Figure 2.
Mycelial growth inhibition of U. virens *at the Centre by* Trichoderma harzianum *at the periphery.*

Biological control by *Trichoderma viride*, *Trichoderma virens*, *Trichoderma harzianum* and *Trichoderma reesei* were studied under *in vitro* and reported that all the isolates of Trichoderma have showed antagonistic activity against *U. virens* [26] but their utilization is not advisable as they are the preliminary results, which are not tested in fields. There is a report of *Antennariella placitae* (endophyte) as a good candidate for application as safe biological control agent against *U. virens* in vitro and in vivo [27]. The biological control by *Bacillus subtilis* showed least false smut disease severity under field evaluation (First author, unpublished). Biological control is eco-friendly and safe to the environment. They are much cheaper than fungicides. Thus, bio-control of rice false smut disease either individually or in integrated disease management approach might offer a more effective substitute to unsafe chemicals which is uneconomical and cause a substantial damage to the public health, environment as well as groundwater pollution. It is also considered as a very worthy alternative since it mimics the nature's own way of equilibrating the population of living organisms in the ecosystem. Whenever possible, bio-agents should be used because it is a neglected area of false smut research. Future research is desirable to bring out effective bio-agent for false smut disease.

5. Management through plant extracts

The utilization of plant extracts in disease management is a contemporary eco-friendly approach and gaining attention bearing in mind that of its benefits over chemical pesticides. The advantages of such plant products are that they are easily biodegradable, without any residue, non-phytotoxic and are easily absorbed by the plants and cost-effective method. Plant products such as certain leaf extracts and plant oils could also be used to control rice false smut. A group of researchers investigated plant extracts under *in vitro* against rice false smut pathogen which was considerably inhibited by bulb extract of garlic (*Allium sativum*), rhizome extract of turmeric (*Curcuma longa*), leaf extracts of lantana (*Lantana camara*) and bael (*Aegle marmelos*), whereas plant oils lemon grass (*Cymbopogon flexuous*) cinnamon (*Cinnamomum zeylanicum*), and palmarosa (*Cymbopogon martinii*) oils that completely inhibited the *U. virens* growth [19]. Since, fungicides are harmful, plant extracts along with bio-agents offer safe solution to the management of false smut. Future research may focus to find out effective plant extracts to manage false smut disease in rice.

6. Management through resistant variety

Management of plant diseases by use of resistant cultivars is cost-effective, durable and practical strategy. Unfortunately, no progress has been made to develop or improve rice variety/cultivars resistance to false smut disease, which might be due to lack of efficient artificial inoculation method to evaluate disease resistance reliably or absence of resistant gene donor. There are few reports on identification of quantitative trait locus (QTL) in rice against false smut [28–31]. However, their incorporation or utilization to improve rice cultivars against false smut is lacking. Therefore, R-gene should be identified and incorporated into an elite variety without compromising yield and can go a long way as resistant variety.

7. Integrated disease management

Integrated disease management utilizes all available resources, minimum use of chemicals and focus more on cultural practices. All possible methods are combined to manage the disease in a holistic manner because not a single method is effective enough to manage the disease. In the past few years, the disease has become a potential threat to rice cultivation and is difficult to manage by means of both fungicides and crop rotation alone or any other traditional control methods of plant diseases. Thus, an integrated method is important for successful management, especially under challenging conditions of rice production. Incorporation of resistant varieties, good cultural management tactics and use of recommended fungicides and bio-pesticides are indispensable for the management of false smut of rice.

Wenquning, which is a suspension of *Bacillus subtilis* in solution of validamycin, has been widely used in China for the management of false smut of rice [21]. However, there is limitations like the difficulty of on-time application and getting strains from the unfavorable weather around the heading dates had stalled its control efficiency and resulted in failures to control the disease. The success and sustainability of integrated disease management approach, especially with resource-poor farmers, significantly depends on their participation in helping generate locally precise methods and solutions appropriate for their particular farming systems and integrating control mechanisms that are ecologically sound and readily available to them. Future, research is required for integrated disease management in different locations wherever, false smut is severe and threatening. Such methods should be simple to follow, acceptable and easily available with the farmers.

8. Conclusion

False smut is gradually emerging as a potential threat to rice cultivation around the globe. Since, there is no single effective method to combat the disease, all-available and suitable methods should be utilized to manage the disease as a short term strategy. However, for long-term strategy, the breeding and utilization of resistant cultivars are considered as the most effective strategies to manage false smut disease. Yet, little is known about the resistance gene(s) and quantitative trait loci for this important disease as well as molecular mechanisms for resistance against *U. virens*. Consequently, there is an increasing demand for new and effective methods

to supplement the existing disease management strategies to achieve superior control of false smut. Therefore, the research for resistant variety is the need of the hour for making the rice production a sustainable movement. Among the management methods available for false smut disease, the method should be chosen based on the disease intensity and economic status of the farmers. If the marginal farmers faced severe threat of false smut, management by cultural practices viz., change of sowing time to avoid the disease is one simple with no-cost involved and wherever available use of effective bio-agents. If the farmers can afford, timely application of fungicides in moderation as a preventive measure but not as curative. The use of resistant cultivar and integrated disease management should also be recommended for such progressive farmers when such varieties are available.

9. Future challenges

For further research, the following points may be taken up with respect to rice false smut disease.

1. Standardization of artificial inoculation technique for false smut disease.

2. The role of toxins in conferring pathogenicity of the pathogen.

3. Role of enzymes like chitinase in management of the disease.

4. The threat pose by false smut with respect to climate change.

5. Biological control of false smut.

6. A rice variety that is both climate resilient and false smut resistant may tackle the twin problems of rice farming in the future.

7. Management of the disease by application of nanotechnology

Conflict of interest

The authors declare no conflict of interest.

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