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Seed-borne Fungal Diseases of Rice: A Hidden Threat to Global Food Security

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Introduction

Rice (*Oryza sativa* L.) serves as a staple food for about 3.5 billion people globally, particularly in Asia where the majority of rice is produced and consumed. China and India alone account for over 55% of both global rice production and consumption (Kong *et al.*, 2015). As global demand for rice continues to rise, researchers, geneticists, and breeders are actively developing high-yielding rice varieties to meet this growing need. In terms of dietary energy, rice provides 20% of the world's total, surpassing wheat (19%) and maize (5%). In some Asian countries, rice constitutes over 70% of the total calorie intake, underscoring its significance in regional food security.

A wide range of fungal pathogens have been identified in rice seeds, with 56 fungal species documented, including 41 that are seed-borne (Ou, 1985). Of the 153 identified seed-borne pathogens, 18% are classified as quarantine pathogens, 65% as native pathogens, and 17% as storage pathogens (IRRI, 1987). These diseases not only affect germination rates but also facilitate the spread of infection from seedlings to mature plants.

Seed-Borne Pathogens and Their Impact on Rice Production

Seed-borne pathogens, may be present internally or externally or as contaminants, can drastically reduce or eliminate seed germination, cause seed abortion, rot, necrosis, and seedling damage. These pathogens can spread infection systemically or locally within the plant, causing disease progression throughout its growth stages. Seed-borne diseases are a highly efficient mechanism for the widespread dissemination of plant pathogens, affecting rice crops worldwide.The extent of infection varies based on environmental conditions, rice variety, and locality. In certain agro-ecological settings, seed-borne diseases lead to yield losses ranging from 50% to 80%, depending on disease severity and crop sensitivity. According to Neergaard (1977), seeds are the best carriers of a number of infectious agents that cause the majority of plant diseases and significantly reduce agricultural productivity.

Among the most damaging rice diseases are brown leaf spot, rice blast, stem rot, and bacterial leaf blight. These diseases are caused by a range of pathogens, including *Fusarium moniliforme*, *Pyricularia oryzae*, *Drechslera oryzae, Rhizoctonia solani, Sarocladium oryzae, Sclerotium oryzae, Xanthomonas campestris pv. oryzae, and Trichoconiella padwickii* (Khan *et al.*, 1990; Wahid *et al.*, 2001; Gill *et al.*, 1999). These diseases contribute significantly to yield losses in rice-producing regions, with *Pyricularia oryzae*, the pathogen responsible for rice blast, capable of reducing yields up to 75% in India (Padmanabhan, 1965). This disease impacts both upland and irrigated rice systems and remains a major problem across most rice-producing nations.

The brown spot disease in rice, caused by *Bipolaris oryzae* (telemorph = *Cochliobolus miyabeanus*), has been documented in Japan since 1900 and is prevalent in all rice-growing countries, including India, China, Japan, Myanmar, Sri Lanka, Bangladesh, Iran, and parts of Africa (Ou, 1985; Khalili *et al*., 2012). In India, the disease is more severe in the states of Bihar, Chhattisgarh, Madhya Pradesh, Odisha, Assam, Jharkhand, and West Bengal, particularly in dry or direct-seeded rice systems. Under severe conditions, the disease forms brown or black patches on glumes, which may eventually cover the entire seed. Under favorable conditions, the conidiophore and conidia form on the patches, giving them a velvety texture. Brown spot contributed to the 1942 Bengal famine, resulting in crop losses of 50–90%. Another enduring rice disease is bakanae, or foot rot, caused by *Fusarium moniliforme*, which affects major rice-growing regions and is associated with yield losses between 4% and 20%. Research has shown that the fungus is primarily located within the embryo (Reddy & Sathyanarayana, 2001), and severe infections can result in discolored grains with a pink hue due to the presence of fungal conidia.

Aflatoxins produced by the *Aspergillus* group have been shown to adversely impact seed germination, seedling vigor, and elongation (Purushotham and Shetty, 1996). These toxins inhibit chlorophyll synthesis, disrupt enzyme function, and cause endoplasmic reticulum degranulation, all of which can impede seedling growth (Dashak and Lewellyn, 1977).

Clean seeds are crucial for lowering the risk of disease. Fungicides can be used to protect seeds; dry seeds can be soaked in a fungicide solution or treated with a fungicide that contains benomyl or benomyl-t. Fungicides such as triflumizole, propiconazole, prochloraz, or a thiram and benomyl combination can be employed if resistance arises. To separate lightweight, contaminated seeds, another technique is to immerse them in salt water. *Trichoderma harzianum* treatment of seeds can lessen the severity of diseases such as Fusarium for natural protection. While ozone can enhance seed quality and disinfect seeds based on dosage, time, and seed coat texture, non-thermal plasma therapy provides an alternative to traditional fungicides and hot water. Hot water treatment has been used since the 1920s, and until the introduction of systemic fungicides in the 1960s, it was the only therapy available to eliminate deep-seated seed diseases. To remove fungal infections such as rice blast (*Magnaporthe grisea*) in paddy seeds, keep them in cold water for 6-12 hours and then heat them to 50ºC for 1-2 minutes. To treat rice leaf spot disease (*Cochliobolus miyabeanus*), keep seeds at 51ºC for 7 minutes (Kendrick, 1942).

Conclusion

Rice cultivation is critical to global food security, particularly in Asia, where it provides billions of people with their major source of calories. However, seed-borne diseases represent substantial and ongoing difficulties, endangering yield stability and harvest quality. These diseases diminish germination rates and allow infections to move from seed to seedling, eventually damaging mature plants in several locations. Such extensive crop damage is especially worrying in places where rice accounts for a significant share of daily caloric intake, threatening local food security and the livelihoods of millions of smallholder farmers who rely on reliable harvests. Biological controls, chemical treatments, cultural practices, and the creation of disease-resistant rice varieties are all part of integrated disease management (IDM) techniques that are needed to address these issues. Vitavax 200 was found most effective against the seed borne pathogens of rice. Breeders can now create rice strains that are immune to seed-borne diseases like brown spot and rice blast thanks to advancements in genetic engineering, which lessens the need for fungicides. Improved seed treatments, such hot-water treatments and seed coating, reduce pathogens in regions where disease propagation is more likely. Rice production may be protected against seed-borne diseases by implementing a multifaceted strategy that includes enhanced seed technologies, resistant cultivars, and sustainable disease management.

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