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Brown Spot of Rice: Etiology, Epidemiology and its Management

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Brown spot disease, caused by the fungus *Bipolaris oryzae*, is a significant threat to rice cultivation, particularly in regions with limited water and nutritional imbalances. First identified in India in 1922, this disease has been linked to historical events such as the Bengal famine of 1943, highlighting its potential for widespread devastation. It primarily affects rice plants from the seedling to the milk stage, causing characteristic brown lesions on leaves and glumes, which can coalesce, leading to yield losses. Environmental factors, such as consistent rainfall, high temperatures, and nutrient deficiencies, exacerbate the disease's spread. Management strategies include host resistance through selective breeding, biological controls using *Trichoderma* species and botanical extracts, and chemical management with fungicides. Despite advancements in disease management, further research into the epidemiology of the pathogen and its interaction with host plants is essential to develop sustainable control measures, particularly in low-input and upland farming systems.

Introduction

Brown spot was initially discovered in India in 1922, and the fungus responsible was identified as *Helminthosporium oryzae*. Two epiphytotics caused by brown spot disease of rice have been documented, one in 1918-19 in the Krishna-Godavari delta in southern India and the other in 1942 in Bengal. Famine Enquiry Commission chaired by Sir John Woodhead in 1945, stated that this was one of the key contributing factors to the Bengal famine in 1943. The disease is more common in areas where water is scarce and there is a nutritional imbalance, particularly a shortage of nitrogen. The disease can diminish yield by up to 40% in India at the seedling stage, depending on rice cultivars and infection stage.

The pathogen

The fungus was first named *Helminthosposium oryzae* by Breda de Haan in 1900, then Subramanian and Jain renamed it *Drechslera oryzae* (1966). Because most of the conidia germinate from two end cells, Shoemaker (1959) dubbed it *Bipolaris oryzae*. The fungus was named *Ophiobolus miyabeanus* by Ito and Kuribayashi (1927) after they discovered a teleomorph of it in culture. The fungus was originally assigned to the genus *Cochliobolus* by Drechsler (1934), but it was formally reassigned to that genus by Dastur (1942). The name *C. miyabeanus* is used at present. Inter- and intracellular mycelium is produced by the fungus, which appears as a greyish brown to dark brown mat on infected tissues. It is grey to olive or black in colour in culture. The sporophores are thick, erect, geniculate, and emerge in clusters of 3-5 through stomata. They are dark olivaceous at the base and lighter towards the tip. Conidia are five to ten septate, with the oldest conidium at the bottom. Conidia are often somewhat curved and broadest in the centre. Conidia that are fully matured are dusky or brownish, and they germinate with two polar germ tubes, one from each of the thin-walled areas, whereas less mature, sub hyaline spores may form germ tubes from intermediate segments.

Symptoms

From seedling to milk stage, the pathogen destroys the crop. The symptoms manifest as little spots on the coleoptile, leaf blade, leaf sheath, and glume, with the leaf blades and glumes being the most conspicuous. On leaves, typical spots are brown with a grey or whitish centre, cylindrical or oval in shape, like sesame seeds, and have a yellow halo, but immature spots are small, round, and may look as dark brown or purplish brown dots. The leaf dries up after many spots coalesce. The burned appearance of the impacted nursery may frequently be identified from a distance due to the demise of the seedlings. The spots on vulnerable cultivars are substantially larger, measuring up to 1 cm or more in length. Dark brown conidiophores and conidia form on the spots under ideal conditions, giving them a velvety look. The fungus can break through the glumes and leave black blotches on the endosperm. Severe grain infection has been observed to inhibit germination, seed rotting, and pre-emergence damping off.

Disease epidemiology

When there is constant rain, overcast weather, and a high day temperature, the disease spreads quickly. For the pathogen to establish itself, the host leaf must be wet for 8 to 24 hours. The degree of infection increases with the age of the host tissues. This means that the later stages of rice plants are more impacted. Furthermore, as shown by **Carvalho *et al*., (2010)** a deficit of N or K enhances the disease severity. *H. oryzae*, like many other fungal necrotic diseases, has a brief incubation period of less than 24 hours. Approximately 6 days after initial establishment, the greatest sporulation occurs. The disease is particularly prevalent in the dough and mature stages of grains. The survival rate of the fungus in soil and seeds is influenced by fertilisation, sowing timing, microclimate, and soil type. The disease is only seen in locations where rainfall is unevenly distributed and there is a lot of dew.

Disease management Host resistance

Brown spot of rice management is most cost-effective when the disease-resistant host plant is used. Previously, breeding efforts were focused on diseases such as blast and bacterial blight; however, brown spot disease of rice now requires significant attention. Several varieties of upland rice germplasm, both exotic and indigenous to eastern India, have shown partial and complete resistance to the brown spot pathogen in field circumstances. Three genotypes, BPT 1788, MTU 1067, and Swarnadhan, were shown to be moderately resistant to the disease's stalk rot phase **(Sunder *et al*., 2005)**. Some anatomical characteristics of rice plants, such as bigger epidermal cells and more silicated cells, have been linked to resistance. The phenomena of resistance has been linked to a rapid host response accompanied by increased polyphenol production and oxidation products. The levels of phenols, lignin, flavonoids, silicon, and oxidative enzymes in rice leaf tissue are highly correlated with the sensitivity of rice cv. Giza 180 and Arabi to brown spot. Giza 180 (a less sensitive cultivar) has significant amounts of total phenols and flavonoids in healthy leaves. In both cultivars, these chemicals increased in response to infection, while lignin and silicon declined.

Biological Control

Trichoderma sp., particularly *T. harzianum*, is known to produce a wide range of metabolites, including cyclic polypeptides, antibiotics, peptides, volatile and non-volatile chemicals, which have an allelopathic effect on fungal development. *T. pseudokoningii* has been recognised as the most effective in terms of disease control and seed germination and seedling growth. Trichoderma, Bacillus, and Pseudomonas were the most commonly utilised commercially available bio-control agents. Spraying *P. fluorescens* based on talc has been found to be useful in lowering brown spot severity **(Joshi *et al*., 2007)**.

Brown spot disease has also been reported to be treated with plant extracts and botanicals. Leaf extracts of *Eucalyptus citriodora* and *Ageratum conyzoides* also inhibited fungal growth and had positive outcomes. *Anacardium occidentale*, *Bixa orellana*, *Ichnocarpus frutescens*, *Macaranga peltata*, and *Uvaria navum* aqueous leaf extracts completely prevented conidial germination. The extracts of *Agave americana* at 0.1 per cent and *A. sativum* & *Pithecellobium dulce* at 10% (Raju *et al*., 2004) inhibited spore germination and mycelial growth of *B. oryzae* by more than 50% and 90%, respectively. Similarly, oils from palmarosa (0.1%), Biotos 2.5 ml/l, and Achook 5 ml/l and Neemazal 3 ml/l and Wanis 5 ml/l were among the bio-pesticides that considerably reduced brown spot severity and boosted yield.

Chemical management

The most effective and frequently recommended way of disease control is the application of fungicides to control brown spots. Brown spot disease can be effectively treated using fungicides such as iprodione, propiconazole, azoxystrobin, and carbendazim. Fungicides like Propiconazole at 1 ml/l and Hexaconazole at 2 ml/l produced excellent outcomes in the lab and in the field. Brown spot control has also been proven to be effective with Topsin M + Indofil M-45. Spraying of Hexaconazole and Propiconazole during the early booting stage and at 50% flowering reduced the incidence of brown spot and yield loss associated with the disease. The mycelial growth inhibitors Dithane M-45, Kitazin, Hinosan Thiram, Shield, Foltaf, Ridomil, Bitoxazol, PP 296, triadimenol, tridemorph, and edifenphos are particularly effective **(Arshad *et al*., 2013)**. Seed treatment with thiram (2 g/kg) along with three sprays of Ridomyl MZ or Companion proved highly effective against brown spot.

Conclusion

Brown spot, caused by *B. oryzae*, is a devastating rice disease that occurs worldwide, especially in low inputs environments and upland direct planting situations. The disease causes brown spots on leaves that are frequently encircled by a yellow halo, as well as black or dark brown spots on glumes, resulting in significant quantitative and qualitative losses in paddy and milled rice grain output. There is a need to look into the epidemiological elements that cause the disease to start and spread. The origins of primary inoculum and their involvement in disease incidence are unknown. Physical variables that influence the host physiology and are linked to a higher frequency of brown spots must be addressed, especially in light of recent improvements in the use of various molecular tools.

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