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Integrated Management of Brown Spot of Rice Caused by *Bipolaris oryzae*: Epidemiology, Pathogenesis, and Sustainable Control Strategies

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Brown spot of rice, caused by the fungal pathogen *Bipolaris oryzae* (syn. *Cochliobolus miyabeanus*), is a globally significant foliar disease that reduces rice yield and grain quality. Characterized by brown lesions with yellow halos on leaves, brown spot tends to be most severe under low-input, water stress and nutrient deficient conditions. Control is challenging owing to pathogen variability, fungicide resistance, and limited host resistance. Integrated disease management combining cultural practices, resistant germplasm, biological controls, and judicious fungicide use provides a sustainable framework for reducing disease impact and ensuring food security.

Keyword: *Bipolaris oryzae*, Biological resistant, IDM, Spore, Sustainable agriculture

Introduction

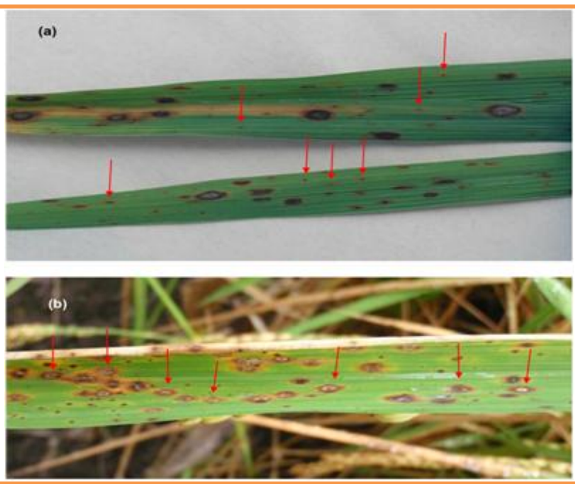
Rice (*Oryza sativa* L.) is one of the most important staple food crops worldwide, feeding more than half of the global population. Major rice-producing countries include China, India, Indonesia, Bangladesh and Vietnam. Among them, India ranks second globally in rice production, contributing nearly 22–24% of total world rice output. In India, rice occupies about 44–46 million hectares with production exceeding 130 million tonnes annually (Devi *et al*., 2026). Within India, eastern states play a crucial role in national rice security. Bihar is one of the major rice-growing states in eastern India, cultivating rice on approximately 3.2–3.5 million hectares with production ranging between 7–8 million tonnes annually. However, productivity in Bihar remains comparatively lower than the national average due to abiotic stresses (flood, drought, nutrient deficiency) and severe disease pressure. The humid subtropical climate of Bihar, characterized by high relative humidity and monsoon rainfall, creates favorable conditions for fungal diseases.

Rice production is significantly constrained by various biotic stresses including fungal, bacterial, viral, and nematode diseases. Among fungal diseases, rice blast caused by *Magnaporthe oryzae* is considered the most destructive, leading to severe yield losses under conducive conditions(Altaf *et al*., 2026). Sheath blight, caused by *Rhizoctonia solani*, affects high-yielding varieties under intensive cultivation. False smut caused by *Ustilaginoidea virens* has emerged as a serious problem in many rice ecosystems. Bacterial diseases such as bacterial leaf blight caused by *Xanthomonas oryzae pv. oryzae* and viral diseases like rice tungro disease transmitted by leafhoppers also contribute substantially to yield instability. Additionally, nematode diseases such as root-knot nematode (*Meloidogyne spp*.) and white tip nematode (*Aphelenchoides besseyi*) further reduce productivity.

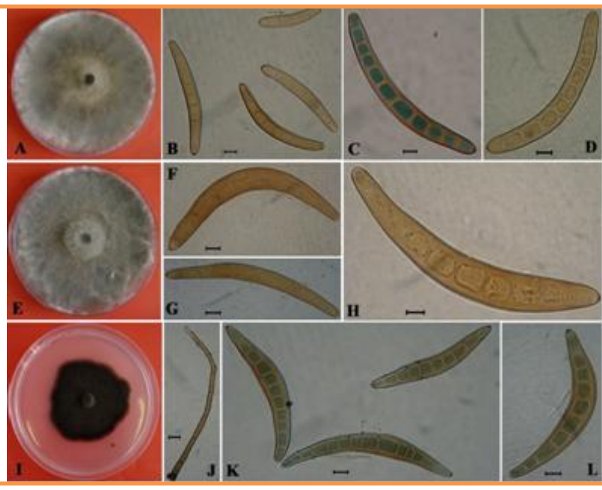
Among these diseases, brown spot of rice, caused by *Bipolaris oryzae* (syn. *Cochliobolus miyabeanus*), remains one of the oldest and most persistent fungal diseases of rice. Historically, brown spot gained global attention during the Bengal famine of 1943(Lidwell *et al*., 2026), where severe epidemics were associated with large-scale crop failure under nutrient-deficient conditions. The disease primarily affects leaves but can also infect coleoptiles, nodes, glumes, and grains, leading to poor grain filling and reduced seed quality. Yield losses may range from 10–20% under moderate infection to more than 50% in susceptible varieties grown under stress conditions. Brown spot severity is closely linked with environmental factors such as high temperature (25-30°C) (Zhao *et al.*, 2026), prolonged leaf wetness, and nutrient imbalances particularly nitrogen and potassium deficiency. In regions like Bihar, where marginal farmers often adopt low-input cultivation practices, the disease becomes more prevalent. Climate change–induced variability in rainfall and temperature further intensifies disease outbreaks. Given its widespread distribution, economic significance, and association with stress-prone ecosystems, brown spot requires an integrated management approach combining resistant varieties, cultural practices, biological control agents, and judicious fungicide use. Understanding its epidemiology and pathogenesis is essential for developing sustainable control strategies and ensuring stable rice production at global, national, and regional levels.

Epidemiology and Pathogenesis

Disease Symptoms & Spread: Brown spot symptoms include small, oval to spindle-shaped brown necrotic lesions, often with a yellow halo.The pathogen produces airborne conidia that disperse with wind and rain splash, enabling epidemics under favourable environmental conditions.



(Kaboré *et al.*, 2025)



(Ahmadpour *et al.*, 2014)

Pathogen Biology: *Bipolaris oryzae* is a necrotrophic foliar pathogen that infects leaves at early and mid-growth stages, affecting leaf integrity and grain filling. The pathogen has a wide host range and exhibits significant morphological and molecular variability, complicating resistance breeding.

Epidemiological Drivers: Disease incidence increases with leaf wetness, high relative humidity, and suboptimal nutrition, particularly nitrogen and potassium deficiencies, which compromise host defenses.

Integrated Management Strategies

Cultural and Preventive Practices

Water management: Avoid prolonged leaf wetness by optimizing irrigation to reduce humidity in the canopy.

Nutrition: Balanced fertilizer use (adequate potassium, phosphorus) enhances host resistance and reduces disease severity.

Host Resistance: Breeding for genetic resistance is a cornerstone long-term solution. Recent QTL studies identify key loci associated with brown spot resistance, highlighting prospects for developing resistant cultivars.

Chemical Control: Fungicides remain effective when applied judiciously: Tebuconazole, propiconazole(Altaf *et al.*, 2026) have shown significant inhibition of brown spot development and yield protection under field conditions.Fungicide rotation is recommended to prevent resistance evolution.

Biological Control and Sustainable Alternatives: Biocontrol agents like *Trichoderma spp*. and *Pseudomonas fluorescens* show strong antagonism against *Bipolaris oryzae* (Kishore *et al*., 2022) and can enhance plant defense enzymes.Endophytes within rice tissues suppress pathogen establishment and promote growth, offering an eco-friendly disease mitigation strategy. Research into phenolic antioxidants and beneficial bacteria (*Bacillus amyloliquefaciens*) suggests further sustainable management avenues.

Integration of Methods: Field studies indicate that combining biological seed treatments, foliar applications of biocontrol agents, and timely fungicide sprays significantly reduces disease incidence compared with single methods alone.

Results

Recent integrated management experiments demonstrated:Seed treatment with *Trichoderma viride*, coupled with propagated application and propiconazole at booting stage, reduced brown spot incidence and improved yields compared to untreated controls.The efficacy of certain fungicides varies by environment and pathogen strain, underscoring the need for localized recommendations. Biological agents increased defence enzyme activities and provided complementary control alongside reduced-dose chemical fungicides.

Conclusion

Brown spot of rice caused by *Bipolaris oryzae* continues to challenge rice production globally due to its environmental adaptability and the lack of widely resistant cultivars. However, integrated disease management that combines cultural practices, host resistance, biocontrol agents, and targeted fungicide applications can sustainably reduce disease impact while minimizing chemical inputs. Continued research into pathogen biology, host genetics, and eco-friendly control methods will be essential to future control strategies.

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