Sheath blight of rice: challenges and management

Rice (*Oryza sativa* L) is one of the most widely consumed cereal crops, grown in more than a hundred countries. Around 40,000 different varieties of rice exist in the world, with China producing the largest amount of rice (142.3 million tonnes) followed by India (110.4 million tonnes) (FAO: Rice Market Monitor 2018). Sheath blight (ShB) of rice, caused by *Rhizoctonia solani* Kunh AG1-IA (*anamorph*), *Thanatephorus cucumeris* (Frank) Donk (teleomorph), a soil-dwelling fungus, has become a major threat worldwide. The disease causes significant grain yield losses of up to 50%. First reported in Japan in 1910, the disease has subsequently spread across regions where rice is grown under intense cultivation. Apart from rice, *R. solani* has a broad host range infecting over 27 families of plants, causing diseases like sheath and leaf blight, root, crown, hypocotyl, pod and belly rot, banded leaf, brown patch and canker.

Fig. 1. Rhizoctonia solani AG1-1A showing sclerotia on PDA.

R. solani survives in the soil as a hard, weather-resistant structure known as a sclerotium. The sclerotium contains food reserves, helping the fungus to survive in soil 3 years or more. After coming into contact with the rice plant, the sclerotium undergoes myceliogenic germination. The fungus secretes cell wall degrading enzymes to break down complex cellulose, hemicellulose and pectin of the rice plant into simple sugars, which are used by the fungus to obtain nutrition and establish infection. Warm temperatures (~28-32°C), high humidity (~95%) and a high level of nitrogen fertilizer favour the infection establishment process. Thereafter, infection spreads from leaf sheath to leaf blades, panicles and tillers creating a 2-3 cm long and 1 cm wide necrotic lesion. The lesion spreads upwards resulting in stem lodging which disturbs canopy architecture, affects photosynthesis and causes poor grain filling, ultimately leading to plant death. At the end of the disease cycle, *R. solani* produces sclerotia on the surface of the infected or dead plant which drop into the soil and remain viable until the next crop cycle.

The key factor behind ShB outbreaks is the broad host range of the pathogen, which can be explained as different strains of *R. solani* producing diverse effector molecules related to pathogenicity and escape from host recognition. Although chemical fungicides can manage the ShB to a large extent, this comes along with the risk of environmental pollution and non-target effects on beneficial soil-microbes. Therefore, an alternative strategy is to use an integrated disease management system utilising natural fungicides in combination with biological agents such as *Pseudomonas fluorescens*, *Bacillus* spp., *Trichoderma* spp., *Gliocladium* spp., different antibiotics and trehalose. ShB spreads rapidly in cultivation with poor spacing and with overuse of nitrogen fertilizers.

Fig. 2. Necrotic lesion developed on the rice sheath cv. IR 50

Hence, optimising nitrogen fertilizer along with adoption of sparse plantation, postharvest drying and clearing of fields, and crop rotation with non-host crop plants can reduce the incidence of fresh infections and minimise disease re-occurrence. Early detection of phenotypic and physiological parameters by Unmanned Aerial Systems can aid in restricting the disease spread at the early stage of infection. QTL analysis and transcriptome studies have identified several potential ShB loci and candidate resistance genes in rice plants. The underlying pathogenicity and disease resistance mechanisms are not well understood and should be a priority for research. Also, RNA-based reverse-genetic approaches such as gene silencing using bacterially produced dsRNA, RNA clay and CRISPR-mediated knock-out of susceptible host genes, also can aid in achieving ShB resistant rice varieties. In addition, strengthening linkages between researchers, media, government and community-based organizations in spreading awareness about the disease and adoption of new technologies among farmers, can further aid in successful elimination of ShB infection.

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