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Bakanae: An emerging disease of aromatic rice

Rohit Chhabra **and Lavanya Vij**
Department of Botany, Punjab Agricultural University, Ludhiana (Punjab) India
(Email: lavanyavij4@gmail.com)

Rice is an important cereal cop belonging to family *Poaceae* and its production is affected by many biotic factors *viz.,* diseases caused by bacteria, nematodes and fungal infestation are the most significant constraints causing low yield of this crop in India. The major diseases that affect the economics of rice are bakanae (*Fusarium fujikuroi*), blast (*Pyriculariaoryzae*), stackburn (*Alternaria* spp.) and brown leaf spot (*Bipolarisoryzae*) of rice. The worldwide annual losses due to rice diseases are estimated to be about 10-15 per cent on an average basis. In Punjab, Bakanae (Foot rot) has become an economically important disease of aromatic rice cultivars. The word Bakanae is of Japanese origin which means naughty bad seedling referred to as foolish seedling. Very high yield losses due to epidemic breakout of bakanae disease were observed in the rice growing areas in Asia where it holds its high economic value (Adam *et al.,* 2018). Bakanae was first noted by Ito and Kimura in 1828 in Japan. During recent years, the prevalence of this disease has been reported from all parts of Asia. The incidence of bakanae disease in India has particularly been reported in aromatic and improved rice cultivars (Bashyal *et al.,* 2014) thereby, having profound effect on quality of seed.

The disease is caused by the pathogen *Fusarium fujikuroi*. The pathogen produces numerous toxic secondary metabolites and mycotoxins, *viz.,* gibberellic acid, moniliformin, fusaric acid, bikaverin, carotenoids and fumonisins (Puyam *et al.,* 2017). The disease causes seedling blight, seedlings rot, foot rot, excessive elongation of infected plants, grain sterility as well as grain discolouration that ultimately effects grain yield and seed quality. The pathogen induces abnormal elongation of seedlings due to gibberellic acid, whereas, foot rot, grain sterility and discoloration due to production of fusaric acid. *F. fujikuroi* is regarded as the most virulent species causing bakanae disease and produces extensive gibberellic acid that is responsible for elongation of internodes infected with bakanae (Kaur *et al.,* 2014). The bakanae fungus is found widely in temperate and tropical environment with wide host range (Kazempour and Elahinia, 2007). The pathogen is seed-borne (Nishio *et al.,*1980) as well as soil-borne (Pannu *et al.,* 2012). *Fusarium fujikuroi* is a polycyclic ascomycete which reproduces sexually and asexually through conidia and ascospores within a sac known as ascus. It perpetuates from one season to other on host crop debris buried in soil or in infected seed. The diseased seedlings appear to be slightly slender and later become yellowish-green to pale. Infected seedlings are not killed immediately by the pathogen. Fungus shows milky white growth with pinkish border and rosy pink pigmentation on lower nodes of stem at later stages of growth. The panicle infection is caused by secondary air-borne conidia and ascospores discharged from diseased plants from heading to harvest. The maximum discharge of ascospores from diseased plants in air has been observed during night. The fungus grows intercellularly in stigma and anthers within 48 h and finally reaches and covers the ovary. The fungus infects rice seedlings through roots and the base of the stem and becomes systemic multiplying within the infected tissues. The pathogen overwinters in perithecia and infects through soil in seed that are not pre-infected. Fungus is found to be viable in seeds of diseased plants for 4-5 months at room temperature and more than 3 years in cold storage. The conidia are propagated by water and wind leading to new infection in rice fields. At harvesting, airborne ascospores or conidia may contaminate the seeds during flowering stage of crop.

High humidity and cloudy weather is favourable for pathogen establishment. A temperature of 27-30ºC is the optimum for pathogen infection and 35ºC is required for disease development. Bakanae is observed in all rice growing conditions as rice requires warm wet growing season. Transmission of spores and conidia take place from one plant to another through agency of wind and water. The pathogen population is reduced by the application of nitrogen fertilizers. The pathogen activity was best in soil amended with lactose, maltose and mannitol as carbon source and ammonium sulphate and sodium nitrate. Aromatic rice cultivars are more susceptible to this disease as compared to non-aromatic rice cultivars as revealed by varietal screening studies (Ghazanfar *et al.*, 2013). Spraying with bavistin and benomyl is an effective strategy to reduce the disease occurrence. Clean seeds should be used to minimize the occurrence of the disease. Salt water can also be used to separate lightweight and thereby reduce seed borne inoculum. Chemical seed treatment is the viable method available for management of this emerging disease. 80-90 per cent of inoculum load can be reduced by soaking the seeds in 0.3 per cent sodium hypochlorite solution for 2 hours. Hot water seed treatment is also common earlier.

There are many fungicidal treatments which cause maximum reduction in mycelial growth and sporulation of pathogen. Some of them are Benomyl, Thiram, Mancozeb, Fludioxonil, Prochloraz, Thiophanate, Iprodione+ triticonazole, Carbendazim + thiram, Benomyl + thiram and Carboxin + thiram. Among the non-systemic fungicide, only Dithane-45 is effective at 300 ppm. Many technologies have been proposed to reduce yield losses caused by bakane, but disease management is yet largely dependent upon chemical control measures which may impose hazardous threats to the human health and environment. Due to such ecological challenges, the focus is on cultivars that are tolerant to disease for a sustainable alternate. However, extensive and recurrent use of fungicides usually cause a slow erosion of disease control due to a gradual loss of sensitivity on the target pathogen and also contribute to environmental pollution. The application of fungicide is neither practical nor environment-friendly. Utilization of host resistance has been an alternate way to manage the disease, hence identification of such sources of resistance are necessary.

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