Agri Articles
(e-Magazine for Agricultural Articles)
Volume: 03, Issue: 04 (JULY-AUGUST, 2023)
Available online at http://www.agriarticles.com
©Agri Articles, ISSN: 2582-9882

Bakanae: An Emerging Disease of Aromatic Rice

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Bakanae disease caused by *Fusarium fujikuroi* Nirenberg is an important emerging disease of rice throughout the world. Its incidence changes according on growing areas and cultivars used, and it causes considerable yield losses of 3.0-95.4%. It is one of the major issues with rice, especially with scented rice in India recently and it is getting worse and worse for sustainable rice production in other regions of the rice-growing world. Currently, following the introduction of resistant cultivars, seed treatment with fungicides is the most significant disease management approach utilized globally.

Geographical distribution and economic significance: It has been reported in all of the world's rice-producing nations, including Turkey, Pakistan, Thailand, Japan, Europe, America, Africa, the Philippines, California, Nepal, Bangladesh, Cameroon, Nigeria, Vietnam, Indonesia, Malaysia, Sri Lanka, Ivory Coast, Uganda, Brazil, Spain, China, Trinidad, Iran, Venezuela, Mexico, etc. (Cumagun *et al*., 2011). Due to changes in cultivation circumstances, the disease is becoming a significant issue across South and South East Asia, including India, Nepal, Thailand, Indonesia, and Japan (Bashyal *et al*., 2016). It was first identified in India by Thomas (1931).

This disease has been reported from different parts of country like Uttar Pradesh (Pavgi and Singh, 1964), Bihar, Andhra Pradesh (Vidyasekaran *et al*., 1967), Assam, Maharashtra (Parate and Lanjewar, 1987), Punjab (Bedi and Dhaliwal, 1970), West Bengal (Hajra *et al*., 1994), Tripura (Sarkar 1986), Odisha (Kauraw, 1981), etc. In India bakanae disease is more prevalent in basmati growing states and high disease incidence was recorded in different districts of Haryana, Punjab and Uttar Pradesh (Bashyal and Aggarwal, 2013; Bashyal *et al*., 2014). Yield loss of 25% has been reported in Bangladesh (Hossain *et al*., 2007). Desjardins *et al*. (2000) reported about 40% reduction in crop yield in Nepal. Bakanae disease is responsible for 20-50% reduction in crop production in Japan while 3.7-14.7% yield reduction has been reported in Thailand (Kanjanasoon 1965; Ito and Kimura 1931). The disease is known to cause a yield loss of 10-50% in Pakistan (Ghazanfar *et al*., 2013). It is one of first disease of rice described scientifically responsible for yield losses ranging from 3.0-95.4% varied with regions and cultivars grown (Singh and Sunder, 2012). In India, the prevalence and incidence of bakanae disease has been reported particularly on basmati rice cultivars (Bashyal *et al*., 2014; Gupta *et al*., 2014). The yield losses ranging from 15-25% have been reported from Uttar Pradesh, Assam, Andhra Pradesh, Tamilnadu, Haryana and Punjab states of India (Pannu *et al*., 2012; Sunder *et al*., 2014).

The Pathogen: *Fusarium fujikuroi* is a plant pathogenic fungus belonging to the genus *Fusarium* of Ascomycota. The fungus is extensively widespread throughout the world in nations where rice is grown and it differs in taxonomy and morphology depending on where it is found. *F. fujikuroi* is a part of the *F. fujikuroi* species complex (FFSC), which is divided into the American, African, and Asian clades and has at least 50 phylogenetic species

(Niehaus *et al*., 2016). Bakanae of rice has been associated with three FFSC members: *F. fujikuroi*, *F. proliferatum* and *F. verticillioides*. Among them, *F. fujikuroi* is found only in Asia (Wulff *et al*., 2010).

Figure 1. Symptoms of bakanae disease

Symptoms: The disease is caused by one or more *Fusarium* species and its complex of symptoms includes stunting, root rot, crown rot, seedling blight and the most noticeable signs of etiolation, hypertrophic effect or abnormal elongation of infected plants (Fig. 1). In different parts of the world, foot rot, seedling rot, grain sterility, grain discolouration and the final impact on yield and seed quality have all been recorded (Desjardins *et al*., 2000). Gibberellins are fungus-produced growth-stimulating compounds that cause excessive plant elongation (Malonek *et al*., 2005). Fusaric acid, a non-specific a compound that is harmful to plants, is another phytotoxin that the fungus releases (Desjardins *et al*., 2000). The bakanae infection causes the seedlings to grow taller and develop chlorotic stems and leaves that change from yellowish-green to light as the infection increases. The disease can spread to both the primary field and the nursery stage. Even seedlings that resist infection in the nursery run the risk of passing away from the attack soon after being transplanted. Foot rot was the name given to the disease since it was discovered in India that adventitious roots could develop from the stem's lower nodes (Thomas, 1931). On rice leaves, Sasaki (1973) recorded the development of lesions. A pinkish-white cottony growth of fungus mycelium may be seen at the base of the plant.

Management: Use of clean, disease-free seed and seed dressing constitutes the first and most essential strategy to reduce the spread of the disease because it is primarily stated that the disease is seed-transmitted (Webster and Gunnell, 1992). In recent time, seed treatment with chemicals is the most effective management practice for bakanae disease in India (Gupta *et al*., 2014) and widely practiced in most of East Asia. Seed treatment with fungicides like benomyl, thiram, benomyl+thiram, carbendazim+thiram, carboxin+thiram, fludioxonil, mancozeb, iprodione+triticonazole, prochloraz, thiophanate methyl and ipconazole was found effective against the disease (Ghazanafar *et al*., 2009; Karov *et al*., 2009; Ora *et al*., 2011). Bakanae incidence has been significantly decreased by the use of carbendazim, both as a dry seed treatment and as seed soaking in a fungicidal suspension (Sunder *et al*., 2014).

When a nursery was uprooted in standing water as opposed to vattar (dry) conditions, the incidence of disease was significantly lower in those plots. Along with seed treatment, nursery applications of carbendazim, such as sand mix broadcast @1g/m^2 seven days prior to uprooting and seedling dip in 0.1% carbendazim solution for three hours, also proved to be extremely successful in lowering the prevalence of Bakanae disease (Sunder *et al*., 2014). *Trichoderma viride* and *Pseudomonas fluorescens* have both been proven to be successful in India for managing rice bakanae disease. In India, it has been demonstrated that *Pseudomonas fluorescens* and *Trichoderma viride* are both effective at treating rice bakanae disease. According to Wyawahare *et al*. (2012), fields treated with FYM 10t/ha + *Trichoderma* + *Pseudomonas* had lower disease incidence. At the present time, numerous screening methods have been used and proven successful against the rice bakanae disease in various countries.

Conclusion

Around the world, rice growing is becoming increasingly dangerous due to the Bakanae disease, particularly in India where it has led to severe losses in basmati cultivars. The most common and virulent *Fusarium* species worldwide have both been identified as *F. fujikuroi*. In India, seed treatment with fungicides is presently the most widely used management strategy for bakanae disease control. Some strains of *Trichoderma* and *Pseudomonas* have been found effective against the disease.

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