Egyptian Journal of Crop Protection, 19(2): 19-28.2024.
https://doi.org/10.21608/ejcp.2024.296298.1033

Official Publication of Egyptian Society of Plant Protection
Egyptian Journal of Crop Protection
ISSN: 2805-2501 (Print), 2805-251X (Online)
https://ejcp.journals.ekb.eg/

The Prevalence and Incidence of Bakanae Disease of Rice in Bangladesh

Husna A.[1,2], Mohamed Nor N. M. I.[1], Latiffah Z.[1] and Miah M. A.[3*]

[1]School of Biological Sciences, University Sains Malaysia, Malaysia.
[2]Dept. of Biotechnology, Patuakhali Science and Technology University, Bangladesh.
[3]Dept. of Entomology, Patuakhali Science and Technology University, Bangladesh.*

ABSTRACT

The prevalence and incidence of bakanae disease were determined through an investigation in the rice fields of 21 rice-growing districts of Bangladesh from 2020 to 2022. During investigation, bakanae was observed in the rice fields of 16 districts in where Habiganj, Brahmanbaria, Kishoreganj and Netrokona were found to be more prevalent (70-80%) for bakanae. The highest disease incidence was observed in Habigonj (8%) and Brahmanbaria (5 %) when cultivated with the rice variety BRRI 29 and BRRI 28, respectively. It was also noticed that the prevalence and incidence of disease was high in Kishoreganj, Netrokona, Habiganj, Brahmanbaria district where both BRRI 29 and BRRI 28 variety were cultivated. It is concluded that the haor area viz. Habiganj, Brahmanbaria, Kishoreganj and Netrokona were most prone and the rice variety BRRI 29 and BRRI 28 were susceptible to bakanae in the rice growing areas of Bangladesh. Therefore, variety selection should be considered carefully for sustainable rice yield.

Key words: Rice-growing districts, Bakanae, Incidence, Bangladesh.

Introduction

Rice is a highly popular and widely consumed main food crop globally. Over 90% of the global rice production and consumption occurs in Asian countries (Singh et al., 2013). Rice is the primary agricultural product that serves as the main source of nutrition in Bangladesh. Bangladesh has a rice producing area of 11.90 million hectares, which accounts for approximately 75% of the total cultivable land. Bangladesh currently ranks as the third largest rice producer globally, following China and India. The rice industry accounts for 50% of the agricultural gross domestic product (GDP) and 16% of the total national income. During the cultivation process, the rice plant is susceptible to several diseases caused by fungi, bacteria, viruses, nematodes, and other pathogens. These diseases result in considerable reductions of rice production annually. Rice blast, brown spot, and sheath blight are widely recognized fungal diseases that have been associated with significant yield losses. However, in recent years, Bakanae has emerged as a significant disease, producing substantial

*Corresponding author email:mamiah81@yahoo.com

reductions in rice production. Climate change, delayed sowing and transplanting, and inappropriate crop management methods have caused minor diseases into significant ones (Husna et al., 2020).

The term "Bakanae" refers to the abnormal elongation of a rice plant and can be termed as *stupid rice plant* or *foolish seedling* (Sun and Snyder, 1981). Bakanae is linked to various species of Fusarium, however the primary causative pathogen that has been detected is *Fusarium fujikuroi* (also reported as *F. moniliforme*) (Wulff et al., 2010). In addition, *F. proliferatum* has been documented as a causative agent of bakanae disease in rice (Quazi et al., 2013). *F. fujikuroi* can infect rice plants at any stage, from before they emerge to when they are fully grown. The foot-rot or bakanae disease, which is caused by *F. moniliforme*, has emerged as a significant economic threat to basmati rice in India over the past ten years.

Bakanae disease mainly effect on rice seedlings, which can be detected at any stage of the growing season. If the infection is severe, it can adversely affect the germination of rice seeds, leading to unsatisfactory results (Iqbal et al., 2011). Infected seedlings exhibit elongation, reduced thickness and a minor chlorotic appearance in comparison to healthy seedlings. The development of symptoms is influenced by the quantity of inoculum, the strain of the fungus, and the relative concentrations of gibberellin and fusaric acid. The occurrence and intensity of the Bakanae disease symptoms differ depending on the geographical areas and the specific strain. Bakanae primarily spreads through infected seeds, however it can also persist in the soil. Contaminated seeds, infected crop residues in the soil from the previous season, or conidia on diseased stems are the primary means of virus transmission. These conidia can be transported by wind and rain. (Gupta et al., 2015). Bakanae is particularly concerning in comparison to other rice diseases due of its susceptibility to passive transmission from infected seeds, rather than being entirely driven by environmental factors.

Bakanae disease has become a highly major disease in numerous rice-producing nations in Asia, including Bangladesh. The occurrence of Bakanae disease was initially identified in Bangladesh in 1953 by Bangladesh Agricultural Research Institute (Anonymous, 1958), while its first description dates back to 1828 in Japan (Ito, 1931). In various regions of Bangladesh, Bakanae disease is called by different local names such as Hiska, Bejat, or Dig. In Bangladesh, farmers mostly rely on fungicides rather than cultural methods to control Bakanae disease. However, managing the disease has become more challenging since the fungal population has developed resistance to fungicides (Carter et al., 2008).

Bakanae is increasingly emerging as a significant threat to the sustainable production of rice in the countries where rice cultivation is prevalent. Over the past few years, Bakanae disease has been progressively expanding and been documented in previously unaffected regions of Asian countries, like Bangladesh. Bakanae has emerged as a prevalent disease in China, Japan,

Thailand, Pakistan, India, and Nepal over the past decade. In India, the rice crop has experienced significant qualitative and quantitative yield losses in the field, ranging from 15-25 %, due to bakanae disease. (Pannu et al. 2012). Similarly, Pavgi and Singh (1964) documented that the disease resulted in yield reductions of 15% in India and 40-50% in Japan. In addition to research on yield losses, it was discovered that the bakanae pathogen was present in the maximum proportion (1-24%) in the seeds of various basmati rice cultivars (Bashyal and Aggarwal, 2013). This indicates that the disease has a significant impact on the quality of the seeds. The estimated yield loss in Bangladesh owing to Bakanae disease is up to 25%, directly affecting the overall rice production in the country (Hossain et al., 2011). Significant occurrences of bakanae disease have been documented in Nepal and the Philippines (Desjardins et al., 2000; Reyes, 1939). Furthermore, the presence, frequency, and rate of bakanae disease have been documented in all states in India where basmati rice is cultivated (Pannu et al., 2012). Disease incidence ranging from 10% to 70% was documented in several nations afflicted by bakanae disease, as reported by Gupta et al. (2014) and Jain et al. (2019).

In Bangladesh, the prevalence and incidence of Bakanae disease is a significant issue in the rice cultivation regions. Curiously, there have been no reports yet on the prevalence, and incidence of rice Bakanae disease in Bangladesh. Hence, this study was conducted to determine the prevalence, and incidence of rice bakanae disease in various rice growing areas of Bangladesh aiming to develop effective strategies for managing this emerging disease and minimizing yield losses.

Materials and Methods

The investigation was conducted during the year 2020-2022 in twenty-one (21) rice growing districts of Bangladesh for checking the prevalence and incidence of bakanae disease (**Fig 1**). In total 130 rice fields were visited randomly in these districts. During the field visit, the presence or absence of bakanae disease signs and symptoms were precisely examined. For each field, a comprehensive assessment of the rice crop was conducted in order to determine the prevalence and incidence of the bakanae disease.

Disease Prevalence

The disease prevalence was recorded according to infected rice fields which showed the symptoms of bakanae disease.

$$\text{Percent Disease Prevalence} = \frac{\text{Rice Field Showing Bakanae Disease Symptoms}}{\text{Total Rice Field Surveyed}} \times 100$$

Disease incidence

The disease incidence was documented from the 5 randomly selected subplots, each containing 100 rice plants, in each sample field. The percentage of disease incidence was computed using the method described by Teng and James (2001).

$$\text{Percent Disease Incidence} = \frac{\text{Total Number of Infected Plants}}{\text{Total Plants Examined}} \times 100$$

Fig. 1. Survey site (marked) showed twenty-one (21) rice growing districts in Bangladesh.

Results

During the survey in twenty-one districts of Bangladesh, bakanae affected rice fields were found in 16 districts of Bangladesh viz. Dhaka, Narayanganj, Gazipur, Narsingdi, Kishoreganj, Netrokona, Cumilla, Brahmanbaria, Feni, Habiganj, Sylhet, Kushtia, Jessore, Chuadanga, Gaibandha and Rangpur. On the contrary, there was no bakanae affected field noticed in Barisal, Patuakhali, Khulna, Rajshahi and Chapainawabganj district during the investigation period.

The distribution of bakanae infected rice fields was inconsistent during the whole growing season. The predominant symptom of the disease is the appearance of yellowing and elongation in the affected plants, as noticed in the field. Thin and elongated rice plants with yellow leaves were noticed in the rice

fields of most districts (**Fig. 2**). The mature plants in Kishoreganj, Netrokona, and Habiganj district were seen to have a yellow flag leaf that stood upright and had a more horizontal position. The diseased seedlings exhibited a greater angle between the leaf and the stem compared to the healthy seedlings (**Fig.2**). Besides, adventitious roots, stem rot, root rot and whitish fungal mass on the stem was found in the rice fields of Gazipur and Chuadanga district (**Fig 3**).

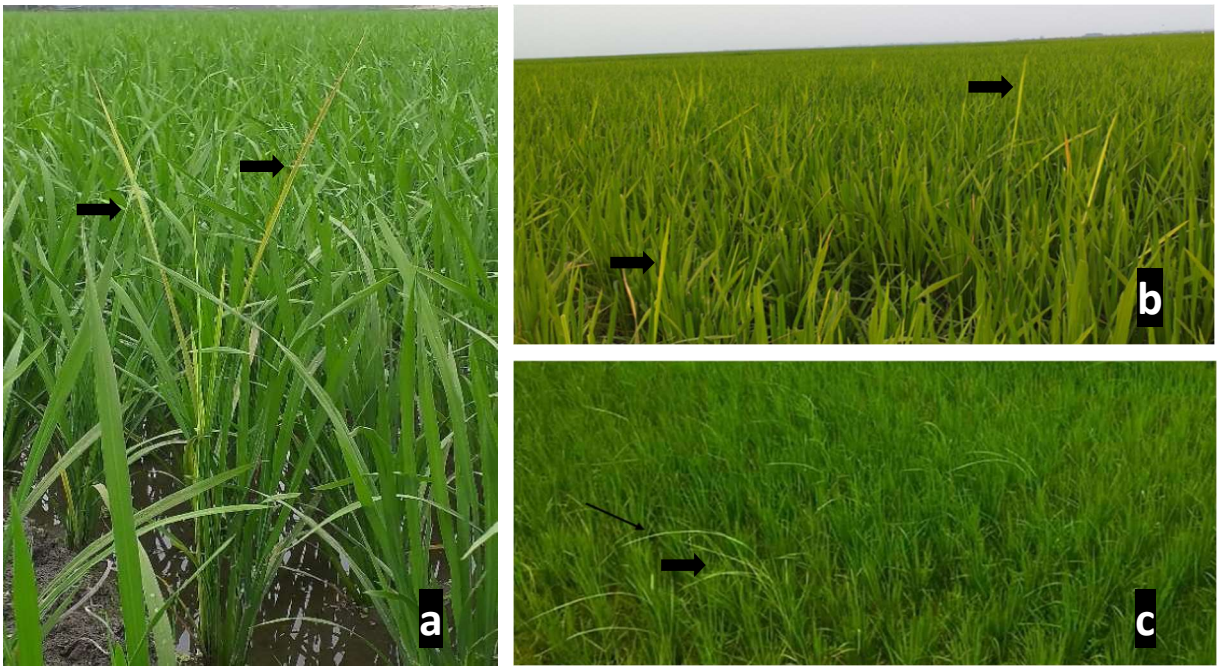

Fig. 2. Symptoms of Bakanae disease (Thin, yellowing and elongation of infected plants) as observed at a) Habiganj, b) Brahmanbaria, c) Netrokona districts in Bangladesh.

Fig. 3. Symptoms of Bakanae disease, a. Adventitious roots and stem rot, b. whitish fungal mass on the stem, c. root rot.

Bakanae disease of rice has recently been distributed widely in different rice growing countries of Asia along with other countries in the world. In recent years, this disease is considered as a cause of concern of the rice farmers of Bangladesh. In the present study, the rice fields at different rice growing districts

of Bangladesh were visited in order to check the presence or absence of bakanae disease. During investigation, the disease was found with around 70-80% prevalence in Habiganj, Brahmanbaria, Kishoreganj and Netrokona district. On the contrary, there was no bakanae infected field was found in Khulna, Barisal, Patuakhali, Rajshahi and Chapainawabganj district. Besides, 10-60% prevalence was found for bakanae disease in the other districts of Bangladesh (**Table 1**).

In Bangladesh, bakanae disease incidence has been increasing considerably and low to moderate disease incidences have been reported frequently. In this study, 21 districts were visited for checking bakanae disease incidence during the survey period.

The highest percentage of disease incidence was recorded in the rice fields cultivated with BRRI 29 and BRRI 28 rice variety in Bangladesh. During visit it was observed that the rice variety BRRI 29 was cultivated in 10 districts (Dhaka, Narayanganj, Gazipur, Narsingdi, Kishoreganj, Netrokona, Brahmanbaria, Feni, Habiganj and Rangpur) and BRRI 28 was cultivated in 6 districts (Netrokona, Kishoreganj, Comilla, Brahmanbaria, Habiganj and Chuadanga). Besides, the rice variety BR 12, BRRI 55, BRRI 89, Jiramini (local variety), Aloron (Hybrid) and Rod miniket (Indian local variety) were found to be susceptible to bakanae disease in our study (**Table 1**).

The disease incidence was recorded from 1-8% in different districts when cultivated with BRRI 29. The highest disease incidence was observed in Habigonj district (8%) followed by Brahmanbaria (6%) and Netrokona (5%) district. Besides, the disease incidence was observed from 1-5 % in different districts when cultivated with the rice variety BRRI 28. The highest disease incidence was observed in Brahmanbaria (5%) followed by Netrokona/ Habigonj (4%) and Feni district (3%) when cultivated with BRRI 28. It is assumed that BRRI 29 and BRRI 28 might be bakanae susceptible rice variety. Interestingly, the bakanae disease incidence was noticed in Netrokona, Habiganj, Kishoreganj and Brahmanbaria district when cultivated with both BRRI 29 and BRRI 28 rice variety during investigation.

Discussion

Bakanae disease has rapidly increased in Asian countries, particularly in Bangladesh. In recent years, the disease is emerging as a significant and widespread disease. The bakanae disease often affects all sections of the rice plant, including the roots, crowns, stems, leaf sheaths, and panicles, throughout the entire growing season.

The symptoms of rice bakanae disease have been investigated by several researchers over the last years. Jain et al. (2019) found that the primary symptom of bakanae disease is the elongation of afflicted rice plants. Infected plants with bakanae disease have a yellowish coloration compared to healthy plants. A pale-colored pathogen growth was observed on the nodes of the most severely affected plants. Some plants affected by bakanae disease have a panicle, although the panicle of diseased

plants appears chaffy and pale in colour. Gupta et al. (2014) reported that the disease demonstrates in the fields as plants that are somewhat yellowish, delicate, and unnaturally elongated. Over time, these plants grow quicker than others. The leaves dry rapidly from the lower parts of the plant and then perish within a few weeks. Nonetheless, observations have been made on the formation of adventitious roots from the lower nodes of the culms and the presence of whitish fungal growth on the lower parts of the plants. Furthermore, the condition is characterized by the observation of white to pinkish fungal growth, which serves as an additional diagnostic feature.

In this study, it was explored that the prevalence and incidence of bakanae disease of rice has been increased considerably particularly in the northeastern region i.e. the Haor areas (Habiganj, Brahmanbaria, Netrokona and Kishoreganj) of Bangladesh. In the haor areas, only one crop i.e. rice has been cultivated repeatedly year after year. The haor farmers mostly cultivated BRRI 29 and BRRI 28 rice variety and even they were not interested to change the rice variety for cultivation. These might be one of the reasons behind the bakanae disease in the haor area.

Multiple studies were conducted in the previous years on the prevalence and incidence of bakanae disease in rice. Hossain et al. (2015) revealed that bakanae disease of rice is a significant emerging pathogen in Bangladesh. The disease incidence reached a peak of 22.64% during the Aus season. Remarkably, the decrease in yield was 1.32% even when the disease incidence was as low as 3%. Hossain et al. (2011) also found that the rice variety BRRI 28 exhibited susceptibility to bakanae disease.

Furthermore, Gupta et al. (2014) documented that bakanae disease has become a growing concern for rice cultivation, specifically affecting basmati rice in northern India. The disease exhibited a prevalence rate of 100% in multiple states of India. Khilari et al. (2011) discovered that the Basmati variety PB 1121, which is widely favored by farmers in all basmati-growing regions of India, is highly vulnerable to bakanae disease. Besides, Rathaiah et al. (1991) stated that bakanae incidence of 4.17% led to a grain production reduction of 3.04%. Zainudin et al. (2008) documented that bakanae disease is prevalent in nations where rice is cultivated for commercial purposes.

This disease is particularly widespread in Asian countries, such as Malaysia and Indonesia, with varying levels of disease severity ranging from scale 1 to 5 and disease incidence ranging from 0.5% to 12.5% (**Table 1**).

Table1: Prevalence and incidence of bakanae disease of rice in Bangladesh

Division	Year of survey	Districts	Specific Location	GPS Coordinates	Number of fields surveyed	Infected fields	(%) disease prevalence	Percent (%) disease incidence on different rice varieties							
								BR12	BRRI 28	BRRI 29	BRRI 55	BRRI 89	Jiramini	Aloron	Rod Minikat
Dhaka	2020	Dhaka	Demra	23°43′40″N, 90°28′23″E	5	1	20	-	-	1	-	-	-	-	-
	2022	Narayanga-nj	Arihajar	23⁰ 37' 5" N, 90⁰ 29' 59" E	5	2	40	-	-	1	-	-	-	-	-
	2020	Gazipur	Kaliganj	23⁰ 55' 39"N, 90⁰ 34' 26" E	5	3	60	-	-	2	-	-	-	-	-
	2020	Narsingdi	Nars. Sadar	23°55'22.7"N 90°43'03.7"E	5	2	40	-	-	2	-	-	-	-	-
Mymen-sing	2020	Kishoreganj	Austagram	24⁰ 16' 52"N, 91⁰ 5' 27"E	10	7	70	-	2	2	-	-	-	-	-
	2020	Netrokona	Netr. Sadar	24°54'32.5"N 90°43'27.9"E	5	4	80		4	5	-				
Comilla	2020	Comilla	Bramonpara Chauddagram	23°36′53″N, 91°6′25″E 23°13′3″N, 91°18′22″E	10	6	60		3			2.5	-	-	-
	2020	Brahmanb aria	Nasirnagar	24⁰ 11' 14"N, 91⁰ 10' 41"E	10	8	80	-	5	6	-	-	-	-	-
	2022	Feni	Poshoram	23⁰ 12' 48"N, 91⁰ 26' 52"	5	3	60	-	-	3	-	-	-	-	-
Sylhet	2021	Sylhet	Syl. Sadar	24⁰ 53' 5"N, 91⁰ 54' 45"E	5	3	60	-	-		1				
	2021	Habiganj	Habi. Sadar	24⁰ 20' 44"N, 91⁰ 25' 9" E	5	4	80	-	4	8	-	-	-	-	-
Khulna	2021	Khulna	Khul. Sadar	22°48'43.2"N 89°30'25.6"E	5	0	0								
	2021	Kushtia	Poradah	23⁰ 51' 2"N, 89⁰ 1' 57"E	5	1	20	-	-	-	-	-	2	-	-
	2022	Jashore	Hoybatpur	23⁰ 16' 8"N, 89⁰ 10' 30"E	5	1	20	-	-	-	-	-	-		1
	2021	Chuadanga	Badumaji Housepur	23°45′14″N, 88°57′07″E 23°44′54″N, 88°57′26″E	10	2	20	2	2		-	-	-	-	-
Barisal	2021	Barisal	Bari. Sadar	22°41'40.0"N 90°17'37.1"E	5	0	0								
	2022	Patuakhali	Dumki	22°28'06.9"N 90°22'22.6"E	5	0	0								
Rangpur	2022	Rangpur	Pirganj	25⁰ 26' 12"N, 89⁰ 18' 51"E	5	2	40	-	-	2	-	-	-	-	-
	2022	Gaibandha	Sadullapur	23°13′3″N, 91°18′22″E	5	2	40	-	-	-	-	-	-	2	-
Rajshahi	2021	Rajshahi	Tonore Godagari	24°35'13.8"N 88°34'30.5"E 24°27'26.4"N 88°20'05.3"E	10	0	0								
	2021	Chapainaw-abganj	Chap. Sadar	24°33'12.8"N 88°17'32.3"E	5	0	0								

Conclusion

Bakanae disease, caused by *F. fujikuroi*, poses a substantial risk to rice production in Bangladesh. The disease can result in significant reductions in rice production, making it a crucial worry for farmers and the agricultural economy. The frequency, distribution, and rate of occurrence of rice bakanae disease was investigated through this study. The haor areas were found to be the most prevalent for bakanae of rice. Besides, the rice cultivars BRRI 29 and BRRI 28 exhibited higher susceptibility to bakanae disease. The rice growers of the

Haor areas of Bangladesh should more alert regarding variety selection and seed treatment to manage this emerging disease. Nonetheless, the adjacent regions of the haor area are in the risk of bakanae that is also a matter of concern. Therefore, research on bakanae disease should be emphasized in Bangladesh for sustainable rice production.

Authors Contributions

Conceptualization, AH, MAM; data curation, AH, MAM; formal analysis, AH, MAM; Investigations, AH, NMIMN; Methodology, AH, MAM; writing original drafts, and writing and editing AH, MAM, LZ, NMIMN; All authors have read and agreed to the purplish version of the manuscript.

Acknowledgements

The authors would like to extend their sincere thanks to the Upazila Agricultural Officers (UAO), Department of Agriculture Extension, Ministry of Agriculture, Bangladesh of the survey area to provide information, help in sampling and encourage for carrying out this work.

Funding:

This research received no external funding.

Institutional Review Board Statements:

Not Applicable.

Informed Consent Statements:

Not Applicable.

Data Availability Statements:

The data presented in this study are available on request from the corresponding author.

Conflicts of interest:

The author declares no conflict of interest.

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Received: *June 08,2024.*
Revised: *December 08,2024.*
Accepted: *December 23 ,2024.*

How to cite this article:
Husna A., Nik. M. I. Mohamed Nor, Latiffah and Miah M. A. (2024). The Prevalence and Incidence of Bakanae Disease of Rice in Bangladesh. *Egyptian Journal of Crop Protection*, 19 (2):19-28.