

Effect of temperature on rice (*Oryza sativa*) seedling disease incidence and severity in Bangladesh

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Abstract. Rubayet MT, Prodhan F, Mamun MAA, Kader MA, Hossain MM, Masum MMI, Hoque MZ, Rahman MM, Biswas JC. 2025. Effect of temperature on rice (*Oryza sativa*) seedling disease incidence and severity in Bangladesh. *Nusantara Bioscience* 17: 235-242. Seedling diseases are strongly influenced by temperature and cultivation environment, posing serious challenges to rice production under changing climates. To investigate these effects, two simultaneous experiments were conducted in Bangladesh, at Rangpur (25.6962°N, 89.2676°E) and Gazipur (24.0361°N, 90.3963°E) using BRRI dhan28 and BRRI dhan29 under open-field and polythene-covered conditions. Seedling emergence was consistently higher in polythene-covered plots, suggesting improved establishment in warmer microclimates. Three major diseases were detected across sites: bakanae (*Fusarium moniliforme*), blast (*Pyricularia oryzae*), and brown spot (*Bipolaris oryzae*). Varietal and environmental interactions were evident, with BRRI dhan29 showing greater susceptibility to bakanae in open-field conditions, while BRRI dhan28 was more prone to blast. Brown spot severity showed no significant differences between locations, indicating a lesser influence of variety and microclimate. Physiological observations revealed that healthy seedlings exhibited higher chlorophyll content (Soil Plant Analysis Development/SPAD values), whereas bakanae-infected seedlings displayed abnormal elongation relative to healthy plants. These results demonstrate that temperature and cultivation environment exert significant effects on rice seedling health, and that varietal responses differ according to disease type. Findings underscore the need for integrating varietal resistance and environment-specific management strategies to mitigate seedling disease risks in the context of climate change.

Keywords: Bakanae, blast, brown spot disease, climate change

INTRODUCTION

Rice cultivation is presently and will continue to play a vital role in feeding the world's population. It is the primary dietary energy source in 17 Asian and Pacific nations, 9 North and South American countries, and 8 African countries (Priya et al. 2019). However, rice production, like other agricultural outputs, has been significantly influenced by climate change and may face even greater threats soon (Gornall et al. 2010). As the global demand for rice continues to grow, its resilience to environmental changes becomes even more crucial. Climate change is considered the greatest menace to humanity, as agriculture is highly sensitive to shifts in climatic factors. During the last century, the average global temperature has risen by 0.74°C (Gautam et al. 2013). This warming trend is expected to accelerate, causing shifts in agricultural production patterns (Wachira et al. 2021). The increase is largely attributed to greenhouse gases such as carbon dioxide, methane, nitrous oxide, and chlorofluorocarbons, with CO₂ being the major driver of global warming (Nunes 2023). According to the

Intergovernmental Panel on Climate Change, global mean temperature may increase by 0.9-3.5°C by 2100 if current emission trends continue (Haq et al. 2010). These changes profoundly affect crop development and yield, as well as the reproduction, spread, and severity of many plant diseases (Gautam et al. 2013). For instance, sheath blight (*Rhizoctonia solani* J.G.Kühn), once a minor disease in the early 1970s, has now become a major rice disease. This change in disease patterns has led to significant yield losses in several rice-producing regions. Similar shifts in the occurrence and severity of numerous other diseases and insect pests have also been reported (Haq et al. 2010). Moreover, elevated temperature and CO₂ concentrations pose heightened risks of late blight (*Phytophthora infestans* (Mont.) de Bary) in potato, and serious rice diseases such as blast (*Pyricularia oryzae* Cavara) and sheath blight (*R. solani*) (Kobayashi et al. 2006; Gautam et al. 2013; Rubayet and Hossain 2024).

Despite this growing concern, limited studies have investigated how changing temperature regimes influence rice seedling diseases in Bangladesh, where rice is not only

the staple food but also central to food security and livelihoods (Lahlali et al. 2024). Seedling diseases are particularly critical because they can substantially reduce crop establishment, leading to downstream effects on yield. In Bangladesh, where rice farming is vital for the economy, understanding these early-stage diseases could help mitigate their impact on food production. With an increasing risk of unpredictable weather patterns, understanding how environmental temperature fluctuations affect disease dynamics at the early stages of crop growth is essential. Understanding how ambient temperature fluctuations affect the incidence and severity of diseases such as bakanae, blast, and brown spot at the seedling stage is therefore essential (Hue et al. 2025). This insight could lead to the development of predictive models, helping farmers make informed decisions on disease management. This knowledge will sharpen our ability to predict disease outbreaks under field conditions and to develop timely, location-specific management strategies. It will also provide the foundation for building more resilient rice varieties that can withstand the pressures of climate change, ultimately contributing to food security in the long term. Keeping this view, the present study was undertaken to assess the impact of ambient temperature on rice seedling disease incidence, severity under open and polythene-covered environments in two major rice-growing regions of Bangladesh.

MATERIALS AND METHODS

Two experiments were conducted at Rangpur and Gazipur (Figure 1), Bangladesh during 2021-2022 for assessment of the temperature impact on disease incidence and severity on rice seedlings. Two popular varieties of rice such as BRRI dhan28 and 29 were collected from the Bangladesh Rice Research Institute. After that land was prepared according to the agronomic practices and made 1 square meter size 12 plots. Whereas 3 plots open (P0) and 3 plots sealed with transparent white polythene sheet (P1) for BRRI dhan28 (V1). The rest of the plots were prepared in the same way for V2 (BRRI dhan29). A small hole was kept in both varieties for gas exchange purposes (Figure 2). The intercultural operations were done whenever it was necessary. These varieties were selected because BRRI dhan28 and BRRI dhan29 are among the most widely

cultivated rice types in Bangladesh and differ in their responses to climatic stressors. The polythene-covered treatment simulates microclimate modification practices increasingly used to mitigate temperature extremes.

Treatments

The experiment consisted of four treatments: BRRI dhan28 grown under open field conditions (V1P0), BRRI dhan28 covered with a white transparent polythene sheet (V1P1), BRRI dhan29 grown under open field conditions (V2P0), and BRRI dhan29 covered with a white transparent polythene sheet (V2P1). Each treatment was replicated three times and laid out in a Randomized Complete Block Design (RCBD) to minimize the effects of environmental variability. The seedbed was monitored for seedling emergence, disease incidence, and severity over a period of 40 days after sowing.

Data recording

The data were collected on disease symptoms, incidence, and severity in both locations. In the meantime, the weather data were also recorded by using digital thermometer during the whole period. The natural disease infestation was confirmed by symptom study according to the standard procedure (Barnett and Hunter 1972; Mian 1995). After that, 10 seedlings from each plot were uprooted randomly for assessment of every individual disease incidence and severity. The bakanae disease was graded 0-4 scale (Ooi 2002; Zainudin et al. 2008). On the other hand, brown spot and blast were scored on a 0-9 scale (IRRI 2002, 2013) (Table 1).



Figure 2. A. Open filed, B. Polythene sheet covered plot

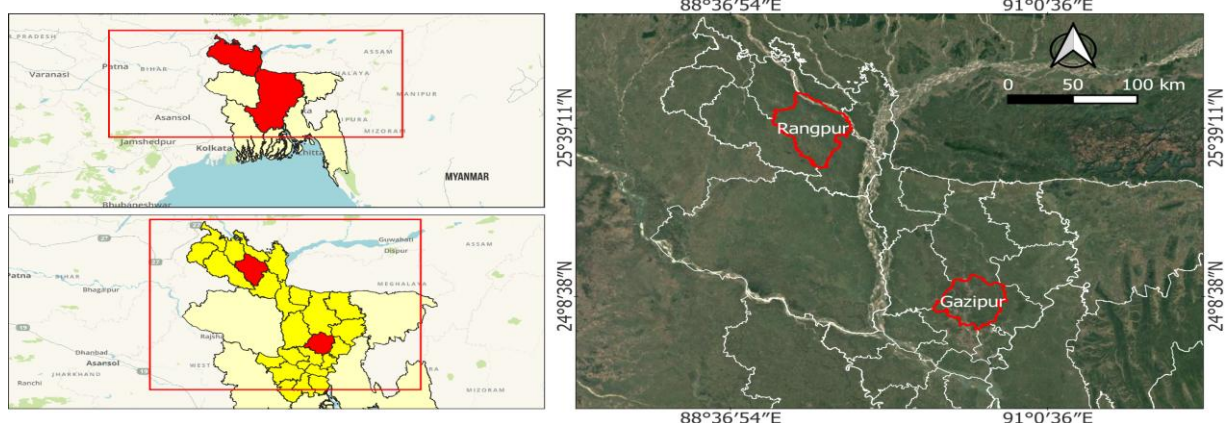


Figure 1. Location of the experimental sites in Rangpur and Gazipur, Rangpur and Dhaka Division, Bangladesh

Table 1. Bakanae, blast and brown spot disease scoring of rice seedling

Disease scale	Bakanae disease symptom	Blast disease symptom	Brown spot infection rate (%)
0	No infection	No infection	No infection
1	Normal growth but leaves beginning to show yellowish–green	Small brown specks of pinpoint size or larger brown specks without sporulating	<1
2	Abnormal growth, elongated, thin and yellowish-green leaves; seedlings also shorter or taller than normal	Small roundish to slightly elongated, necrotic gray spots, about 1-2 mm in diameter, with a distinct brown margin	1-3
3	Abnormal growth, elongated; chlorotic, thin and brownish leaves; seedlings also shorter or taller than normal	Lesions type is same as in scale 2, but a significant number of lesions on upper leaf area	4-5
4	Seedlings with fungal mass on the surface of infected plants or died	Eye-shaped lesions, >3 mm infecting < 4 % of leaf area	6-10
5		Leaf area infecting 4-10%	11-15
6		Leaf area infecting 11-25%	16-25
7		Leaf area infecting 26-50%	26-50
8		Leaf area infecting 51-75% and many leaves are dead	51-75
9		> 75% leaf area affected	76-100

Finally, the Disease Incidence (DI), and Percent Disease Index (PDI) were calculated by the following formulas (Rahman et al. 2013).

$$DI = (\text{No. of infected plants} / \text{Total No. of plants assessed}) \times 100$$

$$PDI = [\text{Summation of all ratings} / \{\text{Total No. of rating} \times \text{Max. disease grade (4)}\}] \times 100$$

Data analysis

The recorded data were summarised using mean values and standard errors across replications. Disease incidence and severity were calculated as percentages based on the number of affected seedlings relative to the total seedlings observed. The results were compared descriptively across treatments and locations to highlight varietal and environmental differences.

RESULTS AND DISCUSSION

The digital thermometer was used for taking maximum and minimum temperatures in the open field and closed environments separately. The average maximum and minimum temperatures were higher in the polythene wrapped plots in both locations. But the temperature was significantly different between two selected locations (Figure 3). The present study showed that temperature strongly influenced the incidence and severity of bakanae, blast, and brown spot diseases at the seedling stage (Lahlali et al. 2024; Hue et al. 2025). Higher temperatures in polythene-covered plots favored seedling emergence but also created conditions that altered disease pressure. Bakanae was more severe in BRRI dhan29 under open conditions, which is consistent with reports from Bangladesh where warmer, drier seedbeds enhance *Fusarium* infection. By contrast, BRRI dhan28 was more susceptible to blast, aligning with previous studies in Asian rice systems where elevated temperatures and humidity favored *Pyricularia* outbreaks (Gória et al. 2013; Nazifa et al. 2021). Brown

spot severity did not differ significantly between locations, indicating that this disease may be less sensitive to short-term temperature fluctuations. The use of polythene sheets, while beneficial for seedling emergence, may unintentionally modify microclimate conditions that influence disease dynamics, which has important implications for farmer practices under changing climate scenarios.

Effect of temperature on seed emergence of rice

Percent of seed emergence was slightly higher in Gazipur compared to Rangpur considering open and closed conditions. The maximum 96% emergence was found in BRRI dhan29 at Gazipur and 95.33% at Rangpur under polythene-wrapped plot (Table 2).

An intriguing element of plant growth is the impact of ambient temperature on seed germination and seedling emergence. These crucial phases of a plant's life cycle are greatly influenced by the temperature of the surrounding environment. The process through which a dormant seed develops into a seedling that is actively developing is known as seed germination. An important aspect of starting and controlling this process is ambient temperature. For proper germination, several plant species have different temperature needs. While some seedlings prefer lower temperatures, others need warmth. These temperature preferences are frequently linked to the variety's native environment and adaptations. The right temperature promotes enzymatic activity, metabolic functions, and water uptake all of which are necessary to start and maintain germination. Extreme temperatures, either too hot or too low, can, nevertheless, impair seedling vigor and germination rates. Seedlings emerge from the earth once the germination process has started and start their path to becoming adult plants. This fragile growing stage is still impacted by ambient temperature. To sustain cellular respiration and metabolic processes, which help seedlings acclimate to their surroundings, sufficient temperature is required. While extreme heat can cause stress and harm, cooler temperatures can decrease the rate of development. Additionally, environmental temperature affects how quickly

seedlings grow and emerge. Warmer conditions often encourage quicker development, but cooler conditions might impede or delay the emerging process (Yang et al. 2022; Liu et al. 2025; Mishra et al. 2025)

Effect of temperature on bakanae disease of rice

Bakanae is caused by *Fusarium moniliforme* J.Sheld. (Sexual stage: *Gibberella fujikuroi* (Sawada) Wollenw., 1931). The diseased seedlings were much taller, slender compared to healthy seedlings and detected easily by their tall pale green leaves (Figure 4). Additionally, the infected seedlings became chlorotic and crown rot. Older leaves exhibited abnormal elongation and produced adventitious root from the first nodes above the ground level. BRRI dhan28 was infected by 39.67% bakanae disease and BRRI dhan29 by 55.56% in Rangpur under open field environment. There was around 10-15% disease that appeared in Gazipur under the same condition. Despite there being no disease found in sealed plot at Gazipur but 14-40% prevailed at Rangpur (Table 3).

Table 2. Effect of temperature on rice seed emergence at Rangpur and Gazipur in Bangladesh

Treatments	% emergence	
	Rangpur	Gazipur
V1P0	77.33	81.67
V1P1	94.33	96.00
V2P0	76.33	76.67
V2P1	95.33	96.00

Table 3. Bakanae disease incidence and severity at Rangpur and Gazipur in Bangladesh

Treatments	% disease incidence	
	Rangpur	Gazipur
V1P0	36.67	11.11
V1P1	14.44	0.00
V2P0	55.56	15.56
V2P1	40.00	0.00

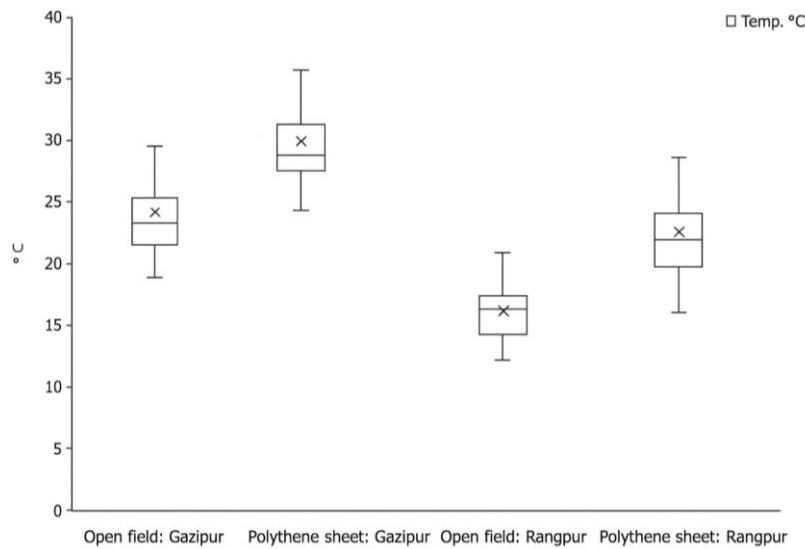


Figure 3. Temperature records at Rangpur and Gazipur in Bangladesh, under open field and polythene-covered conditions. Values represent the mean ± standard error of three replications

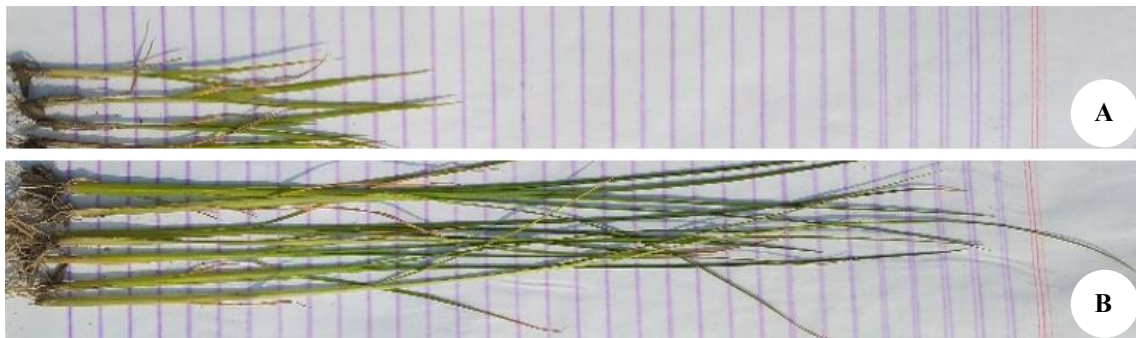


Figure 4. Bakanae disease symptom of rice: A. Healthy and B. Diseased seedlings

The Soil Plant Analysis Development (SPAD) value between healthy and bakanae infected plants at Rangpur and Gazipur were statistically significant difference. Infected seedling chlorophyll content was drastically dwindled as opposed to healthy seedling (Figure 5). In the meantime, the height of the seedling was shown fully reverse figure in both locations and conditions (Figure 6). There are many predisposing factors such as high temperature (around 35°C) and excess nitrogenous fertilizer for bakanae disease incidence and severity in seedbed and main field. The optimum temperature for symptom development of bakanae disease is affected by 35°C and asymptom >20°C (Hino and Furuta 1968; Takeuchi 1972). But application of excess nitrogen fertilizer and 30-35°C is optimum environmental condition for bakanae disease severity in Bangladesh (Asmaul et al. 2020).

treatment expect closed conditions at Rangpur. Numerous spots were coalesced and caused death of the leaf (Figure 7). The highest disease incidences 53.33 and 20% were recorded in V1P0 and V2P0, respectively Rangpur. Under the same condition below 30% disease infestation was found at Gazipur (Table 4). There was no positive interaction between host and pathogen in case of V1P1 and V2P1 at Gazipur. The SPAD value in healthy seedling was more than 3 folds higher at Rangpur and above 20 times at Gazipur (Figure 8). The effect of temperature could play a substantial role in rice blast incidence. According to the Rajput et al. (2017) the range of blast disease infection is 22-32°C and optimum temperature is 27°C.

Table 4. Blast disease incidence and severity at Rangpur and Gazipur in Bangladesh

Treatments	% disease incidence	
	Rangpur	Gazipur
V1P0	53.33	30.00
V1P1	46.67	0.00
V2P0	33.33	13.33
V2P1	16.67	0.00

Effect of temperature on blast disease of rice

Blast rice is one of the most devastating diseases across the globe, which is caused by *P. oryzae* (Sexual stage: *Magnaporthe oryzae*). The prominent symptom of the seedling appears on the leaf. During the experiment in both locations and conditions, typically reddish brown with grey or whitish center eye-shaped lesion was found in all

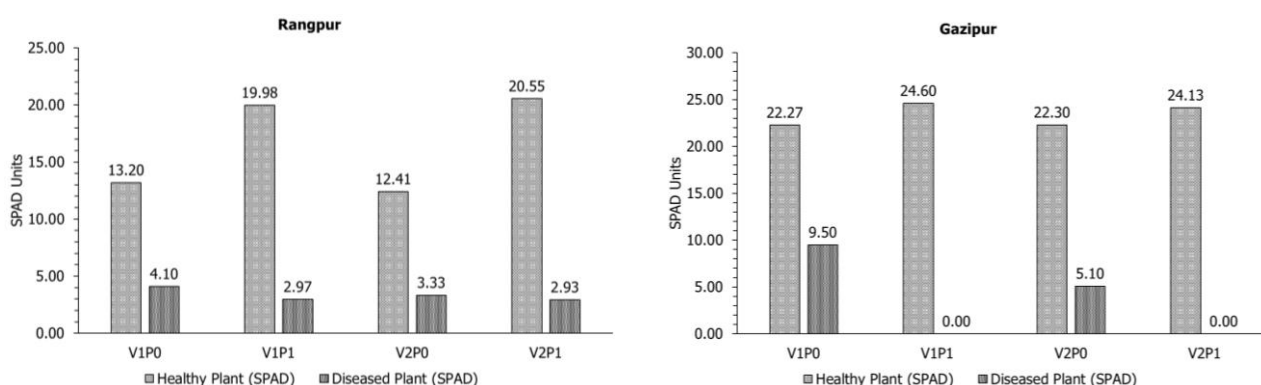


Figure 5. Correlation of Soil Plant Analysis Development (SPAD) value between healthy and bakanae infected seedlings at Rangpur and Gazipur in Bangladesh

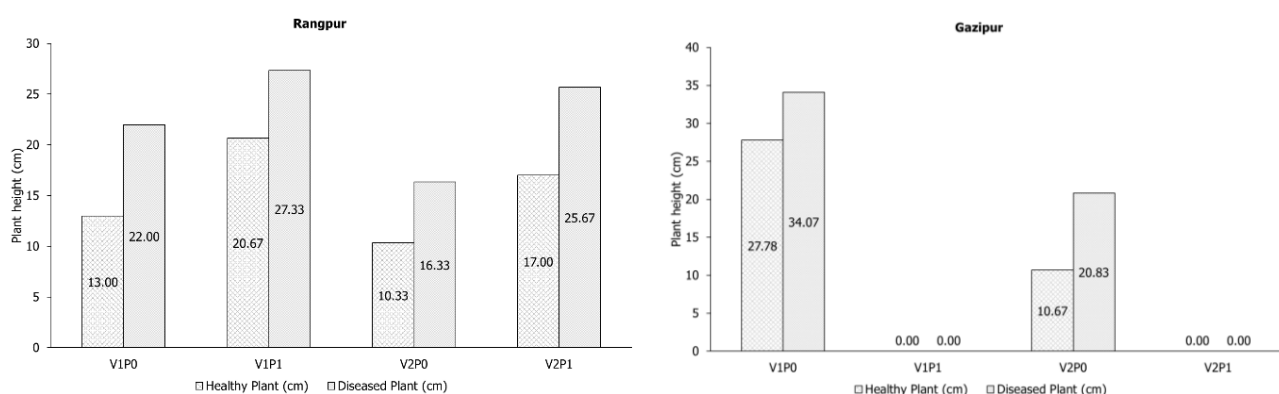


Figure 6. Difference between healthy and bakanae infected seedling height at Rangpur and Gazipur in Bangladesh



Figure 7. Blast disease symptom of rice

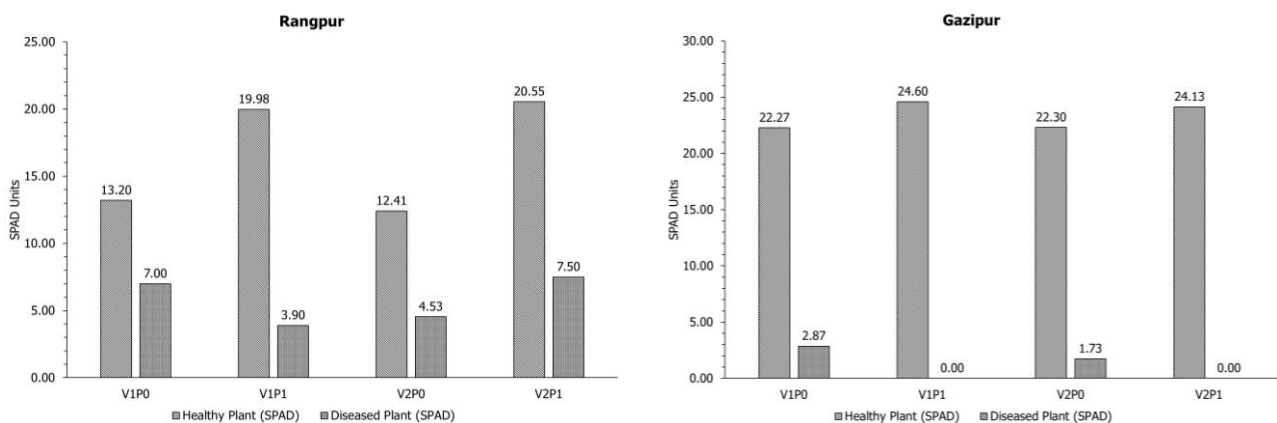


Figure 8. Correlation of Soil Plant Analysis Development (SPAD) value between healthy and blast infected seedlings at Rangpur and Gazipur in Bangladesh

Effect of temperature on brown spot disease of rice

Brown spot is *Bipolaris oryzae* (Breda de Haan) Shoemaker (Sexual stage: *Cochliobolus miyabeanus*). The seedling was infected by the pathogen and developed cylindrical or oval, dark brown with yellow halo circular spot on the leaf surface. Several spots were coalesced and the leaf dried up (Figure 9). The disease incidence was the highest 60% at Rangpur in the V1P0 plot and around 14% less in Gazipur. In V2P0, brown spot disease infestation rate was 36.67% and one-third, respectively at Rangpur and Gazipur. But at Gazipur, there was no disease found under the polythene covered plots (Table 5). The SPAD value difference between infected and healthy seedling was 0.53-20.55 at Rangpur and 0.00-24.60 at Gazipur (Figure 10). The favorable environment for brown spots is 24 to 30°C temperature and >92.5% humidity, leaf wetness (Picco and Rodolfi 2002).

Effect of temperature on PDI of bakanae, blast, and brown spot of rice seedlings

The effect of temperature was prominent on bakanae, blast, and brown spot disease severity on rice seedlings at Rangpur and Gazipur. Between these two locations, Rangpur was the most congenial for pathogen growth, development,

and spreading during the whole period. As a result, disease severity was higher in case of both varieties as well as both conditions. But the disease severity was null under the closed environment at Gazipur (Figure 11). Among the three diseases at two locations, the maximum around 75% and minimum around 15% seedling of BRRI dhan28 infected by blast at Rangpur under open field and polythene covered plots, respectively. Similarly, the maximum >65% disease seedling of BRRI dhan28 infected by brown spot at Gazipur under open field. There were no diseases under the polythene that covered plots in both varieties at Gazipur.

Table 5. Brown spot disease incidence and severity at Rangpur and Gazipur in Bangladesh

Treatments	% disease incidence	
	Rangpur	Gazipur
V1P0	60.00	46.67
V1P1	13.33	0.00
V2P0	36.67	13.33
V2P1	16.67	0.00



Figure 9. Brown spot disease symptom of rice

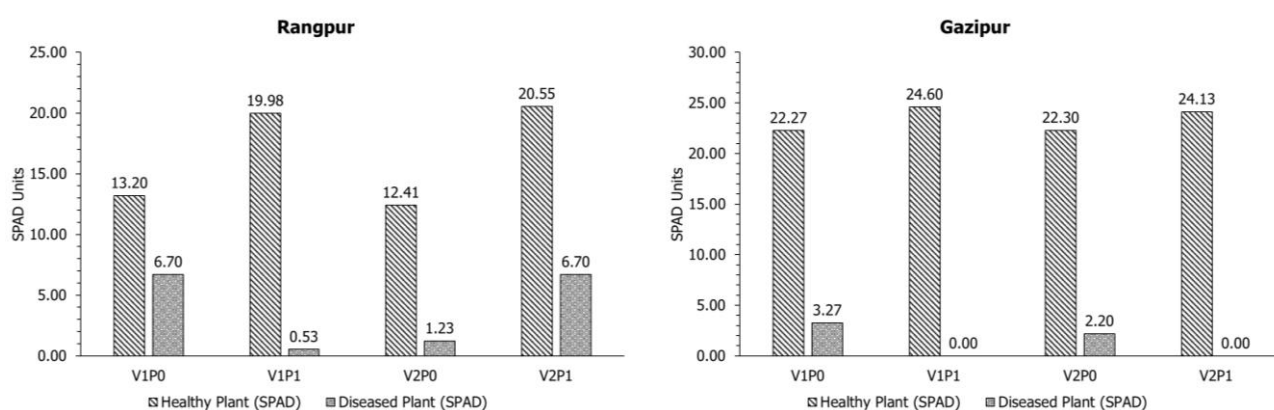


Figure 10. Correlation of Soil Plant Analysis Development (SPAD) value between healthy and brown spot infected seedlings at Rangpur and Gazipur in Bangladesh

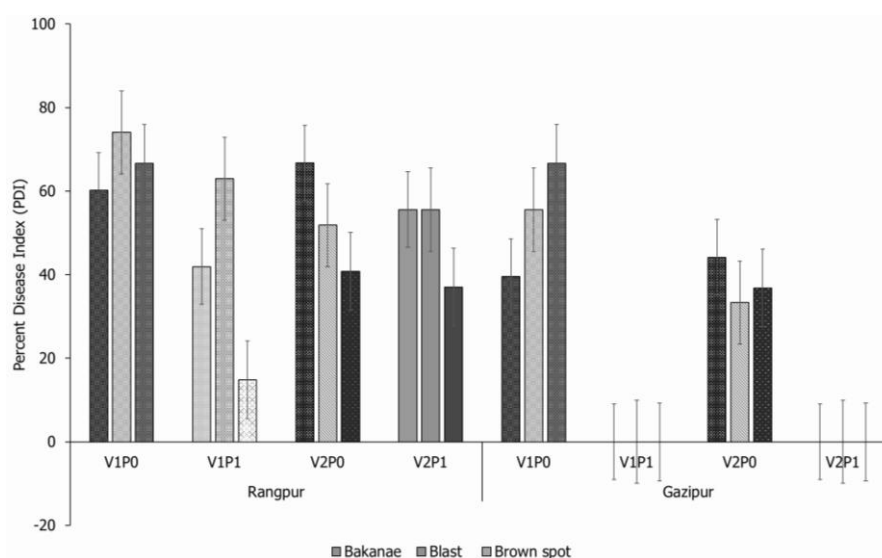


Figure 11. The severity of rice diseases under open and closed environmental conditions at Rangpur and Gazipur in Bangladesh

In conclusion, this study demonstrated that temperature and cultivation environment significantly influence the incidence and severity of rice seedling diseases. BRRI dhan29 was more susceptible to bakanae in open-field conditions at Rangpur, while BRRI dhan28 was more prone to blast in the same environment. Brown spot occurred in

both varieties, with moderate severity, but differences between sites were not significant. Polythene covering enhanced seedling emergence but also modified the microclimate in ways that affected disease development. These findings highlight the importance of adjusting seedbed management practices in Bangladesh to minimize disease risk. For

bakanae-prone areas, especially when cultivating BRRI dhan29, the use of covered seedbeds, fungicide treatment, or tolerant varieties is advisable. For blast-susceptible BRRI dhan28, integrated strategies including resistant cultivars, regular monitoring, and fungicide application may be required. As the study was limited to one season, further multi-season and multi-location trials are recommended to confirm these outcomes.

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