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Occurrence of Blast Disease in Rice in Bangladesh

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Abstract
Incidence and severity of blast disease of rice was recorded in ten agro-ecological zones (AEZs) of Bangladesh during Boro (November to May; irrigated ecosystem) and Transplanted Aman (July to December; rain fed ecosystem) seasons. Disease incidence and severity was higher in irrigated ecosystem (Boro season) (21.19%) than in rain fed ecosystem (Transplanted Aman season) (11.98%) regardless of locations (AEZs). It was as high as 68.7% in Jhalak hybrid rice variety followed by high yielding rice cultivar BRRI dhan47 (58.2%), BRRI dhan29 (39.8%), BRRI dhan28 (20.3%) during Boro and in BRRI dhan34 (59.8%) during T. Aman season. Maximum yield loss was noted in AEZ9 for both the seasons. Percent yield loss was higher in all the locations for Boro season (irrigated ecosystem) compared to T. Aman season (rain fed ecosystem). In the crop sequence1 (CS-1= Crop cycle with one rice followed by fallow/other crops) disease incidence was 16.7% and in crop sequence2 (CS-2= Crop cycle with two rice followed by fallow/other crops) it was 31.9%. Most popularly adopted Boro rice was BRRI dhan28 (29.6%) followed by BRRI dhan29 (25.9%) and T. Aman rice was BRRI dhan34 (22.9%).

1. Introduction

Rice (*Oryza sativa* L.) is a staple food for half of the world's population [20]. It is central to Bangladesh's economy, accounting for nearly 20 percent of gross domestic product (GDP) and providing about one-sixth of the national income of Bangladesh [19].

Blast disease of rice (caused by *Pyricularia grisea* (Cooke) Sacc) is one of the most devastating diseases in rice growing regions worldwide [22], causing 11-15% yield loss annually [3]. The climatic changes [4], especially water scarcity helps researchers think to develop production technologies for cultivation of rice under lower water conditions which may increase the incidence of many rice diseases particularly *Piricularia grisea* [9]. Incidence and severity of blast disease is increasing especially in the Boro season. In recent years, in Bangladesh, frequency of blast occurrence has increased with invasion into new areas (north and northwest parts of the country). The most popular and mega varieties BRRI dhan29 and BRRI dhan28 are recognized highly susceptible to blast disease [2]. Moreover, all local and improved aromatic rice varieties grown in wet season are vulnerable to neck blast [1, 13]. For blast disease management at field level chemical control is mainly practiced and other options particularly water management is mostly difficult to practice [11, 14].

Information on blast disease incidence, severity, cultivar susceptibility, crop sequence and ecosystem analysis, yield loss across the locations and seasons in HYVs (High

Yielding Varieties) and locally improved aromatic cultivars of rice are limited. Hence, the present study was undertaken to know the seasonal occurrence, distribution and severity of blast disease and to estimate the yield loss of rice due to this disease.

2. Materials and Methods

2.1. Location and Season

The survey on rice blast disease was conducted in farmers' fields of selected ten Agro Ecological Zones (AEZs) of Bangladesh (Figure 1) during Boro (November to May; irrigated ecosystem) and Transplanted Aman (July to December; rain fed ecosystem). In each season, survey was conducted during post flowering stage of the rice crop to observe panicle blast.

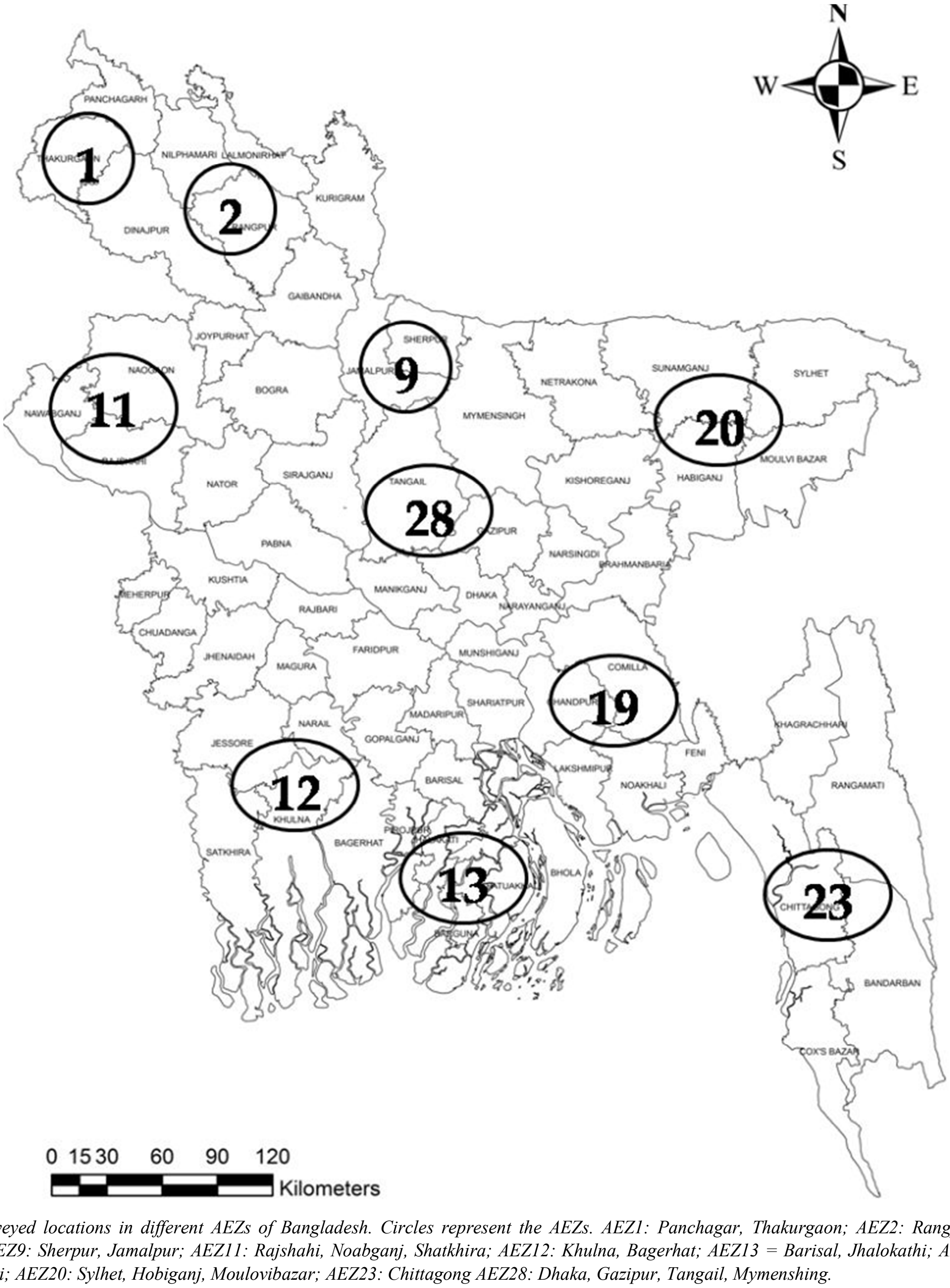

Figure 1. Surveyed locations in different AEZs of Bangladesh. Circles represent the AEZs. AEZ1: Panchagar, Thakurgaon; AEZ2: Rangpur, Kurigram, Nilphamari; AEZ9: Sherpur, Jamalpur; AEZ11: Rajshahi, Noabganj, Shatkhira; AEZ12: Khulna, Bagerhat; AEZ13 = Barisal, Jhalokathi; AEZ19: Comilla, Chandpur, Feni; AEZ20: Sylhet, Hobiganj, Moulovibazar; AEZ23: Chittagong AEZ28: Dhaka, Gazipur, Tangail, Mymenshing.

2.2. Disease Incidence (DI) and Disease Severity (DS)

Disease severity was assessed following IRRI [11] based on symptoms. Disease incidence was assessed using the following formula:

$$\text{Disease incidence (\%DI)} = \frac{\text{Total number of infected panicle in hill}}{\text{Total number of panicle in hill}} \times 100$$

2.3. Field Selection and Sampling Pattern

Soil type, cropping pattern and cropping intensity were taken into consideration in order to select locations. Then fields from each location were randomly selected for investigation. Twenty seven fields or plots from each AEZ were selected with each field having a size of at least 1500 square meter. In each location and season, intensive rice areas under rain fed and irrigated conditions were selected.

For the survey of blast disease, a zigzag sampling pattern was followed in this study [17]. At every 50-step interval a single hill (consists of several tillers/plant) was selected and the disease records were taken.

2.4. Assessment of Cultivar Susceptibility, Incidence and Adoption

This was expressed as an incidence of blast disease across all locations [8] of the surveyed areas in Bangladesh. Disease severity was assessed by 0-9 scale as described by [17]. Cultivar susceptibility was expressed by % disease incidence. Adoption of cultivar was expressed by percentage.

2.5. Crop Sequence and Ecosystem Analysis

Crop sequence was divided into 2 major groups based on rice cultivation intensity: i) annual cycle comprising one-rice crop followed by fallow/other crop/rice (CS-1) and ii) annual cycle with two-rice cultivation followed by fallow/other crop/rice (CS-2). Similarly, the ecosystem was classified into irrigated (I) and rain fed (II).

2.6. Assessment of Yield Loss by Blast Disease

Data generated from the survey were used in this exercise. Yield loss due to panicle blast was calculated following the model equation developed by [16]: y =1967.95-18.72x where, y represents yield in lb/ha and x = percent disease incidence caused by panicle blast.

2.7. Data Analysis

Data on disease incidence and severity, cropping sequence and ecosystem and cultivar adaptability were collected. Percent data and mean data were presented with standard error. Arc sine transformation of data was performed.

3. Results and Discussion

3.1. Assessment of Disease Incidence and Severity Across the Location and Season

Mean %DI during Transplanted Aman and Boro in AEZ2, AEZ12 and AEZ20 were lower having 7.04, 7.04 and 7.78%, and 17.22, 17.96 and 12.96% respectively (Figure 2). Disease severity in these 3 AEZs was 0.52 to 0.70 in Transplanted Aman season and 1.19 to 1.48 in Boro season (Figure 3). Farmers of these locations used medium to optimum dose of nitrogen fertilizer and their fields were obtained moist during the survey period. Hashimoto [10] observed the susceptibility of blast pathogen to moisture and found inverse relation of blast susceptibility with soil moisture.

Comparatively higher disease pressure was observed in AEZ 9 and AEZ19 during Boro season. Mean %Di was 37.96% and 31.30% respectively in these two locations (Figure 2). Similarly DS was higher here (3.63 and 2.7 respectively). In T. Aman season %DI and DS was higher in AEZ9 and AEZ13 (Figure 2 and 3). In these AEZs blast outbreaks often occurs and perhaps the pathogen locally invade either in alternate host or in seed. Year round intensive rice production is practiced in AEZ19 and AEZ9. Similar observation was reported for tropical Asia [17] and previously in Bangladesh [15]. Differences between locations/fields in management practices may also account for variation in disease incidence. Nitrogen fertilizer has a strong impact on blast disease by creating a dense canopy and a favorable microclimate for infection [7]. High level of N also results in less epicuticular deposition on rice leaves, increased infection cushion formation by *P. oryzae* gather susceptibility to blast disease. Shahjahan [18] observed blast outbreaks in the north-east, east, central, south and south-west parts of the country. These areas vary in soil and some physical characteristics, also Silicon content is comparatively low [21]. Farmers of these areas cultivate high yielding cultivars which are susceptible to blast disease. They apply high doses of nitrogen fertilizer to obtain high yield. They remove water from field at ripening stage. Hence fields remain dry at this stage. These conditions might favor blast disease outbreak.

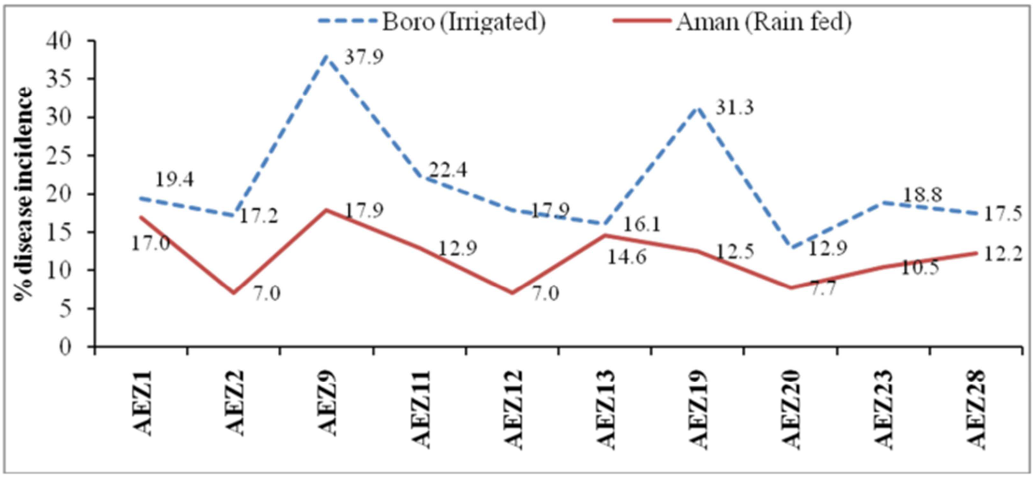

Figure 2. *Mean percent disease incidence of blast disease in different AEZs.*

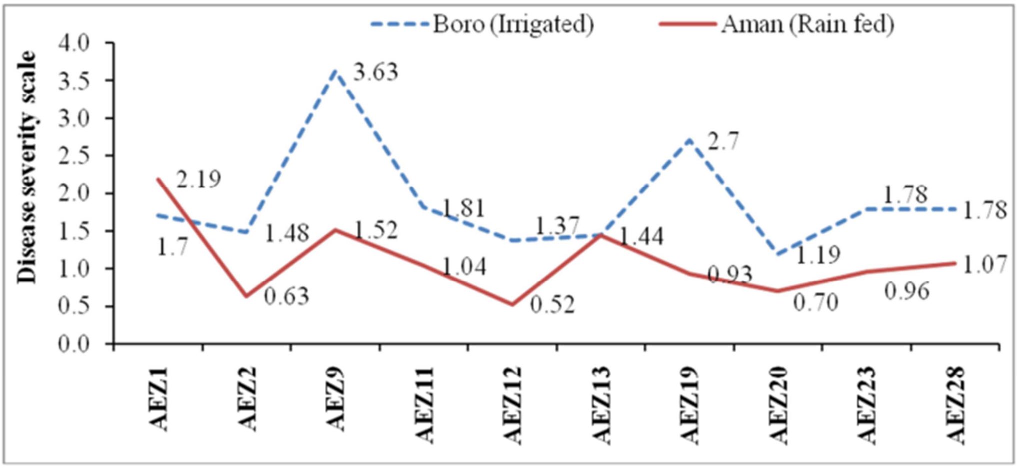

Figure 3. *Mean disease severity scale of blast disease in different AEZs.*

3.2. Assessment of Cultivar Susceptibility, Incidence and Adoption

Among the popular rice cultivars observed during Boro season, the most widely grown was BRRI dhan28 (29.6%) in irrigated ecosystem followed by BRRI dhan29 (25.9%), BRRI dhan47 (14.8%), Jhalak hybrid (11.1%) and BRRI dhan50 (7.4%) while BRRI dhan45 was the lowest grown popular cultivar (3.7%). In case of rain fed ecosystem (T. Amanseason), BRRI dhan34 was recorded as the most popularly adopted cultivar (22.9%). Local aromatic rice, BRRI dhan49 and BRRI dhan46 were observed as moderately adopted rice cultivars ranged from 11.4 to 17.1%. Lower adoption (2.9 to 8.6%) was noted for the cultivar BRRI dhan41, BRRI dhan33, BRRI dhan39 and BRRI dhan40 while BRRI dhan39 and BRRI dhan44 was the lowest (2.9%) adopted cultivars.

Regardless of location and cropping sequence the disease incidence was higher in Jhalak hybrid rice (68.7%) followed by BRRI dhan47 (58.2%), BRRI dhan29 (39.8%), BRRI dhan28 (20.3%) in irrigated land (Boro season). BRRI dhan45 was noted with the lowest disease incidence (5.6%). Disease severity ranged from 0-7. In case of rain fed ecosystem (T. Aman season), higher disease incidence was found in the cultivar BRRI dhan34 followed by local aromatic ranging from 50.7 to 59.8%. Moderately susceptible (10.2 to 22.1% DI) cultivars were BRRI dhan33, BRRI dhan39 and BRRI dhan44. Lower disease incidence (4.9 to 9.3%) was observed in the cultivars BRRI dhan49, BRRI dhan40, BRRI dhan46 and BRRI dhan41.

Our results indicate that the problem of blast disease might stem from the introduction of highly susceptible rice cultivars. Since their introduction they have become popular among farmers because of its high-yielding potential, and the fact that about 11-30% of the area was planted with the cultivar at the time of the study. The low values of percent disease incidence and disease severity were probably caused by the low inoculum sources and the availability of excessive water that flooded the plantation. Similar observations were made by [14] and [11]. They reported that in tropical areas, flooding the soil as often as possible could be effective in suppressing blast incidence. The present observations are in agreement with the above authors.

Two BRRI released high yielding Boro cultivar, BRRI dhan29 and BRRI dhan47 are highly susceptible to blast disease. A hybrid cultivar Jhalak, which was imported from China, was also found severely infected by this disease during the surveyed season. Similar reports were presented by [2]. These four cultivars were intensively cultivated in AEZ19 and AEZ9.

On the other hand all local and improved aromatic rice cultivars grown in wet season (Transplanted Aman) are vulnerable to neck blast [13]. An improved BRRI released aromatic cultivar, BRRI dhan34 and other local aromatic cultivars were intensively cultivated in different locations of surveyed fields, especially in AEZ9. A HYV Transplanted Aman rice BRRI dhan44, susceptible to blast disease, along with aromatic rice was cultivated in AEZ13 where blast disease pressure was also high. In AEZ 13 dry season irrigated rice was cultivated after potato/wet season rice harvest. A similar cropping practice being followed in AEZ 9 where blast is endemic and occurrence largely depends on northern wind patterns in Nov-Dec and March-May from Himalayan and hilly parts of India and Nepal [2].

3.3. Crop Sequence and Ecosystem Analysis

In the crop sequence 1 (CS-1) the incidence was 16.7%. However, it was 31.9% in crop sequence 2 (CS-2), nearly two times higher than in the former (Figure 4). Regardless of cultivar and location, mean % DI and DS of blast disease differed significantly in ecosystem. The %DI was higher in irrigated ecosystem (21.19%) than in rain fedecosystem (11.98%). On the other hand, the trend in decreasing DS was similar to that of %DI (Figure 5).

It was also noted that fields that followed Aus-Transplanted Aman-Boro crop sequence (CS-2) were associated with severe disease outbreaks in Sherpur, Jamalpur, Mymensingh (AEZ9) and Noakhali district (AEZ19) in Boroseason. The findings are in accordance with the findings of [15]. Shahjahan [18] also reported that the cultivation of a non-rice crop in between two rice crops reduced blast disease incidence. Bhuiyan *et al*. [5] observed that blast disease was transmitted by rice seed and seed samples of Boro carried more pathogen than Transplanted Aman. These might be the reason of having more disease infestation in Boro (irrigated) than Transplanted Aman (rain fed).

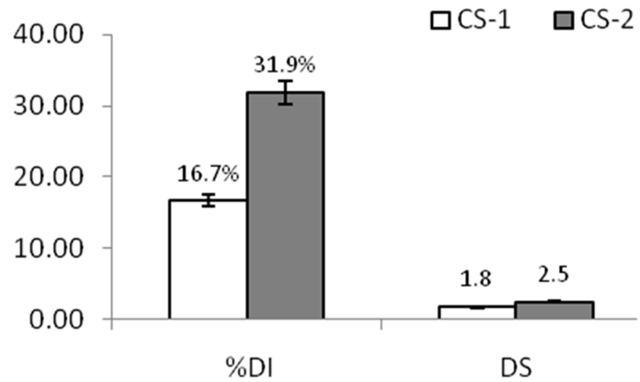

Figure 4. *Mean (mean±s.e.) disease incidence and severity of blast in two different crop sequences. CS-1 = Crop cycle with one rice followed by fallow/other crop/rice; CS-2 = Crop cycle with two rice followed by fallow/other crop/rice.*

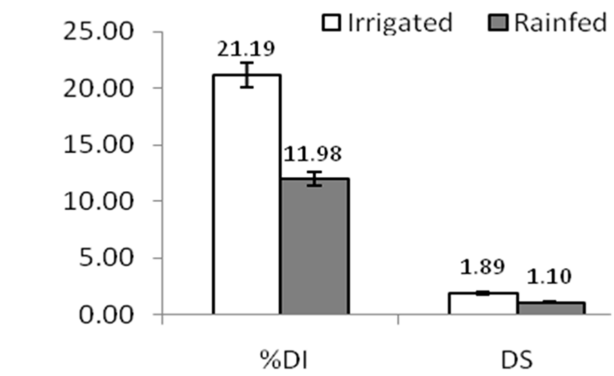

Figure 5. *Mean (mean±s.e.) disease incidence and severity of blast in two different rice growing ecosystems irrespective of cultivar and location.*

3.4. Assessment of Yield Loss Due to Blast Disease

Location (irrespective of cultivar) and cultivar (irrespective of location) specific yield loss was calculated from the disease data gathered from survey (Table 1). In irrigated ecosystem, the highest yield loss (65.4%) was estimated for hybrid Jhalak rice followed by high yielding cultivar BRRI dhan47 (55.4), BRRI dhan29 (37.9), BRRI dhan28 (19.3) and BRRI dhan50 (18.5) while the lower yield loss was recorded in BRRI dhan45 (5.3). In rain fed ecosystem (T. Aman season), higher yield loss (56.9%) was recorded in BRRI dhan34 followed by other local aromatic rice. Medium yield loss was observed in BRRI dhan39 and BRRI dhan44 which ranged 11.2-21.0% while yield loss was lower in BRRI dhan33, BRRI dhan41, BRRI dhan46, BRRI dhan40 and BRRI dhan49 ranged 4.7-9.7%.

The location based estimated yield loss was presented in Figure 6. In irrigated land, higher yield loss (34.7%) was noted in AEZ9 followed by AEZ19 (28.6%), AEZ11 (20.5%), AEZ1 (17.8%), AEZ23 (17.3%), AEZ12 (16.4%), AEZ28 (16.1%), AEZ2 (15.8) and AEZ13 (14.7%), while lower yield loss was recorded in AEZ20 (11.9%). In case of rain fed land lower yield loss (6.4%) was observed in AEZ2 and AEZ12 preceded by AEZ20 (7.1%), AEZ23 (9.7%), AEZ28 (11.2%), AEZ19 (11.5%) and AEZ11 (11.9%). In contrast, higher yield loss was predicted for AEZ9 (16.4%) followed by AEZ1 (15.5%) and AEZ13 (13.4%). Percent yield loss was higher in all the locations for Boro season compared to T. Aman season.

Survey in the present study on yield loss revealed that blast infected panicle causes severe yield loss. Yield loss is positively correlated with the incidence of severe neck blast [6]. Similar results were obtained by [12] who advocated that for every 10% of neck blast there was about a 6% yield reduction and a 5% increase in chalky kernals, which lowered the rice quality by one or two classes.

Under the present study, it was found that yield loss was highly correlated with disease incidence, indicating that management effort should be directed to limit disease dissemination. Despite of the absence of survey information spanning multiple years, the current results have yielded epidemiological information across the country that provide a practical basis for better management of rice blast disease in

Bangladesh.

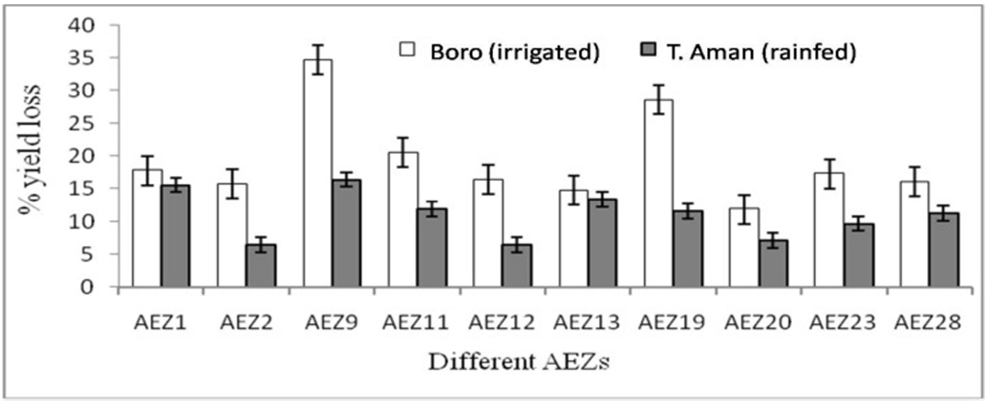

Figure 6. *Comparison in Percent yield loss (mean±s.e.) in Boro and Transplanted Amanin different AEZs irrespective of cultivar.*

4. Conclusion

Blast disease incidence was higher in Boro than in Transplanted Aman crops across the locations. The cultivation of a non-rice crop in between two rice crops reduced blast disease incidence. Disease incidence was higher in Jhalak hybrid rice in Boro and in BRRI dhan34 in Transplanted Aman. In the case of rain fed ecosystem, BRRI dhan34 was recorded as the most popular adopted cultivar whereas BRRI dhan28 in irrigated ecosystem. Higher yield loss was associated with Boro hybrid Jhalak and Transplanted Aman cultivar BRRI dhan34. Higher yield loss was noted in AEZ9 for both the seasons.

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