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Research Article

AN INVESTIGATION ON DISEASE INCIDENCE, GRAIN YIELD AND QUALITY OF BRRI DHAN29 IN BANGLADESH

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Abstract

Rice crops are susceptible to disease, which causes large yield losses in many Asian countries. The influence of disease incidence and severity on grain yield and quality of the rice (*Oryza sativa* L., cv. BRRI dhan29) was investigated in three different locations of Chief Farm Superintendent's (CFS) farm viz. Near Weather Yard (location-1), Near Agronomy Farm (location-2) and Near CFS farm office (location-3), Bangladesh Agricultural University (BAU), mymensingh, Bangladesh during boro season. In location-1, both brown spot and sheath blight were recorded whereas in location-2 and in location-3 only brown spot was recorded. Severity of brown spot was lowest at the location-1 and the highest at the location-3. Combined incidence of brown spot and sheath blight decreased the yield considerably whereas brown spot did not alone. Maximum severity of sheath blight was observed both in flowering and soft dough stage and minimum at maximum tillering stage. The lowest infection index of brown spot was obtained at maximum tillering stage and the highest infection index was obtained at soft dough stage whereas maximum and minimum infection index of sheath blight of rice were recorded at soft dough stage and maximum tillering stage, respectively. Aparently healthy seeds, spotted seeds, discoloured seeds, deformed seeds and chaffy grains were found among the three locations. Germination percentage was highest in healthy seeds compared to other category seeds. *Alternaria padwickii, Alternaria tenuis, Bipolaris oryzae*, *Curvularia lunata* and *Fusarium semitectum* were found to be associated with the seed. The highest and lowest occurrence of *A. padwickii, A. tenuis, B. oryzae, C. lunata* were recorded from chaffy grains and from healthy seeds, respectively. It is suggest that disease incidence and severity was gradually increased with the age of the plant and reduced yield and quality of BRRI dhan29.

Keywords: Incidence; quaility; rice; severity; yield

Introduction

Rice (*Oryza sativa L.*) is the most important cereal crop in Asia producing about 90% of the world production (IRRI, 2008). In Bangladesh an average yield of rice is 2.43 t ha^{-1} that is low compared to that of china (6.1 t ha^{-1}), India (3.0 t ha^{-1}), Indonesia (4.5 t ha^{-1}), Philippines (3.42 t ha^{-1}) and Vietnam (4.63 t ha^{-1}) (FAO, 2004). Among reasons of low yield of rice, diseases pose a major threat to its production (Ou, 1985; Groth *et al.,* 1991). In Bangladesh, 43 different diseases are known to occur in rice (Fakir, 2000). Out of 43 diseases, 10 diseases viz. brown spot, narrow brown spot, blast, sheath blight, sheath rot, bacterial leaf blight, stem rot, bakanae or foot rot, tungro and ufra are considered as the main constrain for rice production in Bangladesh which caused 10-15 % average yield loss (BRRI, 1999).

Damage severity by diseases mostly varied with the stage of the crop, cultivars, and to some extent with location and weather conditions. Assessment of the incidence and severity of plant disease is important to determine the geographic distribution and status of the disease throughout a region in order to prioritize research. In Bangladesh, detailed information regarding the status of diseases are scanty. Therefore, it is essential to document the diseases of rice and their damage severity.

Rice is prone to be attacked by a variety of soil borne and seed borne fungal pathogens. Most of the major diseases of rice are seed borne (Fakir, 2000). As the most destructive rice diseases prevalent across the globe are caused by fungus (Ling, 1980). Fungi growing on seeds can cause discoloration and reduce seed yield (Pinciroli *et al.*, 2013). As such, health quality of rice seed is quite poor in the country. Considering these views, in this study, we investigated the disease incidence and severity of rice and their impact on yield, intensity of different seed-borne fungi and germination of BRRI dhan29.

Materials and Methods

Experimental Site

The experiment was carried out in three different locations of CFS farm viz. location-1 (Near Weather Yard), location-2 (Near Agronomy Farm) and location-3 (Near CFS office), BAU, mymensingh, Bangladesh during boro season.

Experimental Design

The experiment was laid out in randomized complete block design (RCBD) with three replications. The unit plot size was 10 m^2 (4 m × 2.5 m).

Plant Materials and Growth Conditions

BRRI dahn29 was used as a plant materials. Seeds of BRRI dhan29 were collected from the agronomy farm, BAU, mymensingh. The seeds were soaked in water for 48 h and sprouted for 3 days in shade in moist gunny bags. The sprouted seeds were then broadcasted on the seed bed. Thrity-day old seedlings were transplanted in the field at plant to plant distance 10 cm and row to row distance 20 cm using 2-3 seedlings hill^{-1}.

The crop was fertilized with urea, triple superphosphate (TSP), muriate of potash (MOP), gypsum and zinc sulphate at the rate of 220, 85, 85, 74 and 5 kg ha^{-1}, respectively. The entire amount of TSP, MOP, gypsum and zinc sulphate were broadcast into the soil at final land preparation. The whole amount of urea was applied as top dressing at three equal splits at 20, 35 and 55 days after transplanting. All intercultural operations were performed in time as per requirement of the crop.

Disease Incidence and Severity

Ten plants from 10 randomly selected hills of each plot were tagged for grading the severity of diseases. The severity of two diseases viz., brown spot and sheath blight were recorded following IRRI recommended grading scale (Standard Evaluation System for Rice). The disease severity was recorded in the five growth stages of the plant namely maximum tillering stage, booting, panicle initiation stage, flowering stage and soft dough stage. Disease severity of brown spot (*B. oryzae*) of rice was measured on a 0-9 scale of Standard Evaluation System for Rice (Anonymous, 1996). The scale is 0 = no incidence, 1 = less than 1% leaf area affected, 2 = 1-3% leaf area affected, 3 = 4-5% leaf area affected, 4 = 6-10% leaf area affected, 5 = 11-15% leaf area affected, 6 = 16-25% leaf area affected, 7 = 26-50 leaf area affected, 8 = 51-75 % leaf area affected and 9 = 76-100% leaf areas affected. Disease severity of sheath blight (*Rhizoctonia solani*) of rice was recorded using Standard Evaluation System scale (IRRI, 1996). The scale based on relative lesion height. The scale is 0 = No infection observed, 1 = lesions limited to lower 20% of the plant height, 3 = 20-30%, 5= 31-45%, 7 = 46-65%, 9 = More than 65%.

Percent Infection Index

Percent infection index was calculated by following the formula as described by Singh (2000).

$$\%\text{ infection index } = \frac{\text{Sum disease ratings} \times 100}{\text{Total of disease ratings} \times \text{Maximum disease grade}}$$

Yield Parameters

The crops were harvested at full ripening stage and then weight of grains plant^{-1} and grain yield ha^{-1} were calculated.

Seed Health Test

Seed health testing was performed using dry inspection method in seed plathology center, BAU, mymensingh. Four hundred seeds were taken randomly from each collected sample for dry inspection method. The seed sample were categorized visually for the presence of any distinct disease symptom or any other physiological abnormalities and were grouped into healthly, spotted, discoloured, deformed and chaffy grains. The different seed categories were expressed in percentage.

Seed Germination and Identification of Fungus Associated with Seed Samples

Seed borne pathogens in seed sample was detected using blotter method as previously described by ISTA (1996). Three layers of blotting paper (Whatman filter paper no. 1) soaked in water and were placed at the bottom of plastic petridish (diameter: 9 cm) and thereafter 25 seeds were placed on the moist filter paper. The petridishes containing seeds were incubated at 20 ± 2℃ under alternating cycles of 12h near ultraviolet light and darkness for 10 d. Time to time watering was done to keep the filter paper moist. After incubation, number of germinated seeds was counted from each petredish to calculate the germination rate. Then the incubated seeds were examined under stereobinocular microscope in order to record the incidence of different seed borne fungi that grew out of the seeds. For proper identification of fungi temporary slides were prepared and observed under compound microscope.

Statistical Analysis

The data were analyzed statistically in MSTAT program. The analysis of variance were performed using LSD and correlation matrix.

Results and Discussion

Disease incidence and severity of BRRI dhan29 were recorded in three locations at different growth stages viz. maximum tillering, booting, panicle initiation, flowering and soft dough (Table 1). In location-1, brown spot and sheath blight were recorded whereas in location-2 and in location-3 only brown spot was recorded. Among the three locations, severity of brown spot was lowest (0.5, 0.7, 0.7, 0.8 and 0.9 grade at the five growth stages, respectively) in the location-1 and the highest severity of brown spot (1, 1, 1, 1.5 and 2 at the five growth stages, respectively) was recorded from the location-3.

Table 1: Disease severity of brown spot and sheath blight of rice in different locations at different growth stages.

Growth stages	Disease severity grade (0-9 scale)			
	Brown spot			Sheath blight
	Location-1	Location-2	Location-3	Location-1
Maximum tillering	0.5	1.0	1.0	0.8
Booting	0.7	1.0	1.0	1.2
Panicle initiation	0.7	1.4	1.0	1.6
Flowering	0.8	1.4	1.5	2.1
Soft dough	0.9	1.6	2.0	2.1

Munshi and Singh (2000) reported that sheath blight (*R. solani)* was able to infect rice plants at tillering and flowering stages. However, maximum severity of sheath blight (2.1 grade) was observed both in flowering and in soft dough stage and minimum disease severity (0.8 grade) was observed at maximum tillering stage (Table 1). This result indicates that disease incidence and severity increased with the age of the plant. This is an agreement with the findings of Dubey and Toppo (1997) and Sania *et al.* (2015) who found that susceptibility to the sheath blight and brown spot, initially increased with the increasing age of rice plants. Singh *et al.* (2002) also observed that susceptibility of rice plants to sheath blight disease initially increases with increasing growth stage of crop with maximum susceptibility recorded at soft dough stage.

Percent infection index for brown spot and sheath blight of rice of BRRI dhan29 was also recorded at five growth stage (Table 2). The lowest infection index (9.95%) of brown spot was obtained at maximum tillering stage and the highest infection index (36.36%) was obtained at soft dough stage, whereas maximum (28.90%) and minimum (13.77%) infection index of sheath blight of rice were recorded at soft dough stage and maximum tillering stage, respectively. This suggest that percent infection index increased with age of plant. Sheath blight infection from panicle initiation to flowering resulted in yield loss by reducing the mean grain weight and the number of filled grains (Cu *et al.*, 1996). *B. oryzae*, the pathogen of brown spot causes severe infection during the reproductive phase of the plant that causes both quantitative and qualitative losses (Klomp, 1977).

Grain weight plant^{-1} and grain yield were recorded in three locations (Table 3). Highest grain weight plant^{-1} (27.26 g) was recorded in location-3 followed by location-2 (26.12 g) whereas lowest grain weight plant^{-1} (21.65 g) was obtained in location-1, suggesting that disease incidence and severity has direct effect on grain weight plant^{-1} which is consistent with the results of Singh *et al.* (2013). The highest yield was recorded in location-3 (6.27 t ha^{-1}) followed by location-2 (6.08 t ha^{-1}) while it was lowest in location-1 (4.75 t ha^{-1}) (Table 3). This result suggest that sheath blight incidence decreased the yield considerably and minimum incidence and severity results maximum yield. Groth (2008) and Bernardes *et al.* (2009) observed that sheath blight causes up to a 50% decrease in the rice yield under favourable conditions around the world.

Table 2: Percent infection index at different growth stages for brown spot and sheath blight of rice in different locations.

Locations	Disease	% infection index at different growth stages				
		Maximum tillering	Booting	Panicle initiation	Flowering	Soft dough
Location-1	Brown spot	10.66 b	16.92	16.21	20.90 b	22.19 b
Location-2	Brown spot	26.71 a	20.86	21.55	19.11 b	20.57 b
Location-3	Brown spot	9.95 b	23.59	19.72	30.53 a	36.36 a
L.S.D (0.05)		8.42	NS	NS	9.02	9.71
Location-1	Sheath blight	13.77	18.62	21.16	27.16	28.90

Table 3: Effect of disease incidence on grain weight plant^{-1} (g) and yield (t ha^{-1}) of BRRI dhan29.

Locations	Diseases recorded	Grain weight plant^{-1} (g)	Yield (t ha^{-1})
Location-1	Brown spot + Sheath blight	21.65	4.75
Location-2	Brown spot	26.12	6.08
Location-3	Brown spot	27.26	6.27

Good quality of seed is an important factor which ensures successful crop production. Using good quality and cleaned seed of rice, yield could be increased by 7-20% (Diaz *et al.*, 1998). Quality of seeds was studied by seed health testing in dry inspection and in blotter method in the laboratory. Among the locations, the samples contained 28.58–33.97% apparently healthy seeds, 21.58-30.42% spotted seeds, 4.75-8.33% discoloured seeds, 6.51-7.2% deformed seeds and 20.08-36.42% chaffy grains, where the lowest chaffy grain (20.08) was obtained from location-3 and highest chaffy grain (36.42%) was recorded from location-2 followed by location-1 (35.58%) which is statistically simillar (Table 4). However, Pandey and Singh (2010) found maximum number of heathy seeds and minimum number of spotted seed, discoloured seed, deformed seed, chaffy seed were found in rice. Percent weight of healthy seeds 42.71-44.81, spotted seeds 30.17-37.73, discoloured seeds 5.85-8.33, deformed seeds 5.70-7.50 and chaffy grains 5.15-10.61 were found among the three locations (Table 5). Seed weight was significantly higher in the normal-looking seeds than in the discolored ones (Danquah *et al.*, 1976). This results indicate that disease incidence and severity results in reduction of yield and quality due to decrease in number of filled grain plant^{-1} and different catagories of seeds, respectively. It has been found that by using clean apparently healthy seeds, disease incidence of rice can be reduced to 53.87% (Hossain and Doullah, 1998).

Percent germination of seed under different locations showed reduced germination in spotted, discoloured and deformed seeds compared to healthy seeds. From all locations highest (99.0-98.50%) and lowest germination (71.0-80.50%) percentage were recorded from healthy seeds and discolored seeds, respectively (Table 6). Pandey and Singh (2010) observed that healthy seed gave maximum number of germination of rice. Grain discoloration is an economically important disease of rice which is caused by various fungal and bacterial pathogens. Seed germination was lower in the discolored seeds than in the normal-looking seeds (Danquah *et al.*, 1976). Our results consist of this finding that grain discoloration decreased seed germination (Table 6). Ahmed *et al.* (2013) and Sharma *et al.* (1987) reported that germination decreased in proportional with discolouration severity. Moreover, Danquah et al. (1976) reported that infected seeds are often discolored, an indication of poor seed quality.

Table 4: Percent different categories of seeds under dry inspection of three locations.

Locations	**% of different categories seeds**				
	Healthy seed	**Spotted seeds**	**Completely discoloured seeds**	**Deformed seeds**	**Chaffy grains**
Location-1	30.00	21.58	6.33	6.51	35.58 a
Location-2	28.58	23.59	4.75	6.66	36.42 a
Location-3	33.97	30.42	8.33	7.2	20.08 b
L.S.D (0.05)	NS	NS	NS	NS	12.78

NS =Not significant

Table 5: Percent weight of different category seeds of three locations.

Locations	**% of weight of different categories seeds**				
	Healthy seeds	**Spotted seeds**	**Completely discoloured seeds**	**Deformed seeds**	**Chaffy grains**
Location-1	44.81	30.17	6.91	7.50	10.61 a
Location-2	42.71	36.16	5.85	6.10	9.45 a
Location-3	43.09	37.73	8.33	5.70	5.15 b
L.S.D (0.05)	NS	NS	NS	NS	12.78

NS =Not significant

Table 6: Germination percentage of different categories seeds of three locations.

Locations	**% germination of different categories seeds**			
	Healthy seeds	**Spotted seeds**	**Completely Discoloured seeds**	**Deformed seeds**
Location-1	99.0	89.50	71.0	80.50
Location-2	98.50	93.00	80.50	88.0
Location-3	99.0	85.00	83.50	84.50

Table 7: Seed borne fungal infection on different category seeds of three locations.

Locations	Fungi associated with the seed	% Seed borne fungi infection				
		H.S.	S. S.	C.D.S.	D.S.	C.G.
Location-1	*Alternaria padwickii*	1	1.0	2.0	3.0	8.0
	Alternaria tenuis	1.5	3.0	7.5	4.5	4.5
	Bipolaris oryzae	15.5	21.0	39.0	22.5	32.5
	Curvularia lunata	16.5	19.25	36.5	38.13	60.5
	Fusarium semitectum	21.0	16.0	6.0	6.0	3.0
Location-2	*Alternaria padwickii*	1.5	2.62	2.0	0.5	7.0
	Alternaria tenuis	1.37	4.0	12.0	8.5	32.5
	Bipolaris oryzae	23.0	27.5	39.0	25	78.5
	Curvularia lunata	6.0	11.0	17.0	6.5	38.0
	Fusarium semitectum	15.0	26.5	16.5	33.0	4.0
Location-3	*Alternaria padwickii*	0	0	0	0	3.5
	Alternaria tenuis	2.5	1.0	7.5	9.5	21.0
	Bipolaris oryzae	5.5	26.5	23.0	26.0	51.5
	Curvularia lunata	3.5	15.5	15.0	24.5	50.5
	Fusarium semitectum	16.0	9.0	14.5	8.5	1.0

H.S. = Healthy seeds, S.S. = Spotted seeds, C.D.S. = Completely discoloured seeds, D.S. = Deformed seeds and C.G. = Chaffy grains.

Results showed that five fungi viz., *A. padwicki*, *A. tenuis*, *B. oryzae*, *C. lunata* and *F. semitectum* were found to be associated with the seeds of different samples of the three locations (Table 7). This is an agreement with Bhuiyan *et al.* (2013) who found six important pathogenic fungi viz. *B. oryzae*, *A. padwickii*, *Sarocladium oryzae*, *C. lunata*, *Aspergillus niger* and *Fusarium* spp. in rice seed samples collected from two different locations in Bangladesh. The association of seed-borne fungi of rice also have been reported by many researchers (Sharma and Vaid, 1997; Nahar, 2003; Ahmed *et al.*, 2013). The most predominant was *B. oryzae* with the seeds of different samples of the three locations ranged 5.5-78.5%, followed by *C. lunata* (3.5-60.5%), *A. tenuis* (1.5-32.5%), *A. padwickii* (0-8%), where the lowest occurrence was recorded from healthy seeds (5.5%) and the highest occurrence was recorded from chaffy grains (78.5%). The occurrence of *F. semitectum*on, the seed surface of different samples of the three locations ranged from 1-33% where the lowest occurrence was recorded in chaffy grains and the highest occurence was recorded in deformed seeds (Table 7). This suggest that rice is prone to devastating diseases such as brown spot caused by *B. oryzae*. Gopalakrishnan *et al.* (2010) observed that the most predominant one was *B. oryzae* which was associated with 58.89% seed samples. Habib *et al.* (2012) and Ahmed *et al.* (2013) also found that screening of rice seed samples for seed-borne fungi revealed aximum incidence of *B. oryzae*.

The fungi that are reported to be associated with discoloration of grains are *B. oryzae*, *A. padwickii*, *P. oryzae*, *Fusarium moniliforme*, *F. graminearum*, *Ngrospora oryzae* and *Curvularia* spp. (Ou, 1985; Arshad et al., 2009). Among them, *B. oryzae* was the most prevalent fungi causing seed discoloration and reduce seed germination in rice (Ou, 1985; Mondal *et al.*, 1998; Ibrahim and Abo El-Dahab, 2014). Islam *et al.* (2012) also observed a general trend of negative correlation between seed germination and fungi associated with rice seed. Control of seed-borne fungi will increase percentage of seed germination and grain yield (DGISP, 1985). This results indicates that pathogenic fungal association with the seeds have profound effects on weight of grain (Table 5) and germination (Table 6). Khare (1999) suggest that seed borne pathogens affect seed quality.

From this study, it had clearly been found that disease incidence and severity was gradually increased with the age of the plant. Due to disease incidence and severity, different categories of seeds associated with fungi and reduced germination in infected seeds compared with healthy seeds which might be the cause of yield and quality reduction of BRRI dhan29.

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