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# Screening Rice Germplasm against Sheath Blight Disease of Rice and its Integrated Management in Bangladesh

S Parveen[1*], M A Ali[2] and M A Ali[3]


## ABSTRACT

Fifty-seven rice germplasm collected from BRRI Genebank were screened against sheath blight (ShB) by artificial inoculation in field and laboratory conditions in T. Aman 2012. Significant differences on relation to lesion height (RLH) among the germplasm were observed, where the highest (83%) was recorded in susceptible check, BR11 and the lowest (8.33%) was in Orgoja. Severity score of ShB was recorded maximum (9) in Dudhsail, Basi, Chaula mari, Holdemota, Calendamota, Semmua, Kotijira, Halisail, Horakani, Kalisura, Ashfuli, Huglapata and BR11 as highly susceptible to ShB, whereas it was minimum (1) in Orgoja. Gopal ghosh was observed as moderately tolerant with 27.33% RLH and severity score 3, while Kala binni, Khazur chari, Binni, Kalagora, Patjait and Dorkumur found moderately tolerant with severity score 5. In detached sheath inoculation method in test tube, most of the germplasms found highly susceptible, except Orgoja as resistant and Gopal ghosh as moderately tolerant. However, Orgoja showed resistance in both field inoculation and detached sheath inoculation methods. But, Dorkumur was found moderately tolerant in field and highly susceptible in detached sheath inoculation in laboratory. The experiment of Integrated Disease Management (IDM) packages was conducted in the farmer's field with BR11 at Fulpur, Mymensingh during T. Aman 2013. The IDM practices of rice ShB resulted profound effect. Relative lesion height, percent disease index, tiller infection and hill infection were maximum (68%, 69%, 86% and 79% respectively) in $T_6$ (control) and minimum in $T_1$ [FDR (removal of floating debris) + 30 July transplanting + Potash (K) fertilizer (202 g decimal$^{-1}$) + Top dressing of urea (247 kg ha$^{-1}$) in four equal splits at 15 days interval + single spray of fungicides of Azoxystrobin 10% (0.17 kg ha$^{-1}$) + Tebuconazole 90% (500 ml ha$^{-1}$)]. Moreover, the highest number of panicles per m$^2$, filled grains per panicle and grains yield were recorded in $T_1$ (160, 150 and 6.25 t ha$^{-1}$ respectively) and the minimum in $T_6$ (227, 120 and 3.6 t ha$^{-1}$ respectively). Therefore, the best IDM package was $T_1$ for its effective control of ShB disease as well as yield maximization of rice. Finally, Orgoja could be used in resistance breeding for varietal improvement and the IDM package of $T_1$ need to be recommended to prescribe in the farmer's field after simulation in different AEZs and seasons with different varieties of Bangladesh.


**Key words:** Germplasm, resistance, integrated management, sheath blight, rice

## INTRODUCTION

Bangladesh agriculture involves food production for 163.65 million people (Salam *et al.*, 2014), where rice is the principal food. This increasing population requires increasing crop yields for stable supply of grain to achieve food security of the country. Consequently, the national average production needs to be increased from 3 to 5 t ha$^{-1}$ in next 20 years (Mahbub *et al.*, 2001). In Bangladesh, rice production area is 11.01 million hectares of land during 2016-17 (BBS, 2018). However, 36.27 million metric tons of rice is produced in the country during 2017-18 (AIS, 2019). Sheath blight (ShB) of rice was first reported in Japan by Miyakie in 1910. It is caused by *Rhizoctonia solani* Kuhn. It is considered as the most damaging major epidemic disease of rice (Li *et al.*, 2012). ShB is an important disease of rice, especially in intensive rice production systems. The average incidence of ShB in Bangladesh is about 20.3% (Ali *et al.*, 2003). The yield loss caused by ShB in Bangladesh ranged from 14 to 31% under farmer's field (Shahjahan *et al.*, 1986). The presence of one or many factors

[1]Senior Scientific Officer, Training Division, BRRI, Gazipur 1701, [2]Professor, Department of Plant Pathology, Faculty of Agriculture, BAU, Mymensingh and [3]Director (Administration and Common Service), BRRI, Gazipur 1701. *Corresponding author's E-mail: parveenbrri@yahoo.com.

may enhance the severity of ShB beyond economic threshold levels, thereby incurring low to high yield losses.

Incidence and development of ShB of rice depends on climate, host and soil factor (Damicone *et al.*, 1993). Short duration and semi-dwarf cultivars are more susceptible to ShB (Groth and Lee, 2002). During rice ShB epidemics, severe lodging may occur (Wu *et al.*, 2012). Differences in yield loss between very susceptible and moderately resistant cultivars are substantial. On infection by *Rhizoctonia solani,* semi-dwarf varieties show more than twice the reduction in yield and milling quality.

Breeding for resistance against ShB has not been successful due to lack of sources of resistant genes (Rao, 1995; Hashiba and Kobayashi, 1996). Resistance source against ShB disease of rice is not available in Bangladesh and anywhere (Jalal Uddin *et al.*, 2000). Consequently, none of the high yielding varieties is resistant to ShB disease neither in Bangladesh nor elsewhere in the world. Fortunately, rice land races have proven to be highly adaptive to diverse environmental conditions and are believed to harbour a number of valuable genetic resources for crop improvement (Karmakar *et al.*, 2012; Roychowdhury *et al.*, 2013; Ganie *et al.*, 2014). Some of the landraces such as Buhjan, Banshpata, Bhasamanik, Nagra Sail, Raghu Sail are tolerant to rice ShB (Dey, 2014). Therefore, local or land races of rice need to be exploited for getting resistant or moderately resistant or even better tolerant sources for ShB disease.

The control of ShB in the field so far is mainly relied on the use of fungicides, which is not sustainable for its residual effect along with the potential risk of resistant to fungicides overtime. Disease management programme against ShB can concentrate different approaches such as incorporating cultural practices, exploitation of host resistance, biological control with *Trichoderma harzianum* and *Trichoderma viride* and chemical control. Ashrafuzzaman *et al*. (2005) also reported that emphasis should be given on different management options to control ShB disease of rice. For clean cultivation, burning the crop residues, destroy grasses and other hosts from the field, collecting and burying floating debris after final land preparation may reduce infection foci. Instead of applying excess dose of nitrogen, split application of K fertilizer with last top dress of urea can reduce its infestation. Application of 40 kg MP/ha as top dress in two equal splits and transplanting with 20 cm × 20 cm spacing have affect on ShB (Hossain and Mia, 2001). Large amount of N and phosphate (P) is favourable for ShB disease (Dasgupta, 1992) and high potash (K) or PK is useful for infection (CRRI, 1977). Therefore, the present research programme was planned and designed to develop management technologies of the disease with the aim of recommending suitable control strategies in Bangladesh. The present study was under taken to screen germplasm for their reaction to ShB and to develop an integrated management practice for controlling ShB of rice in Bangladesh.

## MATERIALS AND METHODS

### Screening of rice germplasm against ShB of rice

**Rice germplasm.** A total of 57 rice germplasm collected from BRRI Genebank were screened against ShB disease of rice in the field through hill inoculation method and BR11 was used as susceptible check (Table 1).

**Table 1. Primary information of the germplasms used for screening resistance source against sheath blight.**

| Acc. no.* | Variety | Acc. no. | Variety | Acc. no. | Variety |
|---|---|---|---|---|---|
| 4111 | Gopal ghosh | 4794 | Kalahati | 5221 | Kalisura |
| 4112 | Chata bazail | 4795 | Khajur chhori | 5222 | Akra |
| 4113 | Ram dash | 4849 | Rayeda | 5223 | Ushi har |
| 4114 | Paizra | 5121 | Jamni | 5250 | Ashfuli |
| 4118 | Kala binni | 5122 | Chaula maghi | 5286 | Ranisalut |
| 4149 | Beto | 5190 | Bushi hara (mota) | 5289 | Buripagli |
| 4155 | Chini kani | 5192 | Lohamugra | 5298 | Harisankar |
| 4156 | Minki | 5193 | Chaula mari | 5300 | Birinde |
| 4162 | Kasrail | 5194 | Kalagora | 5310 | Orgoja |
| 4163 | Khazur chari | 5195 | Patjait | 5316 | Nonamurchi |
| 4239 | Binni | 5196 | Holdemota | 5319 | Gandhakusturi |
| 4267 | Birpala | 5197 | Kanchachikon | 5327 | Huglapata |
| 4271 | Rayda | 5198 | Dholeshwar mota | 5329 | Gota |
| 4272 | Dhaki rayda | 5199 | Calendamota | 5330 | Dorkumur |
| 4768 | Kaijhuri | 5212 | Semmua | 5337 | Changi |
| 4773 | Dudhsail | 5213 | Kotijira | 5345 | Rasasail |
| 4777 | Kashra | 5217 | Ashkor | 5347 | Sackhorkhana |
| 4778 | Katarangi | 5218 | Baskor | -- | BR11 |
| 4792 | Basi | 5219 | Halisail | | |
| 4793 | Sada pankaich | 5220 | Horakani | | |

* BRRI Genebank accession number.

**Field experiment.** The experiment was conducted at the experiment field of Bangladesh Rice Research Institute (BRRI), Gazipur during T. Aman 2012. A levee was made surrounding plots to maintain standing water up to 5.0 cm inside. Land was prepared 15 days before transplanting/seedling. Ploughing and cross ploughing followed by laddering was done by power tiller. Weeds were cleaned manually. The seedlings of the tested germplasms were raised in plastic tray in the Plant Pathology net house. Thirty-day-old 2-3 seedlings per hill were transplanted with a spacing of 20 cm × 15 cm. Fertilizers were applied @ 405: 150: 202: 135: 10 g decimal$^{-1}$ of urea, TSP, MOP, gypsum and zinc sulphate. All fertilizers were applied in basal, except urea (Anonymous, 2010). For agronomic, weed management, irrigation and drainage and insect management current standard recommendations were followed (Anonymous, 2007).

**Preparation of inoculum.** One hundred PDA plates in glass petridishes were prepared following the standard procedure. The fungus (*Rhizoctonia solani)* was grown in the petridishes containing PDA medium and incubated for seven days at room temperature (25 to 30°C) for growth and development of the pathogen.

**Inoculation of pathogen.** Inoculations were done at maximum tillering stage (Bhaktavatsalam *et al.*, 1978). Two methods of inoculation were employed for inoculation of germplasms by *Rhizoctonia solani*. After seven days of inoculation lesion length and leaf sheath length were measured and calculated. The methods were as follows:

a. Hill inoculation-Total hill were inoculated with *Rhizoctonia solani* Kuhn culture (7 days) grown on PDA medium. Prior to inoculation, eight hills were tagged randomly in the central area of each plot in the field for inoculation. Inoculation was done by inserting a piece of culture medium (cutting the culture medium into eight pieces) at the middle of each hill in the afternoon, colonized by the ShB pathogen in a tagged rice hill and maintained standing water onward of the crop growth to maintained high moisture below canopy level for disease development (Sharma and Teng, 1990).

b. Detached sheath inoculation-Detached sheath was inoculated in moist test tube (Fig. 1). In detached sheath inoculation method, one tiller from each entry was taken *i.e.* three tillers for three replications. Tillers were cut in such a way that leaf sheath did not separate from stem or remain in contact with stem and uniform in size. Water soaked cotton was placed at the bottom of the test tube and then placed 6-9 mm mycelial block (growing pathogen) inside the sheath. The test tube was then plugged with soaked cotton.

**Data recording.** The disease severity was recorded from the data collected from 25 hills in each replication of each treatment. Severity was calculated by relative lesion height (RLH) (McKinney, 1923). Data were recorded for each treatment following standard evaluation system (SES) for rice in 0-9 scale (Anonymous, 1996). Data of the lesion height, plant height, 1000 grain weight and grain yield (g hill$^{-1}$) were also recorded. In detached sheath inoculation method, ShB severity was measured by RLH using the following formula-

$$\text{RLH} = \frac{\text{Lesion height (cm)}}{\text{Leaf sheath height (cm)}} \times 100$$

**Integrated management of ShB of rice**

**Field experiment.** The experiment was conducted in the farmer's field with BR11 at Fulpur, Mymensingh during T. Aman 2013. Plant to plant spacing was 15 cm and row to row distance was 16 cm. Randomized RCBD was used with four replications. Plot size was 2.5 m × 4 m. Plot to plot distance was 0.5 m and block to block distance was 1 m. The best options obtained from the results of different experiments (Parveen, 2016) were included into integrated disease management (IDM) packages and were simulated in the field. The treatments used in this study were shown below:

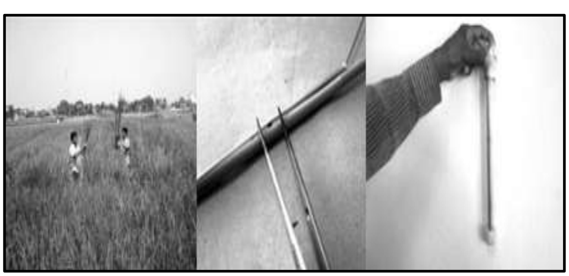

Fig. 1. Detached sheath inoculation method of screening against ShB of rice.

$T_1$=FDR (removal of floating debris) + 30 July planting + Potash (K) fertilizer (202 g decimal$^{-1}$) + Top dressing of urea (247 kg ha$^{-1}$) in four equal splits at 15 days interval + single spray of fungicide [Azoxystrobin 10% (0.17 kg ha$^{-1}$) + Tebuconazole 90% (500 ml ha$^{-1}$)]. $T_2$= 30 July planting + K-dose + top dressing of urea in four equal splits at 15 days interval + single spray of fungicide. $T_3$= K-dose + top dressing of urea in four equal splits at 15 days interval + single spray of fungicide. $T_4$= Top dressing of urea in four equal splits at 15 days interval + single spray of fungicide. $T_5$= Single spray of fungicide. $T_6$= Control.

**Inoculation of pathogen.** Same as hill inoculation method.

**Data collection.** Twenty-five hills were selected at random from each experimental unit. Number of infected tillers and hills were counted. Incidence was recorded by tiller infection and expressed in percentage, while severity by relative lesion height (RLH) and percent disease index (PDI) (McKinney, 1923). Data were recorded for each treatment following standard evaluation system (SES) for rice in 0-9 scale (Anonymous, 1996). Data on total tiller, infected tiller, plant height, panicle per m$^2$, filled grain, unfilled grain, 1000 grain weight (TGW) and grain yield were also recorded. PDI was measured by using the following formula-

$$\text{PDI} = \frac{\text{Total rating}}{\text{No. of observation} \times \text{Maximum grade}} \times 100$$

**Statistical analysis.** The data were subjected to statistical analysis and ANOVA (analysis of variance) were constructed following RCBD by SPSS 2.05 programme for both the experiments. The treatment means were compared by LSD test at probability level P=0.05.

RESULTS AND DISCUSSION

**Assessment of germplasm against ShB of rice**

Table 2 shows that there was a variation among the germplasms on ShB disease development and yield through hill inoculation in the field. Significant differences on RLH among the germplasms were observed. The highest RLH was recorded in BR11 (83%) and the lowest was in Orgoja (8.33%). The maximum (9) severity (SES) score of ShB was recorded in Dudhsail, Basi, Chaula mari, Holdemota, Calendamota, Semmua, Kotijira, Halisail, Horakani, Kalisura, Ashfuli, Huglapata and BR11, which were highly susceptible (HS) to ShB disease, whereas the minimum severity score (1) was observed in Orgoja. Gopal ghosh was observed as moderately tolerant to ShB disease with 27.33% RLH and severity score 3. Moreover, Kala binni, Khazur chari, Binni, Kalagora, Patjait and Dorkumur found moderately tolerant to ShB with severity score 5. On the other hand, the highest yield was found in Beto (18.23 g hill$^{-1}$), Rayda (18.15), Ushi har (18.23) and Buripagli (18.15) and the lowest in Kashra, Calendamota, Orgoja and Sackhorkhana (4.85 g hill$^{-1}$) germplasms (Table 3).

**Table 2. Reaction of screened germplasm against ShB due to artificial inoculation of *Rhizoctonia solani* through hill inoculation method in the field.**

| Acc. no. | Variety | Growth duration | Plant height (cm) | RLH (%) | SES score | Reaction |
|---|---|---|---|---|---|---|
| 4111 | Gopal ghosh | 150 | 131 | 27.33 | 3 | MT |
| 4112 | Chata bazail | 151 | 140 | 47.66 | 7 | HS |
| 4113 | Ram dash | 152 | 144 | 54.00 | 7 | HS |
| 4114 | Paizra | 149 | 127 | 63.00 | 7 | HS |
| 4118 | Kala binni | 151 | 129 | 38.00 | 5 | MT |
| 4149 | Beto | 155 | 154 | 53.00 | 7 | HS |
| 4155 | Chini kani | 147 | 141 | 61.66 | 7 | HS |
| 4156 | Minki | 156 | 141 | 61.33 | 7 | HS |
| 4162 | Kasrail | 154 | 141 | 53.66 | 7 | HS |
| 4163 | Khazur chari | 148 | 141 | 41.33 | 5 | MT |
| 4239 | Binni | 147 | 137 | 43.66 | 5 | MT |
| 4267 | Birpala | 141 | 136 | 54.33 | 7 | HS |
| 4271 | Rayda | 149 | 136 | 50.33 | 7 | HS |
| 4272 | Dhaki rayda | 146 | 150 | 60.00 | 7 | HS |
| 4768 | Kaijhuri | 142 | 119 | 56.33 | 7 | HS |
| 4773 | Dudhsail | 154 | 149 | 69.00 | 9 | HS |
| 4777 | Kashra | 145 | 147 | 51.66 | 7 | HS |
| 4778 | Katarangi | 145 | 151 | 64.66 | 7 | HS |
| 4792 | Basi | 140 | 115 | 75.33 | 9 | HS |
| 4793 | Sada pankaich | 138 | 149 | 53.66 | 7 | HS |
| 4794 | Kalahati | 143 | 149 | 62.33 | 7 | HS |
| 4795 | Khajur chhori | 142 | 150 | 56.66 | 7 | HS |
| 4849 | Rayeda | 145 | 152 | 56.33 | 7 | HS |
| 5121 | Jamni | 147 | 150 | 64.66 | 7 | HS |
| 5122 | Chaula maghi | 149 | 144 | 63.33 | 7 | HS |
| 5190 | Bushi hara (mota) | 150 | 153 | 57.00 | 7 | HS |
| 5192 | Lohamugra | 149 | 150 | 55.33 | 7 | HS |

**Table 2. Continued.**

| Acc. no. | Variety | Growth duration | Plant height (cm) | RLH (%) | SES score | Reaction |
|---|---|---|---|---|---|---|
| 5193 | Chaula mari | 145 | 151 | 72.66 | 9 | HS |
| 5194 | Kalagora | 149 | 141 | 42.33 | 5 | MT |
| 5195 | Patjait | 149 | 152 | 45.00 | 5 | MT |
| 5196 | Holdemota | 150 | 146 | 68.66 | 9 | HS |
| 5197 | Kanchachikon | 153 | 156 | 64.66 | 7 | HS |
| 5198 | Dholeshwar mota | 154 | 165 | 60.33 | 7 | HS |
| 5199 | Calendamota | 155 | 161 | 66.33 | 9 | HS |
| 5212 | Semmua | 152 | 142 | 69.33 | 9 | HS |
| 5213 | Kotijira | 150 | 134 | 70.00 | 9 | HS |
| 5217 | Ashkor | 149 | 146 | 55.33 | 7 | HS |
| 5218 | Baskor | 150 | 158 | 49.33 | 7 | HS |
| 5219 | Halisail | 148 | 149 | 66.00 | 9 | HS |
| 5220 | Horakani | 148 | 166 | 67.33 | 9 | HS |
| 5221 | Kalisura | 149 | 144 | 74.33 | 9 | HS |
| 5222 | Akra | 148 | 174 | 54.00 | 7 | HS |
| 5223 | Ushi har | 152 | 144 | 52.66 | 7 | HS |
| 5250 | Ashfuli | 161 | 98 | 66.66 | 9 | HS |
| 5286 | Ranisalut | 165 | 147 | 59.00 | 7 | HS |
| 5289 | Buripagli | 163 | 165 | 58.33 | 7 | HS |
| 5298 | Harisankar | 153 | 164 | 51.33 | 7 | HS |
| 5300 | Birinde | 157 | 150 | 64.66 | 7 | HS |
| 5310 | Orgoja | 160 | 160 | 8.33 | 1 | R |
| 5316 | Nonamurchi | 155 | 152 | 55.00 | 7 | HS |
| 5319 | Gandhakusturi | 152 | 139 | 65.00 | 7 | HS |
| 5327 | Huglapata | 154 | 147 | 73.33 | 9 | HS |
| 5329 | Gota | 151 | 152 | 57.66 | 7 | HS |
| 5330 | Dorkumur | 159 | 153 | 41.66 | 5 | MT |
| 5337 | Changi | 151 | 151 | 55.66 | 7 | HS |
| 5345 | Rasasail | 159 | 113 | 62.33 | 7 | HS |
| 5347 | Sackhorkhana | 153 | 128 | 53.66 | 7 | HS |
| -- | BR11 | 145 | 115 | 83.00 | 9 | HS |
| LSD (P=0.05) | | | | | | |

MT=Moderately tolerant, HS=Highly susceptible, R=Resistant.

**Table 3. Yield and 1000 grain weight (TGW) of screened germplasms against ShB due to artificial inoculation of *Rhizoctonia solani* through hill inoculation in the field.**

| Acc. no. | Variety | TGW (g) | Yield (g hill-1) |
|---|---|---|---|
| 4111 | Gopal ghosh | 20.13 | 6.92 |
| 4112 | Chata bazail | 21.14 | 8.17 |
| 4113 | Ram dash | 24.63 | 9.05 |
| 4114 | Paizra | 25.05 | 9.60 |
| 4118 | Kala binni | 29.11 | 10.05 |
| 4149 | Beto | 20.38 | 18.23 |
| 4155 | Chini kani | 9.19 | 5.30 |
| 4156 | Minki | 29.27 | 6.32 |
| 4162 | Kasrail | 26.14 | 14.55 |
| 4163 | Khazur chari | 21.44 | 7.24 |
| 4239 | Binni | 10.22 | 8.22 |
| 4267 | Birpala | 20.33 | 10.92 |
| 4271 | Rayda | 24.37 | 18.15 |
| 4272 | Dhaki rayda | 12.40 | 10.36 |
| 4768 | Kaijhuri | 29.16 | 10.28 |
| 4773 | Dudhsail | 14.03 | 10.07 |
| 4777 | Kashra | 16.05 | 4.85 |

**Table 3. Continued.**

| Acc. no. | Variety | TGW (g) | Yield (g hill-1) |
|---|---|---|---|
| 4778 | Katarangi | 13.33 | 8.40 |
| 4792 | Basi | 15.55 | 10.18 |
| 4793 | Sada pankaich | 16.26 | 12.56 |
| 4794 | Kalahati | 12.89 | 11.03 |
| 4795 | Khajur chhori | 15.19 | 10.59 |
| 4849 | Rayeda | 12.30 | 5.82 |
| 5121 | Jamni | 20.49 | 11.91 |
| 5122 | Chaula maghi | 26.87 | 16.03 |
| 5190 | Bushi hara (mota) | 27.06 | 5.55 |
| 5192 | Lohamugra | 27.12 | 10.17 |
| 5193 | Chaula mari | 21.44 | 7.24 |
| 5194 | Kalagora | 10.22 | 8.22 |
| 5195 | Patjait | 20.33 | 10.92 |
| 5196 | Holdemota | 19.37 | 10.15 |
| 5197 | Kanchachikon | 12.40 | 10.36 |
| 5198 | Dholeshwar mota | 29.16 | 10.28 |
| 5199 | Calendamota | 16.05 | 4.85 |
| 5212 | Semmua | 13.33 | 8.40 |
| 5213 | Kotijira | 15.55 | 10.18 |
| 5217 | Ashkor | 16.26 | 12.56 |
| 5218 | Baskor | 12.89 | 11.03 |
| 5219 | Halisail | 21.14 | 8.17 |
| 5220 | Horakani | 24.63 | 9.05 |
| 5221 | Kalisura | 25.05 | 9.60 |
| 5222 | Akra | 29.11 | 10.05 |
| 5223 | Ushi har | 20.38 | 18.23 |
| 5250 | Ashfuli | 9.19 | 5.30 |
| 5286 | Ranisalut | 20.33 | 10.92 |
| 5289 | Buripagli | 24.37 | 18.15 |
| 5298 | Harisankar | 12.40 | 10.36 |
| 5300 | Birinde | 29.16 | 10.28 |
| 5310 | Orgoja | 10.05 | 4.85 |
| 5316 | Nonamurchi | 12.30 | 5.82 |
| 5319 | Gandhakusturi | 20.49 | 11.91 |
| 5327 | Huglapata | 11.87 | 5.40 |
| 5329 | Gota | 27.06 | 5.55 |
| 5330 | Dorkumur | 27.12 | 10.17 |
| 5337 | Changi | 12.40 | 10.36 |
| 5345 | Rasasail | 29.16 | 10.28 |
| 5347 | Sackhorkhana | 16.05 | 4.85 |
| -- | BR11 | 23.98 | 13.98 |
| LSD (P=0.05) | | 0.83 | 0.76 |

Table 4 shows that Orgoja was resistant against ShB disease of rice with the minimum RLH (11.66%) and severity score (1), whereas Gopal gosh was moderately tolerant to ShB with 40.56% RLH and severity score 5 through detached sheath inoculation method in test tube. But, rest of the germplasms with RLH ranging from 48.33 to 89.66% along with BR11 (90.68%) (Fig. 2) were found highly susceptible against ShB. Comparing the two inoculation method (*i.e.* hill inoculation and detached sheath inoculation) Orgoja was found as resistant and Gopal ghosh as moderately tolerant to ShB disease. In detached sheath inoculation method in test tube, most of the germplasms were found highly susceptible to ShB except Orgoja and Gopal ghosh. Dorkumur was found moderately tolerant in field condition but it showed high level of susceptibility to ShB in case of detached sheath

**Table 4. Reaction of screened germplasms against ShB due to artificial inoculation of *Rhizoctonia solani* through detached sheath inoculation in test tube.**

| Acc. no. | Variety | RLH (%) | SES score | Reaction |
|---|---|---|---|---|
| 4111 | Gopal ghosh | 40.56 | 5 | MT |
| 4112 | Chata bazail | 70.33 | 9 | HS |
| 4113 | Ram dash | 60.00 | 7 | HS |
| 4114 | Paizra | 74.33 | 9 | HS |
| 4118 | Kala binni | 72.33 | 9 | HS |
| 4149 | Beto | 82.66 | 9 | HS |
| 4155 | Chini kani | 61.66 | 7 | HS |
| 4156 | Minki | 67.33 | 9 | HS |
| 4162 | Kasrail | 58.00 | 7 | HS |
| 4163 | Khazur chari | 72.66 | 9 | HS |
| 4239 | Binni | 78.33 | 9 | HS |
| 4267 | Birpala | 68.00 | 9 | HS |
| 4271 | Rayda | 59.66 | 7 | HS |
| 4272 | Dhaki rayda | 72.33 | 9 | HS |
| 4768 | Kaijhuri | 63.00 | 7 | HS |
| 4773 | Dudhsail | 69.00 | 9 | HS |
| 4777 | Kashra | 53.00 | 7 | HS |
| 4778 | Katarangi | 57.33 | 7 | HS |
| 4792 | Basi | 75.33 | 9 | HS |
| 4793 | Sada pankaich | 65.66 | 9 | HS |
| 4794 | Kalahati | 75.00 | 9 | HS |
| 4795 | Khajur chhori | 67.33 | 9 | HS |
| 4849 | Rayeda | 69.66 | 9 | HS |
| 5121 | Jamni | 64.66 | 7 | HS |
| 5122 | Chaula maghi | 63.33 | 7 | HS |
| 5190 | Bushi hara (mota) | 56.00 | 7 | HS |
| 5192 | Lohamugra | 65.33 | 7 | HS |
| 5193 | Chaula mari | 72.66 | 9 | HS |
| 5194 | Kalagora | 65.66 | 9 | HS |
| 5195 | Patjait | 63.33 | 7 | HS |
| 5196 | Holdemota | 81.33 | 9 | HS |
| 5197 | Kanchachikon | 73.66 | 9 | HS |
| 5198 | Dholeshwar mota | 83.00 | 9 | HS |
| 5199 | Calendamota | 66.33 | 9 | HS |
| 5212 | Semmua | 78.00 | 9 | HS |
| 5213 | Kotijira | 76.33 | 9 | HS |
| 5217 | Ashkor | 55.33 | 7 | HS |
| 5218 | Baskor | 64.00 | 7 | HS |
| 5219 | Halisail | 66.00 | 9 | HS |
| 5220 | Horakani | 77.33 | 9 | HS |
| 5221 | Kalisura | 74.33 | 9 | HS |
| 5222 | Akra | 57.33 | 7 | HS |
| 5223 | Ushi har | 66.00 | 9 | HS |
| 5250 | Ashfuli | 75.00 | 9 | HS |
| 5286 | Ranisalut | 61.66 | 7 | HS |
| 5289 | Buripagli | 68.00 | 9 | HS |
| 5298 | Harisankar | 67.66 | 9 | HS |
| 5300 | Birinde | 84.66 | 9 | HS |
| 5310 | Orgoja | 11.66 | 1 | R |
| 5316 | Nonamurchi | 71.66 | 9 | HS |

**Table 4. Continued.**

| Acc. no. | Variety | RLH (%) | SES score | Reaction |
|---|---|---|---|---|
| 5319 | Gandhakusturi | 64.66 | 7 | HS |
| 5327 | Huglapata | 76.66 | 9 | HS |
| 5329 | Gota | 89.66 | 9 | HS |
| 5330 | Dorkumur | 48.33 | 7 | HS |
| 5337 | Changi | 72.00 | 9 | HS |
| 5345 | Rasasail | 62.33 | 7 | HS |
| 5347 | Sackhorkhana | 57.33 | 9 | HS |
| -- | BR11 | 90.66 | 9 | HS |
| LSD (P=0.05) | | 17.52 | | |

MT=Moderately tolerant, HS=Highly susceptible, R=Resistant.

inoculation method (Fig. 2). In general, dwarf, short duration and photo insensitive varieties were more susceptible to ShB. Prasad and Eizenga (2008) tested 73 *Oryza* genotypes for identifying resistant sources. They found only seven accessions moderately resistant to ShB. On the other hand, Moni (2012) found no resistant variety against ShB.

a) BR11 b) Dorkumur

Fig. 2. ShB symptoms of BR11 and Dorkumur due to artificial inoculation of *Rhizoctonia solani* through detached sheath inoculation method in test tube.

**Integrated management of ShB of rice**

Table 5 shows that the integrated management packages of ShB of rice resulted profound effect. Relative lesion height (RLH) was the maximum (68%) in $T_6$ (Control). The minimum RLH was 8% in $T_1$ (FDR + 30 July planting + Potash (K) fertilizer (202 g decimal$^{-1}$) + top dressing of urea (247 kg ha$^{-1}$) in four equal splits at 15 days interval + single spray of fungicide) and $T_3$ (K-dose + top dressing of urea in four equal splits at 15 days interval + single spray of fungicide). RLH was significantly different in different treatment combinations. $T_2$ (30 July planting + K-dose + top dressing of urea in four equal splits at 15 days interval + single spray of fungicide) and $T_3$ (K-dose + top dressing of urea in four equal splits at 15 days interval + single spray of fungicide) significantly differed in RLH. $T_4$ (Top dressing of urea in four equal splits at 15 days interval + single spray of fungicide) and $T_5$ (Single spray of fungicide) was different in RLH. Difference between $T_3$ and $T_4$ in RLH was also significant. There was significant difference in PDI (Percent disease index) among the treatment combinations. The maximum PDI was 69% in $T_6$ and the minimum 5% in $T_1$. $T_2$ and $T_3$ also differed significantly. Similarly, PDI of $T_4$ differed significantly from that of $T_5$. Moreover, tiller infection was 5% in $T_1$ which was significantly different from $T_2$ with 17%. $T_3$ and $T_4$ were also different in tiller infection. There was 25% tiller infection in $T_4$ and 39% in $T_5$. The maximum tiller infection was 86% in $T_6$. Besides, hill infection was 79% in $T_6$ (Control) as compared to 47% in $T_5$ (Single spray of fungicide). The difference was significant. In $T_1$ only 3% of the hills became infected, but it was 15% in $T_2$, 19% in $T_3$ and 35% in $T_4$ and all the treatments differed significantly.

**Table 5. Effect of integrated disease management (IDM) on ShB of BR11 rice variety during T. Aman 2013.**

| Treatment | RLH (%) | PDI (%) | Tiller infection (%) | Hill infection (%) |
|---|---|---|---|---|
| $T_1$ | 8f | 5f | 5f | 3f |
| $T_2$ | 17e | 16e | 17e | 15e |
| $T_3$ | 23d | 25d | 21d | 19d |
| $T_4$ | 36c | 39c | 25c | 35c |
| $T_5$ | 49b | 51b | 39b | 47b |
| $T_6$ | 68a | 69a | 86a | 79a |

Means followed by the same letter in a column did not differ significantly at the 5% level by LSD.

Table 6 shows that the effect of integrated management of ShB on yield and yield components. The maximum number of panicles per $m^2$ was recorded in $T_1$ (260) and the minimum in $T_6$ (Control) (227). There was no difference between $T_5$ (231) and $T_6$. However, the number of panicles per $m^2$ was 251 in $T_2$, 245 in $T_3$, 238 in $T_4$ and 231 in $T_5$ and all the treatments differed significantly. Number of filled grains per panicle was also significantly different in different treatments. It was 150 and 145 in $T_1$ and $T_2$. The minimum number of filled grains per panicle was recorded in $T_6$ (120) which differed significantly for that in $T_5$ (125). Significant difference was also observed between $T_3$ (139) and $T_4$ (131). Number of unfilled grains was the lowest in $T_1$ and the maximum in $T_6$. Significant difference was also observed between $T_3$ and $T_4$ as well as $T_5$ and $T_6$. Similarly, difference between $T_4$ and $T_5$ was also significant in number of unfilled grains per panicle. But there was no effect of integrated management of ShB on grain size. Weight of 1000 grain was 20 g in all treatments. Significant difference was observed between the treatments in grain yield of rice due to integrated management of ShB disease. The maximum yield was recorded in $T_1$ (6.3 t $ha^{-1}$) and the minimum in $T_6$ (3.6 t $ha^{-1}$). Yield was 6.0 t $ha^{-1}$ in $T_2$ as compared to 5.5 t $ha^{-1}$ in $T_3$ and the difference was significant. Similarly, $T_4$ produced 5.2 t $ha^{-1}$ which was significantly lower than that of $T_5$ (4.5).

Finally, the present study revealed that the best IDM package was $T_1$ which included removal of floating debris, transplanting on 30 July, potash (K) fertilizer (202 g $decimal^{-1}$), urea top dressing (247 kg $ha^{-1}$) in four equal splits at 15 days interval and single spray of Azoxystrobin (10%) + Tebuconazole (90%) combination. Because, the maximum RLH, PDI, tiller infection and hill infection were found in control plot ($T_6$), whereas it was lower in the IDM packages and minimum in $T_1$ plot. Grain yield was also significantly higher in the IDM plots due to minimum incidence of ShB. Because, ShB was very low and grain yield was maximum in the plots where IDM was applied against ShB of rice due to its trace infection. Therefore, it can be concluded that the IDM package ($T_1$) though highly effective to control ShB of rice, but the result needs validation across the ecosystem. However, *Rhizoctonia solani* is an universal soil borne facultative and epidemic pathogen. The pathogen is difficult to control unless control measure is taken on time. Many scientists narrated that a single method of control is not effective in most cases to control ShB but IDM is recommended by the researchers (Mew *et al.*, 2004). Host resistance is a sustainable and economic method but there is no such resistant cultivar (Groth *et al.*, 1993). Antagonist such as *Trichoderma* may be a good option to include in IDM package (Dey *et al.*, 2004). ShB infection at flowering stage reduce grain yield due to higher amount of unfilled grains (Cu *et al.*, 1996) as because of damage of leaf sheath by the disease, affect water and nutrients supply to the growing spikelets (Lee and Rush, 1983).

**Table 6. Effect of IDM on yield and yield components of BR11 during T. Aman 2013.**

| Treatment | Panicle per $m^2$ | Filled grain $panicle^{-1}$ | Sterile pikelet $panicle^{-1}$ | TGW (g) | Yield (t $ha^{-1}$) |
|---|---|---|---|---|---|
| $T_1$ | 260a | 150a | 40f | 20 | 6.25a |
| $T_2$ | 251b | 145b | 47e | 20 | 6.00b |
| $T_3$ | 245c | 139c | 53d | 20 | 5.52c |
| $T_4$ | 238d | 131c | 61c | 20 | 5.15d |
| $T_5$ | 231e | 125d | 67b | 20 | 4.49e |
| $T_6$ | 227e | 120e | 61a | 20 | 3.60f |
| Significance | * | * | | | * |
| CV (%) | 5.15 | 8.65 | 18.40 | 0.0 | 19.16 |
| LSD 0.05 | 4.00 | 3.50 | 4.90 | NS | 0.22 |

Means followed by the same letter did not differ at the 5% level by LSD. NS=Not significant. TGW=1000 grain weight

## CONCLUSIONS

ShB of rice is considered as one of the major constraints of rice production in Bangladesh. Almost all HYVs and hybrid varieties are susceptible to the disease. Method for controlling the disease is an urgent need. Among the 57 germplasms, the local cultivar Orgoja (acc. no. 5310) showed resistance to ShB in both hill inoculation in field and detached sheath inoculation in test tube, which could be used in resistance breeding for varietal improvement programme of rice. On the other hand, the best integrated disease management (IDM) package was $T_1$ which included removal of floating debris, transplanting on 30 July, potash (K) fertilizer (202 g decimal$^{-1}$), top dressing of urea (247 kg ha$^{-1}$) in four equal splits at 15 days interval and single spray of Azoxystrobin (10%) + Tebuconazole (90%) combination. Because, ShB was very low and grain yield was high in the plots where $T_1$ package was applied. Therefore, it can be concluded that the IDM package ($T_1$) though highly effective to control ShB of rice, but the result needs validation in the farmer's field in different seasons with different rice varieties across the different AEZs of Bangladesh.

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