Original Research Article

Screening of Red-kernelled Deep Water Rice Germplasm of Assam, India for Disease and Pest Resistance

N. K. Gogoi¹, D. Chowdhury¹, P. Saikia¹ and K. K. Sharma²

¹Regional Agricultural Research Station, ²Department of Plant Breeding and Genetics, Assam Agricultural University, North Lakhimpur, Assam, India

*Corresponding author

A B S T R A C T

Fifty nine (59) red-kernelled deep water rice (DWR) germplasm were screened under natural condition against major diseases and pests viz. sheath blight (ShB), sheath rot (ShR) and stem borer (SB) infestation at the Regional Agricultural Research Station (RARS), Assam Agricultural University, North Lakhimpur, Assam. None of the germplasm was free from the observed diseases and pest. Disease intensity of ShB ranged from 3.33% to 44.44% and the intensity of ShR ranged from 4.44% to 35.56%. The incidence of white ear heads due to SB infestation ranged from 2.22% to 52.21%. No germplasm was found to be resistant against ShB and ShR diseases. Four germplasm viz. Arg Bao, Buruli Bao, Kalburuni Bao and Pora Negheri Bao were found moderately resistant (MR) to ShB disease, while Arg Bao, Basudev Bao, Boga Amona Bao, Dal Bao, Garo Bao and Sarmora Bao showed MR reaction to ShR disease. Against SB infestation, thirteen numbers of germplasm showed resistant reaction. Among all the germplasm, five germplasm viz. Arg Bao, Basudev Bao, Dal Bao, Rayada B8 and Sarmora Bao showed MR reaction to both diseases and pest tested. These germplasm may be used as donors in resistant DWR breeding programmes against the tested pathogens and pest.

Keywords
Red-kernelled Deep Water Rice Germplasm, Pest Resistance

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Introduction

Rice (Oryza sativa L.) is the major food crop in the world with the global production of 769.6 million tones from 167.25 million hectares area (Anon., 2019). India has the world's largest area under rice with 44.7 million hectares area (Anon., 2018). Rice in Assam covers 24.34 lakh hectares area and is grown as Sali (winter rice), Ahu (autumn rice), Boro (summer rice) and Bao or Deep Water Rice (DWR). DWR is grown in low-lying, swampy and flood-prone areas with water stagnation beyond 50 cm, where other crops cannot be cultivated due to prolonged water stagnation for a period of 2-6 months. As a conservative estimation, Assam has approximately 100,000 ha area under DWR cultivation (Rohilla et al., 2019). Most of the DWR varieties have red kernels, which is due to the accumulation of polyphenols and anthocyanins in the aleurone layer and it possesses antioxidant properties (Mudoi and Das, 2019). Red kernelled rice varieties
possess resistance to drought, flood, submergence, alkalinity, salinity, and resistance to pests and diseases (Chaudhary and Tran, 2001). These are also rich in iron, zinc, vitamins and minerals (Chowdhury et al., 2016). Owing to its high nutritional value coupled with its default organic nature, DWR in Assam has seen a steady rise in demand in the European market and thus many marginal farmers are getting benefitted. Several diseases and pests are known to infest rice plants in Assam and the major ones infesting DWR are sheath blight (ShB), sheath rot (ShR) and stem borer (SB). Red kernelled DWR genotypes conserved at RARS, North Lakhimpur include several indigenous landraces and these genotypes may provide important sources of resistance to diseases and pests. Use of resistant varieties is the safest strategy in plant health management in the present day context of sustainable agriculture. Keeping these perspectives in view, the present investigation was undertaken to find out the resistant sources in red kernelled DWR against ShB, ShR and SB infestation under natural condition.

**Materials and Methods**

**Location**

The experiment was carried out at the research farm of RARS, North Lakhimpur (Latitude: 27°14'05.15"N, Longitude: 94°08'29.55"E, Elevation: 102 m above mean sea level) during the Kharif seasons of 2016-2017.

**Planting material and experimental design**

Fifty nine (59) genotypes of red kernelled DWR were taken from the Germplasm Collection Bank maintained by the Plant Breeding section of RARS, North Lakhimpur. The field trials were laid out in randomized block design with two replications adopting standard package of practices for DWR. The seeds of all genotypes were sown during the 1st week of June in small beds for raising nursery and 30 days old seedlings were transplanted at 25 cm X 20 cm spacing in 5.0 m x 3.0m size plots.

**Disease and pest assessment**

Ten plants of each plot were randomly selected, marked and used for scoring ShB, ShR and SB infestation in terms of white ear head (WEH) incidence. The disease scores were recorded based on 0-9 SES scale (IRRI, 2013) where, 0=No infection, 1=lesion limited to lower 20% of the plant height, 3=20-30%, 5=31-45%, 7=46-65%, 9=more than 65% for ShB disease and 0=No disease, 1=less than 1% diseased tiller, 3=1-5%, 5=6-25%, 7=26-50% and 9=51-100% for ShR disease.

The percent disease index (PDI) was calculated using the following formula (Campbell and Madden, 1990).

\[
\text{Per cent Disease Index} = \frac{\text{Sum of numerical values}}{\text{Number of plants observed} \times \text{Maximum disease rating value}} \times 100
\]

Observations on the incidence of SB in terms of WEH were recorded at the maturity stage and the per cent white ear damage was calculated using the following formula (Heinrichs et al., 1985).

\[
\text{Per cent WEH} = \frac{\text{Number of white ear heads}}{\text{Number of productive tillers}} \times 100
\]

Based on PDI, the reaction of the genotypes was assessed on a 0-9 scale where, 0= Highly resistant, 1=Resistant (1-5%), 3=Moderately resistant (6-10%), 5=Moderately susceptible (11-15%), 7= Susceptible (16-25%) and 9=Highly susceptible (≥26%) (IRRI, 2013).
Data analysis

Data were subjected to statistical analysis (Analysis of variance) using PASW-18 Statistics and Microsoft Excel. Cluster analysis of data was performed following average linkage method using squared Euclidean distance and Dendrograms showing relative grouping of red rice germplasm were constructed.

Results and Discussion

Identification of resistance sources in DWR germplasm

The 59 (fifty nine) red-kernelled DWR germplasm screened for ShB, ShR and SB infestation revealed a significant variation among the germplasm in their response to the observed diseases and pest. Incidence and severity of ShB was observed more compared to ShR disease. It was revealed that none of the germplasm was free from the observed diseases and pest. Disease intensity of ShB ranged from 3.33% to 44.44% and the intensity of ShR ranged from 4.44% to 35.56 (Table 1). The incidence of WEH due to SB infestation ranged from 2.22% to 52.21% (Table 2). Based on the average PDI, the germplasm were grouped into six groups. No germplasm was found to be resistant against ShB and ShR diseases. Four germplasm viz. Arg Bao, Buruli Bao, Kalburuni Bao and Pora Negheri Bao were found moderately resistant (MR) to ShB disease, while Arg Bao, Basudev Bao, Boga Amona Bao, Dal Bao, Garo Bao and Sarmora Bao showed MR reaction to ShR disease (Table 3). Against SB infestation, thirteen numbers of germplasm viz. Ahina Bao, Amona Bao, Arg Bao, Basudev Bao, Dal Bao, Dolmora, Jeng Bao 2, Kekuwa Bao, Kon Bao, Rangi 2, Sonamukhi Bao 2, Sunmoti Bao 2 and Ujoni khamti Bao showed resistant reaction, while nineteen others showed MR reaction against the pest (Table 3). Among all the germplasm, five germplasm viz. Arg Bao, Basudev Bao, Dal Bao, Rayada B8 and Sarmora Bao showed MR reaction to the diseases and pest tested. These germplasm may be used as donors in resistant breeding programmes against the tested pathogens and pest, however further screening with artificial inoculation under high pathogen inoculum and insect pressure is required for these selected germplasm.

Based on estimated Euclidean distances, the DWR germplasm could be clubbed into five groups for ShB disease (Fig. 1a) viz. MR (4 germplasm) and moderately susceptible (MS) group (10 germplasm), MS group with lower PDI (30 germplasm), MS group with higher PDI (9 germplasm), Susceptible (S) group (5 germplasm) and Highly susceptible (HS) group (1 germplasm). For ShR disease (Fig. 1b), germplasm could be grouped as MR (9 germplasm), MS with lower PDI group (16 germplasm), MS with high PDI group (23 germplasm), S group (10 germplasm) and HS group (1 germplasm). For SB infestation (Fig. 1c), germplasm could be grouped as resistant (13 germplasm) and MR group with lower PDI (10 germplasm), MR with higher PDI group (19 germplasm), S group with lower PDI (2 germplasm) and S group with higher PDI (5 germplasm) and HS group (1 germplasm).

Pavani et al., (2018) screened 196 germplasm lines of rice against ShB disease under natural conditions and found fifty seven (57) entries as MR. None of the entries were found immune or resistant. Kumar et al., (2017) evaluated 12 genotypes of rice under submergence condition for ShB and bacterial leaf blight (BLB) disease resistance and recorded the minimum disease incidence of ShB in IR 96321-1447-521-B-2-1-2 and minimum BLB disease incidence in IR96321-1099- 227-B-3-1- 3.
### Table 1: Per cent disease index of sheath blight and sheath rot diseases in red-kernelled deep water rice germplasm under natural condition

| Germplasm     | Per cent Disease Index* | Germplasm     | Per cent Disease Index* | Germplasm     | Per cent Disease Index* |
|---------------|-------------------------|---------------|-------------------------|---------------|-------------------------|
|               | Sheath blight | Sheath rot   | Sheath blight | Sheath rot   | Sheath blight | Sheath rot   |
| Ahina Bao     | 10.50 (18.88) | 15.20 (22.89) | Dolmora       | 24.44 (29.54) | 24.44 (29.62) | Pora Negheri Bao | 3.33 (10.39) | 12.22 (20.40) |
| Amona Bao     | 14.44 (22.21) | 25.56 (30.35) | Garo Bao      | 7.78 (15.95)  | 5.00 (12.92)  | Rayada B8        | 25.56 (30.30) | 20.00 (26.54) |
| Arg Bao       | 3.33 (10.39)  | 5.00 (12.75)  | Happy Bao     | 14.44 (22.14) | 13.33 (21.39) | Rongadhar Kekuwa Bao | 24.44 (29.50) | 11.11 (19.43) |
| Badal Bao     | 10.00 (18.38) | 15.56 (23.21) | HJB Amona     | 33.33 (35.18) | 16.67 (24.07) | Rangi 1          | 7.78 (16.17)  | 11.11 (19.43) |
| Badam Bao     | 22.22 (28.10) | 11.11 (19.46) | Jeng Bao 1    | 11.11 (19.27) | 12.22 (20.43) | Rangi 2          | 5.50 (13.41)  | 10.00 (18.39) |
| Bangla Bao    | 16.67 (24.05) | 17.78 (24.92) | Jeng Bao 2    | 12.22 (20.38) | 26.67 (31.07) | Saikia Bao       | 18.89 (25.71) | 30.00 (33.17) |
| Baola Bao     | 12.00 (20.20) | 15.30 (23.02) | Jul Bao       | 6.67 (14.90)  | 16.67 (24.04) | Salkhosora Bao   | 13.33 (21.39) | 14.44 (22.30) |
| Basudev Bao   | 13.33 (21.25) | 4.50 (12.21)  | Kalkuruni Bao | 4.44 (12.10)  | 8.89 (17.33)  | Sanjul Bao       | 16.67 (24.08) | 14.44 (22.29) |
| Betu Bao 1    | 10.00 (18.35) | 28.89 (32.50) | Kekuwa Bao    | 27.78 (31.78) | 14.44 (22.33) | Sarmora Bao      | 11.11 (19.12) | 5.00 (12.92)  |
| Betu Bao 2    | 18.89 (25.65) | 26.00 (30.65) | Kekuwa bora Bao | 13.33 (21.39) | 10.00 (18.39) | Sonamukhi Bao 1  | 23.33 (28.86) | 12.22 (20.44) |
| Bezel Bao     | 16.00 (23.33) | 5.50 (13.52)  | Khutijul Bao  | 21.11 (27.30) | 8.89 (17.33)  | Sonamukhi Bao 2  | 12.20 (20.36) | 23.33 (28.86) |
| Boga Amona Bao | 6.67 (14.90) | 4.44 (12.05)  | Kola Dhepa Bao | 6.67 (14.89)  | 11.11 (19.46) | Sonamukhi Bao 3  | 22.22 (28.10) | 15.56 (23.18) |
| Bogagotha Bao | 13.33 (21.36) | 11.11 (19.47) | Kon Bao       | 12.22 (20.39) | 28.89 (32.51) | Sunmoti Bao 1    | 7.78 (16.19)  | 6.67 (14.92)  |
| Borjul Bao    | 6.67 (14.82)  | 16.67 (24.08) | Madel Bao     | 13.33 (21.35) | 35.56 (36.58) | Sunmoti Bao 2    | 11.11 (19.29) | 21.11 (27.31) |
| Buruli Bao    | 4.44 (12.12)  | 8.00 (16.40)  | Miyan Bao     | 20.00 (26.54) | 18.89 (25.72) | Swaragfola Bao   | 23.33 (28.86) | 7.78 (16.18)  |
| Chenga Bao    | 27.78 (31.74) | 10.00 (18.43) | Moimonsingia Bao | 5.56 (13.61)  | 13.33 (21.39) | Tarkekuwa Bao    | 31.11 (33.85) | 13.33 (21.39) |
| Cheni maguri Bao | 17.78 (24.85) | 6.00 (14.00)  | Nasati Bao    | 11.11 (19.29) | 14.44 (22.29) | Thiangotha Bao   | 5.56 (13.61)  | 13.33 (21.39) |
| Dal Bao       | 11.11 (19.45) | 5.00 (12.92)  | Negerhi Bao   | 16.67 (23.89) | 17.78 (24.92) | Tulsi Bao        | 17.78 (24.91) | 16.67 (23.97) |
| Depha Bao 1   | 27.78 (31.80) | 25.56 (30.35) | Panikekuwa Bao 1 | 44.44 (41.79) | 18.89 (25.75) | Ujonki khantli Bao | 13.33 (21.35) | 11.11 (19.43) |
| Depha Bao 2   | 11.11 (19.42) | 26.40 (30.92) | Panikekuwa Bao 2 | 11.11 (19.31) | 17.78 (24.91) |                  |              |              |

* S.Ed.(±) 2.07 1.22  
C.D. (p=0.05) 4.12 2.41

* Data in parentheses are angular transformed values
Table 2 Per cent incidence of white ear head caused by rice stem borer in red-kernelled deep water rice germplasm under natural condition

| Germplasm       | White Ear Head (%)* | Germplasm       | White Ear Head (%)* | Germplasm       | White Ear Head (%)* |
|-----------------|---------------------|-----------------|---------------------|-----------------|---------------------|
| Ahina Bao       | 3.76 (11.11)        | Dolmora         | 4.14 (11.73)        | Pora Negheri Bao| 13.44 (21.49)       |
| Amona Bao       | 3.36 (10.52)        | Garo Bao        | 22.79 (28.50)       | Rayada B8       | 7.93 (16.31)        |
| Arg Bao         | 3.93 (11.31)        | Happy Bao       | 5.17 (12.98)        | Rongadhar Kekuwa Bao | 5.60 (13.67)  |
| Badal Bao       | 14.25 (21.84)       | HJB Amona       | 7.58 (15.94)        | Rangi 1         | 13.13 (21.23)       |
| Badam Bao       | 5.86 (13.88)        | Jeng Bao 1      | 12.33 (20.48)       | Rangi 2         | 3.56 (10.81)        |
| Bangla Bao      | 10.76 (19.07)       | Jeng Bao 2      | 4.32 (11.94)        | Saikia Bao      | 10.25 (18.63)       |
| Baola Bao       | 5.60 (13.62)        | Jul Bao         | 11.19 (19.53)       | Salkhosora Bao  | 8.67 (17.12)        |
| Basudev Bao     | 2.22 (8.51)         | Kalburuni Bao   | 7.08 (15.29)        | Sanjul Bao      | 9.21 (17.61)        |
| Betu Bao 1      | 21.17 (27.34)       | Kekuwa Bao      | 2.43 (8.95)         | Sarmora Bao     | 6.49 (14.71)        |
| Betu Bao 2      | 13.83 (21.80)       | Kekuwa bora Bao | 13.60 (21.63)       | Sonamukhi Bao 1 | 5.20 (13.14)        |
| Bezel Bao       | 52.21 (46.28)       | Khutijul Bao    | 25.59 (30.30)       | Sonamukhi Bao 2 | 3.33 (10.47)        |
| Boga Amona Bao  | 11.28 (19.41)       | Kola Dhepa Bao  | 15.75 (23.29)       | Sonamukhi Bao 3 | 7.33 (15.71)        |
| Bogagotha Bao   | 10.41 (18.81)       | Kon Bao         | 2.79 (9.60)         | Sunmoti Bao 1   | 19.61 (26.13)       |
| Borjul Bao      | 5.76 (13.88)        | Madel Bao       | 16.90 (24.28)       | Sunmoti Bao 2   | 4.89 (12.73)        |
| Buruli Bao      | 13.75 (21.75)       | Miyan Bao       | 6.87 (15.19)        | Swaragfola Bao  | 12.72 (20.85)       |
| Chenga Bao      | 12.15 (20.33)       | Moimonsingia Bao| 13.72 (21.73)       | Tarkekuwa Bao   | 8.15 (16.51)        |
| Cheni maguri Bao| 13.17 (21.25)       | Nasati Bao      | 10.66 (19.05)       | Thiagotha Bao   | 9.75 (18.12)        |
| Dal Bao         | 3.93 (11.36)        | Negheri Bao     | 22.60 (28.36)       | Tulsi Bao       | 8.44 (16.86)        |
| Depha Bao 1     | 8.48 (16.84)        | Panikekuwa Bao 1| 14.60 (22.42)       | Ujonihamti Bao  | 4.00 (11.49)        |
| Depha Bao 2     | 9.83 (18.11)        | Panikekuwa Bao 2| 11.29 (19.61)       |                |                    |

*S. Ed. (±) 1.61
*C.D. (p=0.05) 3.18

* Data in parentheses are angular transformed values
**Table 3** Reaction of red-kernelled deep water rice germplasm against sheath blight, sheath rot and stem borer

| Reaction              | Sheath blight       | Sheath rot       | Stem borer                                                                 |
|-----------------------|---------------------|------------------|----------------------------------------------------------------------------|
| **Highly Resistant (HR)** |                     |                  |                                                                            |
| Resistant (R)         | Nil                 | Nil              | Ahina Bao, Amona Bao, Arg Bao, Basudev Bao, Dal Bao, Dolmora, Jeng Bao, Kekuwa Bao, Kon Bao, Rangi 2, Sonamukhi Bao 2, Sunmoti Bao 2 and Ujoni khamti Bao. |
| **Moderately Resistant (MR)** | Arg Bao, Buruli Bao, Kalburuni Bao and Pora Negheri Bao | Arg Bao, Basudev Bao, Boga Amona Bao, Dal Bao, Garo Bao and Sarmora Bao | Badam Bao, Baola Bao, Borjul Bao, Depha Bao 1, Depha Bao 2, Happy Bao, HJB Amona, Kalburuni Bao, Miyan Bao, Rayada B8, Rongadhar Kekuwa Bao, Salkhosora Bao, Sanjul Bao, Sarmora Bao, Sonamukhi Bao 1, Sonamukhi Bao 3, Tarkekuwa Bao, Thiagotha Bao and Tulsi Bao. |
| **Moderately Susceptible (MS)** | Ahina Bao, Amona Bao, Badal Bao, Badam Bao, Bangla Bao, Baola Bao, Basudev Bao, Betu Bao 1, Betu Bao 2, Bezel Bao, Boga Amona Bao, Bogagotha Bao, Borjul Bao, Chena maguri Bao, Dal Bao, Depha Bao 2, Dolmora, Garo Bao, Happy Bao, Jeng Bao 1, Jeng Bao 2, Jul Bao, Kekuwa bora Bao, Khutijul Bao, Kola Dhepa Bao, Kon Bao, Madel Bao, Miyan Bao, Moimonsingia Bao, Nasati Bao, Negheri Bao, Panikekuwa Bao 2, Rayada B8, Rongadhar Kekuwa Bao, Rangi 1, Rangi 2, Saikia Bao, Salkhosora Bao, Sanjul Bao, Sarmora Bao, Sonamukhi Bao 1, Sonamukhi Bao 2, Sonamukhi Bao 3, Sunmoti Bao 1, Sunmoti Bao 2, Swaragfola Bao, Thiagotha Bao, Tulsi Bao, and Ujoni khamti Bao | Ahina Bao, Badal Bao, Badam Bao, Bangla Bao, Baola Bao, Bezel Bao, Bogagotha Bao, Borjul Bao, Buruli Bao, Chenga Bao, Chena maguri Bao, Dolmora, Happy Bao, HJB Amona, Jeng Bao 1, Jul Bao, Kalburuni Bao, Kekuwa Bao, Kekuwa bora Bao, Khutijul Bao, Kola Dhepa Bao, Miyan Bao, Moimonsingia Bao, Nasati Bao, Negheri Bao, Panikekuwa Bao 1, Panikekuwa Bao 2, Pora Negheri Bao, Rayada B8, Rongadhar Kekuwa Bao, Rangi 1, Rangi 2, Salkhosora Bao, Sanjul Bao, Sonamukhi Bao 1, Sonamukhi Bao 2, Sonamukhi Bao 3, Sunmoti Bao 1, Sunmoti Bao 2, Swaragfola Bao, Tarkekuwa Bao, Thiagotha Bao, Tulsi Bao and Ujoni khamti Bao | Badal Bao, Bangla Bao, Betu Bao 2, Boga Amona Bao, Bogagotha Bao, Buruli Bao, Chenga Bao, Chena maguri Bao, Jeng Bao 1, Jul Bao, Kekuwa bora Bao, Moimonsingia Bao, Nasati Bao, Panikekuwa Bao 1, Panikekuwa Bao 2, Pora Negheri Bao, Rangi 1, Saikia Bao and Swaragfola Bao. |
| **Susceptible (S)**   | Chenga Bao, Depha Bao 1, HJB Amona, Kekuwa Bao, Panikekuwa Bao 1 and Tarkekuwa Bao | Amona Bao, Betu Bao 1, Betu Bao 2, Depha Bao 1, Depha Bao 2, Jeng Bao 2, Kon Bao, Madel Bao and Saikia Bao | Betu Bao 1, Garo Bao, Kola Dhepa Bao, Madel Bao, Negheri Bao and Sunmoti Bao 1. |
| **Highly Susceptible (HS)** | Nil                 | Nil              | Bezel Bao and Khutijul Bao                                                  |
The incidence of ShB and BLB of paddy ranged from 18.6 to 39.0% and 15.3 to 34.0%, respectively. Preetha (2017) screened 46 rice germplasms for their reaction to SB and observed 0 and 45.71% infestation during the Kharif season. Among the germplasm, TP 10003, TP 10004, TP 10039 and TP 08095 were found to have no or minimal incidence and were rated as resistant category. TP 10002, TP 10005, TP 10016, TP 10038, TP 10051, TP 10052, TP 09048 and TP 09052 were rated as MR. Screening of these red-kernelled DWR germplasm to major diseases and pest helped in selecting suitable germplasm for further studies; however further screening with artificial inoculation for consecutive years will help in better selection. The promising resistance genotypes selected in the present study may be further studied and utilize as the genetic sources for disease and pest resistance in rice breeding programmes.

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