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

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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.

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).

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

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).

$$\text{Per cent WEH} = \frac{\text{Number of white ear heads}}{\text{Number of productive tillers}} \text{ X } 100$$

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 (9 germplasm), MR with higher PDI group (10 germplasm), MS 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)
Bao*la *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)	Kalburuni *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)	Thiagotha *Bao*	5.56 (13.61)	13.33 (21.39)
Dal *Bao*	11.11 (19.45)	5.00 (12.92)	Negheri *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)	Ujoni khamti *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	S.Ed.(±)	2.07	1.22	S.Ed.(±)	2.07	1.22
C.D. (p=0.05)	4.12	2.41	C.D. (p=0.05)	4.12	2.41	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

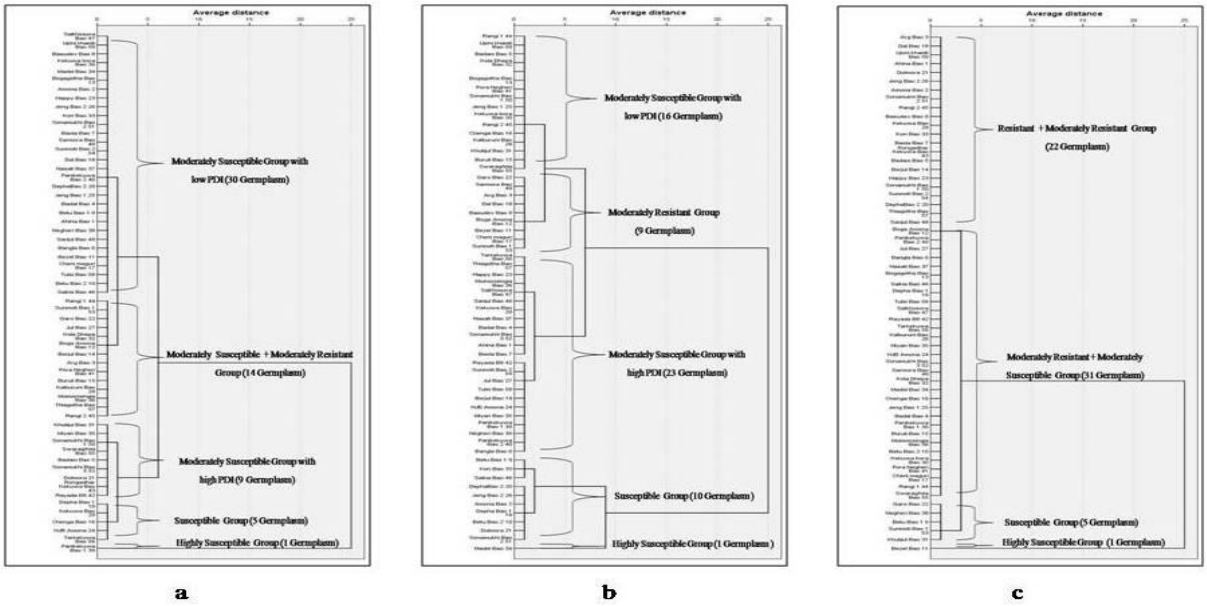
Germplasm	White Ear Head (%)*	Germplasm	White Ear Head (%)*	Germplasm	White Ear Head (%)*
Ahina *Bao*	3.76 (11.11)	Dolmora	4.14 (11.73)	Pora Negheri *Bao*	13.44 (21.49)
Amona *Bao*	3.36 (10.52)	Garo *Bao*	22.79 (28.50)	Rayada B8	7.93 (16.31)
Arg *Bao*	3.93 (11.31)	Happy *Bao*	5.17 (12.98)	Rongadhar Kekuwa *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)
Bao*la *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)	Ujoni khamti *Bao*	4.00 (11.49)
Depha*Bao* 2	9.83 (18.11)	Panikekuwa *Bao* 2	11.29 (19.61)		
S.Ed.(±)	1.61	S.Ed.(±)	1.61	S.Ed.(±)	1.61
C.D. (p=0.05)	3.18	C.D. (p=0.05)	3.18	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)	Nil	Nil	Nil
Resistant (R)	Nil	Nil	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*.
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*, *Bao*la *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*, *Bao*la *Bao*, Basudev *Bao*, Betu *Bao* 1, Betu *Bao* 2, Bezel *Bao*, Boga Amona *Bao*, Bogagotha *Bao*, Borjul *Bao*, Cheni 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*, *Bao*la *Bao*, Bezel *Bao*, Bogagotha *Bao*, Borjul *Bao*, Buruli *Bao*, Chenga *Bao*, Cheni 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*, Cheni 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*

Fig.1 Dendrogram showing the relative grouping of red-kernelled deep water rice germplasm based on reaction to a) sheath blight, b) sheath rot and c) stem borer infestation obtained by average clustering based on squared Euclidean distances



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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