Bangladesh J. Agri. 2019-2021, 44-46: 77-87 *DOI: https://doi.org/10.3329/bjagri.v46i1-6.59976*

GENETIC EVALUATION OF BORO RICE (*ORYZA SATIVA* L.) GENOTYPES UNDER IRRIGATED AND RAINFED CONDITIONS

M.N. Jomadder[1], K.M.K. Huda[1*], M. Jony[1], M.S. Islam[1], M.S.A. Banu[2], M.H. Rashid[1] and S. Parveen[1]

[1]Department of Genetics and Plant Breeding, Sher-e-Bangla Agricultural University (SAU), Dhaka; [2]Bangladesh Agricultural Research Council (BARC), Farmgate, Dhaka. Bangladesh

Abstract

Drought is a major abiotic constraint for growing rainfed rice in Bangladesh. A set of 18 boro rice genotypes were evaluated under irrigated and rainfed conditions to identify the high yielding and stress tolerant genotypes. The experiment was conducted by using randomized complete block design with three replications. Significant variations were observed among the genotypes both in irrigated and rainfed conditions. The genotypes BRRI dhan55, Gopal Deshi and Soilerpona showed the superior performance in terms of grain yield and yield contributing characters under rainfed condition. Based on stress tolerance index (STI) value, the genotypes BRRI dhan55, BRRI dhan58, Soilerpuna and Gopaldeshi were graded as drought tolerant genotypes. Under rainfed condition, yield per plant showed the positive and significant correlation with flag leaf length, number of primary branches per panicle, number of secondary branches per panicle, number of grains per panicle and thousand-seed weight. Path analysis revealed that the number of primary/secondary branches per panicle, and number of unfilled grains per panicle showed the highest positive and direct effect on grain yield under irrigated condition while Plant height, panicle length and thousand-seed weight had the highest direct but negative effect on grain yield.Thousand seed weight, number of primary branches per panicle and number of unfilled grains per panicle showed the highest positive and direct effect on grain yield under rainfed condition. Based on the results, seven genotypes from among the eighteen tested namely BRRI dhan36, BRRI dhan55, BRRI dhan58, BRRI dhan59, Soilerpona, Gopal Deshi and Borail were identified as drought tolerance genotypes with high yield potential.

Keywords: Drought, Genetic evaluation, Rainfed, Rice

Introduction

Rice (*Oryza sativa* L.) is the most important cereal crop in tropical and subtropical regions (Singh *et al.,* 2012) of the world. It is cultivated at least in 114 countries and is the primary source of income and employment for more than 100 million households in Asia (Singh *et al.,* 2015). So, we need more rice production for the increasing population such as high yielding and abiotic stress tolerant varieties by using modern technologies (BRRI, 2019). China is the first position as producer of rice in the

* Corresponding Author: mashnuk@gmail.com

world (FAO, 2020). As a cereal grain, rice is the second most important food crop next to maize and wheat in the world, but its position in Bangladesh is first in terms of providing food, income, and employment. Bangladesh is the fourth largest producer of rice in the world with the annual productions of 35.3 million metric tons (MMT) in the area of 11.8 million hectares. It is being cultivated under diverse ecologies ranging from irrigated to rainfed, upland to lowland and deep water conditions. Drought is considered one of the main constraints that limit rice yield in rainfed and poorly irrigated areas. Drought is a common feature in Bangladesh (north-western part), especially in the dry season (winter and pre monsoon) which causes a substantial reduction of rice yield (Pervin *et al.,* 2015). Rice is sensitive to water stress and shows several morphological changes at different growth stages in response to drought stress (Henry *et al.,* 2016). These involve plant height reduction, leaf rolling, leaf senescence, stomatal closure, decreased leaf elongation and lower dry matter production (Kumar *et al.,* 2015). The local rice varieties are long (up to one meter) and can survive in deep water and as such are suitable to grow in the flooded lands whereas the modern varieties cannot be grown (Ullah *et al.,* 2014). In Bangladesh, Rajshahi division is highly drought affected. Chittagong and Khulna divisions are also known as drought prone area. Water shortage at the grain filling stage may cause drastically seed yield loss. Water stress after or before panicle initiation reduces potential spike number and decreases translocation of assimilates to the grains, which results low in gain weight and increases empty grains (Davatgara *et al.,* 2009).

Drought is a common phenomenon both for the local land races as well as for the modern rice varieties. The effect of drought at the grain filling stage on the local rice yield has not been evaluated so far. Therefore the performance of both the local and the modern varieties under drought stress condition at the reproductive stage should be needed. Considering the above statement, the present study was designed to know the effect and relationship of different yield and yield contributing traits on rice grain yield at both the irrigated and rainfed conditions. It is essentially required to know the morphological potentiality of drought tolerance rice genotypes in order to select drought tolerant varieties. To identify drought tolerant rice varieties, the present study was undertaken to evaluate the effect of rainfed condition at reproductive stage of different local and BRRI released boro rice genotypes.

Materials and Methods

The present investigation was carried out during the boro season of 2018 at the experimental farm of Sher-e-Bangla Agricultural University, Dhaka-1207. The healthy seeds of genotypes of boro rice collected from southern part of Bangladesh along with some BRRI rice varieties were used as experimental materials. The experiment was laid out in randomized complete block design (RCBD) with three replications. Germinated seeds were sown on the seed bed separately and proper tags were maintained. The N, P, K fertilizers were applied in the form of urea, TSP and MP, respectively as recommended dose. After establishment, the 21 days old seedlings were transplanted to the main field. Intercultural, after care operations and necessary gap filling was done as when needed for

better growth and development of rice seedlings. In irrigated condition, flood irrigation was given to maintain a constant level of standing water up to 2 cm in the early stages to enhance tillering, proper growth and development of the seedlings and 10-12 cm in the later stage to discourage late tillering. In rainfed condition, drain out water from the plots to maintain the rainfed condition at reproductive stage. The plots are maintained as a way that's why no water could pass into it as the plots were bordered from surroundings in the reproductive stage. The other stages are same as irrigated condition. Proper weeding and tagging were done. The rice genotypes were harvested manually according to their maturity. Harvested crop from each crop were bundled separately and tagged properly. Stress tolerance index (STI) were calculated by using the following formula:

$$STI = \frac{Y_{pi} \times Y_{si}}{{Y_p}^2}$$

Where,

Y_{pi}= yield of individual genotypes without drought stress

Y_{si}= yield of individual genotypes with drought stress

Y_p = average yield of all genotypes of without drought stress

Data were collected on the following parameters *viz.*, plant height, flag leaf length, flag leaf width, number of primary branches per panicle, number of secondary branches per panicle, panicle length, number of filled grains per panicle, number of unfilled grains per panicle, thousand seed weight and yield per plant. Statistical analysis was done with GENSTAT software program.

Results and Discussion

Mean separation table showed the significant variations were present among the genotypes. Number of unfilled grains per panicle showed the highest CV percentage in both irrigated (20.35%) and rainfed (18.73%) conditions. Plant height showed the lowest CV percentage in both irrigated (10.40%) and rainfed (10.49%) conditions (Tables 1 and 2). BRRI dhan55 (4.42 ton/ha), Gopal Deshi (4.26 ton/ha) and Soilerpona (4.15 ton/ha) showed the highest grain yield under rainfed condition (Table 1 and 2). These water stress tolerance genotypes may be used as the base material for the development of water stress tolerant rice variety, because the development of base materials is the prime work in any breeding program. The genotypes BRRI dhan36 (7.64 ton/ha), BRRI dhan59 (7.23 ton/ha), BRRI dhan58 (7.03 ton/ha) and BRRI dhan55 (7.0 ton/ha) showed the highest grains yield in irrigated condition (Table 1). This study revealed a decrease in mean grain yield among the genotypes due to imposing stress. Adhikari *et al.,* (2017) found similar result in rainfed and drought prone areas. All the genotypes produced higher grain yield in the irrigated compared to rainfed condition. These might be due to that continuous irrigation ensured sufficient field capacity level through until harvest. Reduction of grain yield due to stress in crops has been previously reported by many workers (Dadbakhsh *et al.,* 2011; Farshadfar and Elyasi, 2012; Dixit *et al.,* 2014; Bennani *et al.,* 2017). Moderate level of grain yield was observed here under irrigated condition. Ali and El-Sadek, (2016) also stated that moderate level of grain yield reduction is suitable for selecting stress tolerant genotypes in wheat.

Table 1. Performance of different genotypes under irrigated condition

Genotypes	PH	FLL	FLW	NPBP	NSBP	PL	NFGP	NUGP	TSW	YH
Poshusail	119.00 g	26.00 j	1.75 ab	9.00 e	21.00 j	21.13 h-j	170.0 b	22.00 de	30.00 cd	5.700 i
Gorchihail	118.00 h	27.80 g	1.50 hi	7.00 i	23.00 hi	22.23 d-i	110.0 h	28.00 b	29.00 de	6.240 e-g
Birion	140.00 b	27.60 g	1.55 f-i	10.50 b	27.00 d	23.46 cde	210.0 a	11.67 i	26.00 gh	5.800 hi
Soilerpuna	134.90 d	24.50 m	1.60 c-h	10.00 c	24.00 gh	22.52 c-h	120.0 g	12.33 i	28.00 ef	6.400 d-f
Pankaich	134.00 e	25.50 k	1.65 a-g	8.00 gh	24.00 gh	20.50 j	80.0 j	34.33 a	29.30 de	5.900 g-i
Gopal Deshi	141.00 a	29.20 d	1.77 a	12.00 a	27.00 d	20.93 ij	110.0 h	18.33 fg	31.00 bc	6.200 e-h
Borail	108.90 j	28.80 e	1.56 f-i	9.00 e	32.00 b	20.97 ij	130.0 de	17.67 g	29.60 c-e	6.380 def
BRRI dhan28	89.63 n	33.00 a	1.58 d-i	9.40 d	26.00 def	22.97 c-f	125.9 f	21.37 d-f	28.00 ef	6.133 e-h
BRRI dhan55	100.50 l	32.00 b	1.64 a-g	8.50 f	36.00 a	22.10 e-i	120.0 g	23.17 cd	26.27 gh	7.000 bc
BRRI dhan45	100.00 l	25.20 kl	1.71 a-d	9.50 d	35.00 a	25.21 ab	130.0 de	26.00 bc	31.00 bc	6.500 de
BRRI dhan50	82.00 q	28.23 f	1.66 a-f	9.00 e	26.00 d-f	23.23 c-f	128.0 ef	12.67 i	34.00 a	6.000 f-i
BR 25	138.00 c	27.22 h	1.52 g-i	8.00 gh	23.00 hi	21.22 g-j	122.0 g	19.00 e-g	32.00 b	4.500 j
BRRI dhan86	106.00 k	25.96 j	1.73 a-c	9.00 e	26.00 d-f	25.96 a	119.0 g	12.33 i	29.00 de	4.500 j
BRRI dhan29	91.03 m	23.35 n	1.59 d-h	8.22 fg	26.80 de	23.64 cd	132.2 d	8.33 j	23.23 k	6.500 de
BRRI dhan35	84.00 p	26.00 j	1.62 b-h	8.00 gh	25.00 e-g	21.91 f-j	130.0 de	19.30 e-g	25.73 gh	6.700 cd
BRRI dhan36	79.00 s	27.00 h	1.70 a-e	8.40 f	24.80 f-h	22.64 c-g	129.5 de	21.53 def	26.90 fg	7.637 a
BRRI dhan58	85.00 o	30.00 c	1.50 hi	9.47 d	29.33 c	22.12 e-i	142.3 c	23.50 cd	25.37 g-i	7.027 bc
BRRI dhan59	80.00 r	26.50 i	1.64 a-g	7.80 h	24.13 gh	22.00 e-i	129.9 de	17.43 gh	24.03 i-k	7.220 b
(%) of Lsd	0.7129	0.3387	0.1383	0.3387	1.801	1.468	3.392	3.310	1.611	.4149
Level of significance	**	**	**	**	**	**	**	**	**	**
% CV	10.40%	10.76%	15.08%	12.33%	14.13%	13.94%	11.59%	20.35%	13.50%	14.09%

Note: PH= Plant height (cm), FLL= Flag leaf length (cm), FLW=Flag leaf width (cm), NPBP=Number of primary branches per panicle, NSBP=Number of secondary branches per panicle, PL=Panicle length (cm), NFGP=Number of filled grains per panicle, NUGP=Number of unfilled grains per panicle, TSW=Thousand seed weight (g), YH= Yield per hectare (ton/ha).

** indicates significant at 1% level. Each letter indicates significantly different from other.

STI was used to identify genotypes that produce higher grain yield (ton per hectare) under both irrigated and rainfed conditions. The higher value of STI indicates higher tolerance to stress of the genotypes. Rice genotypes BRRI dhan55 (0.824), BRRI dhan58 (0.726) Soilerpuna (0.707) and Gopaldeshi (0.703) showed the highest value of STI value (Table 3). Therefore, these genotypes were graded to be tolerant to water stress at reproductive stage. With respect to STI value, BRRI dhan55, BRRI dhan58, Soilerpuna, Gopaldeshi, BRRI dhan36, Borail and BRRI dhan59 were the top 7

Table 2. Performance of different genotypes under rainfed condition

Genotypes	PH	FLL	FLW	NPBP	NSBP	PL	NFGP	NUGP	TSW	YH
Poshusail	115.00 d	23.40 h	1.60 a	7.50 gh	19.00 l	RC	100.0 c	22.67 de	19.00 hi	2.570 ij
Gorchihail	111.00 f	24.00 g	1.44 c-f	6.50 j	25.00 fg	20.78 f	30.0 k	38.67 a	23.00 e	2.873 hi
Birion	126.00 a	26.00 d	1.45 b-e	11.90 a	28.50 de	21.51 de	130.0 a	12.33 j	26.50 ab	3.630 cd
Soilerpuna	118.00 c	25.00 ef	1.50 a-d	11.00 c	29.00 cd	23.04 a	85.0 d	12.33 j	26.00 b	4.150 ab
Pankaich	106.00 h	20.00 l	1.25 g	9.20 e	22.50 i	22.09 bc	60.0 i	38.33 a	22.00 f	3.080 gh
Gopal Deshi	126.00 a	27.00 b	1.55 a-c	11.50 b	27.50 e	22.00 bc	80.0 e	17.56 hi	26.30 b	4.260 a
Borail	92.00 l	26.80 bc	1.36 d-g	9.50 e	33.80 b	21.67 d	85.0 d	18.33 g-i	27.20 a	3.850 bc
BRRI dhan28	84.83 m	25.00 ef	1.42 c-f	8.23 f	22.00 ij	23.05 a	110.0 b	27.43 c	23.00 e	3.160 e-h
BRRI dhan55	94.00 j	28.00 a	1.44 c-f	10.60 d	38.00 a	21.79 cd	112.0 b	25.78 cd	24.00 d	4.420 a
BRRI dhan45	93.00 k	20.40 k	1.47 a-d	8.20 f	30.00 c	20.00 g	65.0 h	20.33 e-h	24.00 d	1.470 l
BRRI dhan50	80.00 p	26.60 c	1.50 a-d	7.80 g	22.20 ij	22.14 b	70.0 g	21.00 e-g	25.00 c	3.450 de
BR 25	119.00 b	24.80 f	1.37 d-g	7.70 g	20.60 k	21.29 e	65.0 h	31.00 b	26.00 b	2.300 jk
BRRI dhan86	95.00 i	23.20 h	1.52 a-c	10.50 d	24.20 gh	22.05 bc	76.0 f	18.33 g-i	23.00 e	2.250 k
BRRI dhan29	82.00 n	22.50 i	1.36 d-g	7.50 gh	22.00 ij	20.70 f	68.0 gh	16.00 i	18.50 hi	2.750 i
BRRI dhan35	81.00 o	21.20 j	1.43 c-f	7.20 hi	20.00 kl	19.28 i	80.0 e	23.40 de	18.20 i	3.100 f-h
BRRI dhan36	76.00 s	25.30 e	1.59 ab	7.50 gh	21.00 jk	19.25 i	102.0 c	17.60 hi	19.30 gh	3.400 d-f
BRRI dhan58	78.00 q	23.40 h	1.36 d-g	8.20 f	25.00 fg	19.67 h	82.0 de	23.20 de	21.20 f	3.880 bc
BRRI dhan59	77.00 r	22.20 i	1.46 a-e	8.30 f	22.20 ij	20.10 g	79.0 ef	19.30 f-h	20.00 g	3.210 e-g
(%) of Lsd	0.7944	0.3347	0.1478	0.3222	1.238	19.00 i	3.310	3.271	0.8181	0.3136
Level of significance	**	**	**	**	**	0.3179	**	**	**	**
% CV	10.49%	10.85%	16.29%	12.23%	12.99%	**	12.55%	18.73%	12.21%	16.24%

Note: PH= Plant height (cm), FLL= Flag leaf length (cm), FLW=Flag leaf width (cm), NPBP=Number of primary branches per panicle, NSBP=Number of secondary branches per panicle, PL=Panicle length (cm), NFGP=Number of filled grains per panicle, NUGP=Number of unfilled grains per panicle, TSW=Thousand seed weight (g), YH= Yield per hectare (ton/ha).

** indicates significant at 1% level. Each letter indicates significantly different from other.

performer under stress condition (Table 3). The genotypes BRRI dhan45 (0.255), BRRI dhan86 (0.271), BR 25 (0.277) and Poshusail (0.391) showed the lowest STI (Table 3) value which implies that these were highly susceptible to stress, especially at reproductive stage. Based on STI value, some promising drought tolerant genotypes were identified namely BRRI dhan55, BRRI dhan58, Soilerpuna, and Gopaldeshi. Previously a number of studies showed that STI was an important index for identifying drought tolerant genotypes (Raman *et al.*, 2012; Kumar *et al*., 2014; Muthuramu and Ragavan, 2020).

The analysis of correlation co-efficient among different characters under irrigated (Table 4) condition showed that plant height exhibited significant but negative correlation (-0.535^{**}) with grain yield and non-significant correlation (-0.09^{ns}) under rainfed condition (Table 5). Flag leaf length (0.634), thousand-seed weight (0.480), number of primary branches per panicle (0.438), number of filled grains per panicle (0.472), number of secondary branches per panicle (0.370) were showed the positive and significant correlation with grain yield under rainfed condition (Table 5). Selection based on these important yield contributing traits would be effective for the development of drought tolerant rice varieties because grain yield depends on the contribution of many independent variables.

Table 3. Stress Tolerance Index (STI) of different characters among the genotypes

Genotypes	PH	FLL	FLW	NPBP	NSBP	PL	NFGP	NUGP	TSW	YH
Poshusail	1.189 d	0.828 j	1.077 a	0.874 hi	0.571 l	0.864 h-j	1.020 b	1.340 de	0.736 g	0.391 h
Gorchihail	1.112 e	0.908 i	0.830 f-j	0.589 m	0.824 f-h	0.940 c-f	0.198 n	2.901 b	0.861 ef	0.477 g
Birion	1.511 a	0.977 f	0.860 e-i	1.617 b	1.105 c	1.063 ab	1.637 a	0.378 j	0.889 de	0.561 ef
Soilerpuna	1.394 b	0.834 j	0.918 c-f	1.423 c	0.997 d	0.978 cd	0.612 gh	0.403 ij	0.938 cd	0.707 bc
Pankaich	1.260 c	0.694 n	0.794 h-j	0.953 fg	0.776 g-j	0.887 e-i	0.288 m	3.524 a	0.830 f	0.484 g
Gopal Deshi	1.518 a	1.073 c	1.050 ab	1.787 a	1.066 cd	0.893 e-i	0.528 ij	0.853 gh	1.051 ab	0.703 bc
Borail	0.865 g	1.050 d	0.817 g-j	1.107 e	1.553 b	0.951 c-e	0.663 f	0.873 gh	1.039 b	0.656 cd
BRRI dhan28	0.664 h	1.123 b	0.863 e-i	1.002 f	0.820 f-i	0.985 cd	0.830 c	1.574 cd	0.830 f	0.518 fg
BRRI dhan55	0.818 g	1.219 a	0.903 d-g	1.166 de	1.963 a	0.869 g-j	0.806 cd	1.604 cd	0.814 f	0.824 a
BRRI dhan45	0.811 g	0.700 mn	0.967 b-d	1.008 f	1.505 b	1.098 a	0.507 j	1.416 c-e	0.960 c	0.255 ij
BRRI dhan50	0.550 i	1.022 e	0.953 b-e	0.909 gh	0.828 e-h	0.973 cd	0.538 i	0.718 g-i	1.097 a	0.551 f
BR 25	1.430 b	0.919 hi	0.796 h-j	0.797 jk	0.678 k	0.921 d-h	0.476 k	1.581 cd	1.074 ab	0.277 i
BRRI dhan86	0.851 g	0.820 j	1.006 a-c	1.224 d	0.904 e	1.057 ab	0.542 i	0.611 h-j	0.861 ef	0.271 i
BRRI dhan29	0.660 h	0.715 m	0.832 f-j	0.798 jk	0.845 e-g	0.896 e-h	0.539 i	0.349 j	0.555 kl	0.476 g
BRRI dhan35	0.571 i	0.750 l	0.891 d-h	0.746 kl	0.718 jk	0.830 ij	0.624 g	1.200 ef	0.603 jk	0.554 f
BRRI dhan36	0.526 i	0.930 h	1.034 ab	0.816 ij	0.747 i-k	0.876 f-j	0.792 d	1.020 fg	0.670 hi	0.692 bc
BRRI dhan58	0.582 i	0.955 g	0.785 ij	1.005 f	1.052 cd	0.875 g-j	0.700 e	1.453 c-e	0.695 gh	0.726 b
BRRI dhan59	0.536 i	0.801 k	0.921 c-f	0.838 ij	0.768 h-j	0.822 j	0.616 gh	0.892 f-h	0.619 ij	0.619 de

Note: PH = Plant height (cm), FLL= Flag leaf length (cm), FLW=Flag leaf width (cm), NPBP=Number of primary branches per panicle, NSBP=Number of secondary branches per panicle, PL=Panicle length (cm), NFGP=Number of filled grains per panicle, NUGP=Number of unfilled grains per panicle, TSW=Thousand seed weight (g), YH= Yield per hectare (ton/ha).

Each letter indicates significantly different from other.

Table 4. Correlation co-efficient among different characters under irrigated condition

	PH	FLL	FLW	NPBP	NSBP	PL	NFGP	NUGP	TSW	YP
PH	1	-0.161 ns	-0.065 ns	0.309 ns	-0.204 ns	-0.253 ns	-0.004 ns	0.080 ns	0.261 ns	-0.535 **
FLL		1	-0.028 ns	0.330 *	0.407 **	-0.227 ns	0.017 ns	0.225 ns	0.211 ns	0.249 ns
FLW			1	0.260 ns	0.022 ns	0.190 ns	-0.001 ns	0.017 ns	0.304 ns	0.091 ns
NPBP				1	0.299 ns	0.001 ns	0.271 ns	-0.228 ns	0.294 ns	0.063 ns
NSBP					1	0.120 ns	-0.017 ns	0.122 ns	0.029 ns	0.316 ns
PL						1	0.195 ns	-0.395 *	-0.050 ns	-0.152 ns
NFGP							1	-0.441 **	-0.141 ns	0.067 ns
NUGP								1	0.129 ns	0.097 ns
TSW									1	-0.219 ns
YP										1

Note: PH = Plant height (cm), FLL= Flag leaf length (cm), FLW=Flag leaf width (cm), NPBP=Number of primary branches per panicle, NSBP=Number of secondary branches per panicle, PL=Panicle length (cm), NFGP=Number of filled grains per panicle, NUGP=Number of unfilled grains per panicle, TSW=Thousand seed weight (g), YP= Yield per plant (g).

* indicates: significant at 5%, ** indicates: significant at 1% and ns indicates: not-significant

In the path analysis flag leaf width (0.084), number of primary branches per panicle (0.274), number of secondary branches per panicle (0.166), number of filled grains per panicle (0.101), number of unfilled grains per panicle (0.138) showed positive and direct effect on grain yield under irrigated condition (Table 6). Flag leaf length (0.509), number of primary branches per panicle (0.310), number of filled grains per panicle (0.117), number of unfilled grains per panicle (0.153) and thousand seed weight (0.349) showed the positive and direct effect on grain yield under rainfed condition (Table 7). Flag leaf width (0.084) and number of secondary branches per panicle (0.166) showed the positive direct effect under irrigated condition (Table 6) but these two traits showed the negative direct effect under rainfed condition (Table 7). Sahu *et al., (*2017) observed the similar findings. Selection based on leaf width and number of secondary branches per panicle would not be effective for the development of drought tolerant varieties. Flag leaf length (0.509) showed the positive effect on yield under rainfed condition but revealed negative direct effect on yield under irrigated condition (Table 6 and 7). Therefore, selection based on flag leaf length would be effective. By observing the direct and indirect effects of different yield contributing traits on yield, the breeder can select the best promising genotypes. Results in this study indicated a positive and

highly significant correlation exist between grain yield and other yield contributing characters under stress level. The genotypes that showed high grain yield under non-stressed condition also revealed high yield under stressed condition**.**

Table 5. Correlation co-efficient among different characters under rainfed condition

	PH	FLL	FLW	NPBP	NSBP	PL	NFGP	NUGP	TSW	YP
PH	1	0.076 ns	0.002 ns	0.423 **	0.153 ns	0.616 **	-0.035 ns	0.095 ns	0.357 *	-0.090 ns
FLL			1	0.334 *	0.439 **	0.442 **	0.213 ns	0.510 **	-0.297 ns	0.634 **
FLW			1	0.091 ns	-0.039 ns	-0.119 ns	0.277 ns	-0.308 ns	0.186 ns	0.223 ns
NPBP				1	0.601 **	0.395 *	0.499 **	-0.479 **	0.525 **	0.438 **
NSBP					1	0.340 *	0.241 ns	-0.206 ns	0.528 **	0.370 *
PL						1	0.014 ns	0.046 ns	0.655 **	-0.026 ns
NFGP							1	-0.521 **	0.167 ns	0.472 **
NUGP								1	-0.102 ns	-0.237 ns
TSW									1	0.480 **
YP										1

Note: PH = Plant height (cm), FLL= Flag leaf length (cm), FLW=Flag leaf width (cm), NPBP=Number of primary branches per panicle, NSBP=Number of secondary branches per panicle, PL=Panicle length (cm), NFGP=Number of filled grains per panicle, NUGP=Number of unfilled grains per panicle, TSW=Thousand seed weight (g), YP= Yield per plant (g).

* indicates: significant at 5%, ** indicates: significant at 1% and ns indicates: not-significant

Table 6. Path coefficient among different characters under irrigated condition

	PH	FLL	FLW	NPBP	NSBP	PL	NFGP	NUGP	TSW	YP
PH	**-0.650**	0.014	-0.005	0.085	-0.034	0.088	0.000	0.011	-0.042	-0.535
FLL	0.105	**-0.088**	-0.002	0.090	0.068	0.078	0.002	0.031	-0.034	0.249
FLW	0.042	0.002	**0.084**	0.071	0.004	-0.066	0.000	0.002	-0.049	0.091
NPBP	-0.201	-0.029	0.022	**0.274**	0.050	0.000	0.027	-0.032	-0.048	0.063
NSBP	0.133	-0.036	0.002	0.082	**0.166**	-0.041	-0.002	0.017	-0.005	0.316
PL	0.165	0.020	0.016	0.000	0.020	**-0.346**	0.020	-0.055	0.008	-0.152
NFGP	0.002	-0.002	0.000	0.074	-0.003	-0.068	**0.101**	-0.061	0.023	0.067
NUGP	-0.052	-0.020	0.001	-0.063	0.020	0.137	-0.044	**0.138**	-0.021	0.097
TSW	-0.170	-0.019	0.026	0.080	0.005	0.017	-0.014	0.018	**-0.162**	-0.219

Residual Value (R): 0.699

Note: PH = Plant height (cm), FLL= Flag leaf length (cm), FLW=Flag leaf width (cm), NPBP=Number of primary branches per panicle, NSBP=Number of secondary branches per panicle, PL=Panicle length (cm), NFGP=Number of filled grains per panicle, NUGP=Number of unfilled grains per panicle, TSW=Thousand seed weight (g), YP= Yield per plant (g).

A positive correlation between grain yields has also been reported earlier by many workers (Dadbakhsh *et al.*, 2011; Rahman, 2014; Bennani *et al.*, 2017). Positive and significant correlation also exists between STI and yield/plant as previously reported by other workers (İlker *et al.*, 2011; Toorchi *et al.*, 2012).

Table 7. Path coefficient among different characters under rainfed condition

	PH	FLL	FLW	NPBP	NSBP	PL	NFGP	NUGP	TSW	YP
PH	**-0.143**	0.039	0.000	0.131	-0.011	-0.241	-0.004	0.014	0.125	-0.090
FLL	-0.011	**0.509**	-0.025	0.136	-0.031	-0.083	0.060	-0.045	0.221	0.731
FLW	0.000	0.170	**-0.075**	0.028	0.003	0.047	0.033	-0.047	0.065	0.223
NPBP	-0.061	0.223	-0.007	**0.310**	-0.042	-0.154	0.059	-0.073	0.183	0.438
NSBP	-0.022	0.225	0.003	0.186	**-0.070**	-0.133	0.028	-0.032	0.184	0.370
PL	-0.088	0.108	0.009	0.122	-0.024	**-0.391**	0.002	0.007	0.229	-0.026
NFGP	0.005	0.259	-0.021	0.155	-0.017	-0.006	**0.117**	-0.080	0.058	0.472
NUGP	-0.014	-0.151	0.023	-0.148	0.014	-0.018	-0.061	**0.153**	-0.036	-0.237
TSW	-0.051	0.323	-0.014	0.162	-0.037	-0.256	0.020	-0.016	**0.349**	0.480

Residual Value (R): 0.5

Note: PH = Plant height (cm), FLL= Flag leaf length (cm), FLW=Flag leaf width (cm), NPBP=Number of primary branches per panicle, NSBP=Number of secondary branches per panicle, PL=Panicle length (cm), NFGP=Number of filled grains per panicle, NUGP=Number of unfilled grains per panicle, TSW=Thousand seed weight (g), YP= Yield per plant (g).

Conclusion

The study was designed to investigate the relationship of different yield and yield contributing traits on grain yield and observe the yield performance of different Boro rice genotypes under irrigated and rainfed conditions. Among the eighteen genotypes, BRRI dhan55, Gopal Deshi and Soilerpona showed the superior performance in terms of gran yield and yield attributes under rainfed condition. Therefore, these genotypes could be used for the future water stress breeding program. The genotypes BRRI dhan55, BRRI dhan58, Soilerpona, Gopaldeshi and BRRI dhan36 showed the highest STI value therefore could be recommended as parent materials to develop drought tolerant varieties.

Acknowledgement

The authors are grateful to Sher-e-Bangla Agricultural University for providing experimental materials and support to complete the experiments.

References

Adhikari, M., N.V. Adhiari, S. Sharma, J. Gairhe, R.R. Bhandari, N. Sakshi, and S. Paudel. 2017. Evaluation of drought tolerant rice cultivars using drought tolerant indices under water stress and irrigated condition. *American J. Climate Change*. 8:228-236.

Ali, M.B. and A. El-Sadek. 2016. Evaluation of drought tolerance indices for wheat (*Triticum aestivum* L.) under irrigated and rainfed conditions. *Commun. Biomet. Crop Sci.* 11(1):77-89.

Bennani S, N. Nsarellah, M. Jlibene, W. Tadesse, A. Birouk and H. Ouabbou .2017. Efficiency of drought indices under different severities for bread wheat selection. *Aust. J. Crop. Sci.* 11(4):395-405.

BRRI (Bangladesh Rice Research Institute) 2019. Rice in Bangladesh, Bangladesh Rice Knowledge Bank, Training Division, Gazipur, Bangladesh.

Dadbakhsh A, A. Yazdansepas and M Ahmadizadeh .2011. Study drought stress on yield of wheat (*Triticum aestivum* L.) genotypes by drought tolerance indices. *Adv Environ Bio.* 5(7):1804-1810.

Davatgara, N., M.R. Neishabouria, A.R. Sepaskhahb, and A. Soltanic. 2009. Physiological and morphological responses of rice (*Oryza sativa* L.) to varying water stress management strategies. *Intl. J. Plant Prodn*. 3(4):19-32.

Dixit S, A. Singh and A. Kumar. 2014. Rice breeding for high grain yield under drought: a strategic solution to a complex problem. *Int. J. Agri.* Article ID 863683.

FAO (2020). Information and reporting system for agriculture, Hybrid rice and its development. Food and Agriculture Organization, United Nations, pp. 34-37.

Farshadfar, E. and P. Elyasi. 2012. Screening quantitative indicators of drought tolerance in bread wheat (*T. aestivum*) landraces. *Eur. J. Exp. Biol.* 2 (3):577-584.

Henry, N.T., N.N. Kinh, B.B. Bang, N.T Tram, T.D. Qui, and N.V. Bo. 2016. Hybrid rice research and development in Vietnam. In: Advances in hybrid rice technology. Virmani, S.S., Siddiq, E.A. and Muralidharan (eds.). pp. 325- 341.

Ilker, E, Ö. Tatar, Aykut, F. Tonk, M. Tosun and J. Turk. 2011. Determination of tolerance level of some wheat genotypes to post-anthesis drought. *Tur. J. Field Crops.* 16(1):59-63.

Kumar, N., K. Sarawgi, A.K. Chandrakar, Singh, P.K. and B.K. Jena. 2015. Agro-morphological and quality characterization of indigenous and exotic aromatic rice (*Oryza sativa* L.) germplasm. *J. Appl. Nat. Sci.* 8(1):314-320.

Kumar, S., S.K. Dwivedi, S.S. Singh, S.K. Jha, S. Lekshmy, R. Elanchezhian, O.N. Singh and B. P. Bhatt. 2014. Identification of drought tolerant rice genotypes by analyzing drought tolerance indices and morphophysiological traits. *SABRAO J. Breed. Genet.*46 (2):217-230.

Muthuramu, S. and Ragavan T. (2020) Studies on indices and morphological traits for drought tolerance in rainfed rice (*Oryza sativa* L.). *Elec. J. Plant Breed.* 11(1):1-5.

Pervin, M.S., Halder T. Khalequzzaman, K. Aditya, T.L. and R. Yasmeen. 2015. Genetic diversity and screening of rice (*Oryza sativa* L.) genotypes for drought tolerance at reproductive phase. *Bangladesh Rice J.* 21(1):27-34.

Rahman, S.M. (2014). Heritability, phenotypic correlation and path coefficient studies for some agronomic characters in landrace rice varieties. *World Appl. Sci. J.* 13(5):1229-1233.

Raman, A., S. Verulkar, N.P. Mandal, M. Varrier, V.D. Shukla, J.L. Dwivedi, B.N. Singh, O.N. Singh, P. Swain, A.K. Mall, S. Robin, R. Chandrababu, A. Jain, T.R. Ram, S. Hittalmani, S. Haefele, H.S. Piepho and A. Kumar .2012. Drought yield index to select high yielding rice lines under different drought stress severities. *Rice* 5(31):1-12.

Sahu, H., R.R. Saxena, and S.B. Verulkar. 2017. Genetic variability and character association study for different morphological traits and path analysis for grain yield of rice under irrigated and rainfed condition. *Electr. J. of Pt. Breed.* 8(1):38-45.

Singh, A., A.K. Singh, P. Sharma and P.K. Singh. 2015. Characterization and assessment of variability in upland rice collections. *Electronic J. Pl. Breed.* 5(3):504-510.

Singh, C.M., B. Kumar, S. Mehandi and K. Chandra. 2012. Effect of drought stress in rice: a review on morphological and physiological characteristics. *Trends Bio*. 5(4):261-265.

Toorchi, M., R. Naderi, A. Kanbar and M.R. Shakiba .2012. Response of spring canola cultivars to sodium chloride stress. *Ann Biol Res*. 2(5):312-322.

Ullah, M.J. 2014. Development of intensive cropping system in two coastal districts for increasing production, (Final Report). Krishi Gobeshona Foundation, BARC. Dhaka, Bangladesh.