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EVALUATION OF SUBMERGENCE TOLERANT RICE GENOTYPES THROUGH AGRONOMIC TRAITS

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ABSTRACT

Abiotic stresses adversely affect plant growth and productivity leading to series yield losses. Submergence stress is one the major abiotic stresses that affects crop growth and yield. This study was conducted in the experimental field of Bangladesh Rice Reserch Institute, Gazipur during 2014-2015 to evaluate 46 submergence tolerant rice genotypes through agronomic traits. The experiment was laid out with a randomized complete block designwith three replications. Ten agronomic traits *Viz.* Plant height (cm), effective tillers per plant, Days to 50% flowering (days), flag leaf length (cm), panicle length (cm), panicle weight (g), spikelet fertility (%), days to maturity (days), thousand grain weight (g), and yield/plant (g) were studied to measure nature of association between these traits and yield. Results showed that ample variability existed in all the traits under studied. Grain yield was significantly and positively correlated with panicle weight, spikelet fertility percentage and thousand grain weight of rice. Days to 50% flowering had strong positive association with days to maturity. From this study panicle weight, spikelet fertility percentage, days to maturity and thousand grain weight may serve selection criteria for improving genetic potential of rice.

Keywords: Abiotic stress, submergence tolerance, rice direct effect, yield

Introduction

Bangladesh is the fourth-largest rice growing country in the world in terms of area coverage and production. During the last three decades, rice production has been increased from 10.79 million tonsin 1970 to 36.00 million tons in 2017. Among the 42 biotic and abiotic stresses affecting rice production, submergence has been identified as the third most important constraint for higher rice productivity (Sarkar *et al.* 2006). Scientists have estimated that 4 million tons of rice is being lost every year because of flooding (IRRI 2008).

Submergence stress is a major constraint to rice production during the monsoon flooding season in the rainfed lowlands in south and Southeast Asia (Xu *et al.* 2006). Out of 40 million ha in Asia grown under rainfed lowlands, about 15 million ha are frequently damaged by submergence stress (Huke and Huke 1997). Recently, the extent of submergence stress has increased due to extreme weather events such as unexpected heavy rains that have inundated wider areas across many regions in Asia.

Out of 10.6 million ha of rice productionmore than 2 million ha is affected by flash flooding in Bangladesh (Iftekharuddaula *et al.* 2011). Although a number of high yielding submergence tolerant inbred rice varieties have been developed, development of submergence tolerant hybrid rice varieties is not yet been successful in Bangladesh. Moreover, the level of submergence stress tolerance in rice needs to be enhanced, particularly in genotypes with the short duration genetic background. Hybrid rice varieties development depends on identification of suitable parental lines with appropriate floral characteristics and acceptable yield potential. The present study was undertaken for the evaluation of submergence tolerant elite breeding lines for their floral characters and yield potential.

Materials and Methods

The experiment was conducted at the experimental farm of Bangladesh Rice Research Institute (BRRI), Gazipur during Boro season 2014-2015. The experimental field was of medium high land having well drainage system. Thirty days old seedlings were transplanted on 25 December, 2014 using single seedling per hill at a spacing of 20 cm x 20 cm. Fertilizers were applied @ of 270-130-120-70-10kg/ha Urea, TSP, MoP, gypsum and $ZnSO_4$, respectively. Whole amount of TSP, two-third of MP, total gypsum and zinc sulphatewere applied as basal during final land preparation. Urea was applied in three installments, viz. at 10-15 days after transplanting (DAT), 30-35 DAT and 50-55 DAT. One-third of MoP was top dressed with urea 3rd top dressing. Necessary intercultural operations and protection measures were taken during cropping period for proper growth and development of the plants. The experiment was replicated three times.

Following data were recorded from 10 randomly selected plants per plot in each replication at different times as specified- plant height (cm), effective tiller/plant (no.), days to 50% flowering (days), flag leaf length (cm), panicle length (cm), panicle weight (g), spikelet fertility (%), days to maturity (days), thousand grain weight (g), and yield/plant (g). Data were analyzed using MSTAT-C software.

Results and Discussion

Analysis of variances for each of the 10 yield contributing characters of 46 submergence tolerant lines were estimated. The mean, range, standard error of mean, co-efficient of variation and F-values are presented in Table 1. The mean values of the yield contributing characters of each genotypes with least significant differences at 5% and 1% level of significance are presented in Table 2.

The maximum plant height was recorded in BR9158-19-9-6-9-93 (118.4), while the minimum was recorded in BR9158-19-9-7-8-21 (82.46) followed by BR9157-12-2-37-13-71-41 (83.87), BR9157-12-2-37-13-17-39 (85.22), BR9157-12-2-37-13-15-35 (85.50), BR9158-19-9-6-9-17 (87.30) and BR9158-19-9-6-9-103 (87.53).

The plant height of different breeding lines were obtained as shorter plant stature which would be useful for developing lodging resistant hybrid rice varieties. However, the plant heights of the test entries ranged from 82.46 to 118.37 cm with a mean value of 100.64 cm.

Effective tillers per plant were found significant among the genotypes (Table 2). BR9157-12-2-37-13-15-40 (13.70) was significantly superior over all other genotypes followed by BR9158-19-9-6-9-50 (13.67), BR9157-12-2-37-13-15-25 (12.70) and BR9158-19-9-7-8-38 (12.70). The studied parameter ranged from 8.90 to 13.70 with a mean value of 10.63. Zahid *et al.* (2005) and Ansari (2009) also reported highly significant variation for number of effective tillers per plant, which is an important yield component in rice.

The analysis of variance showed highly significant genetic variation among the genotypes for days to 50% flowering (Table 2). Coefficient of variation for days to 50% flowering was 0.53%. The parameter ranged from 108 to 129 days. The maximum days to 50% flowering was recorded in BR9158-19-9-7-8-3 (133.7) and the minimum in BR9157-12-2-37-13-71-41 (108 days), which were statistically different. Similar variation in days to flowering was reported by Tahir *et al.* (2002) in rice.

Table 1. Variability in 10 characters of submergence tolerant lines growing during Boro 2014-15 season

Characters	Range	Mean	±SE	CV%	F-value
Plant height (cm)	82.46-118.37	100.64	0.146	0.99	222.31
Effective tillers per plant	8.90-13.70	10.63	0.097	6.19	11.89
Days to 50% flowering	108.00-129.00	121.59	0.095	0.53	206.53
Flag leaf length (cm)	18.30-29.39	24.25	0.128	3.59	17.02
Panicle length (cm)	21.28-27.32	23.95	0.065	1.83	52.12
Panicle weight (g)	1.84-4.45	3.17	0.022	4.72	55.65
Spikelet fertility (%)	62.97-90.46	78.17	0.320	2.77	29.21
Days to maturity	141.33-156.67	149.23	0.128	0.58	81.21
1000 grain weight (g)	19.26-26.04	23.34	0.074	2.16	51.25
Yield/plant (g)	12.31-26.38	19.66	0.065	2.25	388.54

Table 2. Mean value and significance status of 46 submergence tolerant lines for different characters grown in Boro 2014-15 season

Genotypes	Plant height (cm)	Effective tillers/plant	Days to 50% flowering (days)	Flag leaf length (cm)	Panicle length (cm)	Panicle weight (g)	Spikelet fertility (%)	Days to maturity (days)	1000 grain weight (g)	Yield/plant (g)
BR9158-19-9-6-7-94	98.30 op	11.57 d-i	122.3 kl	23.96 j-n	24.05 kl	2.02 v	71.73 s-v	150.3 lmn	20.06 q-t	14.51 qrs
BR9158-19-9-6-9-9	98.63 o	9.87 l-q	121.7 l	22.39 o-t	22.86 no	3.15 jkl	80.84 h-k	144.3 st	23.80 h-l	12.31 v
BR9158-19-9-6-9-17	87.30 t	11.77 c-g	121.3 lm	18.30 u	22.03 qr	2.78 o-s	76.01 m-q	146.7 q	19.26 t	13.40 tu
BR9158-19-9-6-9-60	118.4 a	10.97 f-k	118.7 pq	21.49 st	22.14 o-r	2.91 l-o	68.41 v	143.3 stu	20.00 q-t	13.18 tu
BR9158-19-9-6-9-93	118.4 a	9.23 o-q	115.7 t	25.02 f-k	22.77 n-p	3.55 fgh	71.98 stu	144.0 st	24.79 d-g	13.86 st
BR9158-19-9-6-9-101	103.6 ijk	10.63 h-l	129.0 c	25.27 e-j	29.19 a	2.57 stu	62.97 w	147.0 pq	23.80 h-l	13.26 tu
BR9158-19-9-7-8-3	94.37 rs	10.17 k-p	133.7a	27.00 bc	21.87 rs	2.57 stu	77.46 k-o	155.0 cde	24.49 e-h	14.54 qrs
BR9158-19-9-7-8-21	82.46 w	10.30 j-o	121.3 lm	24.44 g-l	24.49 jk	2.96 l-o	71.98 stu	149.0 no	19.84 q-t	13.05 u
BR9158-19-9-7-8-38	100.5 mn	12.70 a-c	118.0 pqr	25.80 c-g	22.05 pqr	2.76 o-s	70.37 uv	143.0 tu	19.46 st	15.12 pq
BR9158-19-9-7-8-51	103.4 ijk	10.23 k-p	126.3 fg	21.83 q-t	24.48 jk	2.01 v	72.02 r-u	149.0 no	21.60 no	14.68 qr
BR9158-19-9-6-9-103	87.53 t	9.15 pq	110.7 u	24.39 g-l	24.55 jk	4.45 a	81.76 hi	143.3 stu	23.81 h-l	17.96 k
BR9158-19-9-6-9-50	98.70 o	13.67 ab	130.3 b	23.16 l-r	21.28 s	2.36 u	73.33 p-u	156.0 abc	20.54 pqr	15.89 no
BR9157-12-2-37-13-71-38	93.53 s	11.33 e-j	125.7 gh	22.05 p-t	23.01 mn	3.11 klm	70.50 tuv	153.7 e-h	21.26 op	15.68 op
BR9157-12-2-37-13-71-26	110.8 c	12.23 c-e	121.7 l	22.34 o-t	22.60 n-q	2.98 k-o	74.56 n-s	147.3 pq	20.16 qrs	15.60 op
BR9157-12-2-37-13-71-41	83.87 vw	9.20 pq	108.0 v	22.90 m-s	24.69 ijk	3.50 gh	82.63 fgh	141.3 v	24.00 g-j	18.74 j
BR9157-12-2-37-13-17-27	107.3 d	10.64 h-l	127.7 de	23.30 l-p	26.28 cd	3.44 hi	77.63 j-n	154.3 def	20.14 qrs	16.14 mno
BR9157-12-2-37-13-71-46	100.6 mn	12.20 c-e	118.7 pq	25.77 c-g	24.88 hij	2.98 k-o	72.50 q-u	146.7 q	23.35 jkl	16.88 l
BR9157-12-2-37-13-17-32	106.4 defg	10.97 f-k	116.3 st	26.42 b-f	25.79 c-g	2.63 p-t	75.80 m-q	146.3 q	20.60 pq	13.22 tu
BR9157-12-2-37-13-17-39	85.22 uv	8.93 q	119.0 op	25.64 c-h	23.01 mn	2.85 n-q	74.59 n-s	149.0 no	23.56 i-l	14.72 qr
BR9157-12-2-37-13-17-36	102.7 jkl	12.60 b-d	126.7 efg	22.80 n-s	25.32 ghi	2.83 n-r	75.56 m-r	152.3 h-k	19.72 rst	14.21 rs
BR9157-12-2-37-13-17-41	106.7 def	11.07 f-k	118.7 pq	23.87 j-n	26.14 c-f	2.98 k-o	74.03 o-t	151.0 klm	23.93 hij	16.42 lmn
BR9157-12-2-37-13-15-42	93.6 s	10.33 j-n	120.0 no	21.78 rst	26.30 cd	1.84 v	71.49 s-v	148.3 op	22.36 mn	16.68 lm
BR9157-12-2-37-13-15-25	101.7 lm	12.70 a-c	118.7 pq	23.14 l-r	21.95 q-s	2.41 tu	63.54 w	147.0 pq	23.09 klm	15.11 pq
BR9157-12-2-37-13-15-30	104.9 ghi	10.70 g-l	117.3 rs	25.42 e-i	24.11 kl	2.83 n-r	72.09 r-u	146.0 qr	23.03 lm	17.83 k
BR9157-12-2-37-13-15-35	85.50 u	9.20 pq	111.7 u	25.07 f-j	24.87 hij	3.62 e-h	83.33 e-h	143.0 tu	23.96 hij	20.47 i
BR9157-12-2-37-13-15-40	104.3 hij	13.70 a	116.0 t	26.34 b-f	27.32 b	4.04 bc	85.93 c-f	142.0 uv	25.75 abc	24.92 ef
BR9157-12-2-37-13-71-32	105.3 efgh	10.98 f-k	118.3 pqr	24.31 h-m	24.36 jkl	3.80 cde	87.45 a-d	143.0 tu	25.57 a-d	25.72 a-d
BR9159-8-5-49-1-4	96.87 pq	10.69 g-l	117.3 rs	26.54 b-e	26.23 cde	3.82 cde	90.46 a	144.7 rs	26.04 a	26.28 ab
BR9159-8-5-40-14-4	102.3 kl	11.70 c-h	120.3 mn	26.95 bc	25.63 d-g	4.34 a	89.18 abc	146.7 q	25.91 ab	25.04 def

Table2. contd.

Genotypes	Plant height (cm)	Effective tiller/plant	Days to 50% flowering (days)	Flag leaf length (cm)	Panicle length (cm)	Panicle weight (gm)	Spikelet fertility (%)	Days to ma-turity (days)	1000 grain weight (gm)	Yield/plant (gm)
BR9159-8-5-49-1-2	111.1 c	11.70 c-h	117.7 qr	29.40 a	26.46 c	3.69 efg	86.67 b-e	147.0 pq	23.71 h-l	25.49 cde
BR9159-8-5-49-1-1	105.2 fgh	10.50 i-m	117.3 rs	25.18 e-j	24.68 ijk	4.23 ab	86.55 b-e	146.0 qr	24.96 c-f	25.99 abc
BR9159-8-5-40-14-5	88.33 t	9.03 q	128.7 cd	21.77 r-t	22.51 n-r	3.13 kl	80.88 h-k	155.0 cde	23.95 hij	25.11 def
BR9159-8-5-40-14-2	107.0 de	9.40 n-q	126.7 efg	24.06 i-n	22.11 pqr	3.050 k-n	82.14 ghi	155.0 cde	24.21 f-i	23.54 g
BR9159-8-5-40-13-10	102.0 klm	9.03 q	129.0 c	26.87 b-d	23.10 mn	3.22 ijk	75.91 m-q	157.0 a	23.87 h-k	22.49 h
BR9159-8-5-40-13-8	100.7 mn	11.33 e-j	118.7 pq	25.88 c-f	25.56 e-h	3.72 efg	90.08 ab	147.3 pq	25.55 a-d	25.59 b-e
BR9159-8-5-40-14-75	99.33 no	12.00 c-f	120.3 mn	27.71 b	25.46 fgh	4.41 a	87.94 a-d	149.3 no	24.11 g-j	26.38 a
BR9159-8-5-40-14-57	115.9 b	9.00 q	120.0 no	22.37 o-t	24.61 ijk	3.61 e-h	81.03 hij	152.0 ijk	24.81 d-g	25.13 def
BR9159-8-5-40-13-63	106.2 defg	9.71 l-q	122.3 kl	23.25 l-q	23.68 lm	3.38 hij	85.48 d-g	155.0 cde	25.20 b-e	24.67 f
BR9159-8-5-40-13-52	107.0 de	9.32 n-q	125.0 hi	25.76 c-g	23.13 mn	2.87 m-p	80.97 h-k	153.3 f-i	23.94 hij	24.67 f
BR9159-8-5-40-13-21	102.6 kl	8.90 q	123.3 jk	25.51 d-h	20.06 t	4.01 bcd	85.46 d-g	154.0 d-g	26.02 ab	25.02 def
BR9159-8-5-40-13-15	106.8 def	9.47 m-q	126.0 fgh	23.24 l-q	22.52 n-r	3.78 def	82.75 fgh	151.7 jkl	23.75 h-l	25.48 cde
Chiherang-sub-1	102.3 kl	10.67 h-l	125.0 hi	23.03 l-r	22.17 o-r	2.59 r-u	77.58 j-o	153.7 e-h	24.43 e-h	23.50 g
IR64-sub-1	93.13 s	10.29 j-o	127.0 ef	25.69 c-h	23.19 mn	2.42 tu	80.02 h-l	155.3 bcd	24.26 f-i	22.44 h
BR9158-19-9-6-7-80	95.60 qr	9.17 pq	128.7 cd	21.04 t	22.52 n-r	2.62 q-t	78.77 i-m	156.7 ab	25.51 a-d	23.69 g
BRRI dhan51	101.6 lm	9.07 q	124.3 ij	23.57 l-o	21.94 qrs	3.51 gh	76.34 m-p	152.7 g-j	25.74 a-c	24.52 f
BRRI dhan52	102.5 kl	10.78 g-l	122.3 kl	23.60 k-o	23.64 lm	3.40 hi	77.13 l-o	150.0 mn	25.85 ab	25.11 def

Flag leaf plays a very important role in photosynthesis and help in accumulating dry matter that is ultimately translated into filled grain. According to Wan and Shong (1981) flag leaf plays an important role in grain yield of rice. BR9159-8-5-49-1-2 possessed the highest flag leaf length (29.39 cm) while the lowest value was observed in BR9158-19-9-6-9-17 (18.30 cm) which were being significantly different.

There was a variation in the tested entries in respect of panicle length. It ranged from 21.06 to 29.19 cm with a mean of 23.95 cm (Table 2). The highest panicle length was obtained in BR9158-19-9-6-9-101 (29.19 cm) followed by BR9157-12-2-37-13-15-40 (27.32 cm) which was statistically significant. The lowest panicle length was obtained from the genotype BR9159-8-5-40-13-21 (20.06 cm) which was distinct from others. Hasan *et al.* (2015) reported that increased panicle length might have significant effect on increased grain yield in rice indirectly.

Panicle weight varied significantly among the tested genotypes. It ranged from 1.84 to 4.45 g with a mean value of 3.17 (Table 2). The highest panicle weight was observed in BR9158-19-9-6-9-103 (4.45 g) followed by BR9159-8-5-40-14-75 (4.41 g) and BR9159-8-5-40-14-4 (4.35g) but these were statistically identical. The lowest panicle weight was observed in BR9157-12-2-37-13-15-42 (1.84 g).

Spikelet fertilities were differed significantly among the tested genotypes. The values for this character ranged from 62.97 to 90.46 % with a mean value of 78.17 % (Table 2). The highest spikelet fertility was recorded in BR9159-8-5-49-1-4 (90.46 %) and the lowest one was recorded in BR9158-19-9-6-9-101 (62.97). Ansari (2009) reported that high spikelet fertility enhanced grain yield in rice.

Days to maturity are the main selection criteria for early maturing hybrids. In respect of days to maturity, it ranged from 141.3 to 157.0 days. The breeding line BR9159-8-5-40-13-10 showed late maturing (157.0 days) and the early maturity was observed in BR9157-12-2-37-13-71-41 (141.3 days). Rice production in Bangladesh is largely rainfed and with increased frequencies of weather extremes, use of short maturing varieties should be emphasized and promoted. Growing short duration varieties of rice has other advantages like filling other crops in between. It has been reported that, adoption of short duration rice varieties is one of the strategies to mitigate emission of methane and nitrous oxide which are greenhouse gases. Since, rice crop is said to be one of the major contributing factors to global warming, growing short duration varieties is one way of reducing such emissions. Karim *et al.* (2007) studied aromatic rice genotypes for variability and genetic parameter analysis and found highly significant mean sum of square due to genotypes for days to maturity. They further reported that variation for days to maturity was attributed by genetic constituent rather than environment.

Significant variation was observed among the tested genotypes for thousand grain weight (Table 2). Coefficient of variation for 1000 grain weight was 2.16 %. The thousand grain weight ranged from 19.26 to 26.04 g. The minimum thousand grain weight was recorded in BR9158-19-9-6-9-17, while maximum in BR9159-8-5-49-1-4. Mondal *et al.* (2005) also found such variation for 1000 grain weight in some modern transplant aman rice which supports the present study.

The genotypes were significantly different for grain yield per plant at 1 % level. Coefficient of variation for grain yield per plant was 2.25 % which indicatedsatisfactory authenticity for the data taken on grain yield. Grain yield per plant ranged from 12.31 to 26.38 g. Robin and Saha (2015) found grain yield of 8.59 g per plant in Kalijira genotype which was much lower than that in the present findings. The minimum grain yield per plant was recorded inBR9158-19-9-6-9-9 and maximum was recorded in BR9159-8-5-40-14-75. Ansari (2009) also reported highly significant variation among the tested maintainer lines regarding yield and yield contributing traits like no. of panicles/hill, spikelet fertility percent, 1000-grain weight and grain yield/hill which were in agreement with the present findings.

The experiment provided essential information regarding differences in yield related traits and floral traits in submergence tolerant lines. All lines showed significant variation for all the characters studied. Some breeding lines have been selected which accounted for high yield potentiality viz. BR9159-8-5-40-14-75, BR9159-8-5-49-1-4, BR9159-8-5-49-1-1 and BR9157-12-2-37-13-71-32. The highest 1000 grain weight was observed in BR9159-8-5-49-1-4. With respect to shorter growth duration BR9157-12-2-37-13-71-41, BR9157-12-2-37-13-15-40 and BR9157-12-2-37-13-15-35 were selected. BR9159-8-5-40-14-75 and BR9159-8-5-40-13-8 were selected in respect of longer anther length and stigma length.

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