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Genetic Variability and Selection Criteria of Drought Tolerant Rice (*Oryza sativa L.)*

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Abstract:

Rice improvement for drought tolerance requires reliable assessment of drought tolerance variability among segregation population. The present study was undertaken to study the genetic variability among different drought tolerant genotypes. Seven rice genotypes including 3 check varieties were evaluated in these experiments in the drought prone environments of the farmers' field. Drought stress was initiated four weeks after transplanting through proper draining of water from the field up to maturity. In the field of drought stress condition, the highest grain yield (4.1 t/ha) was found in IR82635-B-B-145-1 followed by IR82635-B-B-75-2 (3.8 t/ha) while the yield of check varieties ranged from 2.9-3.6 t/ha. According to drought tolerance indices analysis, the lines IR82635-B-B-145-1 introduced as tolerant genotypes that selecting for improved yield in stress condition.

Introduction:

Rice *(Oryza sativa L.)* is the world's most important cereal crop and feeds over half of the global population.It belongs to the Poaceae family. In Bangladesh the major cereal crops are rice and wheat although main focus is on rice production with 79.4 percent of the total cultivatable land area under rice crop as mentioned in FAO/WFP CFSAM 2008 Report. The current world population of 6.85billon expected to reach 8.0 billion by 2020 and rice production must increase by 30-40% in order to meet the growing demand. Rice is the preferred staple food of Bangladesh but the state is a chronically rice-deficit because of drought and/or climatic change. Bangladesh is the fourth larger producer of rice with an annual production of 28930824 metric tons (BBS, 2009) and contributes 14.6% of nation GDP (BBS, 2004). Rice is the world's most important food crop and a primary source of food for more than half the world's population (Khush, 2005). Rice-growing areas consist of the tropics, subtropics, semi arid tropics, and temperate regions of the world. The predominantly rice-growing areas in Asia (130 million hectares) are often threatened by severe abiotic stresses, the most common being drought. These areas include irrigated and rainfed lowlands, which together account for more than 85% of total world rice production (*Gorantla et al*., 2007). Drought is a major problem that limits the adoption of high-yielding rice varieties in drought-prone rainfed rice environments where high sensitivity to even short periods of water deficit constitutes a risk that farmers cannot afford to take (Lafitte *et al*., 2007). To improve crop productivity, it is necessary to understand the mechanism of plant responses to drought conditions with the ultimate goal of improving crop performance in the vast areas of the world where rainfall is limiting or unreliable (Mostajeran and Rahimi-Eichi, 2009). Therefore, this study was conducted to assess the drought tolerance criteria for identifying drought tolerant and sensitive rice genotypes in drought stress and non-stress field conditions and finally select the best suitable lines for improving high-yielding and tolerant rice genotypes.

Materials and methods:

Four field trials under drought prone rain fed environment at Rangpur Sadar, Nilphamari, Kurigram, Lalmonirhat and controlled condition at BRRI, Gazipur during July-November 2012 were conducted to evaluate and select drought tolerant rice germplasm suitable for the Rangpur region of Bangladesh. Seven rice genotypes including 3 check varieties were evaluated in these experiments. Twenty one to twenty four days old seedlings were transplanted @ 2-3 seedlings during 18-23 July 2012 with 20 cm x 20 cm spacing in Randomized Complete Block Design (RCBD) at Rangpur Sadar, Nilphamari, Lalmonirhat and Kurigram, respectively. Twenty five days old seedlings were transplanted with 25 cm x 15 cm spacing in Randomized Complete Block Design in control field condition in Gazipur. Fertilizers @ 69 (149 Kg Urea): 10 (52 Kg TSP):41 (82 Kg MP):11 (60 Kg Gypsum):4 (11 Kg Zn SO_4) Kg NPKSZn/ha with all amounts of P and K were applied at the time of land preparation. Nitrogen was applied at two equal splits at 10 and 20 days after transplanting (DAT). Drought stress was initiated four weeks after transplanting through proper draining of water from the field up to maturity (Plate1). Crops were grown under rainfed condition. Insecticides and other management practices were done uniformly for all the entries in each location. Thirty five-forty participants including farmers, female farmers', researchers and DAE personnel & district coordinators were invited to evaluate the genotypes at maturity stage. The genotypes were labeled with codes and hanged a box for vote (Plate4). The farmers were briefed about the activity (Plate2). Three positive and 3 negative ballot papers were supplied to each participant. At first, the participants moved around the plots and voted in their own judgments (Plate3).

PVS Function: PVS function was arranged at each location with the gathering of at least 30 farmers. Each farmer cast two positive and two negative votes for the best and worst entries, respectively, according to their own judgment. The reasons of liking and disliking for a particular entry were also recorded and preference indices were calculated for each entry following the formula given below.

$$\text{Preference score} = \frac{\text{Total no. of positive votes} - \text{Total no. of negative votes}}{\text{Total no. of votes}}$$

Results and discussion:

Crops of Rangpur and Nilphamari sites faced severe drought stress at reproductive stage and crops of Lalmonorhat and Kurigram site was affected with moderate drought condition while crops of Gazipur were grown under controlled condition. In the field of drought stress condition, the highest grain yield (4.1 t/ha) was found in IR82635-B-B-145-1 followed by IR82635-B-B-75-2 (3.8 t/ha) while the yield of check varieties ranged from 2.9-3.6 t/ha (**Table 1**). Growth duration was ranged from 110-117 days (Table 1). In control condition, almost yield of all test entries ranged from 3.0 to 4.4 t/ha (**Table 2**). Plant heights were reduced in Rangpur region (**Table 1**) due to stress condition compared to control field condition in Gazipur (**Table 2**). Zheng *et al*. (2003) reported that the drought stress significantly reduced grain yield within 25 days after 80% of full heading. Among the entries, IR82635-B-B-145-1, IR82635-B-B-75-2 and IR83383-B-B-129-4 secured 1st, 2nd and 3rd position in Rangpur Sadar (Table 3). Thirty farmers voted for selection of three best varieties. Thirty one farmers in Nilphamari also selected IR82635-B-B-145-1 as the best one followed by BRRI dhan56 and IR82589-B-B-84-3 (Table 4). In Lalmonirhat IR82635-B-B-75-2 secured the first position followed by IR83377-B-B-93-3 and IR82635-B-B-145-1 (Table 5). The preference points of farmer's were higher yield, high tillering, high number of grains panicle^{-1}, strong stem, medium plant type, fineness of grain, expectation of high market price, early maturity, less insect and disease infestation. In Kurigram IR83377-B-B-93-3, IRRI 123 and IR82635-B-B-75-2 ranked the top three positions. According to drought tolerance indices analysis, the lines IR82635-B-B-145-1 introduced as tolerant genotypes that selecting for improved yield in stress condition. The selected promising genotypes would need to be up-scaled through baby trials. It has been committed to supply 2 kg seeds of these lines to respective PVS farmers for growing in their fields under their own management as 'Baby trial' in the next T. Aman season 2013.

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Table 1. Yield, ancillary characters of the entries, PVS Mother Trial (Stress), Rangpur, T. Aman 2012

SN	Designation	Plant Height (cm)	Growth Duration (days)	Grain Yield (t/ha)				
				Rang	Nil	Lal	Kuri	Ave
1	IR83377-B-B-93-3	122	111	3.6	2.8	4.4	4.6	3.2
2	IR83376-B-B-130-2	119	110	3.1	2.8	3.1	3.6	2.9
3	IR83383-B-B-129-4	105	112	4.1	2.7	4.0	3.9	3.4
4	IR82635-B-B-145-1	101	116	4.2	3.9	4.6	4.3	4.1
5	IR82635-B-B-75-2	102	117	4.2	3.5	4.4	4.2	3.8

SN	Designation	Plant Height (cm)	Growth Duration (days)	Grain Yield (t/ha)				
				Rang	Nil	Lal	Kuri	Ave
6	IR82589-B-B-84-3	110	115	1.8	3.7	4.3	4.6	2.8
7	IRRI 123	108	114	3.1	2.7	3.9	4.8	2.9
8	BRRI dhan56 (Ck)	113	110	4.0	3.2	2.9	4.4	3.6
9	BRRI dhan57 (Ck)	111	107	3.2	3.0	3.8	3.7	3.1
10	BINA Dhan 7 (Ck)	100	115	3.3	2.4	3.5	6.0	2.9
	LSD (0.05)	**13.08**	**1.6**	**0.66**				

Table 2. Yield, ancillary characters of the entries, PVS Mother Trial (Stress), T. Aman, 2012

SN	Designation	Plant Height (cm)	Growth Duration (days)	Grain Yield (t/ha)
1	IR83377-B-B-93-3	120	115	3.8
2	IR83376-B-B-130-2	111	111	3.0
3	IR83383-B-B-129-4	109	113	3.7
4	IR82635-B-B-145-1	124	111	3.5
5	IR82635-B-B-75-2	117	113	3.6
6	IR82589-B-B-84-3	107	109	3.4
7	IRRI 123	111	115	4.4
8	BRRI dhan56 (Ck)	102	109	2.7
9	BRRI dhan57 (Ck)	112	107	2.4
10	BINA Dhan 7 (Ck)	115	105	3.1
	Lsd (0.05)	**23.88**	**9.75**	**0.94**

Table 3. Preference Score of PVS Mother Trial (Stress), Rangpur Sadar, T. Aman 2012

Genotypes		Count of Positive and Negative Votes								Preference Score of Farmers	Position
		Male (N =21)		Female (N =9)		Others (N =4)		Total (N = 36)			
		+VE	-VE	+VE	-VE	+VE	-VE	+VE	-VE		
V1	IR83377-B-B-93-3	1	7	0	8	1	0	2	15	-0.078	
V2	IR83376-B-B-130-2	0	5	0	2	0	2	0	9	-0.039	
V3	IR83383-B-B-129-4	11	1	10	0	2	0	23	1	0.111	**3rd**
V4	IR82635-B-B-145-1	20	1	10	1	5	0	35	2	0.156	**1st**
V5	IR82635-B-B-75-2	19	1	10	0	3	0	32	1	0.156	**2nd**
V6	IR82589-B-B-84-3	1	7	0	10	0	2	1	19	-0.089	
V7	IRRI 123	0	14	0	1	0	3	0	18	-0.083	
V8	BRRI dhan56 (Ck)	8	6	0	0	2	0	10	6	0.011	
V9	BRRI dhan57 (Ck)	0	11	0	8	0	1	0	20	-0.106	
V10	BINA Dhan 7 (Ck)	0	9	0	1	0	4	0	14	-0.056	

Table 4. Preference Score of PVS Mother Trial (Stress), Nilphamari, T. Aman 2012

Gneotypes		Count of Positive and Negative Votes								Preference Score of Farmers	Position
		Male		Female		Others		Total			
		(N =21)		(N =11)		(N =7)		(N = 39)			
		+VE	-VE	+VE	-VE	+VE	-VE	+VE	-VE		
V1	IR83377-B-B-93-3	1	7	0	4	0	2	1	13	-0.052	
V2	IR83376-B-B-130-2	2	4	1	4	0	3	6	11	-0.026	
V3	IR83383-B-B-129-4	1	0	1	0	4	1	6	1	0.010	
V4	IR82635-B-B-145-1	20	0	11	0	7	0	38	0	0.161	**1st**
V5	IR82635-B-B-75-2	12	0	0	4	1	1	13	5	0.042	
V6	IR82589-B-B-84-3	14	2	4	0	5	0	23	2	0.083	**3rd**
V7	IRRI 123	0	7	0	4	0	1	0	12	-0.057	
V8	BRRI dhan56 (Ck)	12	2	12	1	4	0	28	3	0.109	**2nd**
V9	BRRI dhan57 (Ck)	1	13	1	3	0	7	2	23	-0.073	
V10	BINA dhan7 (Ck)	0	22	0	10	0	7	0	39	-0.167	

Table 5. Preference Score of PVS Mother Trial (Stress), Lalmonirhat, T. Aman 2012

Gneotypes		Count of Positive and Negative Votes								Preference Score	Position
		Male				Others		Total			
		(N =22)				(N =3)		(N = 34)			
		+VE	-VE	+VE	-VE	+VE	-VE	+VE	-VE		
V1	IR83377-B-B-93-3	15	2	13	0	0	2	28	4	0.106	**2nd**
V2	IR83376-B-B-130-2	4	5	2	4	2	0	8	18	-0.012	
V3	IR83383-B-B-129-4	4	3	0	2	0	1	4	6	-0.004	
V4	IR82635-B-B-145-1	16	1	6	7	2	0	24	8	0.057	**3rd**
V5	IR82635-B-B-75-2	20	0	11	2	0	0	31	2	0.118	**1st**
V6	IR82589-B-B-84-3	5	3	3	2	1	0	9	5	0.012	
V7	IRRI 123	0	20	10	5	0	2	10	27	-0.061	
V8	BRRI dhan56 (Ck)	1	10	4	10	1	3	6	23	-0.061	
V9	BRRI dhan57 (Ck)	1	8	0	17	3	0	4	25	-0.098	
V10	BINA Dhan 7 (Ck)	0	14	4	10	0	1	4	25	-0.081	

Table 6. Preference Score of PVS Mother Trial (Stress), Kurigram. Aman 2012

Gneotypes		Count of Positive and Negative Votes								Preference Score of Farmers	Position
		Male		Female		Others		Total			
		(N =19)		(N =13)		(N =4)		(N = 36)			
		+VE	-VE	+VE	-VE	+VE	-VE	+VE	-VE		
V1	IR83377-B-B-93-3	18	0	12	0	3	0	33	0	0.156	**1st**
V2	IR83376-B-B-130-2	2	5	2	6	1	2	5	13	-0.036	
V3	IR83383-B-B-129-4	2	3	1	5	0	1	3	9	-0.026	
V4	IR82635-B-B-145-1	10	3	4	1	1	0	15	4	0.052	
V5	IR82635-B-B-75-2	6	0	6	0	3	0	15	0	0.063	**3rd**
V6	IR82589-B-B-84-3	1	4	0	0	1	1	2	5	-0.016	
V7	IRRI 123	14	0	13	0	2	0	29	0	0.141	**2nd**
V8	BRRI dhan56 (Ck)	0	13	0	11	0	1	0	25	-0.125	
V9	BRRI dhan57 (Ck)	0	11	0	6	0	4	0	21	-0.089	
V10	BINA Dhan 7 (Ck)	1	14	1	11	1	3	3	28	-0.120	

Plate1: Rice field situation in drought condition.

Plate2: The farmers were briefed about the activity before voting.

Plate3: Rice field situation at mature stage and Voting.

Plate4: Rice field situation at Voting.

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