

IMPROVEMENT OF RICE GENOTYPES FOR SALT AFFECTED AREAS OF BANGLADESH

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ABSTRACT

Among 53 landraces of coastal deltas of Bangladesh, four varieties viz: Capsule, Ashfal, Ashfal balam and Chikiram Patnai were identified as a new source of salt tolerant donors. These landraces showed tolerance to salt stress of EC 12 dSm⁻¹ as same as Pokkali at seedling stage. Also seedling stage tolerance of EC 12 dSm⁻¹ was observed in 16 modern genotypes including four varieties of Vietnam. Of them, OMI490 was the best due to its short growth duration similar to BRRI dhan28 (the mega variety of irrigated ecosystem of Bangladesh) plus >1.0 t/ha grain yield advantage over the mega variety. Furthermore, OM2718, A5996 and BR7109-5R-4 had growth duration similar to BRRI dhan47 (salt tolerant variety) and showed >1.0 t/ha yield advantage over the check. Also, these lines showed non-shattering habit which is lacking in the standard variety (BRRI dhan47). These genotypes thus conserved prospects of future varieties.

Key word: Landrace, salt tolerance, prospective genotypes, rice

INTRODUCTION

Coastal areas of Bangladesh cover about 1.0 M hectare of cultivable lands (Karim *et al.*, 1990). The soil and water are saline due to inundation of sea water. Government efforts have been continuing to construct embankments and polders to protect the lands from intrusion of saline water. Consequently, water stagnation of > 20-60 cm is prevailing in the rainfed lowland rice (RLR) ecosystem. A group of photosensitive and tall rice varieties have been adapted in these areas. Moderately salt tolerant (6-8 dSm⁻¹) rice varieties viz. BR23, BRRI dhan40 and 41 have been observed limited adaptability in these areas due to short seedling height and sensitivity to water stagnation. The deltas are surrounded with rivers and canals. Apparently, there is a huge potentiality of surface water availability for dry season crops in these areas. In fact, a large area remains fallow during dry season (November - April) due to high soil and water salinity. Few farmers cultivate short duration salt sensitive rice varieties in this dry period with irrigation from shallow tube wells. Under these circumstances strengthening of salt tolerant rice variety development and natural resources managements are greatly emphasized. Therefore, studies were taken to i) identify salt tolerant donor (s) adaptable to RLR and ii) salt tolerant high yielding genotypes for irrigated ecosystem for increasing productivity of the coastal areas of Bangladesh.

MATERIALS AND METHOD

Salt tolerant germplasm

In total, 163 rice germplasm composed of 53 landraces from coastal deltas, four national modern varieties, ten somaclonal lines, 27 anther culture derived lines, 62 IR lines and 7 varieties from Vietnam were screened for salt stress tolerance at seedling stage. Pre-germinated seeds were sown on nylon net fitted with styrofoam floating on plastic tray. Full strength nutrient solution was used for growing the seedlings as described by Yoshida *et al.* (1976). After 14 days of sowing the nutrient solution was salinized with EC 6 dSm⁻¹ and it was raised to EC 12 dSm⁻¹ by increasing @ EC 2 dSm⁻¹ at alternate days. Pokkali and IR29 were used as salt stress tolerant and susceptible checks, respectively. The salt stress scoring was done three weeks after the salinization of EC 12 dSm⁻¹. Table 1 showed the rating system. The experiment was carried out in Plant Physiology Division of BRRI in 2006.

Table 1. Modified standard evaluation score (SES) of visual salt injury at seedling stage

Score	Observation	Classification
1	Normal growth, no leaf symptoms	Highly tolerant
3	Nearly normal growth, but leaf tips or few leaves whitish and rolled	Tolerant
5	Growth severely retarded; most leaves rolled; only a few are elongating	Moderately tolerant
7	Complete cessation of growth; most leaves dry; some plants dying	Susceptible
9	Almost all plants dead or dying	Highly susceptible

Evaluation of somaclonal and anther culture derived lines

Two somaclonal (SC) lines developed from the mega variety BRRI dhan29 through seed culture at EC 15 dSm⁻¹ and two anther culture (AC) derived lines from the cross involving salt tolerant parents were evaluated at saline prone station of BRRI Satkhira farm. BRRI dhan29 (salt sensitive but mega variety of irrigated ecosystem) was used as standard check. The trial was conducted during the dry season (irrigated ecosystem) 2006-07. The field layout of the trial was RCB design with three replications. The unit plot size was 5.4m X 2m. Forty days old seedlings were transplanted @ 2-3 seedlings with the spacing of 25 x 15 cm. Fertilizers @ 80:60:40:0.5 kg NPKZn/ ha were used with split application of N at 15, 30 and 50 days after transplanting (DAT). Total amount of P K Zn were applied at the time of final land preparation. Irrigation was given from a shallow tube well and the water contains EC level less than 1 dSm⁻¹. The initial soil (dry soil) salinity ranged from 6-8 dSm⁻¹. Data on plant height, growth duration, spikelet sterility (%), grain shattering, yield and phenotypic acceptance at maturity, were recorded following SES of IRRI (2004).

Evaluation of salt tolerant genotypes in saline prone areas

The study was conducted at BRRI Satkhira farm in the dry seasons (irrigated ecosystem) of 2005-06 and 2006-07. A total of 106 genotypes (those were mentioned in the salt tolerant germplasm section except the landraces and national modern varieties) were grown in 2005-06 and 9 promising lines were sorted out comparing growth duration, phenotypic acceptance, salt stress tolerance and yield performance against BRRI dhan28 (salt sensitive) and BRRI dhan47 (salt tolerant) standard checks. These materials were evaluated with the above mentioned standard checks in 2006-07 in RCB design with three replications. The same crop management practices were followed as described for the evaluation of SC and AC lines mentioned above including the irrigation water. Data were collected on grain shattering, growth duration, plant height, spikelet sterility (%), yield and phenotypic acceptance at maturity.

RESULTS AND DISCUSSION**Salt tolerant germplasm**

Among 53 rainfed lowland rice (RLR) landraces which have been grown in coastal areas of Bangladesh were collected through previous project and screened for salt stress tolerance against EC 12 dSm⁻¹ at seedling stage. Four varieties were scored 1 and 10 others were ranked 3 (Table 2). Importantly, these varieties are tall in stature and tall seedlings are prerequisites for transplanting throughout the coastal areas during RLR ecosystem since >80% fields remaining under water stagnation from 25-50 cm. On the other hand, high yielding recommended varieties viz. BR23 and BRRI dhan40 for coastal areas are moderately salt tolerant (Table 2). These varieties are adaptable to elevated fields only due to their short seedling height. This study, therefore, successfully identified at least four germplasm viz. Capsule, Ashfal, Ashfal balam and Chikiram Patnai which had known adaptability at the prevailing RLR environmental conditions plus salt stress tolerance same as Pokkali. These germplasm would be the new source of breeding for salt tolerance in rice.

The remaining 106 genotypes were screened for salt stress tolerance at seedling stage during irrigated ecosystem. It should be noted that these materials received cold stress in addition to salt stress of EC 12 dSm⁻¹. Table 3 listed down the materials scored between 3 and 5. The tolerant check (Pokkali) was scored 3 when the susceptible check IR29 was died (scored 9). The higher score of Pokkali in this study from Table 2, was probably due to the interaction of prevailing cold temperature (15-20 °C at night) during this study period. It should be noted that BRRI dhan28 (the mega variety of irrigated ecosystem in Bangladesh) showed susceptibility (scored 7)

better than IR29 (ranked 9) when the salt tolerant BRRI dhan47 was scored 3 (Table 3). These results led to identify 16 genotypes tolerant to moderately tolerant at EC 12 dSm⁻¹. Grain yield evaluation of those materials should be done at saline prone area in the irrigated ecosystem. It should be noted that all the somaclonal lines showed susceptible reactions.

Table 2. Salt stress tolerant land races of coastal Bangladesh

Sl no	Designation	Visual score	Sl no	Designation	Visual score
1	Sadamota	3	11	Changai	3
2	Gadi Muri	3	12	Sadabalam	3
3	Kajalsail	3	13	Jamainadu	3
4	Rajasail	5	14	Chikiram Patnai	1
5	Nonabokra	3	15	Nonasail	3
6	Ashfal balam	1	16	BR23	5
7	Patnai23	3	17	BRRI dhan40	5
8	Ashfal	1	18	Pokkali (tolerant ck)	1
9	Capsule	1	19	IR29 (susceptible ck)	9
10	Kalamosa	3			

Table 3. Salt stress tolerant IR and BR lines for irrigated ecosystem

Sl no	Designation	Visual score	Sl no	Designation	Visual score
1	BR7109-5R-2	3	11	OM4498	5
2	BR7109-5R-4	3	12	OM1490	5
3	BR7084-310-AC8	3	13	OM2718	5
4	BR7084-3R-39	5	14	AS996	5
5	IR65192-3B-14-1-1	5	15	IR63311-B-3R-B-10-3	3
6	IR66946-3R-178-1-1	3	16	IR73571-3B-7-1	3
7	IR68657-3B-19-3	5	17	BRRI dhan47 (salt tol. var.)	3
8	BR7084-310-AC3	5	18	BRRI dhan28 (Salt sen. var.)	7
9	IR72049-B-R-22-3-1-1	3	19	Pokkali (tolerant ck)	3
10	IR72593-B-3-2-3-3	3	20	IR29 (susceptible ck)	9

Evaluation of somaclonal and anther culture derived lines

All the SC and AC lines including BRRI dhan29 were observed to be non-shattering type (Table 4). AC lines showed one week longer growth duration than the SC lines and were 4 days longer than the long duration mega variety BRRI dhan29. The high spikelet sterility (%) of AC lines showed a direct negative effect on grain yield. Consequently, AC lines showed poor phenotypic acceptance at maturity and yielded significantly lower than the standard variety. It is important to note that BRRI dhan29 has never been favored by farmers at saline prone deltas due to its longer growth duration. Because, longer the growth duration, higher the crop will suffer from soil and irrigation water salinity at the reproductive phase that leads to negative impact on grain yield. On the other hand, SC lines were few days earlier than BRRI dhan29 and yielded similar to the standard check. Therefore these SC lines will be included in the participatory variety selection (PVS) trials for farmers' judgment.

Table 4. Performance of somaclonal and anther culture derived lines, BRRI Satkhira, Irrigated ecosystem, 2006-07

Sl no	Genotypes	Grain shattering type	Growth duration (days)	PACP at Maturity	Plant height (cm)	Sterility (%)	Yield (t/ha)
01	BRRIdhan29-SC3-27	NS	153	5	97	35	7.5 a
02	BRRIdhan29-SC3-28	NS	153	5	93	28	7.8 a
03	BR7084-310-AC9	NS	160	6	85	44	5.5 b
04	BR7084-310-AC21	NS	161	6	88	41	5.7 b
05	BRRIdhan29 (ck)	NS	156	5	92	29	7.8 a

Note: S= shattering type, NS= Non-shattering type

Evaluation of salt tolerant genotypes in saline prone areas

Among 106 genotypes grown in saline prone site during the crop season 2005-06, nine were selected for this study comparing growth duration and phenotypic acceptance and, in addition, salt stress score similar to the standard variety BRRIdhan47 (Table 2). The salt tolerant check BRRIdhan47 is known to be easy threshing and thus said to be grain-shattering type (Table 5). Non-shattering habit is always important for reducing yield loss at harvest and transportation from the field to threshing ground. Therefore, the new generation variety should have non-shattering trait similar to the mega variety BRRIdhan28. All the tested genotypes showed non-shattering habit (Table 5). Thus the new genotypes added an advantage over the standard check BRRIdhan47. All the genotypes matured more or less similar to BRRIdhan47 except OM1490, which had growth duration similar to BRRIdhan28 (Table 5). Also, OM1490 had better phenotypic acceptance score at maturity than the check. Furthermore, it showed > 1.0 t/ha yields advantage over BRRIdhan28. It indicated its superiority over all the genotypes. All the genotypes showed plant height similar to the check variety except OM4498 which had the shortest stature (Table 5). Again, spikelet sterility (%) was lowest in IR65192-3B-14-1-1 and highest in AS996. The remaining genotypes showed sterility % more or less similar to the checks. Figure 1 showed that all the genotypes had higher grain yield (6.8 - 7.7 t/ha) than standard checks BRRIdhan28 (5.7 t/ha) and BRRIdhan47 (6.4 t/ha). Moreover, OM2718, BR7109-5R-4 and AS996 showed > 1.0 t/ha yield advantage over the salt tolerant variety BRRIdhan47. These lines thus conserved prospects of future varieties for saline prone areas. Therefore, all these genotypes will be included in PVS trial at coastal deltas for including into variety release system.

Table 5. Genotype performance on different characters in yield trial, BRRI Satkhira, Irrigated ecosystem, 2006-07

Sl no	Genotypes	Grain shattering type	Growth duration (days)	PACP at Maturity	Plant height (cm)	Sterility (%)
1	BR7109-5R-2	NS	145	5	90.8	27
2	BR7109-5R-4	NS	145	4	92.2	28
3	BR7084-3R-39	NS	142	4	81.8	29
4	IR65192-3B-14-1-1	NS	140	5	91.8	14
5	IR68657-3B-19-3	NS	143	5	94.4	38
6	OM1490	NS	137	4	81.2	31
7	OM4498	NS	143	5	75.6	28
8	OM2718	NS	140	4	83.5	23
9	AS996	NS	142	4	86.2	32
10	BRRIdhan28 (ck)	NS	136	5	91.2	26
11	BRRIdhan47 (ck)	S	142	5	89.6	25

Note: S= shattering type, NS= Non-shattering type

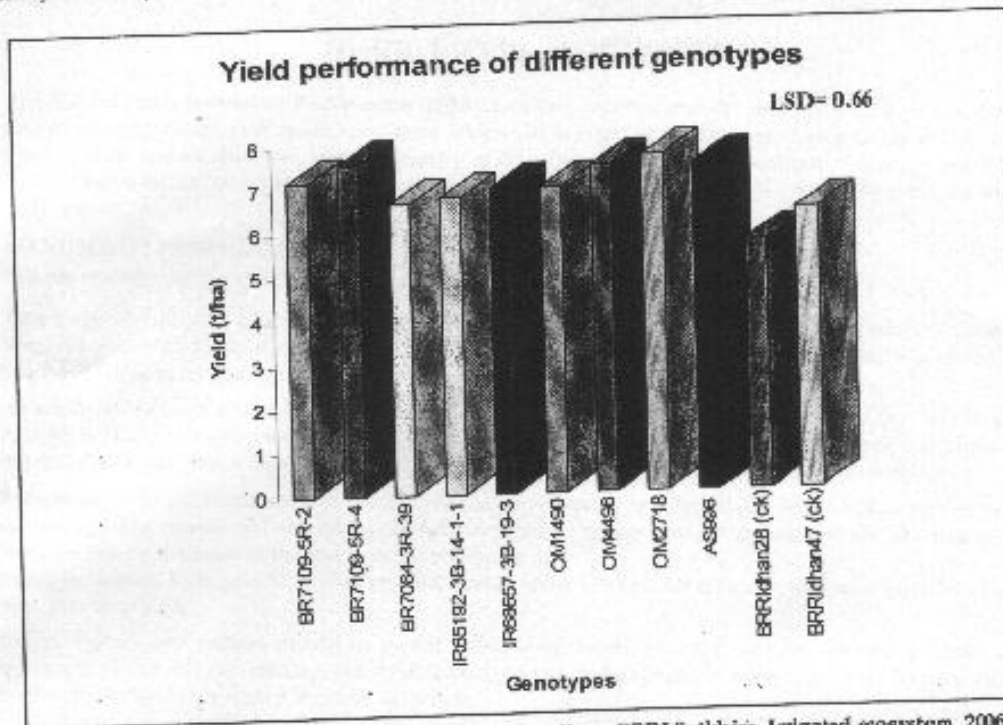


Fig. 1. Yield performance of different advance breeding lines, BRRi Satkhira, Irrigated ecosystem, 2006-07

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