Performance of Rice Landraces Under Salt Stress at the Reproductive Stage Using SSR Markers

ABSTRACT

Rice is the staple food crop of half of the world population and salinity is the most significant causes of rice yield reduction. The aim of this study was to screen 24 rice genotypes including 20 landraces to find out potential germplasm source for salt tolerance breeding program. Screening was performed at reproductive stage by evaluating the yield and yield attributes in sustained water bath maintaining the salinity level at 8 dS/m. Three microsatellite markers linked with salt tolerance quantitative trait loci *viz.* RM234, RM134 and RM9 were selected in response to salinity in rice landraces. At the reproductive stage, four landraces *viz.* Kute Patnai, Kashrail, Bazra Muri and Tal Mugur were identified as salt tolerant on the basis of phenotypic evaluation but SSR based marker, eight rice genotypes *viz* Binadhan-8, Patnai, KutePatnai, BazraMuri, Tal Mugur, Pokkali, Kashrail and FL 378 were found as tolerant. Combined assessment of morphological and SSR markers, four genotypes were considered as true salt tolerant lines. These identified landraces could be a potential germplasm sources for future salt tolerance rice breeding program.

Keywords: *Rice, landraces, salt tolerant, microsatellite marker*

Introduction

Rice (*Oryza sativa* L.) is an important crop that feeds more than half of the world's population. Asian farmers contribute about 92 % of the total world's rice production [1]. But it is very sensitive to salinity stress and currently listed as the most salt sensitive cereal crop with a threshold of 3 dS/m for most cultivated varieties [2]. Salinity is most important abiotic stress that directly regulates the plant growth and development [3-5]. It affects all the growth stages of rice from seedling to maturation [6] but reproductive stage is more sensitive for grain yield production [7] and also reported the most sensitive stages are the early seedling and reproductive (panicle initiation, anthesis and fertilization) [34]. Rice yield in salt-affected land is significantly reduced with an estimation of 30–50% yield losses annually [8]. Due to natural salinity and human interferences, the arable land is continuously transforming into saline that is expected to have overwhelming global effects, resulting in up to 50% land loss by 2050 [9,10].

In Bangladesh, 11.37 million hectares of land produces 34.53 million tons of rice [11] and about 1.8 million ha of coastal land is affected by different degrees of salinity. Most of the southern districts of the country are under saline zones which cover an area of 25-30% of the total cultivable land [12]. The population of Bangladesh is still growing by two million every year and may increase by another 30 million over the next 20 years. Thus, Bangladesh will require about 27.26 million tons of more rice for the year 2020 (http://www.knowledgebank-brri.org/riceinban.php). To increase the production it needs development of salt tolerant variety and utilization of salt affected areas. Methods for salinity tolerance screening are important for the success of a breeding program. As improving yield of plants undergoing salinity stress is one of the main targets of plant breeding, salinity tolerance screening based on agronomical parameters such as growth, yield and yield components has become the method of choice by labs worldwide [13-16].

The use of molecular markers has been increasing considerably in breeding programs because of their reliability and helps in deciding the distinctiveness of species [17]. Among the molecular marker technologies, microsatellite or simple sequence repeats (SSRs) are widely used in rice genetic studies because of their availability, widespread distribution in the genome, high allelic diversity [18-23] and have been found to be efficient for identification of genes and quantitative trait loci in different rice cultivars [24, 25] that can be helpful for plant breeders to develop new varieties. Landraces are currently being used as preferred potential donors of salt tolerance traits because of their local adaptation. Due to genetic similarities between cultivated rice species, the transfer of useful genes from one to another is possible. The presence of markers tightly linked to resistance genes will allow selection and maintenance of the desirable resistant genotypes in breeding process [26, 27]. Thus, the evaluation of rice landraces could provide valuable information for genetic improvement of salt tolerant rice variety.

The objective of this study was to identify the salt tolerant rice landraces based on phenotype and molecular markers which can be used further for marker assisted selection in rice breeding program.

Materials and methods

Plant Materials

A total of 24 rice lines including 20 landraces, 2 BINA (Bangladesh Institute of Nuclear Agriculture) developed high yielding varieties and 2 advanced lines were used in the study (Table 1). BINA developed salt tolerant variety Binadhan-8 was used as tolerant and HYV Binadhan-7 as susceptible control.

Table 1. List of rice genotypes used in the experiment

Sl. No.	Genotypes	Type	Source of collection
1.	Jamai Naru	Bangladeshi Landrace	BINA
2.	Patnai	Bangladeshi Landrace	BINA
3.	Kute Patnai	Bangladeshi Landrace	BINA
4.	Holde Gotal	Bangladeshi Landrace	BINA
5.	Bashful Balam	Bangladeshi Landrace	BINA
6.	Bazra Muri	Bangladeshi Landrace	BINA
7.	Ghunshi	Bangladeshi Landrace	BINA
8.	Chinikani	Bangladeshi Landrace	BINA
9.	Binadhan 7	HYV	BINA
10.	Volanath	Bangladeshi Landrace	BINA
11.	Rupessor	Bangladeshi Landrace	BINA
12.	Kalo Mota	Bangladeshi Landrace	BINA
13.	Nona Kochi	Bangladeshi Landrace	BINA
14.	Tal Mugur	Bangladeshi Landrace	BINA
15.	Ghigoj	Bangladeshi Landrace	BINA
16.	Fulkainja	Bangladeshi Landrace	BINA
17.	Koicha binni	Bangladeshi Landrace	BINA
18.	Nona Bokhra	Indian local cultivar	IRRI
19.	Binadhan 8	Salt tolerant HYV	BINA
20.	FL 378	Salt tolerant exotic line	IRRI
21.	Kashrail	Bangladeshi Landrace	BINA
22.	Jolkumri	Bangladeshi Landrace	BINA
23.	Pokkali	Indian local cultivar	IRRI
24.	FL 478	Salt tolerant exotic line	IRRI

Phenotypic evaluation under the Saline condition

The genotypes were evaluated for their tolerance to salinity under sustained water bath following IRRI standard protocol for salinity screening at the vegetative and reproductive stages [13]. Completely randomized design (CRD) with three replications was followed for experimental design. Both ~~Normal~~ normal and salinized setups were maintained. At first, pot was prepared by inserting a cloth bag inside the pot and then it was filled up with fertilized soil. The fertilizer was used 50 N, 25 P and 25 K mg kg^{-1} of soil respectively. Initially, the soil level was about 1 cm above the topmost circle of holes. The pots with leveled soil were placed in the plastic tray filled up with ordinary tap water. The water was non saline having EC 0.2 dS/m which was measured by EC meter. This serves as water bath. The water level was same as the soil level. The soil was then started to settle down as it absorbs water. To obtain the correct soil level extra soil was added after two days. During this soil settlement process the seeds were kept in the conventional oven for 5 days at 50˚C for breaking the seed dormancy. The oven treated seeds were soaked with tap water for 24 hours for pre-germination. The pre-germinated seeds were sown (3/4 seeds/pot) on the soil surface of the perforated pot. After 2 weeks, the seedlings were thinned to two per pot and the water level was raised up to 1 cm above the soil surface. The water level was maintained daily and the plants were protected from pests and diseases. After 3 weeks of sowing the pots were salinized at EC 8 dS/m by dissolving crude salt and EC was monitored in every week till maturity. Data were recorded on plant height (cm), days to flowering, number of effective tillers/plant, number of field grains and unfilled grains, percent fertility and grain yield (g). The following formula was used for calculating the ~~Percent~~ percent fertility and reduction:

Percent fertility= {(No. of filled grains/ (No. of filled grains+ No. of unfilled grains)} x100

Percent (%) reduction = {(traits in normal - traits in saline)/Traits in normal} x100

DNA extraction, PCR amplification and molecular marker analysis

Modified CTAB mini prep method was followed for genomic DNA extraction from 25-day-old seedling leaf sample [28]. Ten primers were surveyed and among them three primers showed polymorphism and clear bands (Table 1). Each PCR reaction carried out with 13.0µl reactions containing 1.5 µl 10x buffer, 0.75 µl dNTPs, 1µl primer forward, 1µl primer reverse, 0.25 µl taq polymerase, 7.5 µl ddH_2O and 1.0 µl of each template DNA samples. PCR analysis was performed according to our previous study by Akter et al. [29] with little modifications. PCR profile was maintained as initial denaturation at 94^{o}C for 5 min., followed by 34 cycles of denaturation at 94^{o}C for 30 second, annealing at 55^{o}C for 30 second and extension at 72^{o}C for 1min., and a final extension of 7 min. at 72^{o}C. Primer pairs were optimized for PCR to amplify microsatellite loci. Parental varieties were used to identify SSR polymorphism associated with the salt tolerance gene. Finally, we used the three polymorphic SSR markers (Table 2) for genotyping the 24 rice landraces. The amplified PCR products were separated in a 2.5 % agarose gel and then stained in 0.1 g/ml ethidium bromide containing water. Banding patterns were visualized with ultraviolet gel documentation system. The banding patterns of 24 genotypes were scored by comparing with tolerant and susceptible controls and similar banding pattern with Binadhan-8 were considered as tolerant and Binadhan-7 as salt susceptible.

Table 2. The sequence and size of the microsatellite markers used for screening salt tolerant rice lines

Primer name	Expected PCR product size (bp)	Primer sequence		Annealing Temp.(^{o}C)
RM234	156	For.	ACAGTATCCAAGGCCCTGG	55
		Rev.	CACGTGAGACAAAGACGGAG	
RM134	93	For.	ACAAGGCCGCGAGAGGATTCCG	55
		Rev.	GCTCTCCGGTGGCTCCGATTGG	
RM9	136	For.	GGTGCCATTGTCGTCCTC	55
		Rev.	ACGGCCCTCATCACCTTC	

Results and discussion

Phenotypic performance of rice landraces at reproductive stage

A wide range of significant phenotypic variation was observed at reproductive stage among the rice germplasms under 8 dS/m salinity stress. Normal plant growth and development was observed in normal setup but in salinized setup growth and development was retarded. Different adverse symptoms, such cracked and dried leaves, stunted plant growth and early flowering & maturity were observed in saline condition. Rice genotypes showed significant difference in reduction of plant height, panicle length and number of filled grains.

The percentage of plant height reduction ranged from 6.55 to 29.24 and highest reduction rate was observed in Volanath (29.24%) followed by Rupessor (28.59%), Binadhan-7 (27.42%) and Koicha binni (26.88%). On the other hand, Pokkali (6.55%) followed by Binadhan-8 (6.61%), Kashrail (7.54%), FL-378 (8.17%), Tal Mugur (8.84%), Bazra Muri (8.96%), FL-478 (9.43%), Kute Patnai (10.63%), Nona Bokra (10.74%), Jamai naru (12.44%) and Patnai (12.77%) showed comparatively lower reduction rate (Table 3). This reduction may be due to the inhibition of cell division or cell enlargement for salt stress. Reduction in plant height due to salt stress was also reported by Rubel *et al.* [30], Bhowmik *et al.* [31] and Choi *et al.* [32]. Percent reduction in panicle length was ranged from 6.88 to 22.61. Considering the panicle length, Volanath (22.61%), Binadhan- 7 (21.91%), Rupessor (21.35%) and Koicha Binni (21.56%) showed heigher reduction. Besides, Kashrail (6.88%), Pokkali (7.11%), Binadhan-8 (7.20%), FL-478 (7.43%) Patnai (7.69%), FL-378 (8.19%), Bazra Muri (8.72%), Nona Bokra (8.99%), Kute Patnai (9.13%), Tal Mugur (9.40%) and Jamai Naru (9.60%) showed lower reduction in panicle length (Table 3).

Table 3. Effects of salinization (EC 8dS/m) on plant height, panicle length and number of filled grains at reproductive stage of the rice germplasm grown in sustained water bath at BINA

SL No.	Genotypes	Plant height (cm)			Panicle Length (cm)			No. of filled grains/ panicle		
		Non-salinized (mean)	Salinized (mean)	% Reduction	Non-salinized (mean)	Salinized (mean)	% Reduction	Non-salinized (mean)	Salinized (mean)	% Reduction
1.	Jamai Naru	144.40	122.40	15.24	19.80	17.90	9.60	89.30	39.20	56.10
2.	Patnai	134.70	117.50	12.77	20.80	19.20	7.69	112.10	81.20	27.56
3.	Kute Patnai	136.40	121.90	10.63	20.80	18.90	9.13	102.70	58.30	43.23
4.	Holde Gotal	125.50	105.50	15.94	22.63	20.03	11.49	99.20	47.30	52.32
5.	Bashful Balam	138.60	111.70	19.41	22.90	20.10	12.23	122.20	64.10	59.56
6.	Bazra Muri	129.40	117.80	8.96	19.50	17.80	8.72	78.10	51.20	34.44
7.	Ghunshi	141.10	116.40	17.51	21.10	18.50	12.32	88.20	44.80	60.54
8.	Chinikani	123.20	100.30	18.59	18.60	15.40	17.20	101.30	41.20	59.33
9.	Binadhan 7	100.30	72.80	27.42	17.80	13.90	21.91	99.70	27.80	72.12
10.	Volanath	139.20	98.50	29.24	23.00	17.80	22.61	122.20	28.90	76.35
11.	Rupessor	147.60	105.40	28.59	21.87	17.20	21.35	146.90	44.20	69.91
12.	Kalo Mota	138.50	118.90	14.15	23.17	20.40	11.96	116.30	48.40	58.38
13.	Nona Kochi	141.50	118.00	16.61	23.50	21.00	10.64	106.20	46.60	56.12
14.	Tal Mugur	123.30	112.40	8.84	23.40	21.20	9.40	104.10	57.20	45.05
15.	Ghigoj	146.33	115.50	21.07	23.40	19.20	17.95	114.20	57.40	49.78
16.	Fulkainja	138.00	105.40	23.62	17.50	13.89	20.63	99.70	37.60	62.29
17.	Koicha binni	138.40	101.20	26.88	21.80	17.10	21.56	114.60	35.60	68.94
18.	Nona ~~Bokhra~~Bokra	131.30	117.20	10.74	22.03	20.05	8.99	98.80	53.70	45.65
19.	Binadhan 8	87.70	81.90	6.61	21.12	19.60	7.20	131.20	74.60	43.14
20.	FL 378	83.20	76.40	8.17	21.13	19.40	8.19	135.40	75.20	44.46
21.	Kashrail	131.30	121.40	7.54	21.23	19.77	6.88	112.30	67.70	39.72
22.	Jolkumri	134.00	116.20	13.28	22.30	19.80	11.21	133.20	69.60	47.00
23.	Pokkali	131.20	122.60	6.55	23.48	21.81	7.11	120.20	74.90	37.69
24.	FL 478	85.90	77.80	9.43	20.20	18.70	7.43	103.50	53.90	47.92
	$LSD_{(.05)}$	3.51	3.1		0.96	1.06		3.01	1.94	

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Considering the number of filled grains per panicle, Volanath (76.35%), Rupessor (69.91%), Binadhan-7 (72.12%) and Koicha Binni (68.94%) showed higher reduction and Patnai (27.56%), Bazra Muri (34.44%), Pokkali (37.69%), Kashrail (39.32%), Binadhan-8 (43.14%), Kute Patnai (43.23%), FL-378 (44.46%), Tal Mugur (45.05%) and FL-478 (47.92%) showed lower reduction in filled grains per panicle (Table 3).

Under salt stress condition, about 80 unfilled grains panicle^{-1} was found in Volanath, Rupessor, Koicha Binni, and Holde Gotal whereas Kashrail, Pokkali, Binadhan-8, FL-478, Patnai, FL-378, Bazra Muri, Kute Patnai, Tal Mugur and Nonabokra produced less than 50 unfilled grains per panicle (Table 4). But under normal growth condition, the range of unfilled grain was found about 15 to 35 per panicle except Binadhan-7 and Bashful Balam.

Considering the effective tiller plant^{-1} Bashful Balam, Chinikani, Volanath, Rupessor and Fulkainja showed higher (>30) reduction. But Kashrail, Pokkali, Nona Bokra, Kute Patnai, Patnai, Bazra Muri, Kalo ~~mota~~Mota, Binadhan-8 and Kashrail showed lower reduction (< 20) (Table 4).

Under salinized condition, the rice genotypes Binadhan-8, Kashrail, Pokkali, FL-478, Nona Bokra, Kute Patnai, Tal Mugur, Patnai, FL-378 and Bazra Muri showed higher fertility (> 60%) and Rupessor, Koicha Binni, Volanath, Jamainaru, Ghunshi and Holde Gotal showed lower fertility (< 45%) (Table 5). All the genotypes showed more than 70% fertility under normal condition.

Under normal condition all the genotypes produced about 10 g or more yield plant^{-1}. But under salt stress all the genotypes produced less than 10 g yield plant^{-1} proved that yield has been reduced due to salt stress in all tested lines. Jamai Naru, Kute Patnai, Holde Gotal, Bazra Muri, Kalo Mota, Tal Mugur, Binadhan-8, FL-378, Kashrail and Pokkali produced more than 8 g yield plant^{-1} and Ghunshi, Volanath, Binadhan-7, Rupessor and Jolkumri produced less than 5 g yield plant^{-1} (Table 4). This result supported by Asch *et al.* [33] who worked with 80 rice cultivars and found that cultivars differed in their salt uptake and tolerant cultivars had lower salt effect on yield and yield components than susceptible. Filled grain weight and total dry matter weight contributed much variation in grain yield under salinity stress.

Table 4. Mean values of number unfilled grain/plant, effective tiller/plant, days to flowering of studied rice germplasm under salinized (EC 8dS/m) and non-salinized condition at reproductive stage

SL No.	Genotypes	No. of unfilled grain		No. of effective tiller/plant			Days to flowering	
		Non-salinized	Salinized	Non-silanized	Salinized	% Reduction	Non-salinized	Salinized
1.	Jamai Naru	25	74.23	12	9	25.00	133	123
2.	Patnai	30	42.78	10	8	20.00	118	115
3.	Kute Patnai	33	36.45	12	11	8.33	108	105
4.	Holde Gotal	26	91.45	11	8	27.27	114	108
5.	Bashful Balam	70	78.4	11	6	45.45	113	107
6.	Bazra Muri	18	28.34	12	10	16.67	126	123
7.	Ghunshi	22	54.68	7	5	28.57	128	123
8.	Chinikani	20	51.09	10	7	30.00	116	111
9.	Binadhan 7	45	69.2	9	6	33.33	106	101
10.	Volanath	25	101.6	11	7	36.36	126	121
11.	Rupessor	30	99.1	12	8	33.33	103	97
12.	Kalo Mota	17	68.3	11	9	18.18	131	127
13.	Nona Kochi	30	54.3	11	9	27.27	128	124
14.	Tal Mugur	29	44.34	10	8	20.00	92	89
15.	Ghigoj	38	56.34	7	5	28.57	108	105
16.	Fulkainja	25	67.45	12	8	33.33	98	92
17.	Koicha binni	42	88.45	11	8	27.27	96	90
18.	Nona Bokhra	28	41.23	10	9	10.00	103	99
19.	Binadhan 8	30	48.98	12	10	16.67	91	88
20.	FL 378	28	43.8	13	9	25.00	93	89
21.	Kashrail	31	46.7	9	8	11.11	94	91
22.	Jolkumri	32	54.3	10	8	20.00	93	90
23.	Pokkaly	26	35.78	13	11	15.38	96	93
24.	FL 478	25	41.45	14	11	27.27	95	92
	$LSD_{(.05)}$	1.35	2.2		0.34	0.95		

SSR marker survey for salt tolerance rice genotypes

In this experiment, initially ten primers namely, RM314, RM140, RM1594, RM9, RM407, RM510, RM51, RM121, RM134 & RM234 were used for polymorphism survey of twenty four rice landraces. Of them, three SSR markers *viz.*, RM19, RM134 and RM234 showed highly polymorphism and that were selected to evaluate 24 rice germplasms for salt tolerance. According to the phenotypic performance, Binadhan-8 was considered as tolerant and Binadhan-7 was considered as susceptible. The genotypes having similar banding pattern to Binadhan-8 were considered as tolerant and similar to Binadhan-7 were considered as salt susceptible (Table 6).

Table.5 Fertility (%), yield/plant of rice landraces under salnized (EC 8dS/m) and non-salinized condition at reproductive stage

SL No.	Genotypes	Fertility (%)		Yield/plant (g)	
		Non-salinized	Salinized	Non-salinized	Salinized
1.	Jamai Naru	78.13	45.99	10.34	8.45
2.	Patnai	78.89	60.16	16.95	7.36
3.	Kute Patnai	79.18	69.88	18.97	8.34
4.	Holde Gotal	79.23	43.81	17.34	8.87
5.	Bashful Balam	72.89	56.08	16.19	6.19
6.	Bazra Muri	81.27	64.28	13.99	9.95
7.	Ghunshi	80.04	47.16	11.75	4.77
8.	Chinikani	83.51	56.07	9.80	5.83
9.	Binadhan -7	68.90	57.61	6.32	2.34

SL No.	Genotypes	Fertility (%)		Yield/plant (g)	
		Non-salinized	Salinized	Non-salinized	Salinized
10.	Volanath	81.78	44.68	15.34	4.23
11.	Rupessor	83.04	50.35	13.67	4.89
12.	Kalo Mota	87.25	51.46	18.72	8.38
13.	Nona Kochi	77.97	56.53	19.17	5.12
14.	Tal Mugur	78.21	51.54	17.34	8.05
15.	Ghigoj	77.93	61.87	16.42	5.06
16.	Fulkainja	79.95	47.73	11.41	5.59
17.	Koicha binni	58.89	43.98	17.35	5.27
18.	Nona Bokhra	77.92	64.25	13.35	7.96
19.	Binadhan -8	81.39	64.62	19.38	8.11
20.	FL 378	69.29	58.70	15.61	8.13
21.	Kashrail	70.06	61.79	15.86	8.97
22.	Jolkumri	82.44	65.61	10.92	4.67
23.	Pokkali	82.22	73.43	14.43	9.33
24.	FL 478	69.70	55.90	14.08	6.96
	$LSD_{(.05)}$	1.82	1.22	0.69	0.53

Table 6. Genotypic performance of twenty four rice germplasm using SSR markers

Genotypes	Salt tolerance with SSR markers		
	RM9	RM134	RM234
Binadhan-8, Patnai, KutePatnai, BazraMuri, Tal Mugur, Pokkali, Kashrail and FL 378	T	T	T
Binadhan-7, Bashful, Balam, Volanath, Rupessor, Nona Kochi and Koichabinni	S	S	S
Holde Gotal, Kalo Mota, Nona Bokra and FL- 478	S	T	S
Ghunshi	T	S	T
Chinikani	T	S	S
Ghigoj	T	T	S
Fulkainja and Jolkumri	S	S	T
Jamai naru	S	T	T

Where, S=Susceptible and T=Tolerant

As compared to Binadhan-8, genotypes Patnai, Kute Patnai, Chinikani, Tal Mugur, Ghigoj, Bazra Muri, Ghunshi, Kashrail, Pokkali and FL-378 were found tolerant when samples were amplified with RM9 because they positioned in the same level of Binadhan-8. In the same reaction, Holde Gotal, Bashful Balam, Volanath, Rupessor and FL 478 were found susceptible as they positioned in the the same level of Binadhan-7 (Fig. 1). Previously, RM9 marker was also used for identification of salinity tolerance rice genotypes [35].

In case of RM134 primers, BazraMuri, Patnai, Kute Patnai, Holde Gotal, Nona Bokra, Kashrail, Pokkali and FL 378 were found tolerant and Volanath, Rupessor, and Jolkumri were identified as susceptible (Fig. 2). Regarding to RM234 primers, KutePatnai, BazraMuri, Tal Mugur, Kashrail, Pokkali and FL-478 were identified as tolerant. Patnai, Ghunshi, Chinikani, Volanath Nona Bokra and Rupessor were found susceptible (Fig. 3). Recently, the screening of rice genotypes was done using Binadhan-8 rice variety for salt tolerance using RM234 markers [36]. These three primers (RM9, RM134 and RM234) showed polymorphisms in studied genotypes because they showed different banding pattern and discriminate tolerant genotypes from susceptible in relation to Binadhan-8 (tolerant) and Binadhan-7 (susceptible). The results revealed that all the primer pairs detected polymorphism among the rice genotypes. The microsatellite loci were also multiallelic (nine to twelve allele per locus with a mean of 11.33/locus) and the alleles were co-dominant suggesting their relative superiority in detecting DNA polymorphism over some other markers with different allele size. These markers were also reported as highly polymorphic for tagging salt tolerant genes [19,21]. So, our studied three markers might be useful for identifying salt tolerance rice but it should be confirmed for further use.

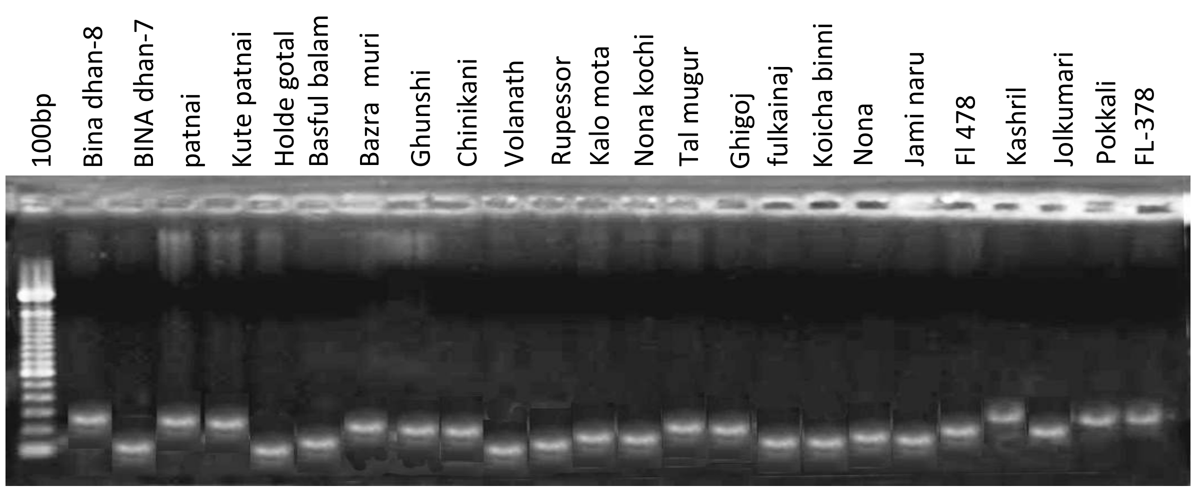

Fig. 1 . Banding profiles of 24 rice germplasm using RM9 primer

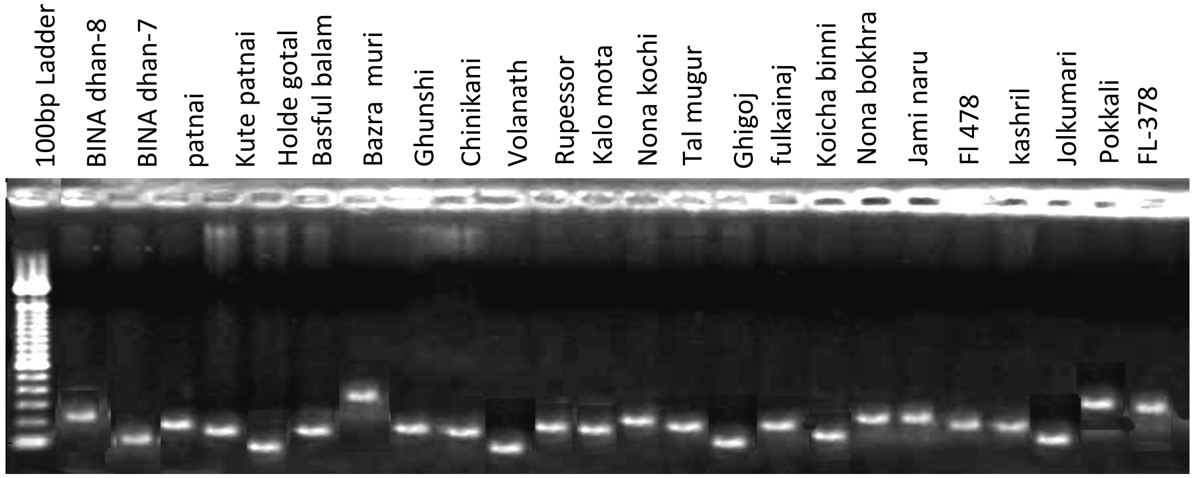

Fig. 2 Banding profiles of 24 rice germplasm using primer RM134

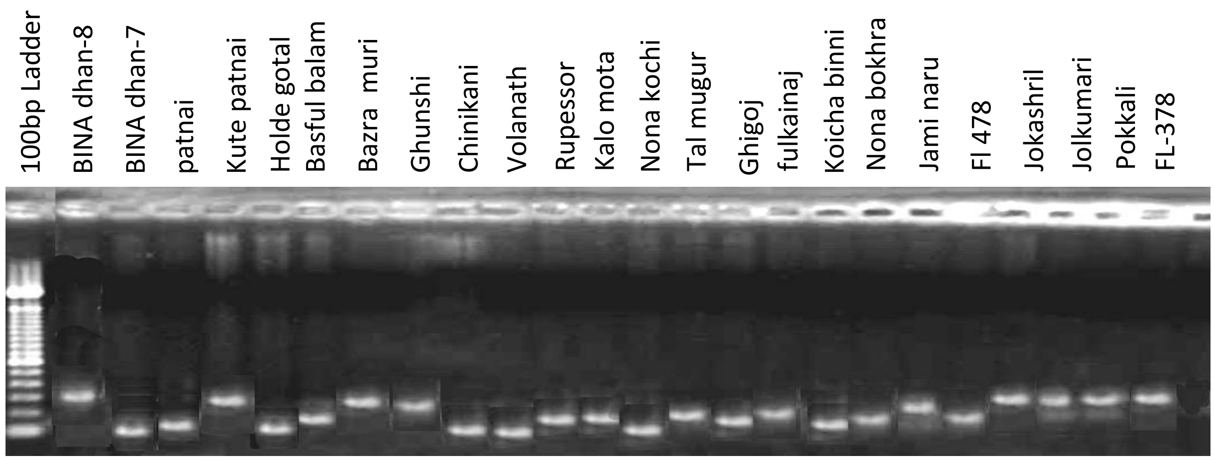

Fig. 3 Banding profiles of 24 rice germplasm using primer RM234

Conclusion

Based on Phenotypic observation, Binadhan-8, Kute Patnai, Kashrail, FL-378, Tal Mugur, Bazra Muri were found as tolerant while Binadhan-7, Rupessor, Koicha Binni, Volanath were found as susceptible. This phenotypic observations support the genotypic findings for identification of salt tolerant rice genotypes. The selected salt tolerant landraces can be used further in rice breeding program to develop salt tolerant high yielding varieties.

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