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Characterization of rice genotypes in relation to salt tolerance related response at early seedling stage

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Abstract
Eighteen rice genotypes were evaluated to assess the seed germination and growth performance of seedlings using two salinity levels (4 and 8 dSm^{-1}). In general, the genotypes exhibited sensitivity to salt stress at germination stage, but greater sensitivity was noticed at early seedling stage. Root length was more affected compared to shoot length followed by shoot fresh and dry weight, root fresh weight and dry weight and K/Na ratio. Using eight morpho-physiological parameters, the rice genotypes were categorized into three groups based on the relative mean performance. The genotypes CSR-13, CSR- 23, CSR-27, CSR-30, CSR-36, CST7-1 and CSR-2K-262 showed considerably higher level of tolerance to salt stress in comparison to the genotypes NDRK-11-1, NDRK-11-3, NDRK-11-4, NDRK-11-5, NDRK-11-6, NDRK-11-7, CSR-2K-219 and CSR-2K-242, which were found to be moderately tolerant. The remaining three genotypes, namely, IR-36, IR-64 and Swarna, were observed to be susceptible to salt stress. Screening under laboratory condition provided a rapid and efficient method for the evaluation of salt tolerance status of genotypes.

Keywords: rice, salinity tolerance, seed germination, seedling growth

Introduction
Among cereals, rice is an important food crop after wheat and maize. Contributing as one of the major staple food item, it provides instant energy and improves peristalsis movement. Since, rice cultivation is adversely affected in a severe manner by abiotic stresses like salinity and drought, which seriously reduces crop productivity [1, 2]. Salinity stress is recognized as one of the biggest problems in the rice growing countries at global level. The origin of salinity is directly or indirectly related to water logging condition. Gradually, salinity increases in irrigated areas due to improper management and practices. Crop yield declines severely when pH of soil solutions exceeds 8.5 or EC values goes over 4 dSm^{-1} [3]. Saline soil contains high concentration of chloride, carbonate and sulphate salts of sodium or magnesium in soil at different proportions. Sodium chloride is the most widespread salt and this is the most important reason behind its choice and preference as a salinizing salt by the researchers.
Rice plant is known to tolerate salinity stress by specific mechanisms, such as, exclusion, delusion and compartmentalization acting upon singly or jointly [3, 4, 5]. Being widely characterized as a salt sensitive plant, it shows different level of tolerance to salinity stress at germination and tillering stage, whereas it shows more sensitivity during early vegetative and reproductive stages [2, 6, 7]. Therefore, screening and development of salt tolerant genotypes is very important for sustainable crop production. Screening of rice genotypes under laboratory conditions has been commonly used technique, because it allows exposure to uniform and exact stress conditions for evaluating salinity tolerance status [8]. This technique is widely accepted to provide rapid screening, which is difficult at the vegetative and reproductive stages [9]. Keeping all these into consideration, the present study was undertaken to evaluate the salinity tolerance status of rice genotypes at different salinity levels.

Materials and Methods
Twenty seeds of each of the 18 rice genotypes used in this study were soaked in water for 12hrs in the Molecular Biology Laboratory of the Department of Agricultural Biotechnology & Molecular Biology, Dr. Rajendra Prasad Central Agricultural University, Pusa, Bihar. The soaked seeds were washed with running tap water and thereafter with 70% ethanol for 30 seconds followed by three rinses in distilled water. Subsequently, the seeds were surface sterilized by using 0.1% mercuric chloride solution for 5 minutes and rinsed with distilled water to avoid contamination. The surface sterilized seeds were kept on wet germination paper placed in petri plate having 10 ml of salt solution along with control. The screening was conducted at two different salinity levels (4 and 8 dSm^{-1}) along with control.

The salt solution were prepared by calculating total dissolved solids [10, 11] and measured by EC meter.

The experiment was designed following completely randomized design (CRD) with two replications. Germination percentage (GP), score for visual salt injury (SES), shoot length (SL), root length (RL), shoot fresh weight (SFD), shoot dry weight (SDW), root fresh weight (RFW), root dry weight (RDW) [12] and potassium and sodium ratio were recorded after 15 days of seed inoculation. The modified standard evaluation system (SES) was used to score visual salt injury (Table 1) at seedling stage [9]. For estimation of potassium and sodium content, 15 days old rice seedlings were washed with dilute HCl followed by deionised water for removal of metallic contaminants. The samples were oven-dried at 60 ºC and crushed to powder. During sample digestion, 0.1 gm sample was digested with diacid in 9:4 ratio of HNO_3: $HClO_4$. The digested sample was cooled and filtered through Whatman No. 1 filter paper. Distilled water was added to make the desired volume. Finally the samples were analysed using flame photometer and the potassium and sodium content in plant was calculated by an index (K/Na ratio). Shoot and roots were separated and weighed by using electronic weighing machine for determining the shoot and root fresh weight. Finally, shoot and root dry weights were taken after 48 hours at 70 ºC until the constant weight was obtained [12].

The overall relative mean values of the genotypes recorded for the eight parameters were used to compare with mean index (MI) value. The experimental genotypes were classified [13] into three groups such as highly tolerant (>MI+1/2 Sd), moderately tolerant (MI±1/2Sd) and highly susceptible genotypes (< MI-1/2 Sd).

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

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

Results and Discussion

Seed germination

Seed germination is one of the most vital and first step of response in which dormant embryo wakes up, grow out of the seed coat and establishes itself as seedling. It was observed that the seed germination started from 3rd to 7th day of inoculation in all genotypes. The overall mean relative performance in respect of seed germination of 18 rice genotypes was recorded as 93.85% at 4 dSm^{-1} followed by 90.89% at 8 dSm^{-1}. The result clearly indicated that seed germination was affected with increasing concentration of salinity stress in accordance with the observation documented by earlier researchers [2, 14]. Amongst all genotypes, remarkably higher seed germination was observed in the case of CSR-2K-242 (97.22%) followed by CSR-13 (96.04%), CSR-2K-262 (95.94%), CSR-36 (95.75%), CST7-1 (95.48%), NDRK-11-1 (92.5%), NDRK-11-6 (92.3%), NDRK-11-7 (91.88%), CSR-2K-219 (91.42%), NDRK-11-3 (91.02%), IR-36 (88.45%), CSR-27 (88.15%), Swarna (88.15%) and IR-64 (Table 2).

Table 2: Mean performance of eighteen rice genotypes for germination (%) under salt stress

Genotype	Germination (%) at different salinity levels					
	C	4 dsm^{-1}	RGP	8 dsm^{-1}	RGP	Mean
NDRK -11-1	100	95.00	95	90.00	90.00	92.50
NDRK -11-3	97.50	92.50	94.87	85.00	87.17	91.02
NDRK -11-4	95.00	90.00	94.73	87.50	92.1	93.41
NDRK -11-5	92.50	87.50	94.59	85.00	91.89	93.24
NDRK -11-6	97.50	92.50	94.87	87.50	89.74	92.30
NDRK -11-7	92.50	87.50	94.59	82.50	89.18	91.88
CST7-1	98.75	92.50	93.67	90.00	97.29	95.48
CSR-2K-219	87.50	82.50	94.28	77.50	88.57	91.42
CSR-2K-242	90.00	87.50	97.22	87.50	97.22	97.22
CSR-2K-262	92.50	90.00	97.29	87.50	94.59	95.94
IR -36	97.50	87.50	89.74	85.00	87.17	88.45
IR -64	87.50	77.50	88.57	72.50	82.85	85.71
Swarna	92.50	81.50	87.12	82.50	89.18	88.15
CSR- 13	95.00	92.50	97.36	90.00	94.73	96.04
CSR -23	92.50	87.50	94.59	85.00	91.89	93.24
CSR -27	95.00	85.00	89.47	82.50	86.84	88.15
CSR -30	87.50	82.50	94.28	80.00	91.42	92.85
CSR -36	90.00	87.50	97.22	82.50	94.28	95.75
Mean	93.40	87.72	93.85	84.44	90.89	92.42
SE (M)	2.585	2.205		3.005		
CD	7.741	6.602		8.996		
CV	3.914	3.552		5.032		

C: Control; RGP: Relative germination percentage

Salt tolerance score using visual salt injury

Taking into consideration the modified SES of visual seedling stage salt injury at 8 dSm^{-1}, the genotypes CST7-1, CSR-13, CSR-23, CSR-27, CSR-30 and CSR-36 were found to be highly tolerant (Score 1), whereas NDRK-11-1 and NDRK-11-5 were rated as tolerant (Score 3). Six genotypes, namely, NDRK-11-3, NDRK-11-4, NDRK-11-6, NDRK-11-7, CSR-2K-219 and CSR-2K-242 were observed to be moderately tolerant (Score 5) and genotypes IR-36, IR-64 and Swarna were rated as susceptible (Score 7) to salt stress (Table3).

Table 3: Visual scoring of rice genotypes under salinized condition (EC 8 dSm^{-1}) at seedling stage

Sl. No.	Genotype	SES Score	Status
1.	NDRK-11-1	3	T
2.	NDRK1-1-3	5	MT
3.	NDRK-11-4	5	MT
4.	NDRK-11-5	3	T
5.	NDRK-11-6	5	MT
6.	NDRK-11-7	5	MT
7.	CST7-1	1	HT
8.	CSR-2K-219	5	MT
9.	CSR-2K-242	5	MT
10.	CSR-2K-262	1	HT
11.	IR-36	7	S
12.	IR-64	7	S
13.	Swarna	7	S
14.	CSR-13	1	HT
15.	CSR-23	1	HT
16.	CSR-27	1	HT
17.	CSR-30	1	HT
18.	CSR-36	1	HT

HT: Highly tolerant; T: Tolerant; MT: Moderately tolerant; S: Susceptible

Seedling stage evaluation

The ability of seedlings to grow under different levels of salinity conditions was assessed by evaluating the shoot and root length, shoot and root fresh weight, shoot and root dry

weight and K/Na ratio. While assessing the seedling growth of all the genotypes, overall relative mean value for shoot length was 93.13% (Table 4). The maximum relative growth in shoot length at 4 dSm^{1} and 8 dSm^{-1} was recorded in CSR-30 (93.79%) followed by CST7-1 (93.38%), CSR-23 (92.73%), NDRK-11-1 (91.84%), NDRK-11-4 (91.63%), CSR-13 (92.73%), CSR-36 (91.30%), CSR-2K-262 (90.85%), CSR-2K-242 (90.71%), NDRK-11-6 (89.74%), NDRK-11-7(87.69%), NDRK-11-3 (87.65%), NDRK-11-5(87.28%), CSR-27 (86.57%), Swarna (85.46%), CSR-2K-219 (85.35%), IR-64 (74.31%) and IR-64 (69.73). Similarly, the overall relative means of root length in all rice genotypes exhibited recognizable variation with the highest value recorded in CSR-13 (94.36%) followed by CSR-2K-262 (94.24%), NDRK-11-7(94.04%), NDRK-11-3 (92.44%), CST7-1 (91.86%), NDRK-11-5(89.61%), NDRK-11-4 (88.12%), CSR-2K-219 (88.06%), CSR-30 (87.38%), CSR-23 (87.19%), NDRK-11-1 (86.88%), CSR-2K-242 (85.29%), NDRK-11-6 (84.90%), Swarna (84.24%), IR-64 (81.02%), CSR-36 (79.61%), CSR-27 (78.63%) and IR-36 (72.10%). The results clearly showed that growth rate decreased with increasing salt concentration at higher salinity level in agreement with the reports of earlier researchers [14, 15]. Furthermore, the root length was observed to be more affected in comparison to shoot length corroborating the earlier reports [2, 16].

Table 4: Mean performance of eighteen rice genotypes for shoot length (cm) and root length (cm) under salt stress

Characters	Shoot length (cm)						Root length (cm)					
Genotypes	C	4 dSm^{-1}	RSL	8 dSm^{-1}	RSL	Mean	C	4 dSm^{-1}	RRL	8 dSm^{-1}	RRL	Mean
NDRK-11-1	9.50	9.20	96.84	8.25	86.84	91.84	9.95	8.89	89.34	8.40	84.42	86.88
NDRK-11-3	8.75	7.85	89.71	7.49	85.60	87.65	9.60	9.05	94.27	8.70	90.62	92.44
NDRK-11-4	11.00	10.06	91.45	10.1	91.81	91.63	12.50	11.25	90.00	10.78	86.24	88.12
NDRK-11-5	8.18	7.53	92.05	6.75	82.51	87.28	10.35	9.90	95.65	8.65	83.57	89.61
NDRK-11-6	7.80	7.35	94.23	6.65	85.25	89.74	11.53	10.80	93.66	8.78	76.14	84.90
NDRK-11-7	9.47	9.30	98.2	7.31	77.19	87.69	10.25	10.13	98.82	9.15	89.26	94.04
CST7-1	9.07	8.81	97.13	8.13	89.63	93.38	13.10	12.43	94.88	11.64	88.85	91.86
CSR-2K-219	9.29	8.05	86.65	7.81	84.06	85.35	12.28	11.25	91.61	10.38	84.52	88.06
CSR-2K-242	7.76	7.45	96.00	6.63	85.43	90.71	15.78	13.92	88.21	13.00	82.38	85.29
CSR-2K-262	7.11	6.79	95.49	6.13	86.21	90.85	12.25	11.88	96.97	11.21	91.51	94.24
IR-36	9.40	7.36	78.29	5.75	61.17	69.73	11.51	10.60	92.09	6.00	52.12	72.10
IR-64	9.10	7.55	82.69	6.00	65.93	74.31	14.68	13.20	89.91	10.59	72.13	81.02
Swarna	8.60	7.95	92.44	6.75	78.48	85.46	12.70	11.75	92.51	9.65	75.98	84.24
CSR-13	7.78	7.45	95.75	6.80	87.40	91.57	13.75	13.10	95.27	12.85	93.45	94.36
CSR-23	9.70	9.35	96.39	8.64	89.07	92.73	11.01	10.65	96.73	8.55	77.65	87.19
CSR-27	9.72	9.39	99.60	7.15	73.55	86.57	6.95	5.70	82.01	5.23	75.25	78.63
CSR-30	9.35	9.30	99.46	8.24	88.12	93.79	9.00	7.67	85.22	8.06	89.55	87.38
CSR-36	9.15	8.60	93.98	8.11	88.63	91.30	10.62	9.77	91.99	7.14	67.23	79.61
Mean	8.92	8.29	93.13	7.37	82.60	87.86	11.54	10.66	92.17	9.37	81.15	86.66
SE (M)	0.395	0.638		0.395			0.908	1.267		0.924		
CD	1.182	1.909		1.181			2.719	3.794		2.766		
CV	6.253	10.796		7.569			11.179	16.633		13.934		

C: Control; RSL: Relative shoot length; RRL: Relative root length

Depending on the concentration of salinity levels, the observation based on fresh weight and dry weight of shoot serves as one of the important indicators for the judgment of tolerance status of rice genotypes against salinity stress. In the present study, considerably greater reduction was observed in the relative mean value of shoot fresh weight at 8 dSm^{-1} in comparison to the relative mean value recorded at 4 dSm^{-1}. Similarly, the overall relative mean of shoot dry weight under salt stress was found to be 80.05% at 8 dSm^{-1} compared to 90.43% at 4 dSm^{-1}. The relative mean of shoot fresh weight at two salinity levels was found to be maximum in CSR-13 (94.58%) followed by CSR -23 (94.47%) and CSR-30 (94.11%), whereas the value was minimum in IR-64 (84.78%). Among the genotypes under evaluation, CSR-30 (93.95%) followed by CSR-23 (93.93%) showed the highest relative mean for shoot dry weight, while the genotype IR-64 (79.44%) had the least mean value (Table 5) followed by Swarna (78.86%), IR-36 (76.27%), NDRK-11-3 (76.13%) and CSR-2K-219 (75.92%). The fresh and dry weight of shoots and roots of all genotypes have also been earlier reported to be affected under salinity stress [16] as observed in the present study. Root length and weight gradually decreased with increasing salinity stress in agreement with the earlier report [17].

Table 5: Mean performance of eighteen rice genotypes for shoot fresh weight (gm) and shoot dry weight (gm) under salt stress

Characters	Shoot fresh weight (gm)						Shoot dry weight (gm)					
Genotypes	C	4 dSm^{-1}	RSFW	8 dSm^{-1}	RSFW	Mean	C	4 dSm^{-1}	RSDW	8 dSm^{-1}	RSDW	Mean
NDRK -11-1	0.452	0.433	95.79	0.369	81.63	88.71	0.074	0.068	91.89	0.061	82.43	87.16
NDRK -11-3	0.366	0.345	94.26	0.298	81.42	87.84	0.088	0.074	84.09	0.060	68.18	76.13
NDRK -11-4	0.466	0.464	99.57	0.344	73.81	86.69	0.068	0.065	95.58	0.051	75.00	85.29
NDRK -11-5	0.413	0.369	89.34	0.321	77.72	83.53	0.077	0.073	94.80	0.064	83.11	88.95
NDRK -11-6	0.466	0.459	98.49	0.377	80.90	89.69	0.089	0.085	95.50	0.074	83.14	89.32
NDRK -11-7	0.434	0.424	97.69	0.358	82.48	90.08	0.080	0.069	86.25	0.059	73.75	80.00
CST7-1	0.484	0.469	96.90	0.435	89.87	93.38	0.082	0.076	92.68	0.072	87.80	90.24
CSR-2K-219	0.434	0.42	96.77	0.375	86.40	91.58	0.081	0.061	75.30	0.062	76.54	75.92
CSR-2K-242	0.349	0.328	93.98	0.300	85.95	89.96	0.067	0.060	89.55	0.055	82.08	85.81

CSR-2K-262	0.362	0.347	95.85	0.305	84.25	90.05	0.078	0.071	91.02	0.061	78.20	84.61
IR -36	0.355	0.327	92.11	0.275	77.46	84.78	0.078	0.063	80.76	0.056	71.79	76.27
IR -64	0.358	0.305	85.19	0.270	75.41	80.30	0.090	0.080	88.88	0.063	70.00	79.44
Swarna	0.345	0.295	85.50	0.280	81.15	83.32	0.071	0.065	91.54	0.047	66.19	78.86
CSR- 13	0.360	0.349	96.94	0.332	92.22	94.58	0.098	0.090	91.83	0.085	86.73	89.28
CSR -23	0.362	0.344	95.02	0.340	93.92	94.47	0.066	0.065	98.48	0.059	89.39	93.93
CSR -27	0.454	0.444	97.79	0.397	87.44	92.61	0.082	0.072	87.80	0.074	90.24	89.02
CSR -30	0.408	0.401	98.28	0.367	89.95	94.11	0.091	0.090	98.90	0.081	89.01	93.95
CSR -36	0.346	0.311	89.88	0.316	91.32	90.60	0.071	0.066	92.95	0.062	87.32	90.13
Mean	0.400	0.379	94.40	0.336	84.07	89.23	0.079	0.071	90.43	0.063	80.05	87.16
SE (M)	0.016	0.025		0.021			0.005	0.004		0.004		
CD	0.047	0.074		0.063			0.015	0.012		0.013		
CV	5.545	9.200		8.828			8.970	7.989		9.742		

C: Control; RSFW: Relative shoot fresh weight; RSDW: Relative shoot dry weight

The fresh weight and dry weight of roots reflected the effect of salt stress during screening of rice genotypes. The overall relative mean of root fresh weight was recorded as 92.98% at 4 dSm^{-1}, whereas 85.47% at 8 dSm^{-1}. Similarly, the relative mean value of root dry weight was 93.66% at 4 dSm^{-1} followed by 85.47% at 8 dSm^{-1}. This regular decrease in the relative root fresh weight and dry weight of rice seedling was probably due to presence of salt stress in the culture plate. While taking into account the relative mean value under salinity stress at 4 dSm^{-1} and 8 dSm^{-1} (Table 6), the value for root fresh weight was found maximum in genotype CSR 13(94.79%) followed by CSR (94.30%), where as it was minimum in IR-36 (81.68%). Likewise, the relative mean value for root dry weight was found to be maximum in CSR-30 (98.02%), whereas it was minimum in NDRK-11-4 (83.92%).

Table 6: Mean performance of eighteen rice genotypes for root fresh weight (gm) and root dry weight (gm) under salt stress

Characters	**Root fresh weight (gm)**						**Root dry weight (gm)**					
Genotypes	**C**	**4 dSm^{-1}**	**RRFW**	**8 dSm^{-1}**	**RRFW**	**Mean**	**C**	**4 dSm^{-1}**	**RDW**	**8dSm^{-1}**	**RRDW**	**Mean**
NDRK-11-1	0.236	0.201	85.16	0.201	85.16	85.16	0.076	0.067	88.15	0.064	84.21	86.18
NDRK-11-3	0.324	0.298	91.97	0.271	83.64	87.80	0.062	0.060	96.77	0.055	88.70	92.73
NDRK-11-4	0.283	0.266	93.99	0.242	85.51	89.75	0.084	0.075	89.28	0.066	78.57	83.92
NDRK-11-5	0.302	0.294	97.35	0.254	84.10	90.72	0.071	0.066	92.95	0.060	84.50	88.72
NDRK-11-6	0.249	0.230	92.36	0.217	87.14	89.75	0.072	0.065	90.27	0.062	86.11	88.19
NDRK-11-7	0.281	0.273	97.15	0.237	84.34	90.74	0.084	0.077	91.66	0.073	86.90	89.28
CST7-1	0.302	0.297	98.34	0.270	89.40	93.87	0.080	0.077	96.25	0.069	86.25	91.25
CSR-2K-219	0.353	0.346	98.01	0.300	84.98	91.49	0.079	0.070	88.60	0.069	87.34	87.97
CSR-2K-242	0.169	0.165	97.63	0.125	73.96	85.79	0.080	0.074	92.50	0.068	85.00	88.75
CSR-2K-262	0.36	0.311	86.38	0.301	83.61	84.99	0.103	0.091	88.34	0.086	83.49	85.91
IR-36	0.363	0.292	80.44	0.301	82.92	81.68	0.060	0.058	96.66	0.046	76.66	86.66
IR-64	0.170	0.162	95.29	0.129	75.80	85.54	0.071	0.070	98.59	0.054	76.05	87.32
Swarna	0.232	0.203	87.50	0.199	85.77	86.63	0.100	0.091	91.00	0.085	85.00	88.00
CSR-13	0.254	0.244	93.52	0.244	96.06	94.79	0.058	0.057	98.27	0.056	96.55	97.41
CSR-23	0.290	0.286	98.60	0.261	90.00	94.30	0.072	0.069	95.83	0.065	90.27	93.05
CSR-27	0.262	0.249	95.03	0.236	90.07	92.55	0.072	0.069	95.83	0.068	94.44	95.13
CSR-30	0.234	0.214	91.45	0.205	87.60	89.52	0.076	0.075	98.68	0.074	97.36	98.02
CSR-36	0.314	0.294	93.63	0.278	88.53	91.08	0.080	0.077	96.25	0.070	87.50	91.87
Mean	0.276	0.256	92.98	0.237	85.47	89.50	0.076	0.071	93.66	0.066	86.38	90.24
SE (M)	0.013	0.015		0.008			0.004	0.004		0.003		
CD	0.038	0.045		0.024			0.012	0.011		0.008		
CV	6.529	8.177		4.856			7.115	7.464		5.888		

C: Control; RRFW: Relative root fresh weight; RRDW: Relative root dry weight

As it is well established, plant experiences osmotic as well as ionic stress due to high salt concentration [18]. Playing a very crucial role in plants, adequate potassium concentration is required for enzyme activation, stabilization of protein synthesis and neutralization of negative charges on proteins [19, 20, 21]. When NaCl is used as salinizing agent, it drastically reduces the potassium concentration and increases sodium concentration. Since sodium is essential in very low concentration and lethal to plant cells at higher concentration, the potassium and sodium ratio was measured to evaluate the effect of salinity at different salinity levels. The overall relative mean for the K/Na ratio was found to be 25.72% at 4 dSm^{-1} followed by 20.89% at 8 dSm^{-1}. Across the salinity levels (Table 7), the relative mean performance for K/Na ratio was maximum in CSR-27 (47.80%) followed by CSR-2K262 (46.29%), CSR-36 (34.5%), CSR-30 (29.72%), CSR -2K-219 (27.00%), NDRK-11-1 (26.36%), CSR-23 (22.41%), CST-7-1(22.04%), CSR-13 (20.72%), NDRK-11-7 (20.30%), NDRK-11-5 (19.14%), NDRK-11-4 (18.30%), NDRK-11-3 (17.09%), NDRK-11-6 (16.48%), CSR-2K-242 (15.92%), Swarna (12.13%) and IR-36 (10.54%). The reduction of potassium concentration was most probably caused by the presence of NaCl in the growth medium, which is known to obstruct the absorption of K^+, Ca^{2+} and Mg^{2+} thereby ultimately increasing the Na concentration [15].

Table 7: Mean performance of eighteen rice genotypes for K/Na ratio under salt stress

Genotype	K/Na					
	C	4 dSm^{-1}	R K/Na	8 dSm^{-1}	R K/Na	Mean
NDRK-11-1	2.390	0.715	27.20	0.610	25.52	26.36
NDRK-11-3	2.430	0.485	19.96	0.385	15.84	17.90
NDRK-11-4	2.595	0.445	18.88	0.460	17.72	18.30
NDRK-11-5	3.460	1.465	20.66	0.610	17.63	19.14
NDRK-11-6	2.365	0.490	16.91	0.380	16.06	16.48
NDRK-11-7	5.615	1.185	21.10	1.095	19.50	20.30
CST7-1	4.255	1.165	27.38	0.715	16.80	22.09
CSR-2K-219	2.555	0.505	36.99	0.435	17.02	27.00
CSR-2K-242	3.045	0.490	14.94	0.515	16.91	15.92
CSR-2K-262	2.225	0.475	65.84	0.595	26.74	46.29
IR-36	3.295	0.415	12.59	0.385	11.68	12.13
IR-64	4.575	0.650	10.71	0.475	10.38	10.54
Swarna	3.860	0.455	12.31	0.460	11.91	12.13
CSR-13	2.400	0.400	21.04	0.490	20.41	20.72
CSR-23	2.610	0.945	17.05	0.725	27.77	22.41
CSR-27	1.710	0.875	51.17	0.760	44.44	47.80
CSR-30	1.455	0.475	32.65	0.390	26.80	29.72
CSR-36	1.710	0.615	35.96	0.565	33.04	34.50
Mean	2.911	0.680	25.74	0.558	20.89	23.10
SE (M)	0.330			0.102		
CD	0.989			0.306		
CV	15.994			25.910		

C: Control; R K/ Na: Relative potassium/Sodium ratio

Seedlings exhibited recognizable reduction in their ability to grow with increase in salt concentration. However, the differential reduction was dependent on the tolerance ability of genotypes, in addition to salinity levels. Considering the genotypic response to salt stress as assessed on the basis of growth related morpho-physiological attributes based mean index value at early seedling stage (Table 8), genotypes CSR-13, CSR-23, CSR-27, CSR-30, CSR-36, CST7-1 and CSR-2K-262 were found to be highly tolerant (>MI+1/2 Sd) to salt stress, whereas NDRK-11-1, NDRK-11-3, NDRK-11-4, NDRK-11-5, NDRK-11-6, NDRK-11-7, CSR-2K-219 and CSR-2K-242 were rated as moderately tolerant (MI±1/2Sd). The remaining three genotypes, namely, IR-36, IR-64 and Swarna were found to be highly susceptible (< MI-1/2 Sd) to salt stress. Thus, there was precise differentiation between genotypes for seed germination and their growth performance under defined salt stress.

Table 8: Mean performance of eighteen rice genotypes considering all parameters in salt stress condition using pooled value of 4 dSm^{-1} and 8 dSm^{-1}

Genotype	RGP	RSFW	RSDW	RRFW	RRDW	RSL	RRL	RK/Na	Mean
NDRK-11-1	92.50	88.71	87.16	85.16	86.18	91.84	86.88	26.36	80.59
NDRK-11-3	91.02	87.84	76.13	87.80	92.73	87.65	92.44	17.90	79.18
NDRK-11-4	93.41	86.69	85.29	89.75	83.92	91.63	88.12	18.30	79.63
NDRK-11-5	93.24	83.53	88.95	90.72	88.72	87.28	89.61	19.14	80.14
NDRK-11-6	92.30	89.69	89.32	89.75	88.19	89.74	84.90	16.48	80.04
NDRK-11-7	91.88	90.08	80.00	90.74	89.28	87.69	94.04	20.30	80.50
CST7-1	95.48	93.38	90.24	93.87	91.25	93.38	91.86	22.09	83.94
CSR-2K-219	91.42	91.58	75.92	91.49	87.97	85.35	88.06	27.00	79.84
CSR-2K-242	97.22	89.96	85.81	85.79	88.75	90.71	85.29	15.92	79.93
CSR-2K-262	95.94	90.05	84.61	84.99	85.91	90.85	94.24	46.29	84.11
IR-36	88.45	84.78	76.27	81.68	86.66	69.73	72.10	12.13	71.47
IR-64	85.71	80.30	79.44	85.54	87.32	74.31	81.02	10.54	73.02
Swarna	88.15	83.32	78.86	86.63	88.00	85.46	84.24	12.11	75.84
CSR-13	96.04	94.58	89.28	94.79	97.41	91.57	94.36	20.72	84.84
CSR-23	93.24	94.47	93.93	94.30	93.05	92.73	87.19	22.41	83.91
CSR-27	95.94	92.61	89.02	92.55	95.13	86.57	78.63	47.80	84.78
CSR-30	92.85	94.11	93.95	89.52	98.02	93.79	87.38	29.72	84.91
CSR-36	95.75	90.6	90.13	91.08	91.87	91.30	79.61	34.50	83.10
Mean	92.80	89.23	85.23	89.23	90.02	87.86	86.66	23.31	80.54
Sd	3.10	4.15	6.02	3.66	3.97	6.38	6.01	10.63	3.81

RGP: Relative Germination Percentage; RSFW: Relative shoot fresh weight; RSDW: Relative shoot dry weight; RRFW: Relative root fresh weight; RRDW: Relative root dry weight; SL: Relative shoot length; RRL: Relative root length; R K/Na: Relative potassium/Sodium ratio.

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