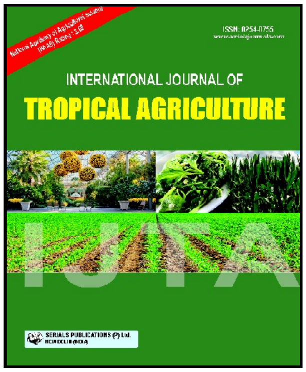

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Effects of NaCl Concentrations on Germination and Growth Attributes at Early Seedling Stages in Ricebean {*Vigna umbellata* (Ihunb.) Ohwi and Ohashi} Accessions

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Abstract: Soil salinity is a major limitation, constraint in production of sustainable agriculture in most of the areas of the world and it becomes the predicament of serious concern. The present study reports the impact of salt stress on seeds germination and different plant growth parameters in twenty ricebean germplasms by germinated seeds in slant method with double filter paper in distilled water (control) and induced 80, 120 and 160 mM of NaCl salt concentrations. The germination percentage and the growth parameters of seedlings were observed by maintenance of three replications and germination percentage was calculated from final count on 5th day and seedlings were allowed to develop for 10 days under indoor laboratory condition for recording the data. The results obtained showed that the inhibition of the germination percentage and total dry weight of the seedlings were observed to decrease with increasing NaCl salt concentration. Again, it had been observed that salinity significantly affected to the percentage of germination with directly proportional to salt concentration and RR-TDW increases with salinity stress. The 120 mM of NaCl salt concentration played key role as an effective salinity stress inducer with less lethal effects. Among all accessions KRB-77, KRB-10 and KRB-273 reported the best performances in the present study against NaCl salinity. These germplasms could show tolerance to salinity might be due to the tolerance to drought stress.

Key Words: Salinity, NaCl, Tolerance index, Salinity susceptibility index.

INTRODUCTION

Salinity is a wide spread across the world and most serious environmental stress for crop plants in arid and coastal regions (Ahmed, 2009) which is limiting the productivity of the different crops with adverse effects on seed germination, plant vigor and critically restrict the crop yield (Munns *et al*., 2008). It has been reported that worldwide 20% of total cultivated and 33% of irrigated agricultural lands are afflicted by high salinity. Furthermore, the salinized areas are increasing at a rate of 10% annually for various reasons, including low precipitation, high surface evaporation, irrigation with saline water and poor cultural practices. It has been also estimated that more than 50% of the arable land would be salinized by the year 2050 (Jamil *et al*., 2011).

Hence, introduction of salt tolerant cultivars is one of the ways to utilize the waste saline water and lands also (Baccio *et al*., 2004). In order to assess the tolerance of the plants to salinity stress, growth or survival of the plant is measured because it integrates the up- or down-regulation of many physiological mechanisms occurring within the plant. Changes in morphological and developmental stress as well as physiological and biochemical processes are some of the mechanisms adapted by plant towards stress (Zhu, 2001). Although ricebean (*Vigna umbellata*) is underutilized legume summer crop and it is versatile (Joshi *et al*., 2008) and has immense potential to explore fully in the saline stress, so need to put extensive work would be carry out. So tolerance against salinity at the germination stage is important in the establishment of costal rice bean (*Vigna umbellata*) in saline soils. Looking to the above fact, an investigation was undertaken to determine the effect of salinity levels developed by using sodium chloride (NaCl) salt on seed germination and plant growth parameters under the natural conditions as well as nutrient composition at plant leaf tissues of different cultivars.

MATERIALS AND METHODS

Twenty rice bean germplasms were used in this experiment provided by Officer-in-charge, AICRP on Forage Crops, Kalyani Centre, Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, West Bengal.

List of the genotypes used in the present experiment:

Sr. No.	*Collector No.*	*IC No.*
1.	KRB-10	IC433978
2.	KRB-44	***
3.	KRB-39	***
4.	KRB-56	***
5.	KRB-66	IC 545609
6.	KRB-73	IC 545616
7.	KRB-77	IC 545620
8.	KRB-81	IC 552964
9.	KRB-90	IC-552973
10.	KRB-95	IC 552978
11.	KRB-100	IC-552973
12.	KRB-102	IC-552985
13.	KRB-104	IC 552987
14.	KRB-115	IC 552997
15.	KRB-116	IC 552999
16.	KRB-126	IC 564832
17.	KRB-179	IC 564882
18.	KRB-211	***
19.	KRB-271	***
20.	KRB-273	IC-573533

***Passport data has been submitted to NBPGR, New Delhi, India

Preparation of Salt Solution

The seeds of the different ricebean genotypes were subjected to the 80, 120 and 160 mM/litre of NaCl which was prepared in the following manner, on the basis of the molecular weight of

$$NaCl = 23 + 35.46 = 58.46 \text{ gm.}$$

Amount of salt (gm)	*Volume (ml)*	*Concentration*
58.46 gm	1000	1 M or 1000 mM
4.677 gm	1000	80 mM
7.015 gm	1000	120 mM
9.354 gm	1000	160 mM

Therefore,

1. 4.677 gm of NaCl in 1 liter of final solution = 80 mM of NaCl
2. 7.015 gm of NaCl in 1 liter of final solution = 120 mM of NaCl
3. 9.354 gm of NaCl in 1 liter of final solution = 160 mM of NaCl

Screening of Genotypes in Different NaCl Salt Concentrations

In the present study, the above mentioned 20 genotypes of ricebean were subjected to 80, 120 and 160 mM salinity level doses for screening by observing the performance of seedlings for salt tolerance. In the bringing of the experiment the viable seeds of the ricebean genotypes were surface sterilized by 0.1% $HgCl_2$ solution for 2 minutes followed by thorough washing in distilled water. Twelve seeds were arranged in row over a glass plate (20 × 30 cm size) lined with blotting paper separately. The whole set was then placed in a transparent polythene bag. Then the seeds were set to germinate in plates containing saline solution absorbed filter paper in the laboratory in presence of sufficient light and aeration. In the treatment plates, salt solution of desired salinity level was used as germinating medium whereas in control pure distilled water was used for the purpose. The seedlings were allowed to develop for 10 days under indoor laboratory condition in bright diffused light, 70-80% relative humidity (R.H) and a temperature range of 25-30°C. Three replications were maintained in all the cases including control. Germination percentage was calculated from final count on 5th day. Data for different parameters were recorded from 10 day old seedlings for the growth and physiological parameters which were removed from glass plate.

Observations on Growth Parameters of Seedlings

Data were recorded on the following characters for screening of genotypes at 80, 120 and 160 mM/litre salinity:

(i) Final Germination Percentage

(ii) Root length (cm)

(iii) Shoot length (cm)

(iv) Total length (cm)

(v) Fresh weight of root (mg)

(vi) Fresh weight of shoot (mg)

(vii) Fresh weight of leaves (mg)

(viii) Total fresh weight (mg)

(ix) Dry weight of root(mg)

(x) Dry weight of shoot(mg)

(xi) Dry weight of leaves (mg)

(xii) Total dry weight (mg)

(xiii) Tolerance index (TI)

(xiv) Salinity Susceptibility Index (SSI)

Tolerance index (TI) under each salinity level was calculated a per Garg and Singla (2004) following the formula:

$$TI = \frac{\text{Dry weight of seedling of a genotypes in saline condition}}{\text{Dry weight of seedling of the same genotypes in non-saline (Control condition)}}$$

For calculating salinity susceptibility index (SSI) the formula of Fisher and Maurer (1978) was used:

$$SII = 1 - X_{SS}/X_{NS}$$

Where X_{SS} and X_{NS} are the means of all the seedlings of a genotypes under salinity-stressed and non-stressed conditions respectively.

In the present study percent relative Reduction (RR%) for different seedling characters of all the genotypes were considered for statistical analysis. Relative reduction of a genotype was computed as –

RR% = [1 – (Mean performance as measured for a character under salinity/the same under control)] × 100.

RESULT AND DISCUSSION

The mean performances of these twenty genotypes at seedling stage were observed in these salinity levels. The results obtained so far for different seedling characters are presented in Tables 1, 2 and 3 respectively. According to Mock and McNeill, (1979) and Koscielniak and Dubert (1985) vigorous seedling provides basis for good crop stand and productivity. Therefore, the evaluation of crops at seedling stage is an important aspect of crop breeding programme with an objective to evolve salt tolerant varieties. Screening of germplasm at seedling stage is readily acceptable as it is based on the simple criterion of selection. Further, it provides rapid screening difficult at vegetative and reproductive stage (Gregorio *et al.*, 1997). Screening under controlled condition reduces the environmental effects and the hydroponic system is free of difficulties associated soil related stress factors. The conventional methods of plant selection for salt tolerance are difficult due to large effects of the environment and low narrow sense heritability of salt tolerance (Gregorio, 1997). Such factor hinders the development of an accurate, rapid and reliable screening technique. Perusal of the results presented in Tables 1, 2 and 3 indicated that four different parameters *viz.*, germination percentage (Ger%), relative reduction for total dry weight (RR-TDW), tolerance index (TI) and salinity susceptible index (SSI) would be more indicative to identify/screen genotypes for tolerance and susceptibility. Therefore, a separate table with the above parameters was prepared (Table 4). In this table the performance of different genotypes with respect to the identified four parameters in all the three concentrations of salinity are presented for the twenty genotypes. Perusal of the results presented in table 4 reveals that the values for a particular parameter varied with the genotype and with the concentration of salt. But for a particular genotype the values for a parameter changed with the change of salt concentration and with increase in salt concentration, the relative reduction also increased. Considering the range for each parameter it was observed that the values obtained at 120 mM was medium.

For example, the germination percentage (Ger%) at 80 mM treatment many of the genotypes were not at all affected exhibiting 100% germination while that at 160 mM was too severe exhibiting many of the genotypes with germination percentage (Ger%) around 50%. In case of the other parameter like RR-TDW, the values were very low in some genotypes like, KRB-10, KRB-77, KRB-81, KRB-95, etc at lower dose i.e., at 80 mM but were very high at 160 mM dose like in case of KRB-90, KRB-211, KRB-100, KRB-102, KRB-116 etc. However, the values for the same parameter were generally medium at 120 mM. Similar trend was noticed in case of the other two parameters also. In case of a particular genotype again, the value obtained for a particular parameter was medium at 120 mM dose. Therefore, it was felt necessary to find out the number of genotypes that were significantly affected, non-significantly affected and no influence of salinity treatment needs to be worked out.

Germination Percentage (Ger%)

ANOVA for germination percentage indicated significant differences among accessions, salinity levels and their interactions. For all lines, germination percentage was higher at the lowest level of salinity (80 mM). Final germination percentage decreased

Table 1

Germination percentage, tolerance index, salinity susceptibility index and relative reduction (RR%) in different seedling characters of 20 genotypes of ricebean at 80 mM of NaCl/litre

Sl. No.	*Genotypes*	*Ger%*	*RR-SL*	*RR-RL*	*RR-TL*	*RR-SFW*	*RR-RFW*	*RR-LFW*	*RR-TFW*	*RR-SDW*	*RR-RDW*	*RR-LDW*	*RR-TDW*	*TI*	*SSI*
1.	KRB-10	94.440	22.676	29.815	26.241	2.316	3.345	33.337	9.924	4.705	41.106	34.632	20.488	81.598	0.399
2.	KRB-39	94.440	57.541	65.460	61.710	54.711	63.331	77.196	62.436	56.689	61.507	80.869	63.515	40.957	1.275
3.	KRB-44	55.553	48.531	68.495	57.833	54.178	74.220	73.330	64.471	18.668	58.607	58.189	41.149	58.849	1.225
4.	KRB-56	72.220	57.938	62.971	62.166	65.707	69.348	87.114	70.841	37.643	65.190	75.729	56.808	43.188	1.448
5.	KRB-66	61.107	57.177	65.712	61.441	73.949	69.662	87.748	74.558	51.843	55.543	83.115	61.870	38.129	1.636
6.	KRB-73	94.440	39.134	64.003	51.903	65.416	52.328	78.536	64.555	40.438	70.217	65.553	55.861	44.138	1.656
7.	KRB-77	100.000	14.140	46.500	29.771	4.765	3.999	48.625	14.138	6.574	28.825	22.394	14.825	85.174	0.438
8.	KRB-81	100.000	18.064	41.884	28.974	9.870	3.951	22.443	10.510	8.104	35.483	34.017	20.477	79.522	0.607
9.	KRB-90	80.553	49.075	71.418	62.786	63.579	43.657	61.660	57.837	56.403	32.857	57.687	50.975	49.025	1.042
10.	KRB-95	100.000	28.574	41.290	31.205	12.866	16.643	53.158	22.528	4.837	45.671	20.839	18.965	81.034	0.563
11.	KRB-100	74.997	66.255	52.693	58.836	63.267	37.700	59.290	56.717	65.405	34.997	64.561	58.682	55.379	0.946
12.	KRB-102	80.553	60.407	69.345	64.844	45.114	46.634	61.163	48.728	38.091	43.651	52.673	43.158	56.842	0.882
13.	KRB-104	88.773	58.606	50.775	54.520	59.293	72.087	80.264	69.383	60.156	72.103	83.192	70.414	36.063	1.309
14.	KRB-115	88.773	16.955	63.284	42.318	21.052	20.277	31.387	22.536	5.348	42.251	44.559	24.576	75.153	0.738
15.	KRB-116	88.773	7.349	82.101	45.352	29.451	49.177	4.298	34.210	33.556	47.465	18.577	36.574	63.270	0.748
16.	KRB-126	83.330	19.545	54.745	39.508	90.843	30.692	52.394	68.475	27.759	35.278	54.238	34.420	65.580	0.704
17.	KRB-179	88.773	12.776	61.670	39.636	23.782	19.885	13.373	21.829	25.261	25.867	40.550	27.234	72.766	0.557
18.	KRB-211	86.107	48.273	65.226	58.487	63.527	24.986	63.640	54.317	68.309	77.403	58.810	69.511	30.489	2.066
19.	KRB-271	94.330	6.156	40.910	24.472	10.972	38.820	40.307	22.069	5.684	46.216	19.453	18.531	81.469	0.550
20.	KRB-273	88.883	5.670	36.715	20.460	10.505	20.024	37.837	19.130	15.767	20.849	17.100	17.108	82.892	0.508
	Mean	85.802	34.742	56.751	46.123	41.258	38.038	53.355	43.460	31.562	47.054	49.337	40.257	59.704	0.996
	C.V.	5.303	2.536	1.218	3.624	2.559	4.286	3.074	2.083	3.242	3.842	3.934	2.114	1.426	14.137
	S.E.	2.627	0.509	0.399	0.965	0.609	0.941	0.947	0.523	0.591	1.044	1.121	0.491	0.492	0.081
	C.D. 5%	7.509	1.454	1.141	2.758	1.742	2.691	2.707	1.494	1.689	2.983	3.203	1.404	1.405	0.232
Range Lowest		55.553	5.670	29.815	20.460	2.316	3.345	4.298	9.924	4.705	20.849	17.100	14.825	29.586	0.438
Range Highest		100.000	66.255	82.101	64.844	90.843	74.220	87.748	74.558	68.309	77.403	83.192	70.414	85.174	2.066

Table 2

Germination percentage, tolerance index, salinity susceptibility index and relative reduction (RR%) in different seedling characters of 20 genotypes of ricebean at 120 mM of NaCl/litre

Sl. No.	*Genotypes*	*Ger%*	*RR-SL*	*RR-RL*	*RR-TL*	*RR-SFW*	*RR-RFW*	*RR-LFW*	*RR-TFW*	*RR-SDW*	*RR-RDW*	*RR-LDW*	*RR-TDW*	*TI*	*SSI*
1.	KRB-10	86.107	14.838	43.332	32.422	30.197	1.230	48.303	14.382	34.019	26.181	14.463	18.512	79.178	0.607
2.	KRB-39	86.107	75.373	73.204	79.341	62.079	78.660	88.940	71.353	40.828	62.076	75.897	59.121	36.485	1.299
3.	KRB-44	49.997	48.647	79.500	67.824	80.430	79.644	91.265	82.921	73.716	77.638	90.923	80.377	19.447	1.733
4.	KRB-56	55.550	85.423	76.586	75.843	73.194	74.236	98.195	77.466	77.550	56.907	90.109	67.306	31.999	1.451
5.	KRB-66	49.887	81.534	78.698	79.184	96.175	81.006	97.427	94.172	77.665	93.400	91.011	78.398	21.383	1.690
6.	KRB-73	86.107	54.900	72.396	62.915	67.324	71.053	87.114	62.807	66.927	32.199	73.021	66.489	33.098	1.434
7.	KRB-77	94.440	24.747	47.349	40.813	16.322	5.414	55.432	27.246	7.612	10.467	46.628	18.834	81.581	0.406
8.	KRB-81	91.663	30.617	35.290	31.492	23.710	21.588	43.539	25.257	16.558	5.733	38.218	19.259	78.961	0.398
9.	KRB-90	47.220	70.831	75.905	73.096	82.992	62.558	68.395	79.589	58.888	32.421	38.354	51.249	48.934	0.839
10.	KRB-95	100.000	25.518	46.125	49.334	32.751	33.621	65.611	40.228	5.454	19.216	41.973	23.650	76.481	0.510
11.	KRB-100	63.993	78.755	62.424	69.326	83.729	62.529	90.080	80.619	54.225	11.105	90.108	47.974	41.318	1.200
12.	KRB-102	72.220	69.161	71.041	66.033	67.813	71.400	75.205	77.197	55.559	47.022	84.778	64.695	35.371	1.361
13.	KRB-104	69.440	49.706	81.015	67.585	57.023	84.230	88.494	78.349	48.419	68.544	75.717	63.930	29.586	1.440
14.	KRB-115	80.553	31.382	61.962	44.193	52.339	20.509	33.481	30.906	88.033	16.667	24.091	77.747	22.249	1.263
15.	KRB-116	80.553	10.054	75.512	44.990	40.244	15.684	7.701	31.515	40.228	52.808	51.967	48.329	51.603	0.912
16.	KRB-126	77.777	49.203	62.318	56.585	27.623	29.485	76.382	41.394	9.195	55.230	72.744	37.788	62.178	0.764
17.	KRB-179	69.220	18.351	74.545	47.954	28.087	36.431	29.107	30.220	9.291	13.263	38.215	47.630	51.184	0.957
18.	KRB-211	72.110	75.562	72.884	75.697	76.970	58.086	84.719	76.444	75.036	58.243	80.010	70.926	29.073	1.417
19.	KRB-271	85.997	10.920	66.637	42.908	4.590	11.227	56.995	20.621	33.229	34.455	11.808	27.690	71.309	0.544
20.	KRB-273	80.553	13.573	69.077	44.188	29.009	49.680	81.414	40.878	20.629	22.063	14.430	20.026	79.974	0.438
	Mean	74.975	45.955	66.290	57.586	51.630	47.414	68.390	54.178	44.653	39.782	57.223	49.497	50.441	1.002
	C.V.	8.006	4.017	2.864	4.060	3.913	4.527	3.404	3.390	4.701	4.653	4.611	3.743	4.665	3.477
	S.E.	3.466	1.066	1.096	1.350	1.166	1.239	1.344	1.060	1.212	1.069	1.523	1.070	1.359	0.020
	C.D. 5%	9.906	3.047	3.133	3.858	3.334	3.542	3.842	3.031	3.464	3.054	4.354	3.057	3.883	0.058
Range Lowest		47.220	10.054	35.290	31.492	4.590	1.230	7.701	14.382	5.454	5.733	11.808	18.512	19.447	0.398
Range Highest		100.000	85.423	81.015	79.341	96.175	84.230	98.195	94.172	88.033	93.400	91.011	80.377	81.581	1.733

Table 3

Germination percentage, tolerance index, salinity susceptibility index and relative reduction (RR%) in different seedling characters of 20 genotypes of ricebean at 160 mM of NaCl/litre

Sl. No.	*Genotypes*	*Ger%*	*RR-SL*	*RR-RL*	*RR-TL*	*RR-SFW*	*RR-RFW*	*RR-LFW*	*RR-TFW*	*RR-SDW*	*RR-RDW*	*RR-LDW*	*RR-TDW*	*TI*	*SSI*
1.	KRB-10	77.777	54.050	66.032	59.765	33.387	30.910	63.869	40.065	23.331	50.605	65.920	40.717	59.283	0.689
2.	KRB-39	69.440	73.549	79.875	76.695	71.839	81.808	94.193	80.499	75.282	83.522	93.974	69.133	17.709	0.856
3.	KRB-44	38.883	73.822	83.770	78.722	85.399	87.238	89.937	87.553	45.544	78.464	94.485	67.794	32.086	1.158
4.	KRB-56	47.220	82.291	79.647	80.886	85.331	81.538	98.294	86.588	48.205	73.096	98.134	70.053	30.067	1.184
5.	KRB-66	38.663	83.642	85.419	84.314	85.731	89.222	98.272	89.290	48.640	81.732	97.683	71.744	28.255	1.222
6.	KRB-73	69.440	77.139	84.094	80.798	77.498	73.787	94.660	80.213	55.047	75.017	95.221	71.155	28.848	1.208
7.	KRB-77	83.330	24.632	55.003	49.542	30.284	26.535	69.063	37.762	13.732	49.394	66.150	33.712	66.325	0.582
8.	KRB-81	83.330	45.697	66.591	51.672	35.295	30.701	69.286	40.854	22.824	61.544	72.470	44.183	55.817	0.748
9.	KRB-90	36.107	83.161	84.360	83.996	87.293	80.894	87.664	85.486	87.339	82.466	87.004	81.867	14.161	1.014
10.	KRB-95	83.330	54.806	63.576	58.072	53.416	38.721	76.500	51.277	30.561	58.914	76.180	49.663	50.344	0.840
11.	KRB-100	44.220	92.550	77.054	84.293	89.140	87.069	95.927	89.840	89.424	85.268	96.087	85.933	10.154	1.064
12.	KRB-102	44.443	86.595	86.809	86.641	82.555	88.031	89.927	85.067	81.911	85.577	89.461	89.467	15.812	1.108
13.	KRB-104	52.777	87.623	87.940	87.665	83.154	93.530	95.104	90.370	83.454	94.057	94.701	75.933	9.550	0.940
14.	KRB-115	52.777	65.875	81.048	74.078	45.910	46.783	57.868	48.498	21.512	52.939	80.382	44.971	55.029	0.988
15.	KRB-116	55.553	44.922	84.274	65.777	62.882	75.824	71.884	67.341	65.265	88.068	73.163	85.467	28.665	1.058
16.	KRB-126	52.777	65.792	81.560	74.365	70.565	56.553	86.891	70.713	71.193	61.839	87.158	75.500	28.224	0.935
17.	KRB-179	44.443	63.173	85.262	74.733	62.245	69.883	64.224	64.473	75.557	67.942	54.908	80.100	28.643	0.992
18.	KRB-211	50.553	90.235	89.960	90.256	86.568	78.705	90.080	85.086	76.895	87.185	92.499	82.053	17.806	1.389
19.	KRB-271	77.777	49.417	71.891	61.148	39.528	21.349	70.183	41.539	33.493	54.906	70.237	45.410	54.919	0.769
20.	KRB-273	75.000	39.112	73.632	55.932	34.354	43.840	80.154	47.462	30.951	50.027	77.186	44.972	55.027	0.757
	Mean	58.892	66.904	78.390	72.967	65.119	64.146	82.199	68.499	54.008	71.128	83.150	65.491	34.336	0.975
	C.V.	10.112	0.745	1.801	3.729	2.545	2.609	2.111	2.202	1.982	2.771	1.274	1.130	2.000	10.077
	S.E.	3.438	0.288	0.815	1.571	0.957	0.966	1.002	0.871	0.618	1.138	0.612	0.427	0.396	0.057
	C.D. 5%	9.828	0.823	2.330	4.490	2.735	2.762	2.863	2.489	1.767	3.252	1.749	1.221	1.133	0.162
Range Lowest		36.107	24.632	55.003	49.542	30.284	21.349	57.868	37.762	13.732	49.394	54.908	33.712	9.550	0.582
Range Highest		83.330	92.550	89.960	90.256	89.140	93.530	98.294	90.370	89.424	94.057	98.134	89.467	66.325	1.389

Table 4
Germination percentage (Ger%), relative reduction in total dry weight (RR-TDW), tolerance index (TI) and salinity susceptibility index (SSI) at 80 mM, 120 mM and 160 mM for 20 genotypes of ricebean taken for NaCl salt standardization

		80 mM				120 mM				160 mM			
Sl. No.	Genotypes	Ger%	RR-TDW	TI	SSI	Ger%	RR-TDW	TI	SSI	Ger%	RR-TDW	TI	SSI
1.	KRB-10	94.440	20.488	81.598	0.399	86.107	18.512	79.178	0.607	77.777	40.717	59.283	0.689
2.	KRB-39	94.440	63.515	40.957	1.275	86.107	59.121	36.485	1.299	69.440	69.133	17.709	0.856
3.	KRB-44	55.553	41.149	58.849	1.225	49.997	80.377	19.447	1.733	38.883	67.794	32.086	1.158
4.	KRB-56	72.220	56.808	43.188	1.448	55.550	67.306	31.999	1.451	47.220	70.053	30.067	1.184
5.	KRB-66	61.107	61.870	38.129	1.636	49.887	78.398	21.383	1.690	38.663	71.744	28.255	1.222
6.	KRB-73	94.440	55.861	44.138	1.656	86.107	66.489	33.098	1.434	69.440	71.155	28.848	1.208
7.	KRB-77	100.000	14.825	85.174	0.438	94.440	18.834	81.581	0.406	83.330	33.712	66.325	0.582
8.	KRB-81	100.000	20.477	79.522	0.607	91.663	19.259	78.961	0.398	83.330	44.183	55.817	0.748
9.	KRB-90	80.553	50.975	49.025	1.042	47.220	51.249	48.934	0.839	36.107	81.867	14.161	1.014
10.	KRB-95	100.000	18.965	81.034	0.563	100.000	23.650	76.481	0.510	83.330	49.663	50.344	0.840
11.	KRB-100	74.997	58.682	55.379	0.946	63.993	47.974	41.318	1.200	44.220	85.933	10.154	1.064
12.	KRB-102	80.553	43.158	56.842	0.882	72.220	64.695	35.371	1.361	44.443	89.467	15.812	1.108
13.	KRB-104	88.773	70.414	36.063	1.309	69.440	63.930	29.586	1.440	52.777	75.933	9.550	0.940
14.	KRB-115	88.773	24.576	75.153	0.738	80.553	77.747	22.249	1.263	52.777	44.971	55.029	0.988
15.	KRB-116	88.773	36.574	63.270	0.748	80.553	48.329	51.603	0.912	55.553	85.467	28.665	1.058
16.	KRB-126	83.330	34.420	65.580	0.704	77.777	37.788	62.178	0.764	52.777	75.500	28.224	0.935
17.	KRB-179	88.773	27.234	72.766	0.557	69.220	47.630	51.184	0.957	44.443	80.100	28.643	0.992
18.	KRB-211	86.107	69.511	30.489	2.066	72.110	70.926	29.073	1.417	50.553	82.053	17.806	1.389
19.	KRB-271	94.330	18.531	81.469	0.550	85.997	27.690	71.309	0.544	77.777	45.410	54.919	0.769
20.	KRB-273	88.883	17.108	82.892	0.508	80.553	20.026	79.178	0.438	75.000	44.972	55.027	0.757
	Mean	85.802	40.257	59.704	0.996	74.975	49.497	50.441	1.002	58.892	65.491	34.336	0.975
	C.D at%%	7.509	1.404	1.405	0.232	9.906	3.057	3.883	0.058	9.828	1.221	1.133	0.162
Lower range		55.553	14.825	29.586	0.438	47.220	18.512	19.447	0.398	36.107	33.712	9.550	0.582
Higher range		100.000	70.414	85.174	2.066	100.000	80.377	81.581	1.733	83.330	89.467	66.325	1.389

as salinity increased (Figure 1). The results indicated that KBR 95, KBR 77and KBR 81 had higher germination percentages which irrigated with higher dose of 160 mM of NaCl salt. Therefore, it indicates that these three genotypes are more tolerant to salinity at germination stage when compared to the other genotypes which had been studied. The germination percentage at 80 mM of salinity treatment many of the genotypes were not affected any more and exhibiting 100% germination while that at 160 mM of salinity dose they were highly effected with the increasing NaCl dose exhibiting many of the genotypes with germination percentage around 50%. Salinity may affect germination by

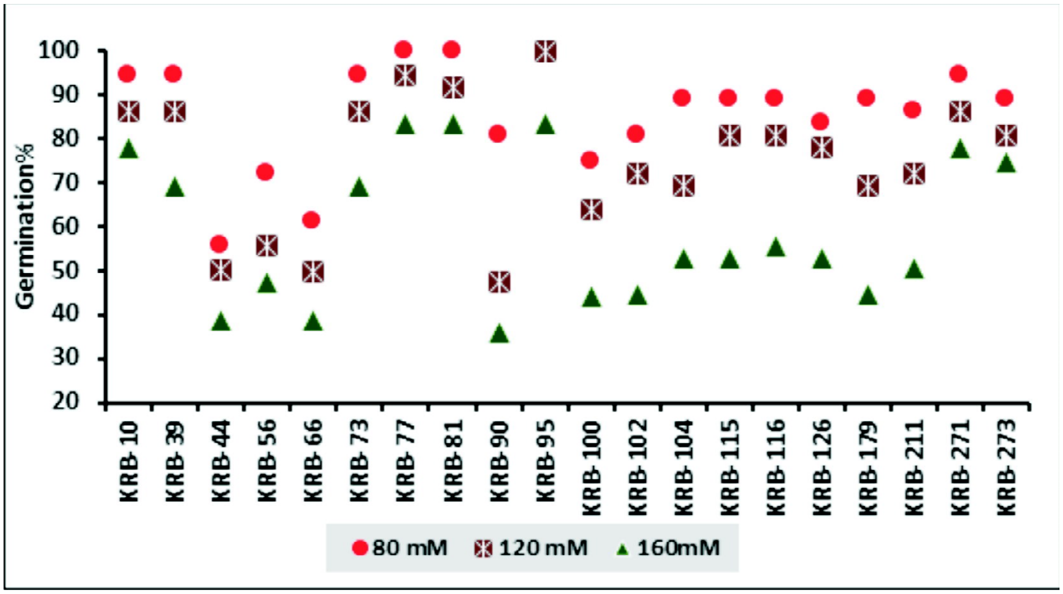

Figure 1: Effect of salinity on germination of ricebean germplasms

facilitating intake of toxic ions which may change certain enzymatic or hormonal activities at physiological level and by decreasing absorption of water because activities and events normally associated with germination, can be proceed at reduced rates. Similar results were also earlier reported by many workers who noticed a progressive gradual decrease in seed germination and growth parameter with progressive increase in salinity stress in many crops. In case of mungbean plant (Maity *et al.* 2000; Yupsanis *et al.*, 2001; Misra and Dwivedi, 2004, Mahajan andTuteja, 2005; Mahadavi and Sanavy, 2007). In barley, Naseer *et al.* 2001. Hossein Askari *et al.* 2016. In Pea (Shahid *et al.*, 2012) and in *P. sativum* (Noreen *et al.* 2007) and in red clover (Asci 2011).

Total Dry Weight (TDW)

In case of the parameter like RR-TDW, the values were very low in some genotypes like, KRB-10, KRB-77, KRB-81, KRB-95, etc at lower dose of 80 mM but values were observed very high at 160 mM dose, like in case of KRB-90, KRB-211, KRB-100, KRB-102, and KRB-116 etc. it had been noticed tharrelative reduction in total dry weight when increasing simultaneously the dose of treatment of salinity increases. In the study of rice seedling, Rahaman *et al.*, (2001) found total dry matter accumulation was significantly suppressed by NaCl of 0.3% and by higher level in all the fourteen cultivars. Kirill Azarin *et al.*, (2016) were observed significantly negative correlation ($p < 0.5$) between the Na+ content and dry weight of shoot and root under 1.2% NaCl stress condition. Verma (1981), found that germination percentage, plant height, fresh and dry weights of shoot and roots decreased tremendously under salt stress. Poonia and Jhorer (1974), found that increased concentration of solutes like Na^+ decreased dry weight of shoots and roots in case of wheat. Therefore, it may be assumed that similar effects might be caused in reduction of dry weight of the treated seedlings in the present experiment

Tolerance Index (TI)

The salinity tolerance scores calculated for twenty ricebean cultivars ranged from 29.58 to 85.17 in lower concentration as shown in table 1. The result elucidated that the increment of NaCl concentration was cause the decreases in salt tolerance of ricebean accession. Even though at 80 mM salinity level,

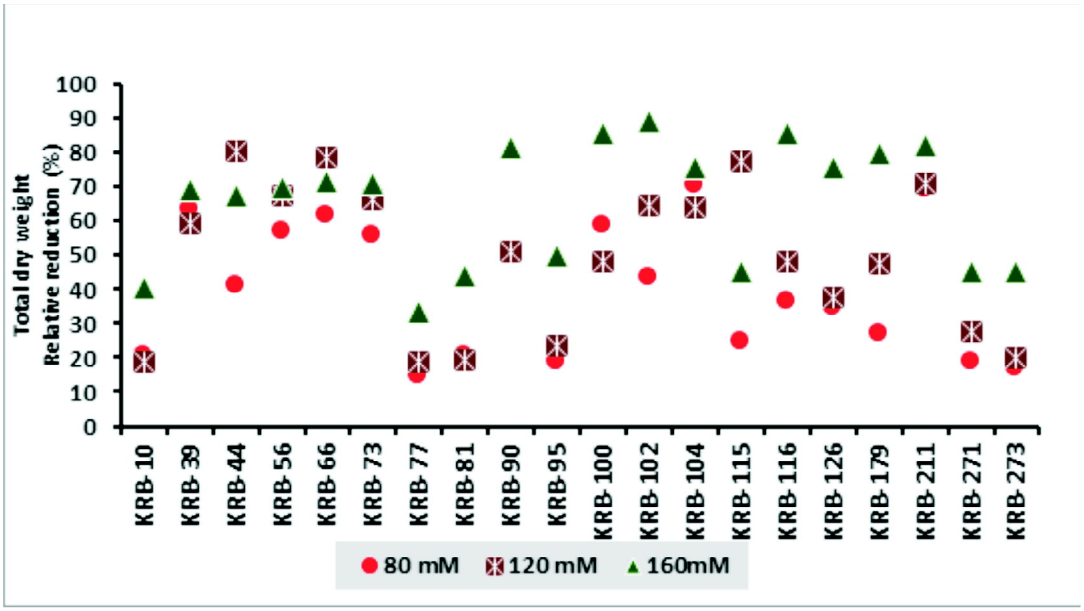

Figure 2: Effect of salinity on dry weight of ricebean seedlings

salinity reduced the overall growth of accession KBR 104, KBR 66 and KBR 39 while in genotype KBR 10, KBR 77 and KBR 273 showed maximum value of salinity tolerance index. The genotypes which performed better under osmotic stress in terms of lesser reduction in various aspects of growth might be related to their water stress tolerance and might be productive in further breeding programmes for drought tolerance. Selection can be made on the basis of these characters at early growth stage to screen a large population for drought stress. The result was in line with previous studies of (Kagan *et al.*, 2010) who reported the salt tolerance index of lentil decrease when salinity levels become increased.

Salinity Susceptibility Index (SSI)

Out of twenty ricebean germplasm screened, KBR 10, KBR 77 and KBR 273 showed minimum value of susceptibility index, while KBR 211followed by KBR 44 and KBR 66 showed maximum values of salinity susceptibility index (SSI), so they are the most sensitive genotypes. The result indicates that salinity susceptibility index of ricebean accession were significantly reduced as salinity concentration increased (Figure 4). Moreover, at 120 and mM of salinity level, salinity easily hampered the overall growth of accession KBR 211, KBR 44 and KBR 66 than the other accessions while, KBR 211 germinate effectively (86.10%) under salt stress but overall growth of accessions were highly hindered by induced salinity level and as result; this accession attained the minimum value of salinity tolerance index (Figure 3). Similar findings were also reported by Die'guez *et al.*, (2000). In comparisons of two parameters *viz.*, TI and SSI it was observed that treatment with 120 mM of NaCl produced effect on seedling traits which was neither too low nor too severe. In case of other morphological characters like relative reduction of shoot length (RR- SL), root length (RR-RL) and total seedling length (RR-TL) similar trend was noticed. Win *et al.* (2011) opinioned that the growth parameters of twelve genotypes of *Vigna* exhibited differential responses to different levels of imposed salinity stress and found plant height, leaf number, shoot and root length, chlorophyll content, shoot and root fresh weight, shoot and root dry weight and leaf area decreased with increasing NaCl salinity. From the comparative view, the salinity level 120 mM seemed to be a stress neither too severe nor too mild for conducting

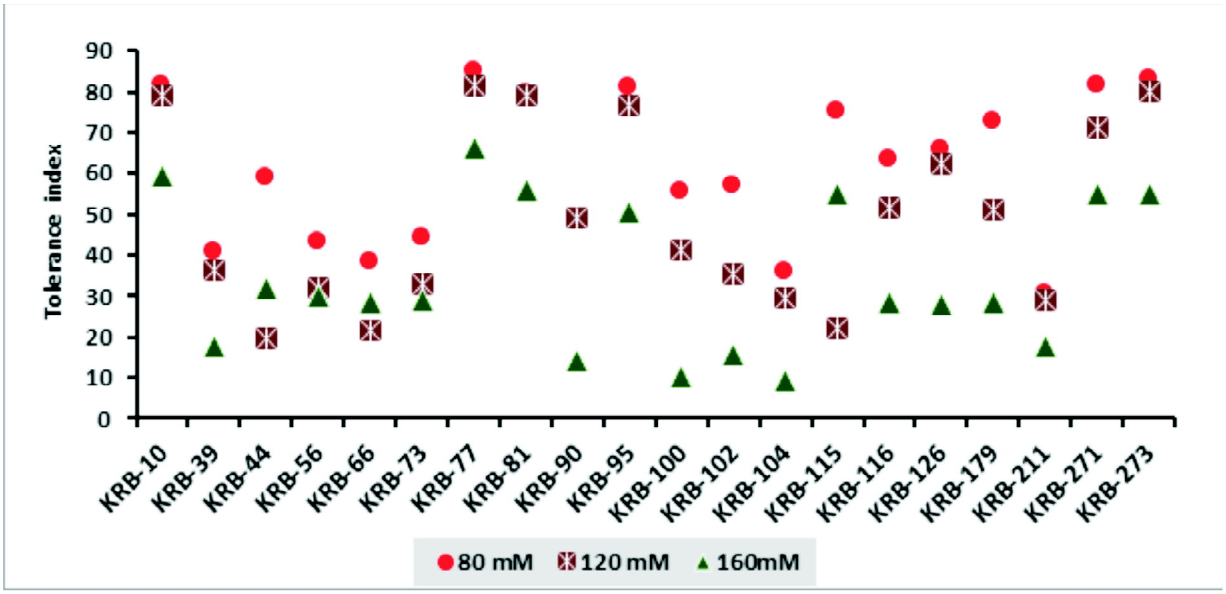

Figure 3: Effect of salinity on salt tolerance of ricebean germplasm

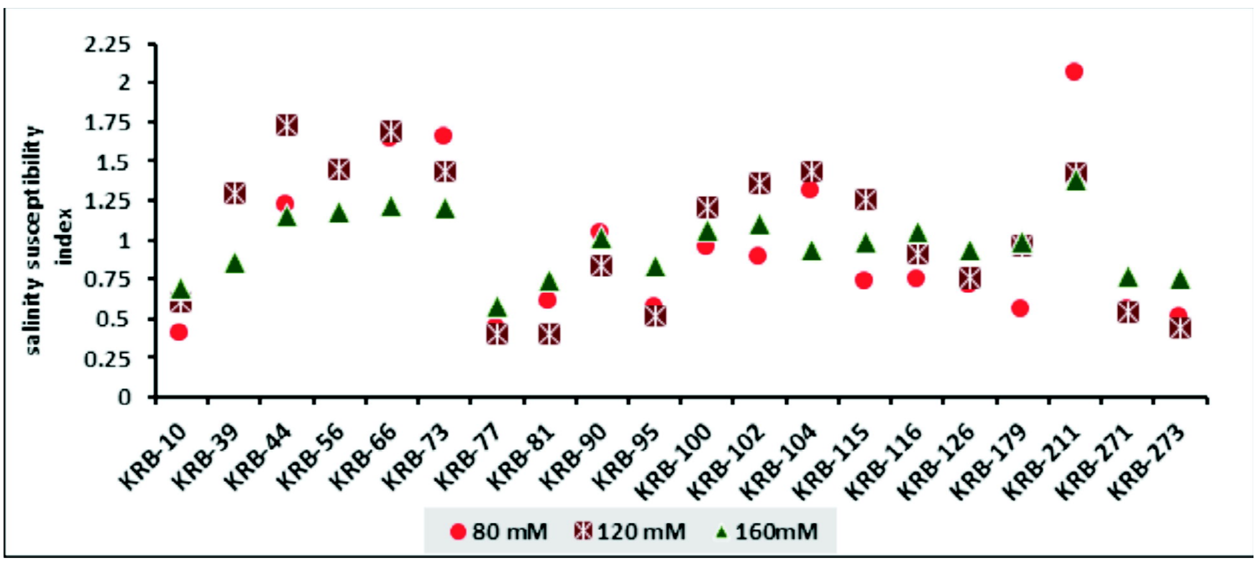

Figure 4: Effect of salinity on salt susceptibility of ricebean germplasm

physiological studies in the present investigation. Rehmani and Hajrasoliha (2003) investigated several salt tolerance *Lucerne* cultivars with several NaCl concentrations and found salt stress decreased plant height and leaf area.

CONCLUSION

In conclusion, experiment method would be cost effective, less time consuming and less laborious to screen the germplasm at early plant growth stage. I he study showed that salt stress decreases the seed germination, total dry matter and genotypic difference in tolerance index due to ionic toxicity, decrease osmotic potential and oxidative stress. Genetic variability offers a valuable tool for studying mechanisms of salt tolerance in ricebean and it will be appreciated to find out ricebean germplasm (s) with genetic tolerance to saline conditions. However, it should be mentioned that the 120 mM NaCl concentration used for inducing salinity conditions in ricebean germplasm resulted as optimum dose because the values at these concentration for the same parameter were generally medium. Yet, under all evaluated conditions among all accessions KBR-77, KBR-10 and KBR-273 showed the best performance in the study against salinity. These germplasm showing tolerance to salinity might be due to tolerance to drought stress by showing less reduction in growth parameter. So, is suggested that the findings may be helpful and fruitful for selection of drought tolerance genotypes of ricebean and may have an important role to establish salt adapted cropping systems.

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