Advances in Crop Science and Technology

Sharma, Adv Crop Sci Tech 2015, 3:4
http://dx.doi.org/10.4172/2329-8863.1000192

Research Article | Open Access

Genotypic Response to Salt Stress: I – Relative Tolerance of Certain Wheat Cultivars to Salinity

Ravi Sharma*

Eco-physiology Laboratory Department of Post-graduate Studies and Research in Botany K R College Mathura Formerly Head Department of Botany K R College, Mathura and Ex-Principal ESS ESS College, Agra (Dr B R Ambedkar University formerly Agra University, Agra) 281 001 UP India

Abstract

Forty two wheat (*Triticum aestivum* L) cultivars screened for their relative salt resistance raising seedlings in half-Hoagland solution (control) salinized with NaCl and maintained at 4, 8, 12 and 16 dsm^{-1} showed a wide range of salt resistance. The growth response to salinity, judged by the shoot and root lengths, ranged from a stimulation in the case of some cultivars at lower salinity levels (4 and 8 EC) to a severe suppression in most of the cultivars at higher levels (12 and 16 EC). It was further observed that the shoot growth was often suppressed more than the root growth with this a level of 12 EC also found to be critical for most of the cultivars except HD–2160 which showed good stand even at a salinity level of 16 EC. Based on these observations, cultivar IWP–72 of the 42 cultivars tested was found to have the maximum sensitivity to salt stress whereas cultivar HD–2160 showed highest salt tolerance. The remaining 40 cultivars fell between the two extremes and were categorized into *sal–sensitive*, *moderately salt – tolerant* and *salt – tolerant* groups exhibiting more than 60%, 40 – 60% and less than 40% reduction respectively in shoot length at 12 EC dsm^{-1} over control.

Keywords: Wheat (Triticum aestivum L); Salt stress; Critical level; Salt–tolerant; Moderately salt–tolerant; Salt–sensitive genotypes

Introduction

The complexion of salt tolerance and the multitude of ways in which plants adapt to it have caused much confusion. Sodium (Na^+) and chloride (Cl^-) are among the most common ions found in excess in saline soils, and some plant species are especially sensitive to one or both of these ions [1-8]. A general suppression of growth is probably the most common plant response to salinity [9]. Crop plants differ greatly in their tolerance to salinity. Differences between species and varieties in regard to salt tolerance have been reported by several workers Bernstein, Hayward, Shannon, Ogra, Sharma , Baijal, Nauhbar, Yadav, Rani , Gautam and Parashar [1-4,6-8,10-20]. In saline soils [2,4,8,21-24] the control of water, the proper techniques of planting and the choice of tolerant crops are essential for their successful use in crop production. The choice of crops is based on: (1) the tolerance to salt; (2) adaptability to climatic or soil characteristics and (3) value of the crop in the individual farm activity. The chances of a crop failure are less if an adequately salt tolerant crop or its variety is selected. The key to improving salt tolerance in plants and studying its inheritance lies in finding sufficient variation within breeding populations and devising a screening procedure capable of identifying resistant or tolerant genotypes.

Further, as the period of seed germination and early seedling stage is the most crucial and important stage in the life cycle of species growing in saline environment [25] the present investigation was, therefore, undertaken to analyze the relative salt tolerance in wheat (*Triticum aestivum* L) at the early seedling stage and to select varieties that could withstand varying concentrations of the salts in their environment.

Materials and Methods

Forty two wheat cultivars (*Triticum aestivum* L) were procured from Wheat Directorate, Cummings Laboratory, Division of Genetics and Plant Breeding, Indian Agricultural Research Institute, New Delhi and Chandra Sekhar Azad University of Agriculture and Technology, Kanpur (UP), India. Screening of wheat cultivars for salt resistance was made by Garrad's Technique (1945) as modified by Sarin and Rao [26] and Sharma [2] and as per method of Sheoran and Garg [11] wherein shoot and root lengths of seedlings were recorded at definite intervals. Here test tubes of uniform size (30 ml capacity) were fitted with rolls of filter paper folded at the top into a cone to support the seeds. The tubes were filled to one-third part with the test solutions so that the solution might not come in direct contact with the growing roots, the salt solution being supplied to the roots through capillary action of the filter paper. Distilled water (represented the mean loss of water from the blanks) was added to each test tube after every 24 hr of interval in order to maintain salt concentration near the target levels throughout the germination period. The seeds were initially sterilized with 0.1% mercuric chloride ($HgCl_2$) solution and later washed thoroughly with distilled water. Three seeds per tube were then transferred to the edge of the filter paper cone and were allowed to grow between the filter paper roll and the wall of the test tube in dark growth chamber at 25 ± 2°C. Fifteen replicates (five tubes each having three seeds) were maintained for each treatment including the controls (half-strength Hoagland solution grown). Observations on the influence of salinity levels at 4, 8, 12 and 16 EC dsm^{-1} of salt solution and the controls on the total length of coleoptile and root at early seedling stage were recorded at 24 hour intervals from 48 hr after sowing up to the end of 120 hr under green safe light. The relative tolerance of different cultivars was evaluated on the basis of the percentage reduction in shoot growth at 12 EC.

All parameters were analyzed by 'Analysis of Variance' (ANOVA)

***Corresponding author:** Ravi Sharma, Eco-physiology Laboratory Department of Post-graduate Studies and Research in Botany K R College Mathura , Formerly Head Department of Botany K R College, Mathura and Ex-Principal ESS ESS College, Agra (Dr B R Ambedkar University formerly Agra University, Agra) 281 001 UP India Tel: 05626455901; E-mail: drravisharma327@yahoo.com.

Received May 27, 2015; **Accepted** Septemebr 22, 2015; **Published** Septemebr 28, 2015

Citation: Sharma R (2015) Genotypic Response to Salt Stress: I–Relative Tolerance of Certain Wheat Cultivars to Salinity. Adv Crop Sci Tech 3: 192. doi:10.4172/2329-8863.1000192

method as given by Panse and Sukhatme [27] wherein Critical Differences (CD at 1 and 5% probability were calculated wherever the results were significant.

Results and Discussion

The observations summarized here clearly demonstrate that exposure to salinity during early seedling stage resulted in stunting of growth of the shoot and root at higher salinity levels. This reduction in shoot and root growth is one of the most commonly observed responses to salinity [2-4,6-8,12-20,28,29].

In agreement with Richards [30] it is observed that the changes induced by addition of NaCl to the growth medium became more distinct with increasing salinity and with prolongation of the period of exposure to salinity. This is perhaps due to a higher intake of ions [2,13,16-18,22] which resulted in toxicity [31-33]. Osmotic effects might also have contributed to the low growth rates under saline conditions [34].

Seed lots of 42 wheat cultivars screened for salinity tolerance at the early seedling stage for shoot and root lengths under varying salinity levels (0,4,8,12 and 16 dsm^{-1}) induced by NaCl as indicated (Table 1), all the main effects *viz.*, variety, treatment and seedling age and their interactions (V × D, V × T, D × T and V × D × T) were highly significant at 0.01 probability with significant differences noticed in the shoot and root growth of all the cultivars studied (Figure 1). The highest mean shoot growth (3.091 cm) was recorded in the cultivar Kharchia followed by **HD-2009**, **Sonalika**, **Sharbati sonora**, **WL-410**, **HD-2236**, **UP-262**, **HS-43**, **IWP-503**, **HP-1303**, **HD-2177**, **HD-2135**, **WH-246**, **K-7634**, **HD-2260**, **Raj-1556**, **UP-115**, **WL-711**, **Moti**, **HD-2282**, **WL-2200**, **Raj-1482**, **HD-1980**, **IWP-72**, **CC-464**, **HD-2275**, **Raj-1409**, **HD-2160**, **HD-1593**, **Raj-1494**, **HD-2252**, **WL-908**, **HD-2267**, **UP-171**, **Raj-1493**, **HD-1977**, **HD-2204**, **K-7631**, **WL-1531**, **WG-1559**, **UP-154** and lastly **WG-1558** with the lowest shoot length of 0.282 cm (Table 2). Similarly, significant differences were also noticed in the root growth of the cultivars studied. The maximum root length (5.974 cm) was observed in the cultivar Kharchia followed by **HD-2009**, **IWP-503**, **Sonalika**, **Sharbati sonora**, **HS-43**, **WL-410**, **CC-464**, **UP-262**, **HD-2135**, **HD-2177**, **Raj-1556**, **UP-115**, **HP-1303**, **WL-2200**, **Moti**, **HD-2275**, **HD-2160**, **HD-2252**, **WL-711**, **WH-246**, **HD-1980**, **IWP-72**, **Raj-1494**, **Raj-1482**, **K-7634**, **HD-2260**, **HD-1593**, **Raj-1409**, **UP-171**, **WL-903**, **HD-2282**, **Raj-1493**, **HD-2236**, **HD-1977**, **HD-2267**, **K-7631**, **HD-2204**, **WL-1531**, **UP-154**, **WG-1558**, and minimum (0.658 cm) was observed in **WG-1559** (Table 2).

Source of Variation	DF	Characters (MSS)	
		Shoot Length	Root Length
Replication (R)	4	0.486375**	0.061000
Varieties (V)	41	45.705478**	161.962530**
Duration (D)	3	1477.620900**	5062.824300**
Treatment (T)	4	298.855950**	884.461750**
V X D	123	10.662409**	12.680032**
V X T	164	3.96484**	7.322207**
D X T	12	70.434100**	87.099666*
V X D X T	492	0.989345**	0.970510**
Error	3356	0.053137**	0.319951**

Shoot Length: G.M. = 1.259 S.Em. ± 0.231 C.V. = 18.310 ** P = 0.01
Root Length: G.M. = 3.093 S.Em. ± 0.566 C.V. = 18.289 ** P = 0.01

Table 1: ANOVA Table (Shoot and Root Growth in 42 Wheat Cultivars).

As indicated in the Table 3 only 11 cultivars showed less than 60% reduction in shoot growth while majority of the 31 cultivars had more than 60% reduction at 16 EC. This is in contrast with root growth (Table 3) where almost a reverse trend was noticed, i.e, out of the 42 cultivars only 15 showed more than 60% reduction at 16 EC whereas 27 had less than 60% reduction. This clearly showed that the shoot is more sensitive to salinity than the root growth. This differential response of shoot and root growth is shown in Table 4 and Figure 2 where the mean shoot growth was found to be more adversely affected than the root growth. Thus, it was interesting to find that not all plant parts were equally affected. In spite of the fact that the roots were directly exposed to the saline environment it seemed significant that shoot growth was affected more adversely than the root growth. With this also 12 EC was found to be a critical level for most of the cultivars. Thus, shoot growth seemed to be better criterion for relative salt tolerance of the cultivars of the same species at early seedling stage. Based on these observations all the 42 wheat (*Triticum aestivum* L) cultivars were categorized into three groups *viz.*, *salt–tolerant*, *moderately salt–tolerant* and *salt–sensitive*, showing <40%, 40–60% and >60% reduction in shoot growth at 12 EC over respective controls (Table 3). Further, the different rates of shoot growth of the three groups (Figure 4) as affected by increasing level of salinity showed a gradual decline in both the salt–tolerant and moderately salt–tolerant cultivars. On the other hand, the salt–sensitive cultivars had a sharp decline in growth with increasing salt concentrations.

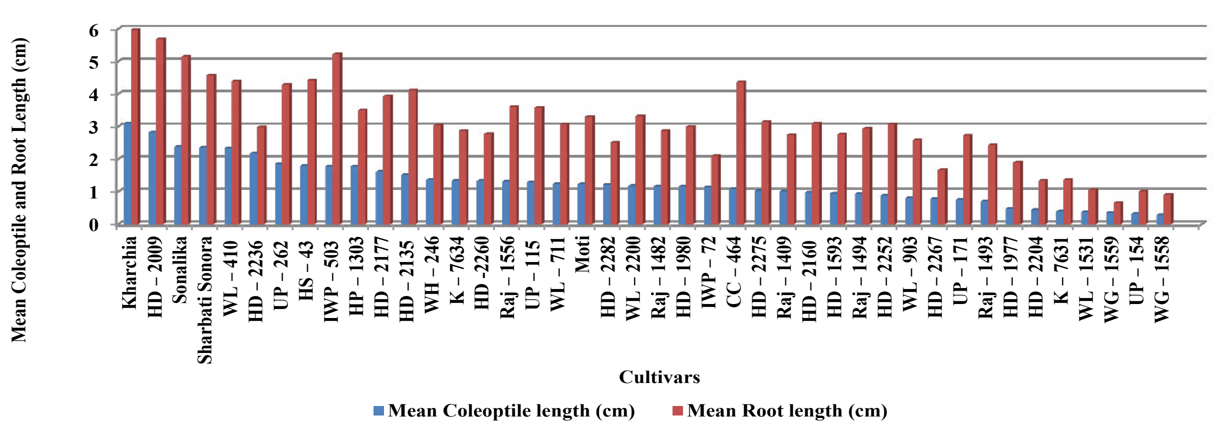

Figure 1: Relative Shoot and Root Growths of Certain Wheat (*Triticum Aestivum* L) Cultivars under Salt Stress at the Early Seedling Stage.

S No	Cultivar	Shoot Growth (cm)						Root Growth (cm)					
		Cont	4EC	8EC	12EC	16EC	Mean	Cont	4EC	8EC	12EC	16EC	Mean
1	HD-2236	3.768	4.279	2.142	0.433	0.211	2.167	4.502	5.004	3.783	1.017	0.581	2.977
2	WL-410	3.326	3.767	2.488	1.455	0.623	2.332	5.122	5.856	4.736	3.849	2.417	4.396
3	Sharbati sonora	3.263	2.956	2.639	1.585	1.315	2.352	5.271	5.190	5.017	4.221	3.158	4.571
4	Moti	2.171	2.063	1.441	0.248	0.217	1.228	5.075	4.463	3.591	1.886	1.501	3.303
5	Sonalika	3.406	2.947	2.409	1.641	1.472	2.375	5.945	5.661	5.319	4.813	3.965	5.140
6	HD-2160	1.069	1.017	0.974	0.911	0.883	0.970	3.627	3.432	3.038	2.814	2.582	3.098
7	HD-2135	2.790	2.052	1.452	0.992	0.276	1.512	6.451	5.287	4.232	2.783	1.843	4.119
8	IWP-503	3.135	2.527	1.869	0.921	0.437	1.778	7.118	6.626	5.745	4.340	2.266	5.219
9	HS-43	2.710	2.509	1.557	1.191	0.793	1.792	6.012	5.568	4.517	3.555	2.454	4.421
10	UP-262	3.374	2.647	2.003	0.977	0.275	1.855	6.630	5.683	4.429	2.969	1.735	4.289
11	HD-2177	2.948	2.329	1.719	0.841	0.198	1.607	5.019	5.482	4.488	2.790	1.853	3.926
12	WG-1559	0.748	0.623	0.193	0.153	0.070	0.357	1.442	1.211	0.293	0.227	0.095	0.653
13	HD-2267	1.516	1.358	0.745	0.180	0.125	0.785	3.658	2.891	1.039	0.619	0.105	1.662
14	IWP-72	2.430	2.015	0.950	0.190	0.125	1.142	4.119	3.496	2.006	0.607	0.240	2.093
15	HD-2282	1.613	1.543	1.445	0.927	0.568	1.219	3.046	2.902	2.844	2.007	1.719	2.503
16	WL-711	1.537	1.429	1.373	1.098	0.709	1.229	3.678	3.586	3.259	2.756	1.999	3.055
17	Raj-1482	1.711	1.654	1.229	0.660	0.554	1.161	3.909	3.762	3.072	1.893	1.729	2.873
18	HD-2260	1.935	1.491	1.406	1.360	0.443	1.327	3.470	3.213	3.096	2.692	1.395	2.773
19	WH-246	2.069	1.909	1.227	0.903	0.702	1.362	3.811	4.353	2.964	2.152	1.904	3.036
20	WL-2200	1.644	1.028	1.850	0.767	0.580	1.174	3.934	3.342	4.148	2.796	2.370	3.318
21	K-7634	1.583	1.533	1.465	1.272	0.826	1.336	3.449	2.941	3.132	2.776	2.046	2.869
22	Raj-1556	1.895	1.542	1.267	1.002	0.835	1.308	4.855	3.957	3.618	2.901	2.704	3.607
23	UP-154	0.420	0.381	0.319	0.255	0.208	0.316	1.196	1.092	1.034	0.898	0.821	1.008
24	HD-1977	0.744	0.620	0.409	0.320	0.301	0.479	2.842	2.506	1.556	1.366	1.178	1.889
25	WG-1558	0.409	0.388	0.292	0.177	0.144	0.282	0.988	1.290	1.191	0.645	0.428	0.908
26	HD-2204	0.681	0.447	0.524	0.292	0.238	0.436	1.716	1.332	1.573	1.068	0.954	1.328
27	WL-1531	0.490	0.445	0.412	0.348	0.162	0.371	1.384	1.265	1.105	0.926	0.566	1.049
28	K-7631	0.560	0.410	0.385	0.315	0.265	0.387	1.834	1.411	1.338	1.164	1.080	1.365
29	Raj-1409	1.824	1.263	0.849	0.711	0.323	1.006	4.377	3.571	2.583	1.952	1.223	2.741
30	Raj-1493	1.104	0.839	0.716	0.561	0.295	0.703	3.599	2.636	2.415	2.189	1.335	2.427
31	Raj-1494	2.095	0.925	0.825	0.594	0.235	0.935	5.685	3.311	2.393	2.013	1.265	2.933
32	WL-903	1.172	0.883	0.797	0.700	0.455	0.801	3.187	2.969	2.711	2.222	1.825	2.583
33	UP-171	1.355	1.116	0.814	0.233	0.198	0.743	4.435	3.592	2.643	1.693	1.245	2.722
34	HD-2275	1.760	1.463	1.127	0.453	0.305	1.021	4.840	3.869	3.138	2.085	1.828	3.152
35	HD-1593	2.148	0.665	0.986	0.596	0.321	0.943	5.365	2.390	3.030	1.870	1.098	2.750
36	HD-2252	1.139	1.216	0.858	0.749	0.403	0.873	3.830	4.189	2.935	2.736	1.637	3.065
37	HP-1303	2.640	2.275	1.504	1.430	1.032	1.776	4.886	3.869	3.366	3.288	2.054	3.493
38	UP-115	1.775	1.523	1.289	1.181	0.713	1.296	4.808	4.312	3.934	2.803	2.050	3.581
39	HD-1980	1.634	1.536	0.987	0.889	0.725	1.154	4.335	4.048	2.534	2.295	1.760	2.994
40	CC-464	1.931	1.103	0.985	0.905	0.465	1.078	6.199	4.515	4.293	3.835	2.968	4.362
41	HD-2009	4.077	3.627	2.583	2.337	1.514	2.824	7.755	6.441	5.383	4.891	3.909	5.675
42	Kharchia	5.291	3.661	2.610	2.277	1.616	3.091	7.838	7.070	5.522	5.110	4.332	5.974
	Means	1.997	1.666	1.267	0.834	0.527	1.259	4.315	3.799	3.167	2.416	1.767	3.092
	CD at 5% P = 0.064 S.Em. ± 0.023							CD at 5% P = 0.351 S.Em. ± 0.126					

Table 2: Shoot and Root Growth of Forty two Wheat Cultivars at Different Salinity Levels.

A significant reduction in shoot and root growth with increasing salinity levels was observed irrespective of cultivars and seedling age (Table 4 and Figure 2). The reduction was more pronounced after 8 EC salinity level. It was observed that the cultivars showed the first sign of germination at 48 hr after sowing irrespective of salinity level and thereafter shoot growth increased significantly with seedling age till 120 hr (Table 4 and Figure 2). In the significant interaction of varieties with treatment the cultivars showed a decrease in shoot growth with salinity levels; however, the varietal variations were quite evident. All the cultivars except **HD-2160**, **Sharbati sonora**, **Sonalika**, **WL-171**, **K-7634**, **Raj-1556**, **UP-154**, **HD-1977**, **K-7631**, **UP-115**, and **HD-1980** showed more than 60% reduction in shoot growth at 16 EC salinity level (Table 3). Like shoot growth, salinity in general, resulted in a reduction in root growth irrespective of cultivars and duration. This decline in root growth was significant at all EC levels. On the other hand, root growth increased significantly with the age of the seedling (Table 5 and Figure 3). Further, it was observed that the cultivars differed significantly in their response to increasing salinity levels and all other cultivars except **HD-2160**, **UP-154**, **Sonalika**, and **WL-2200** showed less than 60% root growth at 16 EC level (Table 6).

The relative comparisons of seedling growth between different wheat cultivars indicated better performance of HD–2160 at almost all levels of salinity when compared with controls. It showed highest tolerance to salinity (i.e., 82.60 percent shoot growth at 16 EC over control) and IWP–72 showing highest inhibition in shoot growth (i.e.,

S.No.	Cultivar	Shoot Growth				Root Growth			
		4EC	8EC	12EC	16EC	4EC	8EC	12EC	16EC
1	HD-2236	113.561*	56.847	11.491	05.599	111.150*	84.029	22.589	12.905
2	WL-410	113.259*	74.804	43.746	18.731	114.330*	92.463	75.146	47.188
3	Sharbati sonora	90.591	80.876	48.574	40.300	98.463	95.181	80.079	59.912
4	Moti	95.025	66.374	11.423	09.995	87.940	70.758	37.162	29.576
5	Sonalika	86.523	70.728	48.179	43.217	95.222	89.470	80.958	66.694
6	HD-2160	95.135	91.113	85.219	82.600	94.623	83.760	77.584	71.188
7	HD-2135	73.548	52.043	35.555	09.892	81.956	65.602	43.140	28.569
8	IWP-503	80.606	59.617	29.346	13.939	93.087	80.710	60.972	31.834
9	HS-43	92.583	64.833	43.948	29.261	92.614	75.133	59.131	40.818
10	UP-262	78.452	59.844	28.956	08.150	85.716	66.802	44.781	26.168
11	HD-2177	79.002	58.310	28.527	06.716	109.224*	89.420	55.588	36.919
12	WG-1559	83.288	25.802	20.454	09.358	83.980	20.319	15.742	6.588
13	HD-2267	89.577	49.142	11.873	08.245	79.032	28.403	16.921	02.870
14	IWP-72	82.921	39.094	7.818	05.144	84.874	48.701	14.736	05.826
15	HD-2282	95.600	89.584	57.470	35.213	95.272	93.368	65.889	56.434
16	WL-711	92.973	89.329	71.437	46.128	97.498	88.607	74.932	54.350
17	Raj-1482	96.668	71.829	38.573	32.378	96.239	78.587	48.426	44.231
18	HD-2260	77.059	72.661	70.284	22.894	92.593	89.221	77.579	40.201
19	WH-246	92.266	59.304	43.644	33.929	114.221*	77.774	56.468	49.960
20	WL-2200	62.530	112.530	46.654	35.279	84.951	105.439*	71.072	60.244
21	K-7634	96.841	92.545	80.353	52.179	85.271	90.808	80.487	59.321
22	Raj-1556	81.372	66.860	52.875	44.063	81.503	74.521	59.752	55.695
23	UP-154	90.714	75.952	60.714	49.523	91.303	86.454	75.083	68.645
24	HD-1977	83.333	54.973	43.010	40.456	88.177	54.750	48.064	41.449
25	WG-1558	94.865	71.393	43.276	35.207	130.566*	120.546*	65.282	43.319
26	HD-2204	65.638	76.945	42.878	34.948	77.622	91.666	62.237	55.594
27	WL-1531	90.816	84.081	71.020	33.061	91.401	79.841	66.907	40.895
28	K-7631	73.214	68.750	56.250	47.321	76.935	72.955	63.467	58.887
29	Raj-1409	69.243	46.546	38.980	17.708	81.585	59.013	44.596	27.941
30	Raj-1493	75.996	64.855	50.815	26.721	73.242	67.101	60.822	37.093
31	Raj-1494	44.152	39.379	28.353	11.217	58.240	42.093	35.408	22.251
32	WL-903	75.341	68.003	59.726	38.822	93.159	85.064	69.720	57.263
33	UP-171	82.361	60.073	17.195	14.612	80.992	59.594	38.173	28.072
34	HD-2275	83.125	64.034	25.738	17.329	79.938	64.834	43.078	37.768
35	HD-1593	30.959	45.903	27.746	14.944	44.547	56.477	34.855	20.465
36	HD-2252	106.760*	75.329	65.759	35.381	109.373*	76.631	71.436	42.741
37	HP-1303	86.174	56.969	54.166	39.090	79.185	68.890	67.294	42.038
38	UP-115	85.802	72.619	66.535	40.169	89.683	81.821	58.298	42.637
39	HD-1980	94.002	60.403	54.406	44.369	93.379	58.454	52.941	40.599
40	CC-464	57.120	51.009	46.866	24.080	72.834	69.253	61.864	47.878
41	HD-2009	88.962	60.902	57.321	39.097	83.056	69.413	63.068	50.406
42	Kharchia	69.192	49.329	43.035	30.542	90.201	70.451	65.195	55.269

Table 3: Shoot and Root Growth of Forty two Wheat Cultivars at Different Salinity Levels (Data expressed as percent over control).

	Interaction Duration				Interaction Treatment				
	Seedling Age (hours)				Salinity Level dsm^{-1}				
	48hrs	72hrs	96hrs	120hrs	Control	4EC	8EC	12EC	16EC
Shoot	0.192	0.562	1.419	2.863	1.997	1.666	1.267	0.835	0.529
	CD at 5% P = 0.048 SEm ± 0.017				CD at 5% P = 0.022 SEm ± 0.008				
Root	0.693	2.122	3.759	5.798	4.314	3.799	3.167	2.147	1.767
	CD at 5% P = 0.020 SEm ± 0.007				CD at 5% P = 0.054 SEm ± 0.020				

Table 4: Relative Shoot and Root Growth (cm) of Certain Wheat Cultivars at Varying Salinity Levels (dsm^{-1}).

only 5.14 percent growth at 16 EC over control). The next cultivars which were relatively lesser tolerant but close to HD–2160 were K–7634, WL–711, WL–1531, HD–2260, UP–115, HD–2252 and UP–154. Based on these growth responses other cultivars of wheat followed a sequence of decrease as shown in Table 3 as far as their resistance to salt stress was concerned.

On the other hand, all the cultivars showed an increase in shoot growth with seedling age. It was evident that the different cultivars exhibited marked differences in their early seedling growth with increasing age of the seedling and that with advancement of seedling age the effect of salt declined and that, in general, tolerance to salinity increased. It was observed that root length increased with age of the seedlings in all the 42 cultivars studied irrespective of the salinity levels. This table also shows that the cultivars differed significantly in their relative root growth. Like shoot, it was observed in the present investigation that irrespective of the cultivars studied the seedlings exhibited increase in salt tolerance with the advancement of age (Tables 4 and 5, Figures 2 and 3).

A stimulation observed in growth of some cultivars as shown in Table 3 marked with asterisk (*) at moderate levels of salinity (4 and 8 dsm^{-1}) confirmed similar observations of Eaton [35] Nieman [9] Ogra and Baijal [36] Sharma [2,7] Nauhbar [16], Yadav [17], Rani [18], Gautam [19] Parashar [20] in certain crop plants. Poljak off-Mayber and Gale [37] reported that Na^+ and Cl^- ions play important roles in the life of the plant within the range of suitable concentrations. The stimulation in growth might be attributed to the nutritional supplementation at low concentrations of the salt [2,4,13].

Thus, it is clear from the data that the cultivars differed in their ability to grow as seedlings under high salinity levels. That wheat showed fairly large varietal differences to salt stress had also been reported earlier by Bhardwaj [38] Sarin and Narayanan [39]. Varietal differences to salt stress were also reported in other agricultural crops by several workers Ayers [40] , Sarin [41], Bhumbla and Singh[42], Puntamkar et al.[43] Taylor[44] Epstein [45] Maas and Hoffman[46], Garrard A[47], Sheoran[48].

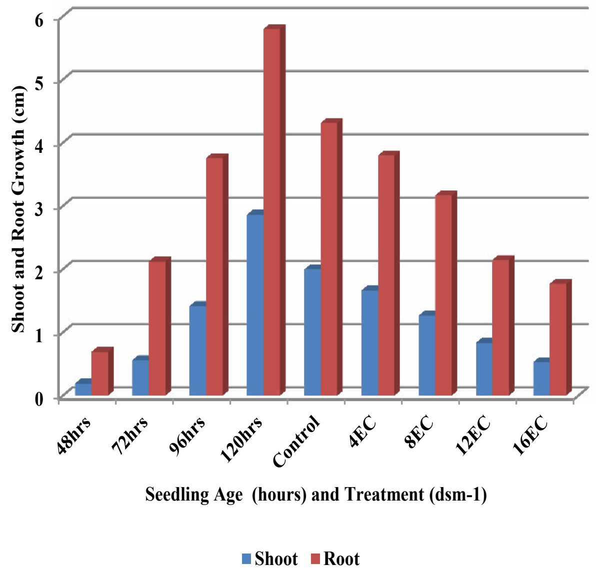

Figure 2: Relative Shoot and Root Growths of Certain Wheat (*Triticum Aestivum* L) Cultivars Under Salt Stress at the Early Seedling Stage

	Seedling Age (hours)	Salinity Level dsm^{-1}				
		Control	4EC	8EC	12EC	16EC
Shoot	48	0.280	0.236	0.184	0.145	0.114
	72	0.901	0.741	0.531	0.372	0.266
	96	2.263	1.905	1.417	0.922	0.588
	120	4.544	3.783	2.935	1.903	1.148
CD at 5% P = 0.044 SEm ± 0.016						
Root	48	1.065	0.868	0.697	0.486	0.347
	72	3.083	2.653	2.152	1.571	1.148
	96	5.192	4.674	3.848	2.934	2.148
	120	7.915	7.002	5.972	4.675	3.425
CD at 5% P = 0.039 SEm ± 0.108						

Table 5: Relative Shoot and Root Growth (cm) of Certain Wheat Cultivars at Varying Salinity Levels (dsm^{-1}) (Treatment X Duration).

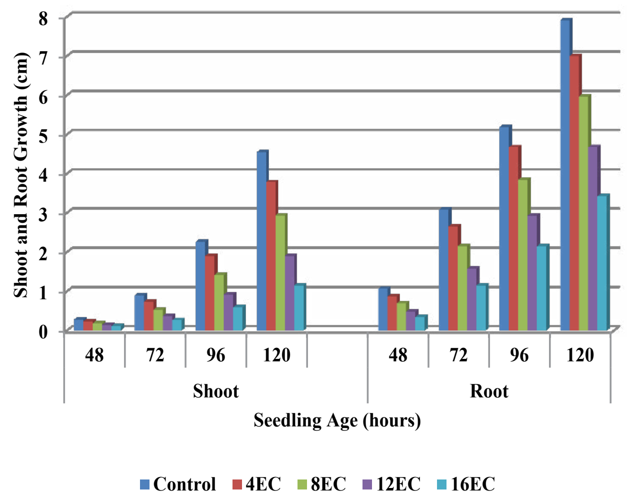

Figure 3: Effect of varying salinity levels on progressive shoot and root growth (cm) of certain wheat (*Triticum aestivum* L) cultivars at the early seedling stage. (Treatment X Duration).

	Group I Salt-tolerant (**Less than 40% reduction**)	**Group II** Moderately Salt-tolerant (**40 – 60% reduction**)	**Group III** Salt-sensitive (**More than 60% reduction**)
CULTIVARS	HD-2160 K-7634 WL-711 WL-1531 HD-2260 UP-115 HD-2252 UP-154	WL-903 HD-2282 HD-2009 K-7631 HD-1980 HP-1303 Raj-1556 Raj-1493 Sharbati Sonora Sonalika CC-464 WL-2200 HS-43 WL-410 WH-246 WG-1558 Kharchia HD-1977 HD-2204	Raj-1409 Raj-1482 HD-2135 IWP-503 UP-262 HD-2177 Raj-1494 HD-1593 HD-2275 WG-1559 UP-171 HD-2267 HD-2236 Moti IWP-72

Table 6: Showing Relative Tolerance of Certain Cultivars of Wheat Based on the Percent Reduction in Coleoptile Growth at 12 EC (dsm-1) Salinity Level.

Conclusion

The observations recorded clearly indicated that the shoot is more sensitive to salt stress than the root and that shoot growth is a better index of relative salt tolerance of different cultivars of the same species at early seedling stage with this also 12 EC salinity level was found to be a critical level for majority of the cultivars. Thus, on the basis of the percent reduction in shoot growth at 12 EC salinity level over respective control all the cultivars were categorized into three groups *viz.*, *salt-tolerant*, *moderately salt-tolerant* and *salt-sensitive*, showing less than 40%, 40–60% and more than 60% reduction respectively.

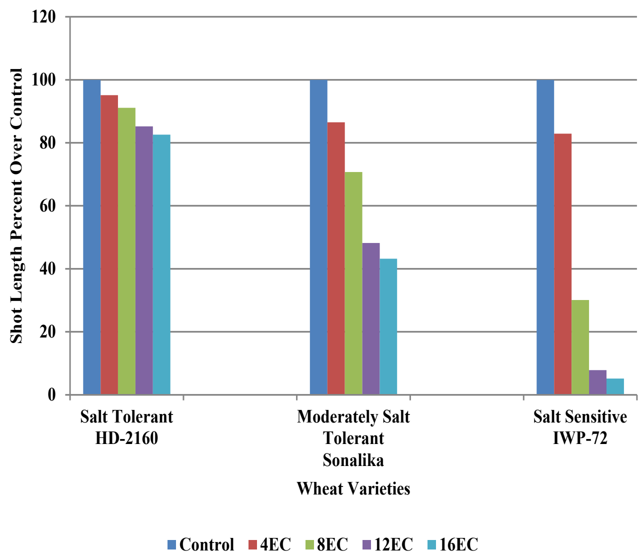

Figure 4: Relative Salt Tolerance of Three Groups (Salt-Tolerant; Moderately Salt-Tolerant and Salt-Sensitiv Wheat (*Triticum Aestivum* L) Cultivars under Salt Stress at the Early Seedling Stage (Data Expressed As Percent Over Control).

Acknowledgements

Author is indebted to Dr B D Baijal (Retd Professor Plant Physiology Department of Botany Agra College, Agra) for expert comments and to the Principal K R College, Mathura for providing necessary facilities.

References

1. Bernstein L, Hayward HE **(**1958) Physiology of salt tolerance. Ann Rev Plant Physiol **9**: 25-46.
2. Sharma, Ravi (1982) Physiology of plant tolerance to salinity at early seedling stage. Ph D Thesis, Agra Univ., Agra.
3. Sharma, Ravi, Baijal BD **(**1985a) genotypic response to salt stress I: Screening for salt-resistance – selection of salt-tolerant and salt-sensitive wheat varieties. National Seminar on Plant Physiology. Institute of Agricultural Sciences BHU Varanasi 12-23 127:74-75.
4. Sharma, Ravi (1987) towards an understanding of the physiology of salt tolerance in wheat (Triticum aestivum L) at early seedling stage; XIV International Bot Cong Berlin, W Germany, 19th July-1 Aug Sym 22: 32.
5. Rani, Saroj (2007) Investigation on salt tolerance parameters specially growth and biochemical traits for selection of salt tolerant lines in legumes at the early seedling stage. PhD Thesis Dr B R Ambedkar Univ. formerly Agra University, Agra.
6. Rani, Saroj, Sharma SK, Ravi Sharma (2009) Germination and early seedling growth in six leguminous crops under salt stress. Plant Archives 9: 145 – 151.
7. Sharma, Ravi, Nidhi Parashar, Sharma SK, Singh DK, et al. **(**2011) Toxic effects of city and industrial effluents vis – a – vis effects of salinity and heavy metal stresses on certain crop plants. XXXIV All India Botanical Conference of The Indian Botanical Society, Oct., 10 – 12, 2011, Department of Botany University of Lucknow, Souvenir and Abstracts, Section VII Plant Physiology, Biochemistry and Pharmacology, O. VII. 29: 285.
8. Sharma (2013) Screening for salt tolerance – Selection of salt tolerant and salt sensitive wheat cultivars; Third National Conference on Innovations in Indian Science, Engineering and Technology (Bilingual Hindi & English) Organized by Swadeshi Science Movement of India, Delhi at CSIR National Physical Laboratory and IARI, New Delhi, Feb. 25 – 27.
9. Nieman RH (1962) some effects of NaCl on growth, phtosynthesis and respiration of twelve crop plants. Bot Gaz 123: 279-285.
10. Hayward HE, Bernstein L **(**1958) Plant growth relationships on salt-affected soils. Bot Rev 24: 584-635.
11. Shannon M C (1978) Testing salt tolerance variability among tall wheat grass populations. Agron J 70: 719-722.
12. Ogra RK (1981) Physiological studies on salt tolerance in Sorghum. Ph D Thesis. Agra University, Agra.
13. Sharma Ravi**,** Baijal BD **(**1984) Ion uptake and ATPase activity in certain wheat cultivars under salt stress conditions. VIII All India Bot Conference, Rajasthan University. J Ind Bot Soc Abst 63: 97.
14. Sharma, Ravi, Baijal BD (1984) Carbohydrate metabolism in salt tolerant and salt sensitive wheat cultivars under salt stress conditions. VII All India Botanical Conference, Rajasthan Univ. J Ind Bot Soc 63: 93.
15. Sharma, Ravi, Baijal BD (1985) Genotypic response to salt stress II: Differential physiological and biochemical response of salt-tolerant and salt-sensitive wheat cultivars; National Seminar on Plant Physiology, Institute of Agricultural Sciences, BHU Varanasi 12-23, Feb. 128: 75-76.
16. Nauhbar, Suman **(**2005) Relative Tolerance of Crop Plants to Salt Stress at the Early Seedling Stage, PhD Thesis, Dr B R Ambedkar Univ. formerly Agra University, Agra.
17. Yadav, Neetu (2006) Physiology of Salt Tolerance for Effective Biological Control of Salinity, Ph D Thesis, Dr B R Ambedkar Univ. formerly Agra University, Agra.
18. Rani, Saroj, Sharma SK, Ravi Sharma (2007) Effect of salinity on germination and early seedling growth in six leguminous pulse crops. XXX Annual Conference Indian Botanical Society, Jiwaji University, Gwalior (MP) India, 28 – 30 Nov. Abst & Souvenir S7. 27: 156.
19. Gautam, Aruna **(**2009) the Problem of Saline Wastelands and their Management – A Biological Approach with Special Reference to Mathura. PhD Thesis, Dr B R Ambedkar Univ. formerly Agra University, Agra.
20. Parashar, Nidhi (2011) Planning and Investigation for City and Industrial Effluent Utilization in Abating Pollution of River Yamuna and Improving Agricultural Production. Ph D Thesis, Dr B R Ambedkar Univ. formerly Agra University, Agra.
21. Sharma**,** Ravi, Baijal BD, Goyal AK(1981a) Salinity – an increasing environmental hazard; First International Conference on Environmental Education, Vigyan Bhavan, New Delhi 16th – 20th Dec. Proc Indian Environmental Society 115: 116 – 117.
22. Sharma, Ravi, Baijal BD (1987) The problem of saline wastelands and their management – a biological approach; National Seminar on Pollution, Conservation awareness and Wastelands development, K.R. College, Mathura 14 – 15 Feb.
23. Babu, Dinesh, Singh DK, Sharma SK, Arti et al. **(**2011) The problem of saline wastelands and their management – a biological approach. XXXIV All India Botanical Conference of The Indian Botanical Society, Oct., 10 – 12, 2011, Department of Botany University of Lucknow, Lucknow, Souvenir and Abstracts, Section VII Plant Physiology, Biochemistry and Pharmacology 6: 274.
24. Sharma (2012) Strategy for sustainable improvement of selected crops-production under saline conditions emphasizing biocontrol of salinity. National Conference on Emerging Trends in Biotechnology and Pharmaceutical Research Feb 18 – 19, Mangalayatan University, Aligarh, Souvenir and Abstract Book, Technical Session II, OP-013: 60.
25. Ranganathan R, Rajalakshmi AK (2006) the effect of NaCl and Na2SO4 salinity on germination behavior of Avicennia officinalis L. Plant Archives 6: 585 – 588.
26. Sarin MN, Rao IM (1956) Effect of sodium sulphate on early seedling growth of gram and wheat. Agra Univ J Res Sci 5: 143–154.
27. Panse VG, Sukhatme PV (1957) Statistical Methods for Agricultural Workers. ICAR (IARI), New Delhi.
28. Ayers AD, Brown JW, Wadleigh CH (1952) Salt tolerance of barley and wheat in soil plots receiving several salinization regimes. Agron J 44: 307-310.
29. Uprety DC (1970) Physiological studies on salt tolerance in two varieties of pea. Ph D Thesis, Agra Univ, Agra.
30. Richards LA (1954) Diagnosis and Improvement of Saline and Alkali Soils. USDA, Agric Hand Book No 60.
31. Ayers AD, Hayward HE (1948) A method for measuring the effects of soil salinity on germination with observations on several crop plants. Amer Proc Soil Sci 13: 224-226.

32. Ota K, Yasue T (1957) Studies on the salt injury to crops, XI the differences on the salt resistance in the young wheat varieties. Gifu U Facul Agric Res Bull 8: 14.

33. Wahhab A (1961) Salt tolerance of various varieties of agricultural crops at the germination stage, Salinity Problems in Arid Zone. Proc Tehran Symp UNESCO 185.

34. Dumbroff EB, Cooper AW (1974) Effects of salt stress applied in balanced nutrient solutions at several stages during growth of tomato. Bot Gaz 135: 219 – 224.

35. Eaton FM (1942) Toxicity and accumulation of chloride and sulphate salts in plants. J Agric Res 64: 357-399.

36. Ogra RK, Baijal BD (1978) Relative tolerance of some sorghum varieties to salt stress at early seedling stage. Indian J Agric Sci 48: 713-717.

37. Poljakoff-Mayber A, Gale J (1975) Plants in Saline Environments, Ecological studies. Springer-Verlag 15: 213.

38. Bhardwaj SN (1959) Influence of NaCl and Na_2CO_3 on some aspects of carbohydrate metabolism in wheat. Mem Indian bot soc 2: 75-78.

39. Sarin MN, Narayanan A (1968) Effects of soil salinity and growth regulators on germination and seedling metabolism of wheat. Physiol Plant 21: 1201-1209.

40. Ayers AD (1953) Germination and emergence of several varieties of barley in salinized soil cultures. Agron J 45: 68-71.

41. Sarin MN (1962) Physiological studies on salt tolerance of crop plants V. Use of IAA to overcome depressing effect of sodium sulphate on growth and maturity of wheat. Agra Univ J Res (Sci) 11: 187 – 196.

42. Bhumbla DR, Singh NT (1965) Effect of salt on seed germination. Sci Cult 31: 96-97.

43. Puntamkar SS, Mehta PC, Seth SP (1970) Note on the inducement of salt resistance in two wheat varieties by presoaking with different salts of varying concentrations. Indian J Agric Sci 41: 717 – 718.

44. Taylor RM, Young EF, Rivera RL (1975) Salt tolerance in cultivars of grain Sorghum. Crop Sci 15: 734-735.

45. Epstein E (1976) Genetic adaptation of crops to salinity; Proceedings, Workshop on Salt Effects on Plant Structures and Processes. Riverside Calif: 51-53.

46. Maas EV, Hoffman GJ (1977) Crop salt tolerance current assessment. J Irrig Drainage Div ASCE 103: 115-134.

47. Garrard A (1945) the effect of b-indolyl acetic acid on the germination and root growth of certain members of cruciferae. New Phytol 53: 165 – 176.

48. Sheoran IS, Garg OP (1978) Effect of salinity on the activities of RNase, DNase and protease during germination and early seedling growth of mung bean. Physiol Plant 44: 171 – 174.

Citation: Sharma R (2015) Genotypic Response to Salt Stress: I–Relative Tolerance of Certain Wheat Cultivars to Salinity. Adv Crop Sci Tech 3: 192. doi:10.4172/2329-8863.1000192