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Screening of Chickpea (*Cicer Arietinum* L.) Genotypes for Seedling Salinity Tolerance

Neeraj Kumar[1], C. Bharadwaj[1], Madan Pal[1], C. Tara Satyavathi[1], Tapan Kumar[1] Tripti Singhal[1] and P.K. Jain[2]*

Abstract: *180 genotypes of chickpea (Cicer arietinum L.) were evaluated for salinity tolerance genetic variability among the selected chickpea genotypes for various seedling biomass related parameters under salt stress and normal conditions reflected presence of significant variation for all the investigated characters. Under salt stress condition there was sufficient decrease in the mean of most the characters understudy. In biomass related study shows that salinity reduces the Root weight by (73.18%) followed by Dry shoot weight and Dry root weight both reduced by (60%), Shoot weight reduced by (56.66%), Shoot length (44.65%)and Root length showed reduction up to (37.38%) under salt stress condition. This showsIrrespective of genotypes the normal grown seedlings had higher values for all the parameters under study while those grown under salt stress had reduced values for all the traits. Genotypesshowing minimum reduction in seedling characters in salt stress conditions mainly were ICCV 00104, ICCV 06101,CSG8962 and JG62.The mean performance for different characters in normal and saline environments revealed that wide range of estimates for characters under study. Seedling salinity tolerance is the basic requirement for genotypes to establish in saline conditions andseedling salinity screening can serve as potential criteria for selecting genotypes for salinity tolerance.*

Keywords: *C. arietinum, variability, seedling screening, salinity.*

Abbreviations: *IARI–Indian Agricultural Research Institute, ANOVA–Analysis of Variance, FRW–Fresh Root Weight, FSW–Fresh Shoot Weight, MM–Milli Molar, RDW–Root Dry Weight, RL–Root Length, SDW–Shoot Dry Weight, SL–Shoot Length.*

INTRODUCTION

Chickpea (*Cicer arietinum* L.) ($2n = 16$) It is well known as one of potential crop to meet the protein hunger. The yield loss in chickpea due to salinity has been estimated to be approximately 8 to 10 per cent of total global production. It accounts for about 15 per cent of the world's total pulse production. During 2013, the global chickpea area was about 13.20 million hectare with production of 11.62 million metric tons and average yield of 880 kg. ha^{-1} (FAOSTAT, 2013).

India is the world's biggest producer, with an annual production of around 8.88 Mt, grown in an area of about 9.21mha.representing 68 per cent of total world chickpea production and average yield of 995 kg ha^{-1} (http://agricoop.nic.in/).

Global annual production losses due to abiotic stresses alone are estimated to be around 3.7 Mt, which amounts to 40-60 per cent average loss. Drought and salinity are two of the most important abiotic stresses that alter plant water status and severely limit plant growth and development. Salinity is one of the major abiotic stresses, ranking only second to drought which affects crop productivity in many parts of the world (Rangasamy, 2006).

[1] Divison of Genetics, ICAR-IARI, Pusa, New Delhi 110012
[2] ICAR-NRCPB, Pusa, New Delhi 110012
* Author for correspondence. *E-mail: chbharadwaj@yahoo.co.in*

World is losing around two thousand hectares of farm soil daily to salt induced degradation, salt spoiled soils worldwide is 20 per cent of all irrigated lands which is an area equal to France. Extensive economic losses due to salinity includecosts of $27 billion plus loss of crop value per year. Every day for more than 20 years, an average of two thousand hectares of irrigated land in arid and semi-arid areas across 75 countries have been degraded by salt, according to a study by UN University's Canadian based Institute for Water, Environment and Health (UNU-INWEH, 2014).

Das *et al*. (2012) studied germination and seedling growth responses of seventy one indigenous germplasm. The lines which showed salinity tolerance displayed lower percent reduction for both roots and shoot length. Seed treatments with crude plant materials were found to be effective to overcome some biotic and abiotic stresses and showed the deleterious effect of salinity can further be reduced in a better way by using nutrient solution along with herbal treatments.

Concentration of salt affects germination, shoot and root length and water uptake of landraces of chickpea. The chickpea (*Cicer arietinum*) germination is reduced and the root undergoes lyses and dries in high concentration of salt even if it germinates. Meanwhile, salt type has different impact on the germination and growth of chickpea. As a result, NaCl has more impact than Na_2SO_4. But seeds of chickpea for both landrace have a maximum tolerant level of salinity with 10dS/m. At this concentration of salinity the seeds show a significant result compared with the control. But at concentration of 15ds/m of Na_2SO_4, the germination and growth of seeds is highly affected and only few seeds start to germinate or raise shoot and root, which dried latter (Tsegazeabe *et al*., 2012).

MATERIALS AND METHODS

The present research work was carried out at the experimental green house facility of Division of Genetics, Indian Agricultural Research Institute (IARI), New Delhi, during the years 2013-14, 2014-15. The mean maximum temperature during winter (November-March) ranges from 20.1°C to 29.1°C and the mean minimum temperature from 5.6°C to 12.7°C. During winter, from December to February the amount of rainfall received was 31.1mm but during peak harvesting period during March it rained about 201.8 mm (http://www.iari.res.in).

For the present investigation which focuses on screening of 180 chickpea genotypes under controlled greenhouse condition as follows:

Selection of Soil and Stress Treatment

The experimental soil was selected from the IARI field and was investigated for initial electric conductivity and pH which was found to be 0.4ds/m and pH 8.1, respectively. The experiment was conducted in both stress and normal condition both replicated in two sets of replication by following the paper cup protocol (Vadez*et al*., 2007) in which about 750 gm of soil was put in each cup and for stress induction upto 8ds/m we treated the each cup with 80mM of saline NaCl solution which was formulated as follows:

Wt. of NaCl required (for 80mM) = molecular wt. of NaCl (g/mol) × ml of water(i.e. for 1L) × 80/1000(mM)

80 moL/m^3 (8ds/m) = 4.68 mg NaC1 in 1 L water

In each cup about 125 ml of saline solution was required to saturate the soil and to induce the salt stress of about 8ds/m in the stress cups, simultaneously the normal sets were also saturated with the normal irrigation water and were allowed to stand. After 3-4 days of treatment, the EC of the paper cups were evaluated for the conformation of salinity.

Sowing of Experimental Material

The study was done on one hundred and eighty chickpea genotypes obtained from Chickpea Breeding Unit, Pulse Research Laboratory, Division of Genetics, Indian Agricultural Research Institute, New Delhi (Annexure I). Two replications each, one for salted and one for normal sets were sown. Four seeds were sown in each cup and after establishment only 2 seedlings were maintained per cup. Seeds were sown at the optimum depth to get good germination and the cups were irrigated to optimum moisture at regular intervals.

Analysis of Variance (ANOVA) for CRD

Statistical analysis of Mean values of the samples from each replication was subjected to statistical software SPSS *vs.* 20 (IBM Corp.). The analysis of variance was carried out as per standard method (Panse and Sukhatme, 1964) for all the characters under study. Variance was analyse on the basis of following statistical model.

$$Y_{ij} = m + g_i + e_{ij}$$

Where, Y_{ij} is the phenotypic observation on i^{th}genotype in j^{th} replication, m is the general mean, g_i is the effect of i^{th} genotype, and e_{ij} is the random

RESULTS

Evaluation of seedling performance of genotypes in normal and salt stress conditions

Seedling screening under normal and salt stress condition was done as per the protocol of Vade z*et al.* (2007) for shoot length, root length, shoot weight, root weight, root dry weight and shoot dry weight. Variance was carried out for all the characters in normal and salt stressed condition. The mean sum of square due to genotypes was found to be highly significant for all the characters under study. The mean for all the genotypes for the characters under study is presented in Table 3. The mean sums of square are highly significant for all the characters studied indicating significant variability in the materials.

Breeding for salt tolerance is more challenging because of its complex character and precise requirement of screening environment which makes the job cumbersome. The analysis of variance for normal and salt stress conditions revealed that the differences among the genotypes were significant. The mean sum of square were highly significant for all the characters *viz.*, shoot length, root length, shoot weight, root weight, shoot dry weight and root dry weight in both normal and salt conditions studied indicating presence of significant variability in the materials (Table 1). The mean sum of square due to genotypes was found to be highly significant.

Under normal conditions , mean shoot length was 12.90 cm, with a minimum of 6cm and a maximum of 22 cm at 40 days of sowing whereas the shoot length in salt stressed pot ranged from 0 cm to 20 cm with an average of 7.14 cm. The root length varied from 2 cm to 14.5 cm with an average value of 9.12 cm in normal and 0 cm to 20 cm in stressed condition with a mean value of 5.56 cm indicating a considerable reduction in root biomass under salt stress.

Shoot weight varied from 0.11 g to 1.43 g with an average value of 0.60 g in normal condition while under salt stress it varied from 0 g to 1.12 g with a mean value of 0.29 g. Root weight showed a variation from 0.025 g to 0.795 g with an average value of 0.223 g under normal condition while under salt stress condition it varied from 0g to 0.59 g with an average of 0.063 g.

The oven dry shoot weight varied from 0g to 0.285 g with mean value of 0.112 g under normal condition and 0 g to 0.19 g with mean value of 0.044 g under stress condition which shows the variable performance of genotypes in different environments. The dry root weight mean value was 0.035 g and varied from 0 g to 0.115 g under normal condition and 0 g to 0.10 g with a mean of 0.015 g under salt stress condition (Table 2).

Table 1
Analysis of variance (ANOVA) for seedling traits under saline and normal environment

Sr. No.	*Character*	*Treatment (mss)*	*Error (mss)*	*F value*	*Sig.*
1.	SL	2983.105**	20.599	144.81	.000
2.	RL	984.196*	24.303	40.497	.000
3.	SW	10.198**	.065	157.627	.000
4.	RW	2.299**	.022	102.513	.000
5.	DSW	.416**	.002	197.695	.000
6.	DRW	.037**	.001	68.150	.000

** Significant at $P < 0.05$

Table 2
Percentage reduction of different trait under stress environment

Sr. No.	*Character*	*Avg. of Normal*	*Avg. of Stress*	*Per cent Reduction*
1.	Shoot length	12.90	7.14	44.65
2.	Root length	8.88	5.56	37.38
3.	Shoot weight	0.60	0.26	56.66
4.	Root weight	0.22	0.059	73.18
5.	Dry shoot weight	0.11	0.044	60
6.	Dry root weight	0.035	0.014	60

Table 3
Mean values of 180 chickpea genotypes in seedling screening experiment under both normal and salt stress environments

		N	S	N	S	N	S	N	S	N	S	N	S
S. No.	GENOTYPE	SL	SL	RL	RL	FSW	FSW	FRW	FRW	SDW	SDW	RDW	RDW
1.	ICCV00104	16.5	12	13	12.24	0.71	0.534	0.41	0.39	0.05	0.045	0.03	0.06
2.	ICCV00105	15.55	6	10.85	3.5	0.7	0.26	0.175	0.1	0.16	0.035	0.06	0.015
3.	ICCV00106	12.15	8.6	11.75	5.5	0.49	0.3	0.42	0.18	0.1	0.055	0.03	0
4.	ICCV00107	11.25	6.25	12.4	2.75	0.335	0.26	0.145	0.027	0.065	0.027	0.035	0.11
5.	ICCV00108	13.8	0	13	0	0.7	0	0.24	0	0.14	0	0.04	0
6.	ICCV00109	9.85	4.75	7.5	2	0.48	5.12	0.155	0.105	0.09	0.0275	0.0265	0
7.	ICCV00110	13.5	9.3	9.5	7.25	0.54	0.175	0.065	0.01	0.12	0.06	0.025	0
8.	ICCV00201	14.3	9.45	11.25	6	0.6	0.45	0.145	0.165	0.13	0.07	0.03	0.025
9.	ICCV00202	16.65	13	10.55	5	0.9	0.55	0.155	0.02	0.175	0.08	0.03	0
10.	ICCV01101	13.65	13	11.25	10	0.59	0.51	0.275	0.1	0.12	0.08	0.04	0.03
11.	ICCV01102	15.1	7.7	10	4	0.725	0.305	0.205	0.1	0.125	0.045	0.03	0.06
12.	ICCV01103	12.85	10.5	10.5	7.3	0.435	0.505	0.115	0.05	0.055	0.065	0.02	0.013
13.	ICCV01104	11	5.3	8.5	4.2	0.28	0.33	0.07	0.01	0.1	0.06	0.02	0
14.	ICCV03101	16.6	6.15	11.6	1.7	0.65	0.165	0.085	0.02	0.145	0.018	0.03	0.008
15.	ICCV03102	9.7	6.5	6	2.2	0.31	0.29	0.105	0.05	0.065	0.04	0.011	0.007
16.	ICCV03103	15.25	7.75	8.5	4.3	0.585	0.435	0.13	0.05	0.14	0.05	0.025	0.05
17.	ICCV03104	12.15	8.85	7.3	3.8	0.425	0.23	0.155	0.04	0.09	0.055	0.04	0.02
18.	ICCV03105	14.9	10.5	9.1	6.3	0.64	0.65	0.12	0.27	0.105	0.07	0.03	0.01
19.	ICCV03106	14.5	7.5	9.75	5.2	0.645	0.42	0.155	0.13	0.14	0.06	0.05	0.02
20.	ICCV03107	16.25	10.5	9.75	6	0.825	0.55	0.43	0.02	0.21	0.1	0.036	0.01
21.	ICCV03108	12.9	9	8.85	3.4	0.62	0.56	0.075	0.09	0.1	0.08	0.0165	0.03
22.	ICCV03109	12.15	9	8.8	4	0.455	0.34	0.15	0.01	0.095	0.07	0.0215	0
23.	ICCV03110	17.45	11.5	11.65	6	0.835	0.35	0.27	0.01	0.165	0.07	0.04	0
24.	ICCV03111	12	7	6.75	4.25	0.6	0.205	0.355	0.03	0.125	0.025	0.054	0.02
25.	ICCV03112	6	9	6.75	4	0.191	0.3	0.105	0.02	0.0355	0.05	0.03	0
26.	ICCV03201	11.2	8.15	8.5	1.5	0.43	0.32	0.105	0.03	0.11	0.04	0.025	0.01
27.	ICCV03202	13.5	7.75	8.75	5.75	0.515	0.3	0.125	0.035	0.105	0.045	0.016	0.014
28.	ICCV03203	12.5	12	8.75	2	0.6	0.12	0.145	0.01	0.1	0.02	0.03	0
29.	ICCV03204	14.25	10.25	10.75	6.25	0.595	0.385	0.105	0.02	0.135	0.065	0.055	0.01
30.	ICCV03205	11.5	11	7.2	3	0.46	0.35	0.0905	0.03	0.09	0.06	0.03	0.01
31.	ICCV03206	12.5	0	9.85	0	0.405	0	0.135	0	0.07	0	0.019	0
32.	ICCV03207	12.5	12.5	13	2	0.77	0.2	0.355	0.01	0.16	0.03	0.035	0
33.	ICCV03208	10.75	10	10.25	10	0.51	0.32	0.245	0.18	0.09	0.04	0.02	0.01
34.	ICCV03209	10.75	0	8.25	0	0.51	0	0.165	0	0.095	0	0.04	0
35.	ICCV03210	13.3	10.4	9	0	0.375	0	0.245	0	0.075	0.05	0.07	0
36.	ICCV03211	7.65	0	5.75	0	0.25	0	0.06	0	0.03	0	0.01	0
37.	ICCV03212	10	5.5	8	4	0.445	0.03	0.13	0.02	0.1	0.004	0.015	0
38.	ICCV03213	10.75	0	9.65	0	0.38	0	0.08	0	0.08	0	0.014	0
39.	ICCV03214	10.7	7.5	6.75	5	0.355	0.3	0.12	0.03	0.06	0.03	0.01	0.002
40.	ICCV04101	9.8	13	13.3	4	0.36	0.48	0.25	0.05	0.055	0.09	0.03	0.02

Cont. table 3

		N	S	N	S	N	S	N	S	N	S	N	S
S. No.	GENOTYPE	SL	SL	RL	RL	FSW	FSW	FRW	FRW	SDW	SDW	RDW	RDW
41.	ICCV04102	16.25	11.5	9.5	9	0.72	0.2	0.32	0.02	0.14	0.04	0.038	0.01
42.	ICCV04103	12.25	0	8.75	0	0.61	0	0.37	0	0.1	0	0.05	0
43.	ICCV04104	11.5	12	8	7	0.305	0.42	0.185	0.05	0.05	0.08	0.015	0.03
44.	ICCV04105	10.75	11	8	3	0.425	0.47	0.175	0.03	0.075	0.075	0.04	0.024
45.	ICCV04106	12.5	0	12.6	0	0.515	0	0.055	0	0.11	0	0.01	0
46.	ICCV04107	12.25	7.9	8.9	3	0.47	0.4	0.15	0.04	0.09	0.03	0.04	0.01
47.	ICCV04108	14.25	0	9.5	0	0.67	0	0.27	0	0.125	0	0.06	0
48.	ICCV04109	8.75	3.5	11	3.01	0.295	0.11	0.25	0.06	0.075	0.03	0.03	0.02
49.	ICCV04110	12.9	0	8.75	0	0.365	0	0.07	0	0.075	0	0.02	0
50.	ICCV04111	13.75	9.5	9.35	13	0.635	0.375	0.19	0.11	0.13	0.055	0.015	0.02
51.	ICCV05102	13.3	4	10.6	3.6	0.775	0.02	0.15	0.01	0.17	0	0.025	0
52.	ICCV05103	12.65	6	9.25	0	0.63	0.14	0.13	0	0.115	0.03	0.02	0
53.	ICCV05105	16.75	12	10	12	1.265	0.53	0.475	0.05	0.25	0.1	0.068	0.02
54.	ICCV05106	16	0	9	0	1.43	0	0.65	0	0.25	0	0.07	0
55.	ICCV05107	9	0	5	0	0.23	0	0.05	0	0	0	0	0
56.	ICCV05109	13	0	8	0	0.475	0	0.09	0	0.12	0	0.033	0
57.	ICCV05110	10.6	12	3.25	11	0.385	0.43	0.025	0.05	0.065	0.09	0.02	0.01
58.	ICCV05112	7.25	0	3	0	0.235	0	0.08	0	0.07	0	0.02	0
59.	ICCV05113	17.1	0	11.25	0	0.665	0	0.095	0	0.145	0	0.015	0
60.	ICCV05114	10.25	12	7.5	20	0.305	0.75	0.035	0.2	0.075	0.12	0.01	0.03
61.	ICCV2	23.5	11	15.35	13.2	1.06	0.325	0.71	0.02	0.115	0.075	0.105	0.04
62.	ICCV05116	10	0	5	0	0.13	0	0.03	0	0.04	0	0.008	0
63.	ICCV06101	25	16.5	12.25	11.2	0.96	0.76	0.475	0.42	0.11	0.095	0.045	0.03
64.	ICCV06102	7.4	0	4	0	0.18	0	0.06	0	0.035	0	0.02	0
65.	ICCV06103	11.55	0	8	0	0.49	0	0.16	0	0.095	0	0.02	0
66.	ICCV92337	16.5	6.5	14.5	13.60	0.755	0.56	0.53	0.32	0.07	0.04	0.045	0.01
67.	ICCV06105	12	0	5.5	0	0.45	0	0.08	0	0.06	0	0.01	0
68.	ICCV06106	13.1	13	9.25	10	0.68	0.35	0.2	0.05	0.155	0.07	0.03	0.01
69.	ICCV06107	13.25	0	6.7	0	0.65	0	0.075	0	0.11	0	0.01	0
70.	ICCV06108	11	0	6	0	0.34	0	0.09	0	0.06	0	0.01	0
71.	ICCV06109	14.25	0	11.25	0	1.05	0	0.46	0	0.19	0	0.1	0
72.	ICCV07101	12.5	0	10.5	0	0.72	0	0.38	0	0.12	0	0.05	0
73.	ICCV07102	10	9.5	8.5	14	0.425	0.3	0.11	0.09	0.075	0.08	0.025	0.03
74.	ICCV07103	10.9	0	9.25	0	0.495	0	0.16	0	0.09	0	0.03	0
75.	ICCV07104	8.75	7	9.5	2	0.445	0.21	0.17	0.02	0.08	0.03	0.025	0.01
76.	ICCV07105	8.75	3.5	9.25	28	0.345	0.18	0.47	0.14	0.065	0.02	0.02	0.03
77.	ICCV07106	9.35	14	6.6	16	0.31	0.5	0.045	0.14	0.045	0.15	0.01	0.08
78.	ICCV07107	13	0	10.2	0	0.72	0	0.25	0	0.11	0	0.02	0
79.	ICCV10316	22.5	9	15	8.32	1.03	0.61	0.68	0.23	0.09	0.05	0.07	0.01
80.	ICCV07109	12.75	0	49.05	0	0.765	0	0.2	0	0.15	0	0.055	0
81.	ICCV3302	22	8	14	13.2	0.93	0.79	0.495	0.36	0.095	0.02	0.04	0.04
82.	ICCV07111	9.1	0	8.5	0	0.2	0	0.05	0	0.04	0	0.01	0

Cont. table 3

		N	S	N	S	N	S	N	S	N	S	N	S
S. No.	GENOTYPE	SL	SL	RL	RL	FSW	FSW	FRW	FRW	SDW	SDW	RDW	RDW
83.	ICCV07112	11	12	7	15	0.405	0.58	0.055	0.07	0.075	0.16	0.01	0.02
84.	ICCV07113	8.75	16.5	6	8	0.56	0.73	0.205	0.08	0.1	0.18	0.05	0.02
85.	ICCV07114	11	5	6	6	0.48	0.4	0.13	0.08	0.07	0.04	0.04	0.03
86.	ICCV07115	11.25	0	6.75	0	0.53	0	0.14	0	0.09	0	0.015	0
87.	ICCV07116	9.85	0	8.85	0	0.52	0	0.13	0	0.08	0	0.02	0
88.	ICCV07117	9.4	13.5	4.7	6.5	0.48	0.8	0.065	0.1	0.09	0.15	0.105	0.06
89.	ICCV07118	8.5	9.25	4.5	7.3	0.37	0.425	0.03	0.09	0.08	0.07	0.007	0.025
90.	ICCV08101	8.75	0	7.5	0	0.279	0	0.18	0	0.1	0	0.045	0
91.	ICCV01318	26	14.5	17	13.67	0.91	0.75	0.44	0.39	0.11	0.065	0.03	0.01
92.	ICCV08103	13.75	0	8.5	0	0.64	0	0.11	0	0.115	0	0.04	0
93.	ICCV08104	10.15	13	6.25	6.7	0.445	0.79	0.04	0.11	0.11	0.14	0.035	0.03
94.	ICCV08105	11.5	0	8.1	0	0.595	0	0.165	0	0.105	0	0.03	0
95.	ICCV08106	17.5	0	12	0	1.13	0	0.41	0	0.205	0	0.065	0
96.	ICCV08107	11.25	0	8.25	0	0.48	0	0.17	0	0.095	0	0.015	0
97.	ICCV08108	8.1	6	5.5	16	0.29	0.36	0.04	0.12	0.055	0.06	0.017	0.04
98.	ICCV08109	10.25	0	7	0	0.445	0	0.12	0	0.07	0	0.03	0
99.	ICCV08110	11.1	12	9.5	13	0.735	0.47	0.305	0.09	0.13	0.17	0.035	0.03
100.	ICCV08111	12	12	2.85	23.5	0.46	0.42	0.063	0.03	0.065	0.065	0.003	0.008
101.	ICCV09101	13.2	0	10.25	0	0.335	0	0.065	0	0.07	0	0.01	0
102.	ICCV09102	9.5	9.5	7.5	7.5	0.47	0.35	0.115	0.01	0.08	0.07	0.02	0
103.	ICCV09103	7.75	0	5.75	0	0.28	0	0.035	0	0.045	0	0.03	0
104.	ICCV09104	13.1	12.5	8.75	12	0.525	0.56	0.1	0.04	0.09	0.13	0.015	0.015
105.	ICCV09105	9.75	0	4.75	0	0.28	0	0.03	0	0.045	0	0.0085	0
106.	ICCV09106	14.05	0	11	0	0.73	0	0.205	0	0.125	0	0.025	0
107.	ICCV09107	11.75	0	7.75	0	0.53	0	0.11	0	0.11	0	0.03	0
108.	ICCV09108	10	0	7.75	0	0.295	0	0.06	0	0.055	0	0.01	0
109.	ICCV09109	13.9	11.5	9	16	0.645	0.67	0.13	0.05	0.12	0	0.05	0
110.	ICCV09110	17.4	14	9.5	10	0.795	0.62	0.205	0.13	0.17	0.09	0.04	0.02
111.	ICCV09111	13.5	12.5	10.5	11	0.585	0.35	0.265	0.09	0.11	0.03	0.025	0.03
112.	ICCV09112	13.35	5.5	10.5	2	0.645	0.085	0.28	0.01	0.12	0.01	0.025	0
113.	ICCV09113	15.1	0	12.25	0	0.795	0	0.22	0	0.15	0	0.03	0
114.	ICCV09114	11.9	13.5	9.9	5.6	0.51	0.45	0.135	0.02	0.1	0.004	0.015	0.008
115.	ICCV09115	9	0	6.75	0	0.3	0	0.03	0	0.055	0	0.015	0
116.	ICCV09116	15.1	14.2	10	7.5	0.815	0.8	0.15	0.01	0.165	0.11	0.055	0
117.	ICCV09117	14	14	8	8.5	0.93	0.66	0.26	0.17	0.14	0.08	0.04	0.02
118.	ICCV09118	6.25	10.5	8.5	14	0.525	0.31	0.135	0.05	0.095	0.07	0.03	0.012
119.	ICCV10	19	11.5	14.5	14.26	0.8	0.68	0.7	0.37	0.125	0.08	0.115	0.02
120.	ICCV10101	9.6	0	6.5	0	0.51	0	0.105	0	0.09	0	0.015	0
121.	ICCV10102	12.3	11	8.5	5.5	0.47	0.48	0.095	0.03	0.11	0.09	0.05	0.01
122.	ICCV10103	16.25	0	11.5	0	0.78	0	0.38	0	0.185	0	0.065	0
123.	ICCV10104	15.5	10	11.1	0	0.86	0.07	0.2	0	0.165	0.04	0.055	0
124.	ICCV10105	9.1	12.5	7	3	0.455	0.45	0.19	0.02	0.085	0.08	0.035	0

Cont. table 3

		N	S	N	S	N	S	N	S	N	S	N	S
S. No.	GENOTYPE	SL	SL	RL	RL	FSW	FSW	FRW	FRW	SDW	SDW	RDW	RDW
125.	ICCV10106	14.25	0	8	0	0.76	0	0.31	0	0.145	0	0.04	0
126.	ICCV10107	10.15	0	6.5	0	0.435	0	0.06	0	0.08	0	0.015	0
127.	ICCV10108	13.5	0	7.5	0	0.555	0	0.13	0	0.095	0	0.04	0
128.	ICCV10109	19	4	11.25	1.5	1.055	0.02	0.255	0.1	0.2	0.01	0.06	0
129.	ICCV10111	26	20	14.5	12.1	1.32	0.89	0.61	0.4	0.065	0.065	0.03	0.02
130.	ICCV10111	21	20	10.5	14.5	1.29	0.37	0.57	0.265	0.135	0.065	0.03	0.06
131.	ICCV10112	15.7	12.8	9.5	13	0.535	0.44	0.04	0.05	0.105	0.09	0.008	0.02
132.	ICCV10113	9	0	5.55	0	0.295	0	0.03	0	0.055	0	0.0075	0
133.	ICCV10114	6.9	0	2	0	0.11	0	0.025	0	0.025	0	0.008	0
134.	ICCV10115	16.2	10	12.45	12	0.815	0.48	0.15	0.05	0.145	0.08	0.055	0.02
135.	ICCV10116	14.1	7.2	8.2	0	0.78	0.18	0.24	0	0.145	0.05	0.065	0
136.	ICCV10117	12.55	16.5	9	14	0.64	1.21	0.175	0.83	0.105	0.08	0.025	0.12
137.	ICCV10118	16.05	16	9.65	13.5	0.995	0.865	0.415	0.12	0.145	0.095	0.075	0.06
138.	ICCV88202	10.8	0	8.4	0	0.46	0	0.16	0	0.115	0	0.025	0
139.	ICCV92944	12.6	10.5	7.6	15	0.675	0.65	0.135	0.14	0.13	0.08	0.055	0.03
140.	ICCV93122	14.6	13.5	9.8	16	0.675	0.83	0.14	0.59	0.12	0.12	0.04	0.11
141.	ICCV95138	11.2	10	4.5	11	0.475	0.6	0.07	0.07	0.075	0.05	0.01	0.02
142.	ICCV97016	10.6	11.15	8.25	11	0.37	0.405	0.155	0.09	0.075	0.08	0.04	0.07
143.	ICCV97022	13.9	9	7.75	14	0.705	0.175	0.195	0.03	0.135	0.036	0.03	0.009
144.	ICCV97024	10.4	0	4.75	0	0.39	0	0.16	0	0.195	0	0.01	0
145.	ICCV97033	11.75	9.5	6	1.5	0.395	0.13	0.085	0.01	0.065	0.04	0.02	0
146.	ICCV97103	12.2	9.5	8.25	4	0.515	0.34	0.27	0.02	0.08	0.07	0.04	0
147.	ICCV97106	11.65	10.5	8.75	17	0.58	0.75	0.23	0.53	0.105	0.13	0.05	0.06
148.	ICCV97107	9.4	12.5	6.55	18	0.33	1.12	0.095	0.81	0.05	0.19	0.035	0.1
149.	ICCV97108	14.8	16.8	4.5	10	0.48	0.35	0.05	0.05	0.06	0.12	0.014	0.01
150.	ICCV97109	15	0	9	0	0.56	0	0.19	0	0.09	0	0.07	0
151.	ICCV97110	15.4	0	10.4	0	1.1	0	0.42	0	0.23	0	0.02	0
152.	ICCV97114	13.15	0	9.5	0	0.595	0	0.245	0	0.09	0	0.035	0
153.	ICCV97115	12.35	8.6	8.85	12	0.755	0.36	0.285	0.04	0.16	0.09	0.02	0.02
154.	ICCV97117	12.8	12.2	11.35	10.4	0.565	0.32	0.265	0.04	0.1	0.08	0.035	0
155.	ICCV97119	24	13	14.5	13.2	1.315	0.78	0.66	0.34	0.125	0.07	0.07	0.03
156.	ICCV97125	9	11	5	9	0.43	0.88	0.11	0.39	0.12	0.14	0.01	0.05
157.	ICCV97126	8.1	0	6.5	0	0.34	0	0.055	0	0.065	0	0.015	0
158.	ICCV97127	10.1	11	6.5	16	0.52	0.76	0.215	0.2	0.09	0.12	0.03	0.06
159.	JG11	11	0	7	0	0.36	0	0.05	0	0.08	0	0.01	0
160.	JAKI9218	9.35	9	7.5	7	0.41	0.3	0.205	0.02	0.075	0.07	0.024	0
161.	CSG8962	24	17	17	14.56	1.085	0.93	0.705	0.45	0.15	0.033	0.11	0.01
162.	JG62	24.5	18.6	17	16.72	0.925	0.74	0.74	0.39	0.1	0.04	0.105	0.01
163.	PUSA1103	26	19.5	17	13.23	1.045	0.4	0.465	0.05	0.155	0.06	0.07	0.03
164.	AVARODHI	27	14.5	16.5	10.56	0.87	0.495	0.52	0.08	0.075	0.075	0.03	0.035
165.	BGD112	14	10.2	15.5	9.98	0.61	0.395	0.415	0.02	0.065	0.075	0.03	0.01
166.	ANNEGIRI	19	16.5	11.25	9.98	1.11	0.43	0.225	0.04	0.125	0.07	0.04	0.05

Cont. table 3

		N	S	N	S	N	S	N	S	N	S	N	S
S. No.	GENOTYPE	SL	SL	RL	RL	FSW	FSW	FRW	FRW	SDW	SDW	RDW	RDW
167.	SBD377	20	14	14.65	10.23	0.77	0.011	0.625	0.18	0.08	0.035	0.055	0.01
168.	PUSA362	24	13	16.5	14.56	0.995	0.13	0.6535	0.09	0.085	0.02	0.07	0.03
169.	ICC1882	20	9	15.5	12.32	0.87	0.185	0.45	0.17	0.085	0.03	0.035	0.01
170.	ICC4958	18	6	13.5	10.23	0.87	0.17	0.34	0.05	0.055	0.01	0.02	0.01
171.	PUSA547	14	11	14.25	11.98	0.535	0.245	0.51	0.02	0.04	0.06	0.03	0.015
172.	PUSA72	26.5	18.8	14.25	13.6	1.215	0.89	0.55	0.36	0.125	0.055	0.06	0.02
173.	L550	16.5	13	14.5	11.72	0.555	0.42	0.605	0.25	0.075	0.07	0.055	0.01
174.	GOKCEE	27	10.5	17.65	15.2	1.175	0.225	0.705	0.16	0.18	0.035	0.11	0.01
175.	IG5844a	26.5	7	18.5	8.65	1.19	0.21	0.835	0.01	0.17	0.02	0.1	0.01
176.	IG5856	24	9	13	10.32	1.055	0.185	0.295	0.05	0.095	0.045	0.03	0.07
177.	IG5857	17.5	10	14.5	6.67	0.65	0.325	0.305	0.04	0.09	0.06	0.015	0.03
178	IG5884	17	10.5	15.5	10.54	0.985	0.25	0.67	0.14	0.13	0.04	0.1	0.01
179.	IG5894	21.5	10	16	7.8	0.98	0.26	0.755	0.02	0.075	0.06	0.09	0.06
180.	IG5906	26	9.5	17.5	9.87	0.855	0.28	0.605	0.01	0.075	0.045	0.055	0.01

N: normal environment; S: salt stress environment

Under salt stress condition there was sufficient decrease in the mean of most the characters understudy. In biomass related study shows that salinity reduces the Root weight by (73.18%) followed by Dry shoot weight and Dry root weight both reduced by (60%), Shoot weight reduced by (56.66%), Shoot length (44.65%) and Root length showed reduction up to (37.38%) under salt stress condition. This shows Irrespective of genotypes the normal grown seedlings had higher values for all the parameters under study while those grown under salt stress had reduced values for all the traits

The present study clearly demonstrated the efficiency of seedling screening for preliminary large scale screening of genotypes for salt tolerance of the present material having considerable amount of genetic variability for salt tolerant related traits. Tripti *et al* 2015also reported seedling screening as an efficient tool for identifying salt tolerance and that there exists close correlation between adult plant tolerance and seedling salt tolerance. Salt tolerant genotypes with low mean yield have no commercial value however can be used as donors in breeding programme. Salt tolerant genotypes with good economic yield under saline environments could be of immense potential for further direct utilization in varietal development for salt stress environments.

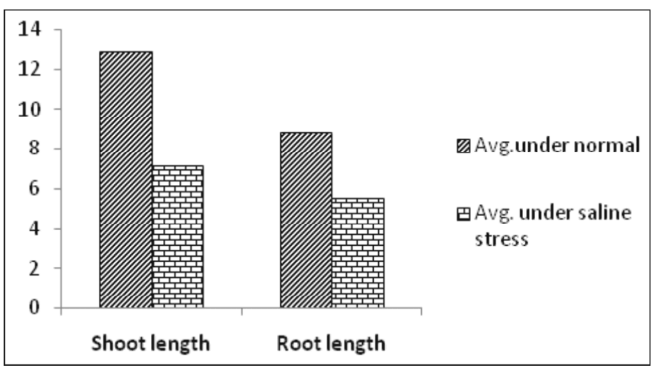
DISCUSSION

The present investigation was carried out to evaluate chickpea genotypes consisting of training population consisting of breeding lines, already reported sources of resistance sources to salinity, newly released varieties and some land races consisting both *desi* and *Kabuli* chickpea lines obtained from Chickpea Unit, Division of Genetics, IARI, New Delhi, India for studying variability under seedling salinity stress.

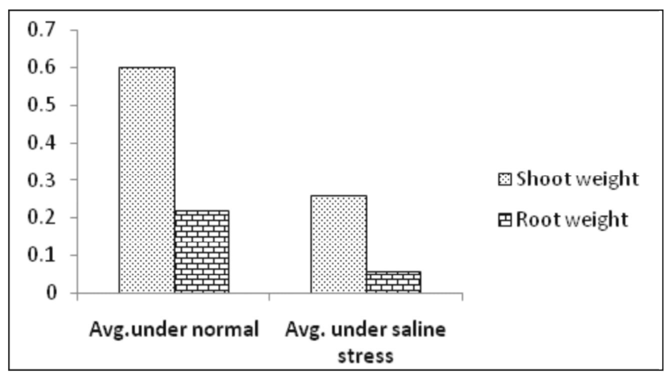
The analysis of variance carried out for all the seedling characters studied under stress were found to be highly significant. Knowledge on nature and magnitude of genotypic and phenotypic variability present in any crop species plays an important role in formulating successful breeding program. In case the variability is very much limited or exhausted due to continuous selection, it is necessary to plan for recombination breeding program for further genetic amelioration. The finding of this investigation will help in the selection of genotype based on their *per se* performance. The mean sum of square are highly significant for all the characters studied indicating significant variability in the materials. The selective capacity depends upon the amount of the heritable variation present. Drought, heat and salinity are three of the most important abiotic stresses that alter plant water status and severely limit plant growth and development. Salinity is one of the major abiotic stresses ranking only second to drought which affects crop productivity in many parts of the world (Rangasamy, 2006). Breeding for salinity tolerance requires presence of considerable variation among the genotypes to be used for breeding purposes. A major constraint of modern agriculture is not only mismanagement of nutrients and land, but also water. In areas where evaporation is very high this problem is many fold. Particularly in areas of chickpea production in world like arid and semi-arid regions, soil salinization is becoming a major constraint (Garg and Singla, 2009).

Hence, it is imperative to develop sustainable cultivars tolerant to salinity. Among the legumes, chickpea is relative salt sensitive (Lauter and Munns, 1986). However being a crop of arid and semi-arid regions the probability of existing of variability in the germplasm for this trait cannot be ruled out (Soussi *et al.*, 1999; Rao *et al.*, 2002). Genetic analysis of seedling salt stress is prerequisite for breeders in selection of desired genotypes. Along with morphological traits, efforts have been put for the genetic improvement in chickpea for various traits. The variation in salinity tolerance depends on various characters such as genotype, seed characteristics, seed composition, climatic factors etc. Seedling salinity tolerance is the most important prerequisite since this character helps the tolerant genotypes to establish in saline soils and grow.

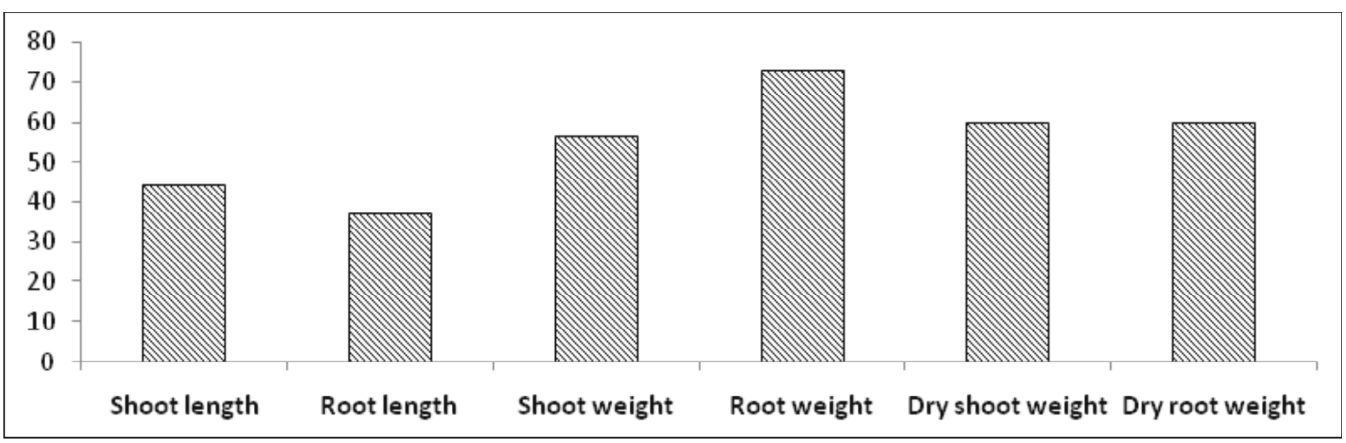
Chickpea is considered as moderately salt tolerant crop species but it shows variation between genotypes in response to saline environment. The deleterious effects of salt stress on plant growth and biomass yield have been associated with reduction in yield parameters. In pursuit to cope up with stress, plants have developed various combating mechanisms to subside the deleterious effects due to salt stress.



1. Percentage Reduction in shoot and root lengths in seedling screening



2. Percentage Reduction in shoot and root fresh weights in seedling screening



3. Percentage Reduction of different seedling growth parameters under saline conditions

Figure 1: Percentage reduction of different trait under stress environment condition

Comparative Performance of Genotypes in Seedling Stage in Normal and Saline Conditions

The mean performance for different characters in normal and salt environments revealed that wide range of estimates for characters under study. Irrespective of genotypes the normal grown seedlings had higher values while those grown under salt stress had reduced values for all the traits percentage of reduction for various traits are presented in table 2. The analysis of variance for normal and saline stress conditions for seedling screening revealed that the differences among the genotypes were significant. The mean sum of square was highly significant for all the characters under saline stress conditions indicating presence of significant variability in the materials.

Increases in agricultural productivity are closely related to the availability of irrigation water for the crops. Chickpea like many other leguminous crops is highly sensitive to terminal moisture stress. The deleterious effects of moisture stress on plant growth have been associated with reduction in yield parameters. Physiologically, many processes are affected, but the most notable are reduced cell growth and decreased leaf area, biomass and yield. In pursuit to cope up with stress phenomenon, plants have developed various combating mechanisms to subside the deleterious effects due to moisture stress. These mechanisms of stress tolerance vary both at inter-species and at inter-varietal level, and even between stages of growth and development. Moisture stress tolerance becomes more complicated in cases where the plant response varies with the stage of stress and the environmental conditions in which it is grown.

In present study various seedling growth and physiological parameters like seedling shoot and root length, fresh and dry weights were studied to ascertain the performance and efficiency of genetically diverse chickpea lines to seedling salinity stress. Since seedling roots play a major role in establishment of seedling and stem growth, a maximum reduction was seen in these parameters. The highly susceptible lines did not even germinate in saline soils. Similar findings were reported by Sivasankarmooorthy (2013), while studying the seedling saline stress of chickpea seedlings. A tolerant genotype was able to produce better root and shoot growth and was able to establish under saline conditions than a susceptible genotype. When growth resources are limited by saline conditions in seedling stages, the plant stand and overall decrease in pot yield will be seen. The present study clearly demonstrated the presence of considerable amount of genetic variability for salinity tolerant related traits among both the released and breeding lines of chickpea. Genotypes showing minimum reduction in seedling characters in salt stress conditions mainly were ICCV 00104, ICCV 06101,CSG8962 and JG62.These will provide immense opportunity to breeder to combine them together in developing the saline tolerant genotypes as well as to study the growth and performance of genotypes under saline conditions.

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