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Original article

Screening of Kabuli-type chickpea genotypes for salinity tolerance under field condition

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Extended abstract

Introduction

Chickpea (*Cicer arietinum* L.) is one of the important legume crops and globally, after beans (*Phaseolus* spp), chickpea is ranked as a second important legume crop (Roy et al., 2010). Chickpea is an important source of proteins for human consumption, especially in the developing countries where people cannot provide animal protein or vegetarian by choice (Zaccardelli et al., 2013). Chickpea plays an important role in the maintenance of soil fertility through nitrogen fixation (Roy et al., 2010). Plants are exposed to wide range of environmental stresses. In among, Salinity is one of the major abiotic stresses causing severe impact on crop production worldwide (Rasool et al., 2012).chickpea is a salt sensitive pulse crop and its yield is seriously affected mainly by salts (Turner et al., 2013). Salinity stress in chickpea adversely affects several morphological features and physiological processes like reduction in growth and ion balance, water status, photosynthesis, increase in hydrogen peroxide, which causes lipid per oxidation and consequently membrane injury. Also proline and carbohydrates are accumulated in plant tissue (Flowers et al., 2010; Ashraf and Harris, 2004). This study is designed to determine the effect of salt stress on physiological and biochemical parameters in chickpea genotypes exhibiting differences in salinity tolerance. The results of this study could provide information on potential physiological and biochemical parameters and could also provide deeper intelligence into tolerance mechanisms than the stresses caused by salinity.

Materials and methods

This experiment was conducted as split-plot based on randomized complete block design with three replications in 2018 at Ferdowsi University of Mashhad, Mashhad, Iran. Salinity with two levels of 0.5 and 8 dSm-1 (NaCl) was considered as main plot and chickpea genotype (17 Kabuli-type genotypes) as sub-plot. The characteristics such as soluble carbohydrates, proline, osmotic potential, MDA, DPPH, relative water content, MSI%, were evaluated in 50% of flowering. At the end of the growing season, crop was harvested and seed yield were determined .

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Results

The highest proline and carbohydrates content was observed in MCC65, MCC92 and MCC95 genotypes, and the lowest in MCC12 genotype. Result salinity stress caused increased 24, 19 and 19% in the amount of osmotic potential, MDA and DPPH. Relative leaf water content and membrane stability was showen respectively 10 and 13% reduction by use salinity stress. Survival percentage, number of branches and canopy height had reduction 6, 22 and 57. MCC65, MCC92 and MCC95 genotypes respectively by 0.183, 0.193 and 0.181 (Kg.m-2) had the highest seed yield and MCC98 and MCC298 had the lowest seed yield. The MCC65, MCC95 and MCC92 genotypes had superior traits, including performance in stress conditions compared to other genotypes, and on the other hand, the MCC98 and MCC298 genotypes had the lowest performance. Among 17 chickpea genotypes, the highest sodium content belonged to MCC95 genotype with 9.5 (mg.g.dw-1) weight and the lowest sodium MCC65 genotype with 5.8 (mg.g-1dw). MCC65 had the highest potassium in non-stress and MCC95 had the highest potassium in salinity stress.

Conclusions

The MCC65, MCC95 and MCC92 genotypes had superior traits, including performance in stress conditions compared to other genotypes, and on the other hand, the MCC98 and MCC298 genotypes had the lowest performance. Finally, further study in relation to the top three genotypes in salinity stress conditions is proposed to identify stress tolerance mechanisms as well as infrastructure as breeding programs.

Keywords**:** Potassium, Osmotic potential, Prolin, Seed yeild, Relative water content

Table 1. Used chickpea genotypes and their origins

No	Seed bank ID		Origin
1	MCC12		IRAN
2	MCC65	Flip88-32C	ICARDA
3	MCC72	5302	ICRISAT
4	MCC77	Flip86-58C	ICARDA
5	MCC92	12228	ICRISAT
6	MCC95	217655	ICRISAT
7	MCC98	6102	ICRISAT
8	MCC139	217897	ICRISAT
9	MCC158	2217	ICRISAT
10	MCC298	CIYT-610	
11	MCC313	Flip90-183C	ICARDA
12	MCC420		IRAN
13	MCC483	Flip93-250C	ICARDA
14	MCC485	Flip93-252C	ICARDA
15	MCC500	Sel95TH1722	ICARDA
16	MCC679		IRAN
17	MCC776	Flip97-111C	ICARDA

MCC: Mashhad Chickpea Collection

Table 2. Physical and chemical properties of the soils used in the field experiments

Organic carbon	EC	pH	K	P	N	Texture
%	$dS.m^{-1}$		--------mg.kg^{-1}----------		%	
0.739	1.2	7.56	157	17.5	0.07	Sandy loam

Table 3. Analysis of variance (Mean squar) efffect of salinity on soluble carbohydrates, proline, osmotic potential, MDA, DPPH, relative water content and MSI in chickpeas genotypes

S.O.V	df	Soluble carbohydrates	Proline	Osmotic potential	MDA	DPPH DPPH	Relative water content	MSI
Block	2	0.938*	0.102^{ns}	1.290**	21.76^{ns}	0.0013^{ns}	22.67^{ns}	9.86*
Salinity(S)	1	33.58**	127.1**	5.642**	1905**	0.1029**	1187**	1972**
Error a	2	0.240	0.080	0.343	12.89	0.0003	65.82	13.04
Genotyp (G)	16	2.849**	2.117**	0.526**	308.5**	0.004**	109.9**	233.7**
S × G	16	2.925**	1.331**	0.344**	16.45*	0.0013**	111.7**	8.150**
Error	64	0.163	0.224	0.051	7.570	0.0005	23.40	2.300
CV%		*19*	*15*	*10*	*5*	*6*	*7*	*2*

ns: no significant,*: significant at probability level of 5%, **: significant at probability level of 1%, CV: Coefficient variation.

Table 4. Effect of salinity stress on soluble carbohydrates, proline, osmotic potential, MDA, DPPH, relative water content and MSI in chickpeas genotypes

Salinity level	Genotyp	Soluble carbohydrate	Proline	Osmotic potential	MDA	DPPH	RWC	MSI
		-------------mg.gfw^{-1}	-------------	Mpa	nm.gFw^{-1}	mg ascorbat.gFw^{-1}	-------- %	--------
0.5 dS.m^{-1}	**MCC12**	2.14^{e}	2.35^{de}	2.05^{bd}	53.71^{ef}	0.270^{k}	78.1^{b}	80.8^{cd}
	MCC65	1.34^{fg}	2.37^{de}	1.95^{bc}	54.20^{cd}	0.350^{d-j}	64.4^{d-h}	88.5^{a}
	MCC72	2.26^{cd}	1.97^{f}	1.92^{bc}	46.74^{gh}	0.317^{g-k}	72.4^{a-h}	77.1^{de}
	MCC77	1.79^{ef}	1.87^{f}	1.99^{bc}	56.74^{bc}	0.303^{i-k}	87.5^{a}	71.2^{e-g}
	MCC92	1.23^{fg}	1.98^{f}	2.10^{bc}	57.82^{bc}	0.320^{f-k}	75.2^{a-f}	87.4^{a}
	MCC95	0.75^{g}	1.71^{f}	2.21^{bc}	46.94^{gh}	0.353^{d-j}	61.0^{f-h}	86.3^{a}
	MCC98	1.83^{ef}	2.36^{de}	2.11^{bc}	43.12^{ij}	0.323^{e-k}	76.7^{a-f}	74.9^{d-f}
	MCC139	1.89^{ef}	2.71^{de}	1.85^{bc}	41.86^{ij}	0.350^{d-j}	82.2^{ab}	76.2^{de}
	MCC158	3.37^{ab}	1.63^{fg}	1.90^{bc}	44.97^{h-j}	0.307^{e-k}	73.1^{a-h}	75.8^{de}
	MCC298	0.74^{g}	1.95^{f}	1.50^{c}	34.33^{j}	0.350^{d-j}	76.7^{a-f}	76.9^{de}
	MCC313	0.70^{g}	1.73^{f}	1.99^{bc}	43.43^{ij}	0.333^{e-k}	73.7^{a-h}	72.2^{e-g}
	MCC420	1.67^{f}	1.78^{f}	1.88^{bc}	54.87^{cd}	0.367^{c-i}	80.9^{ab}	85.4^{ab}
	MCC483	1.46^{f}	1.87^{f}	2.06^{bc}	36.73^{ij}	0.293^{jk}	79.2^{a-d}	81.7^{bc}
	MCC485	1.90^{ef}	1.31^{i}	2.01^{bc}	37.55^{i}	0.343^{e-j}	67.5^{b-h}	70.7^{fg}
	MCC500	0.76^{g}	1.79^{f}	1.70^{bc}	46.98^{gh}	0.320^{f-k}	73.2^{a-h}	73.3^{d-f}
	MCC679	1.44^{f}	1.85^{f}	2.02^{bc}	43.08^{ij}	0.313^{g-k}	72.4^{a-h}	72.6^{e-g}
	MCC776	1.75^{ef}	1.92^{f}	1.80^{bc}	44.13^{h-j}	0.343^{e-j}	72.5^{a-h}	72.7^{e-g}
8 dS.m^{-1}	**MCC12**	2.50^{cd}	3.66^{bcd}	2.11^{bc}	64.06^{ab}	0.377^{b-h}	63.6^{d-h}	70.9^{fg}
	MCC65	4.68^{a}	6.52^{a}	3.50^{a}	55.04^{cd}	0.453^{a}	73.4^{a-h}	84.9^{ab}
	MCC72	3.43^{ab}	3.92^{bc}	2.20^{bc}	53.75^{de}	0.420^{a-d}	64.3^{d-h}	66.8^{l-m}
	MCC77	3.59^{ab}	4.66^{b}	2.06^{bc}	62.71^{ab}	0.373^{c-i}	76.1^{a-f}	65.5^{mn}
	MCC92	3.55^{ab}	6.59^{a}	3.53^{a}	69.05^{a}	0.430^{a-c}	58.2^{h}	79.8^{cd}
	MCC95	2.95^{bc}	4.02^{bc}	3.37^{a}	57.28^{bc}	0.446^{ab}	66.8^{b-h}	75.9^{de}
	MCC98	2.86^{bc}	4.19^{bc}	2.35^{b}	57.60^{bc}	0.377^{b-h}	64.3^{d-h}	65.5^{mn}
	MCC139	3.04^{bc}	4.87^{b}	2.13^{bc}	48.24^{f-h}	0.393^{a-c}	74.0^{a-g}	68.5^{fg}
	MCC158	0.63^{g}	3.25^{c-e}	2.05^{bc}	56.61^{bc}	0.370^{c-i}	65.6^{c-h}	64.0^{gh}
	MCC298	1.62^{f}	3.20^{c-e}	2.23^{bc}	42.13^{ij}	0.370^{c-i}	69.5^{b-h}	64.37^{gh}
	MCC313	1.61^{f}	3.55^{b-d}	2.14^{bc}	52.02^{ef}	0.380^{b-g}	72.2^{a-h}	63.7^{gh}
	MCC420	2.21^{cd}	3.95^{bc}	2.10^{bc}	63.44^{ab}	0.417^{a-d}	62.7^{c-h}	76.6^{de}
	MCC483	2.79^{b-d}	3.27^{c-e}	2.25^{bc}	42.05^{ij}	0.340^{e-k}	64.9^{d-h}	72.8^{e-g}
	MCC485	4.58^{a}	4.11^{bc}	2.13^{bc}	44.21^{hij}	0.357^{d-j}	77.6^{a-e}	65.1^{gh}
	MCC500	1.66^{f}	4.05^{bc}	2.31^{bc}	54.17^{d}	0.380^{b-g}	71.0^{b-h}	65.7^{gh}
	MCC679	0.76^{g}	3.14^{c-e}	2.19^{bc}	55.41^{bc}	0.363^{c-j}	67.4^{b-h}	61.9^{h}
	MCC776	4.07^{ab}	4.15^{bc}	2.40^{b}	56.38^{bc}	0.390^{a-f}	59.2^{gh}	62.3^{h}

Within each column, means fallowed by the same letter are not significantly different based on Duncan test ($p<0.05$).

Table 5. Analysis of variance (mean square) effect of salinity on plant heigh, number of branch, 100-seed weigh, seed yield, survival, Na, K and Na/K (%) in chickpeas genotypes

S.O.V	df	Plant heigh	Number of Branch	100-seed weigh	Seed yield	Survival	Na	K	Na/K
Block	2	54.72**	15.22**	12.77^{ns}	0.0014**	12.56^{ns}	0.820^{ns}	0.0869*	6.190^{ns}
Salinity (S)	1	1068**	64.3**	466**	0.1057**	900**	4230**	7.409**	2266**
Error a	2	0.740	5.765	5.775	0.0001	12.56	0.880	0.0732	5.630
Genotyp (G)	16	1390**	1.974^{ns}	59.56**	0.0078**	24.63^{ns}	5.650**	0.617**	19.35**
S × G	16	26.54**	1.928*	10.96^{ns}	0.0016**	24.63^{ns}	6.340**	0.254**	17.94**
Error	64	5.02	1.844	9.745	0.000004	26.88	0.440	0.0258	3.090
CV%		*6*	*17*	*12*	*2*	*5*	*8*	*14*	*27*

ns: no significant *: significant at probability level of 5%, **: significant at probability level of 1%, CV: Coefficient variation.

Table 6. Effect of salinity stress on plant heigh, number of branch, 100-seed weigh, seed yield, survival, Na, K and Na/K (%) in chickpeas genotypes

Salinity level	Genotyp	Plant height	Number of branch	100-seed weigh	Seed yield	Survival	Na	K	Na/K
		cm		g	$Kg.m^{-2}$	%	----- $mg.gdw^{-1}$ -----		
	MCC12	41.67^{bc}	9.33^{ab}	26.00^{a}	0.101^{j}	100^{a}	1.41^{f}	0.96^{fg}	1.50^{e}
	MCC65	42.67^{ab}	8.00^{ab}	29.67^{a}	0.218^{a}	100^{a}	1.36^{f}	1.40^{de}	1.08^{e}
	MCC72	47.00^{a}	9.33^{ab}	29.67^{a}	0.111^{j}	100^{a}	1.62^{f}	1.06^{ef}	1.51^{e}
	MCC77	49.67^{a}	9.00^{ab}	28.33^{a}	0.143^{g}	100^{a}	1.54^{f}	0.87^{g}	1.81^{e}
	MCC92	44.33^{ab}	8.33^{ab}	32.00^{a}	0.219^{a}	100^{a}	1.47^{f}	1.09^{e-k}	1.82^{e}
	MCC95	44.00^{ab}	8.00^{ab}	33.33^{a}	0.196^{b}	100^{a}	1.68^{f}	1.13^{ef}	1.51^{e}
	MCC98	41.00^{b-d}	8.33^{ab}	31.67^{a}	0.135^{h}	100^{a}	1.50^{f}	0.55^{h}	3.07^{de}
	MCC139	43.00^{ab}	9.33^{ab}	33.33^{a}	0.156^{f}	100^{a}	1.19^{f}	0.84^{g}	1.35e
0.5 $dS.m^{-1}$	**MCC158**	42.33^{ab}	8.33^{ab}	32.33^{a}	0.165^{e}	100^{a}	1.59^{f}	0.68^{g}	2.36^{de}
	MCC298	32.67^{fg}	9.33^{ab}	29.33^{a}	0.113^{i}	100^{a}	1.32^{f}	0.71^{g}	1.90^{e}
	MCC313	44.33^{ab}	10.00^{a}	23.67^{a}	0.128^{h}	100^{a}	1.32^{f}	0.63^{g}	2.26^{de}
	MCC420	44.00^{ab}	8.33^{ab}	23.33^{a}	0.135^{h}	100^{a}	1.48^{f}	1.12^{ef}	1.34^{e}
	MCC483	44.67^{ab}	7.67^{ab}	33.33^{a}	0.178^{c}	100^{a}	1.12^{f}	0.99^{fg}	1.13^{e}
	MCC485	47.00^{ab}	9.00^{ab}	29.00^{a}	0.174^{cd}	100^{a}	1.50^{f}	0.79^{g}	1.98^{e}
	MCC500	37.33^{d-f}	9.33^{ab}	27.00^{a}	0.162^{ef}	100^{a}	1.30^{f}	0.78^{gh}	1.70^{e}
	MCC679	38.33^{cd}	9.67^{ab}	26.67^{a}	0.148^{g}	100^{a}	1.46^{f}	0.80^{g}	1.91^{e}
	MCC776	36.33^{ef}	9.00^{ab}	25.00^{a}	0.143^{g}	100^{a}	1.98^{f}	0.73^{gh}	2.78^{de}
	MCC12	34.00^{fg}	8.00^{ab}	22.33^{a}	0.035^{o}	83^{a}	15.39^{ab}	1.12^{ef}	13.65^{ab}
	MCC65	39.67^{cd}	8.00^{ab}	28.33^{a}	0.149^{g}	100^{a}	15.23^{ab}	2.20^{b}	4.64^{d}
	MCC72	36.33^{ef}	8.00^{ab}	22.00^{a}	0.100^{i}	96^{a}	15.32^{ab}	1.52^{cd}	10.20^{bc}
	MCC77	47.00^{ab}	7.67^{ab}	22.00^{a}	0.143^{g}	95^{a}	15.39^{ab}	1.33^{de}	11.61^{ab}
	MCC92	44.33^{ab}	8.33^{ab}	28.67^{a}	0.167^{de}	97^{a}	14.76^{bc}	1.79^{bc}	6.09^{cd}
	MCC95	43.00^{ab}	7.67^{ab}	31.00^{a}	0.166^{e}	99^{a}	17.37^{a}	2.76^{a}	6.29^{cd}
	MCC98	35.33^{ef}	7.00^{ab}	25.33^{a}	0.047^{n}	95^{a}	12.13^{cde}	1.37^{de}	8.92^{bc}
	MCC139	36.33^{ef}	7.00^{ab}	30.67^{a}	0.086^{k}	94^{a}	16.23^{ab}	1.97^{bc}	8.25^{bc}
8 $dS.m^{-1}$	**MCC158**	35.33^{ef}	8.00^{ab}	27.67^{a}	0.071^{l}	90^{a}	14.79^{bc}	1.03^{efj}	14.52^{ab}
	MCC298	28.67^{g}	5.67^{ab}	19.00^{a}	0.040^{no}	96^{a}	17.06^{a}	1.31^{de}	13.37^{ab}
	MCC313	39.33^{cd}	6.67^{ab}	20.67^{a}	0.065^{lm}	95^{a}	13.28^{cd}	1.39^{de}	9.62^{bc}
	MCC420	28.00^{g}	7.33^{ab}	21.33^{a}	0.061^{lm}	89^{a}	14.87^{bc}	1.17^{ef}	12.81^{ab}
	MCC483	34.33^{fg}	5.33^{b}	24.33^{a}	0.065^{lm}	94^{a}	14.57^{bc}	1.11^{ef}	13.31^{ab}
	MCC485	41.33^{bc}	7.67^{ab}	25.33^{a}	0.092^{k}	95^{a}	10.17^{de}	1.00^{e-g}	15.93^{a}
	MCC500	24.33^{g}	6.67^{ab}	24.67^{a}	0.065^{lm}	90^{a}	12.96^{c-e}	0.97^{fg}	14.00^{ab}
	MCC679	30.67^{fg}	8.33^{ab}	24.33^{a}	0.087^{k}	95^{a}	13.46^{cd}	1.27^{de}	10.78^{a-c}
	MCC776	32.33^{fg}	6.00^{ab}	23.33^{a}	0.066^{lm}	96^{a}	10.82^{de}	0.97^{fg}	16.13^{a}

Within each column, means fallowed by the same letter are not significantly different based on Duncan test ($p<0.05$).

Table 7. Principal component loading for the measured trait of chickpea genotypes

Parameters	Factor	
	PCA 1	**PCA 2**
Proporation of total variation (%)	45.66	13.47
Soluble carbohydrates	-0.55	0.30
Proline	-0.85	-0.02
Osmotic potential	-0.89	0.05
DPPH	-0.82	-0.12
MDA	-0.45	-0.84
MSI	-0.75	-0.11
RWC	0.01	0.55
Plant height	-0.67	0.16
Number of branch	-0.54	-0.51
100-seed weigh	-0.65	0.13
Seed yield	-0.89	0.08
Survival	-0.55	0.65
Na	0.41	0.24
K	-0.81	0.28
Na/K	0.84	-0.11

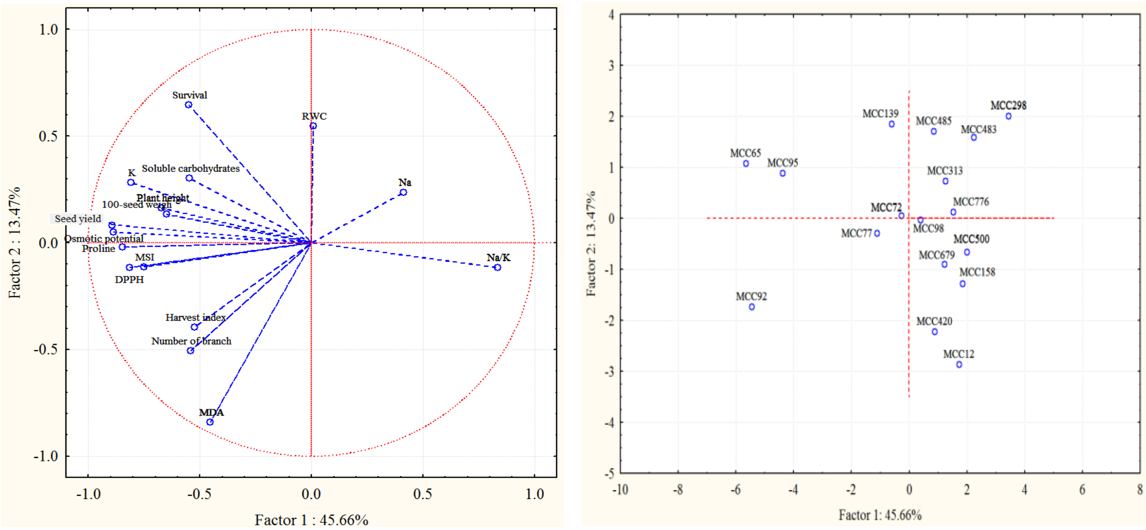

Fig 1. Biplot based on two major principal component factors.