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Screening chick-pea (*Cicer arietinum L.*) for salt tolerance

Prüfung von Kichererbsen (*Cicer arietinum L.*) auf Salztoleranz

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1 Introduction

Salinity is one of the major stress factors which limits crop production in most of the arid and semiarid regions. For example in the western USA, crop production is reduced by salinity possibly as much as 25% on all irrigated land (CARTER, 1975).

However, many measures have been adopted by soil scientists to overcome the salinity problem, but these measures are expensive in terms of money and labour. A possible alternative is the development of crop cultivars/lines or hybrids that are capable of resisting high salt concentrations and producing economic yields under such conditions. This approach has gained considerable attention from many workers (ASHRAF et al. 1986; EPSTEIN, 1985; SANDHU and QUERESHI, 1986; SHANNON, 1985).

Chick-pea offers a great promise as one of the major pulse crops throughout the world. It is grown on a large scale in many countries. Despite its great importance, very little attention has been given to the improvement of salt tolerance in this crop.

The present work was carried out to assess variability in salt tolerance in a range of accessions of chick-pea at germination and seedling stages. The assessment of salt tolerance at every stage life cycle is crucial to determine the ultimate tolerance of the species under study.

2 Materials and Methods

The names and source of thirty two accessions of chick-pea used in the study are given in Tab.1. Since the degree of salt tolerance of a species varies with the stage of its growth, screening of the available material was carried out at the two initial stages, i.e., germination and seedling.

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Tab 1.: Description of seed material of chickpea used in the study.

Accession Name	No. of accession	Country/Institute of origin
C-44, CM 72, CM-88, CM 663, CM 687, C 727, CM 1918, 6153	8	NIAB (Nuclear Institute for Agriculture & Biology), Faisalabad, Pakistan
4973, 6098, 10130, 10571, 10572, 10573, 10574, 10575, 10576, 10577, 10578,10579, 10580, 10581, 10582, 10583, 10584, 10585, 11522, 12906, 12907, 12908, 12909, 12910	24	ICRISAT (International Crops Research Institute for Semi-arid Tropics) Hyderabad, India.

2.1 Germination experiment

The seeds were surface sterilized in 5% sodium hypochlorite solution for five minutes before experimentation. Plastic Petri dishes with internal diameter of 6 cm were used. The different salt treatments of NaCl used were 0 (control), 50, and 100 mol m^{-3} in full strength nutrient solution (RORISON, in Hewitt, 1966).

The germination experiment was conducted in a greenhouse at 27±3° C with 12 h day length, at light intensity of 36 W m^{-2} and relative air humidity of 75%.

Plastic Petri dishes were arranged in a Completely Randomized design, with three replicates, three treatments and 32 accessions. 17 surface sterilized seeds of each accession were placed on filter paper in each Petri dish. 5ml of treatment solution was applied on alternate days to each Petri dish after rinsing out the previous solution. The number of seeds germinated was counted daily and data were recorded for 14 days. A seed was considered germinated when both plumule and radicle had emerged ≥ 0.5 cm. Total germination percentage was expressed as percent of that in the control treatment for each accession and then data were arcsine transformed for the statistical analysis. Rate of germination was determined on the basis of days to 50% germination, caluculated from the untransformed data.

2.2 Seedling Experiment

Plastic beakers of 500 cm^3 size were filled with ordinary river sand. The sand was washed thoroughly with tap water, with distilled water, and finally with full stength Rorison nutrient solution. The experiment was conducted in a growth room at 28±3°C day temperature and 12±2°C night temperature.

The concentrations of NaCl used were 0 (control), and 60 mol m^{-3} in Rorison nutrient solution. The experiment was arranged in a Completely Randomized design, with two replicates, two salt treatments, and 32 accessions. Seven pregerminated seedlings of two weeks old of each accession were transplanted equidistant from each other into each beaker.

All the beakers were irrigated for a further week with full strength Rorison nutrient solution on every other day.

NaCl treatments in full strength Rorison nutrient solution were begun three weeks after the start of the experiment. The salt concentration was increased in aliquots of 20 mol m^{-3} on alternate days until the appropriate salt treatment was attained. Treatment continued with the addition of 500 ml of the appropriate solution to each pot after every two days.

The plants were harvested three weeks after the start of the salt treatment. Plant roots were removed carefully from the sand. Shoots and roots were washed with distilled water and separated. Fresh weight of all the samples was taken. Plant material was dried at 70°C for four days and dry weight taken.

Data for mean plant fresh and dry weight was expressed as relative fresh and dry weight as follows.

$$\text{Relative plant fresh or dry weight} = \frac{\text{Plant fresh or dry wt. at salt concentration}}{\text{Plant fresh or dry wt. at the control treatment.}} \times 100$$

3 Results

3.1 Germination experiment

Analysis of variance of the arcsine transformed data for germination percentage and rate of germination of 32 accessions of chick-pea show that increasing concentrations of NaCl had significantly adverse effect on total germination percentage and rate of germination (Both $P \leq 0.001$). The varietal difference in total germination percentage and rate of germination and the cultivars X concentration interaction for both the characters were also highly significant ($p \leq 0.001$) indicating that different accessions responded differently to NaCl concentration.

The accessions were classified into four groups on the basis of their performance for total germination in NaCl (Tab. 2). Only six accessions, CM 663, CM 1918, 6098, 10571, 10576, and 10580 had higher (above 90%) total germination percentage in saline medium. Most of

Tab. 2. Classification of chick-pea accessions on the basis of their performance for total germination in NACL solution

Classes	Germination percentage	Accession name
I	120-150	CM-663
II	90-120	CM-1918, 6098, 10571,10576, 10580.
III	60-90	CM-88, C-727, 4973, 10130, 10572, 10573, 10574, 10575, 10577, 10578, 10579, 10581, 10583, 10585, 11522, 12906, 12907, 12908, 12909.
IV	30-60	C-44, CM-72, CM-687, 6153, 10582, 10584, 12910.

the accessions had their germination percentage between 60-90 percent, whereas C 44, CM 72, CM 687, 10582, 10584, and 12910 had the lowest (30-36%) germination percentage. It is clear from this classification that there was genetic variability in germination in response to NaCl.

Tab. 3. Mean germination percentage (percent of control) and rate of germination (days to 50% germination) of 32 accessions of chick-pea at different NaCl concentrations (mol $m^{-3)}$ in full strength Rorison nutrient solution

Code No.	Accession No.	Rate of germination			Total germination percentage	
		0 (cont.)	50	100	50	100
		NaCl concentrations mol m^{-3}				
1.	C-44	6.33	—	—	50.00	40.00
2.	CM-72	4.58	—	7.66	40.00	66.66
3.	CM-88	4.66	4.77	8.75	105.00	56.00
4.	CM-663	3.85	5.69	4.75	140.00	114.50
5.	CM-687	3.73	5.00	9.05	56.00	48.90
6.	C-727	6.83	8.50	9.50	81.70	70.00
7.	CM-1918	4.19	5.27	7.25	140.00	80.00
8.	6153	4.50	6.75	—	70.00	46.70
9.	4973	5.12	4.04	5.75	90.00	90.00
10.	6098	4.76	5.63	9.12	116.07	70.00
11.	10130	4.87	5.36	—	93.30	31.10
12.	10571	3.79	4.24	5.72	100.00	93.33
13.	10572	4.20	5.25	9.50	77.80	70.00
14.	10573	4.26	4.31	5.76	101.10	46.70
15.	10574	4.21	5.23	9.00	110.50	58.90
16.	10575	3.73	4.67	5.50	100.00	80.00
17.	10576	3.87	4.90	7.76	110.50	88.40
18.	10577	3.67	4.29	7.00	77.00	54.00
19.	10578	3.66	4.50	8.16	100.00	80.00
20.	10579	3.81	6.25	8.16	73.33	60.00
21.	10580	3.72	4.83	7.25	100.00	86.66
22.	10581	4.26	5.83	7.16	73.33	70.00
23.	10582	3.74	5.20	—	86.66	26.66
24.	10583	4.50	6.92	6.50	74.70	74.70
25.	10584	4.37	—	—	41.20	24.70
26.	10585	4.42	4.62	9.75	74.70	70.00
27.	11522	4.69	5.00	—	101.70	46.70
28.	12906	4.65	4.49	6.50	107.10	65.90
29.	12907	3.96	5.25	6.75	74.10	49.10
30.	12908	4.63	4.62	6.80	96.20	69.90
31.	12909	5.27	5.25	6.50	90.00	60.00
32.	12910	4.59	4.75	9.50	57.60	57.60
	LSD 5%	2.3			36.6	

Data for germination percentage (percent of control) and rate of germination presented in Tab. 3 show that accessions 10584 and CM 72 had the lowest (32.95, 45.00%) and CM 663 the highest (127.25%) total germination percentage in saline medium. The other accessions, C 44, CM 687, 6153, 10582, and 12910 also showed poor (below 60%) germination, whereas CM 1918, 6098, 10571, 10576, and 10580 had higher (above 90%) total germination percentage in saline medium. The rest of the accessions had intermediate (60–90%) total germination percentage at both NaCl treatments.

Data for rate of germination of 32 accessions show that accessions, CM 663, 4973, 10130, 10571, 10573, 10575, 10582, and 11522 had relatively higher rate of germination and CM 72 and C 727 lower rate of germination. All the other accessions had relatively intermediate rate of germination in both salt treatments.

3.2 Seedling experiment

The analyses of variance for shoot and root fresh and dry weights, and shoot and root water content and shoot/root ratio for 32 accessions show that NaCl treatment had significantly inhibitory effect on all characters measured except root water content. Cultivars also differed significantly (all except root water content ($p \leq 0.001$). The cultivar X concentration interactions are also significant for all characters except root water content (Shoot fresh and dry weights, root fresh and dry weights $P \leq 0.001$/shoot water content & shoot/root ration $p \leq 0.01$) again showing that different accessions responded differently to NaCl treatments.

The mean and relative data for different seedling parameters are presented in Tab. 5 and 6. Different accessions have been classified into four groups on the basis of their performance for per cent shoot dry weight in NaCl (Tab. 4).

Tab. 4: Classification of accessions of chick-pea on the basis of their performance in relative shoot dry weight in NaCl (60 mol m^{-3})

Classes	Percent shoot dry weight	accession name
I	40-50	CM-663
II	30-40	C-44, CM-687, C-727, 6153, 4973, 10130, 10574, 10584, 10585.
III	20-30	CM-72, CM-88, C-235, CM-1918, 10571, 10573, 10575, 10576, 10577, 10579, 10580, 10581, 10582, 10583, 11522, 12906, 12907, 12908, 12910.
IV	10-20	6098, 10578, 12909.

Although growth of all the accessions was greatly reduced in saline medium, accessions, C 44, CM 663, C 727, 6153, 10130, 10572, and 10584 produced greater shoot and root fresh and dry biomass in both mean and relative terms than rest of the 24 accessions. The three accessions, 10583, 12908, and 12909 had very low shoot and root biomass at 60 mol m^{-3} NaCl.

Tab. 5: Mean fresh and dry weights (g/plant) of shoots and roots, per cent water content, and shoot/root ratio of accessions of Chickpea after 25 days growth at 0, and 60 mol m^{-3} NaCl nutrient solution.

Code No.	Accession No.	Shoot fresh weight		Shoot dry weight		Root fresh weight		Root dry weight		Shoot moisture content(%)		Root moisture content(%)		Shoot/Root ratio	
		NaCl concentrations in mol m^{-3}													
		0(Cont)	60	0(Cont.)	60	0(Cont.)	60	0(Cont.)	60	0(Cont.)	60	0(Cont.)	60	0(Cont.)	60
1.	C-44	2.43	0.48	0.42	0.135	2.52	0.80	0.41	0.053	82.71	71.12	83.39	93..07	1.00	2.63
2.	CM-72	2.91	0.30	0.425	0.115	3.26	0.36	0.31	0.050	85.14	61.86	90.52	85.98	1.41	2.62
3.	CM-88	2.76	0.30	0.425	0.10	2.64	0.50	0.24	0.053	84.42	64.48	90.59	89.48	1.76	2.18
4.	CM-663	2.14	0.37	0.375	0.16	2.63	0.43	0.37	0.06	82.34	56.04	85.80	85.72	1.01	2.69
5.	CM-687	2.43	0.27	0.37	0.11	2.68	0.35	0.31	0.031	84.59	60.45	88.93	89.93	1.24	3.47
6.	C-727	2.31	0.31	0.32	0.10	1.98	0.35	0.18	0.052	86.03	65.84	90.75	90.22	1.77	2.02
7.	CM-1918	2.25	0.22	0.355	0.09	2.87	0.27	0.35	0.04	84.01	61.97	88.22	86.45	1.06	2.42
8.	6153	2.75	0.41	0.435	0.135	3.20	0.52	0.36	0.066	83.92	66.51	90.12	87.45	1.28	2.20
9	4973	2.38	0.43	0.385	0.135	2.69	0.53	0.38	0.05	83.73	68.09	85.91	90.94	1.01	3.03
10.	6098	2.99	0.28	0.485	0.08	3.08	0.61	0.40	0.06	83.76	69.80	87.05	91.11	1.21	2.03
11.	10130	3.17	0.45	0.50	0.16	2.97	0.66	0.38	0.055	84.21	64.37	86.99	91.89	1.30	3.04
12.	10571	2.50	0.33	0.415	0.09	2.85	0.66	0.40	0.045	83.21	69.35	86.03	92.29	1.06	2.20
13.	10572	3.49	0.42	0.425	0.13	3.09	0.79	0.40	0.061	87.27	68.56	87.03	90.55	1.08	2.23
14.	10573	3.04	0.335	0.42	0.12	2.83	0.65	0.21	0.05	86.15	64.55	92.52	90.04	1.98	2.91
15.	10574	2.32	0.315	0.36	0.11	2.36	0.75	0.32	0.06	84.57	64.71	86.25	90.70	1.18	1.87
16.	10575	2.60	0.25	0.44	0.11	3.15	0.37	0.36	0.06	83.01	57.48	88.49	84.52	1.42	1.89
17.	10576	3.11	0.31	0.52	0.115	3.27	0.58	0.39	0.065	83.08	63.51	87.78	88.92	1.34	1.88
18.	10577	3.10	0.31	0.465	0.11	3.50	0.43	0.37	0.065	84.95	64.58	88.91	84.42	1.24	1.62
19.	10578	2.55	0.20	0.40	0.075	2.65	0.33	0.31	0.04	84.43	61.44	88.05	88.22	1.25	2.16
20.	10579	2.71	0.27	0.43	0.09	3.14	0.39	0.43	0.04	83.93	66.74	86.25	77.36	1.01	2.25
21.	10580	3.03	0.32	0.49	0.115	3.17	0.57	0.33	0.052	83.80	64.37	89.48	90.40	1.47	2.16
22.	10581	2.37	0.25	0.35	0.085	2.77	0.37	0.32	0.05	84.90	63.84	88.04	86.61	1.15	1.97
23.	10582	2.25	0.21	0.35	0.075	2.78	0.29	0.39	0.035	84.49	63.07	86.21	86.56	0.97	2.45
24.	10583	2.11	0.23	0.35	0.105	2.38	0.26	0.26	0.04	82.97	52.94	87.81	84.21	1.34	2.80
25.	10584	2.24	0.37	0.36	0.125	3.14	0.60	0.33	0.06	83.43	66.21	89.22	88.33	1.14	2.16
26.	10585	2.27	0.33	0.33	0.115	2.15	0.34	0.21	0.03	85.43	65.13	90.005	88.37	1.58	3.90
27.	11522	3.12	0.34	0.48	0.12	3.01	0.53	0.39	0.08	84.41	63.64	86.89	85.68	1.24	1.57
28.	12906	2.39	0.34	0.38	0.10	2.83	0.43	0.35	0.036	83.72	67.18	87.18	91.19	1.21	2.86
29.	12907	2.57	0.25	0.43	0.10	2.74	0.38	0.33	0.043	83.2	59.72	87.61	89.21	1.27	2.60
30.	12908	1.82	0.26	0.26	0.065	1.67	0.37	0.18	0.04	85.33	75.11	89.08	89.05	1.48	1.57
31.	12909	2.04	0.17	0.33	0.06	1.92	0.28	0.30	0.056	83.70	64.81	84.53	80.62	1.13	1.12
32.	12910	1.77	0.24	0.30	0.085	2.26	0.38	0.39	0.05	82.97	65.29	82.73	87.00	0.77	1.78
	LSD5%	212			32		412		26		7.6		NS		1.1

The accessions did not differ significantly for root water content. A considerable amount of variability for shoot water content existed in all the accessions examined in this study. Accession, 12908 had the highest (75.11%) and 10583 the lowest (52.94%) shoot water content. Among the other accessions, C 44, 6098, 10571 and 4973 had relatively higher shoot

Tab. 6: Relative fresh and dry weights (%) of shoots and roots, and shoot/root ratio of 32 accessions of chick-pea after 25 days growth in sand culture salinized with 60 mol m^{-3} NaCl in nutrient solution.

Code No.	Accession No	Shoot fresh weight	Shoot dry weight	Root fresh weight	Root dry weight	Shoot/Root tatio
1.	C-44	20.20	33.33	32.30	12.86	266.12
2.	CM-72	10.61	27.67	11.16	17.09	161.43
3.	CM-88	11.02	24.69	19.38	23.09	134.60
4.	CM-663	17.25	43.03	16.38	16.30	265.83
5.	CM-687	11.33	30.36	13.23	9.78	292.88
6.	C-727	13.40	32.81	27.04	28.88	114.46
7.	CM-1918	10.30	25.23	9.88	11.37	123.94
8.	6153	15.32	31.11	17.33	18.17	177.86
9.	4973	19.06	37.23	20.01	12.50	301.40
10.	6098	9.74	17.97	20.18	15.22	167.76
11.	10130	14.54	32.35	22.57	14.32	232.26
12.	10571	13.43	21.47	22.89	11.49	225.77
13.	10572	12.58	30.68	24.79	15.41	204.39
14.	10573	11.01	28.53	23.18	23.41	142.22
15.	10574	13.38	30.47	31.40	19.02	164.39
16.	10575	9.84	25.06	11.97	16.69	158.50
17.	10576	10.12	22.14	18.47	16.90	143.35
18.	10577	10.13	23.63	12.64	17.61	135.74
19.	10578	7.82	19.73	12.53	11.72	183.82
20.	10579	10.08	20.60	11.83	9.25	225.38
21.	10580	10.88	23.82	17.94	15.66	146.12
22.	10581	10.50	23.96	13.53	15.20	167.67
23.	10582	9.31	21.32	9.98	9.35	243.12
24.	10583	11.71	29.88	12.74	14.35	214.73
25.	10584	16.70	34.36	18.49	19.08	199.96
26.	10585	14.53	34.92	15.43	14.48	242.40
27.	11522	10.88	24.76	17.73	20.40	127.17
28.	12906	14.41	27.06	15.31	10.91	262.63
29.	12907	9.86	23.69	14.15	12.89	204.40
30.	12908	15.04	23.69	22.11	23.37	110.39
31.	12909	8.24	17.88	14.60	18.33	101.06
32.	12910	13.62	28.33	17.35	13.22	237.14

water content, whereas accessions, CM-663, 10575 and 12907 had lower shoot water content. All the other accessions had intermediate shoot water content.

Although data for shoot/root ration of 32 accessions show a considerable variation but there was no consistent pattern of increase or decrease in shoot/root ratio. In general high biomass producing accessions had greater shoot/root ration as compared to the sensitive accessions. But an intermediate biomass producing accession 10585 had the highest (3.90) shoot/root ratio at salt treatment, which showed that in the high biomass producing accessions, the shoot was less affected by the NaCl toxicity than the roots.

4 Discussion

A primary requisite in selecting and breeding for salt tolerance is genetic variation for tolerance in the gene pool of the species for which increased tolerance is required.Interspecific and intraspecific variation for tolerance provides scope for selecting for its improvement. A knowledge of the level of variability for salt tolerance in a species can help in devising a selection strategy for tolerance. If sufficient genetic variation for salt tolerance exists in a species, then considerable improvement in tolerance could be expected from selection.

In the present study variability for salt tolerance in 32 accessions of chick-pea was assessed at the germination and seedling stages. Salt tolerance of the accessions was measured in both absolute and relative terms to assess the ultimate tolerance of each entry, although different scientists have different views about these means. For example SHANNON (1984) especially employed relative measure while screening different muskmelon genotypes at the seedling stage, whereas DEWEY (1960) screened 25 strains of *Agropyron* species at germination and considered absolute growth important under salinity stress regardless of growth in control conditions.

It is clear from absolute and relative data for different seedling parameters (Tab. 5 and 6) that high biomass producing accessions C 44, CM 663, C 727, 6153, 4973, 10130, 10572, and 10584 had higher percent shoot water content except accession CM 663. Therefore the eight accessions were classified as the most NaCl tolerant compared with all the other accessions examined in this study. The low biomass producing accessions, 10582, 12908, and 12909 also had higher shoot water content, particularly accession 12908 had the highest (75.11%) shoot water content. So high, intermediate, and low biomass producing accessions did not show consistent relationship for shoot water content (Tab. 5).

Data for total germination percentage (percent of control) and rate of germination presented in Tab. 3 show that some accessions showed consistent relationship between data for total germination percentage and rate of germination. For instance, accession 10584, a high biomass producing accession had the lowest germination percentage (41.1, 24.7) and rate of germination at both the NaCl treatments. Similarly accession CM 663, a high biomass producing accession had the highest (140.00, 114.5%) total germination percentage and rate of germination (4.45) as compared to all the other accessions. Among the other high biomass producing accessions, C 44 and 6153 had the lower total germination percentage and rate of germination, although it was as good as other high biomass producing accessions. Among low biomass producing accessions, 10582 had low and 12908 and 12909 had intermediate total germination percentage and rate of germination.

No consistent correlation was found between data for germination and seedling stage. The tolerance observed in 8 accessions, C 44, CM 663, C727, 6153, 4973, 10130, 10572, and 10584 at the seedling stage was not conferred at the germination stage. Because the 8 highly tolerant accessions (high biomass producing) did not differ from the intermediate and sensitive accessions in both total germination percentage and rate of germination. These results have close relationship with also reported that salt tolerance varies with the different growth stages of a crop (KINGSBURY and EPSTEIN, 1984; AKBAR and YABUNO, 1974; ASHRAF and MCNEILLY, 1988).

The influence of salinity on plant has been studied as its effects on germination, seedling, and later plant growth. Some workers are of the view that selection for salinity tolerance at the seedling stage may not produce tolerant adult plants (SHANNON, 1979; KINGSBURY and EPSTEIN 1984), whereas some others opine that the response of seedling to salinity was very curcial to assess the overall tolerance of a plant species and was highly predictive of the response of adult plant to salinity (GREENWAY, 1965; BLUM, 1985; AZHAR and MCNEILLY, 1987). Nevertheless, NORLYN (1980), KINGSBURY and EPSTEIN (1984), and ASHRAF et al. (1986) while working on barley, wheat, and seven grass species, respectively selected seedlings of these species and derived plants that were tolerant as adults.

The work presented here deals with the salt tolerance at first two growth stages. The tolerance observed in the eight accessions, C-44, CM 663, C 727, 6153, 4973, 10130, 10572, and 10584 may or may not be conferred at the later stages (EPSTEIN and NORLYN, 1977). Because it has long been reported that salt tolerance varies with the different growth stages (AKBAR and YABUNO, 1974; ASHRAF and MCNEILLY, 1988; KINGSBURY and EPSTEIN, 1984; ASHRAF and MCNEILLY, 1988; KINGSBURY and EPSTEIN, 1984; SHANNON, 1978). Nevertheless tolerance observed at the two first stages is of considerable importance to assess the ultimate tolerance of the species (AKBAR and YABUNO, 1974; ASHRAF and MCNEILLY, 1987).

In view of great magnitude of variability for salt tolerance in chick-pea observed in this study, development of salt tolerance in the species could be expected in particular, at the two initial growth stages.

5 Summary

Thirty two local and exotic accessions of chick-pea were screened at the germination and seedling stage in different NaCl concentrations. Six accessions had significantly higher and six accessions had lower total germination percentage in NaCl solution than the other accessions. Rate of germination was determined as days to 50 percent germination. Eight accessions had higher, two accessions lower rate of germination compared with the other accessions examined in the study.

Seven accessions produced significantly greater shoot and root fresh and dry biomass than the other accessions. Three accessions had very poor performance in all growth parameters measured.

The data show that there is a considerable amount of variability for salt tolerance in chick pea which can be exploited to improve its salt tolerance through recurrent selection.

Zusammenfassung

Kichererbsen (*Cicer arietinum L.*), 32 Herkünfte, lokale und ausländische, wurden im Keim- und Pflanzenstadium in verschiedenen NaCl-Konzentrationen auf ihre Salztoleranz geprüft. 6 Herkünfte hatten signifikant höhere und 6 Herkünfte niedrigere Gesamtkeimzahlen in einer NaCl-Lösung als andere Herkünfte. Die Keimrate wurde durch die Tage bis zur 50%igen Keimung bestimmt. 8 Herkünfte hatten höhere, 2 niedrigere Keimraten, verglichen mit den anderen Herkünften.

Sieben Herkünfte erzeugten signifikant mehr Stengel- und Wurzelmasse (frische und trockene Biomasse) als die anderen Herkünfte. In allen gemessenen Wachstumsparametern hatten drei Herkünfte ein sehr geringes Wachstum.

Die Daten zeigen, daß ausreichend Kichererbsenvarianten mit Salztoleranz vorhanden sind die zur Selektion und Verbesserung der Salzverträglichkeit eingesetzt werden können.

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References

1. AKBAR, M. and YABUNO, T. 1974: Breeding for saline resistant varieties of rice. 1-Comparative performance of some rice varities to salinity during early development stages. Japan J. Breed. 24, 176-181.
2. ASHRAF, M.; MCNEILLY, T. and BRADSHAW, A.D., 1986: The potential for evolution of salt (NaCl) tolerance in seven grass species. New Phytol. 103, 299-309.
3. ASHRAF, M.; MCNEILLY, T. and BRADSHAW, A.D., 1986: The response of selected salt tolerant and normal lines of four grass species to NaCl in sand culture. New Phytol. 104, 453-461.
4. ASHRAF, M. and MCNEILLY, T., 1987: Salinity effects on five cultivars/lines of pearl millet (Pennisetum americanum (L.) Leeke) Plant and Soil 103, 13-19.
5. ASHRAF, M. and MCNEILLY, T., 1988: Variability in salt tolerance of nine spring wheat cultivars. J. Agron. Crop Sci. 160, 14-21.
6. AZHAR, F.M. and MCNEILLY, T. 1987: Variability for salt tolerance in Soghum bicolor (L) Moench. under hydroponic conditions. J. Agron. Crop Sci. 159, 269-277.
7. BLUM, A., 1985: Breeding crop varieties for stress environments. CRC Critical Rev. Plant Sci. 2, 199-238.
8. CARTER, D.L., 1975: Problems of salinity in agriculture. pp-25-35. In Plant in Saline Environments Eds. A. Pojakoff Mayber and J. Gale. Springer Verlag, Berlin.
9. DEWEY, D.R., 1960: Salt tolerance of 25 strains of Agropyron. Agron. J. 52, 631-635.
10. EPSTEIN, E. and NORLYN, J.D., 1977: Sea water based crop production: a feasibility study. Science 197, 249-251.

11. EPSTEIN. E., 1985: Salt tolerant crops: Origins, develoment and prospects of the concepts. Plant and Soil 89, 187-198.

12. GREENWAY, H., 1965: Plant response to salin subscrates. VII. Growth and uptake throughout plant development in two varieties of Hordeum vulgare. Aust. J. Biol. Sci. 18, 763-779.

13. HEWITT, E.J., 1966: Sand and water culture methods used in the study of plant nutrition. Common Agri. Bur. Tech. Comm. No. 22 2nd Edn. CAB slough, U.K.

14. KINGSBURY, R.W. and EPSTEIN, E., 1984: Selection for salt resistant spring wheat. Crop. Sci. 24, 310-315.

15. NORLYN, J.D., 1980: Breeding salt tolerant crop plants. In Genetic Engineering of Osmoregulation. Eds. D.W. Rains RC Valentine and A Hollaender. Basic life Sci. 14, pp 293-309. Plenum Press. New York.

16. SANDHU, G.R. and QURESHI, R.H., 1986: Salt affected soils of Pakistan and their utilization. Reclamation and Revegetation Research 5, 105-113.

17. SHANNON, M.C., 1978: Testing salt tolerance variability among tall wheatgrass lines. Agron. J. 70, 719-722.

18. SHANNON, M.C., 1979: In quest of rapid screening techniques for plant salt tolerance. Hort. Science 14, 587-589.

19. SHANNON, M.C., 1984: Breeding, selection and the genetics of salt tolerance. In Salinity Tolerance in Plants. Eds. R C Staple and G H Toenniessen. pp 231-254. John Wiley and Sons, New York.

20. SHANNON, M.C., 1985: Principles and strategies in breeding for higher salt tolerance. Plant and soil 89, 227-241.