Germination and Seedling Growth of Some Chickpea Cultivars (*Cicer arietinum* L.) under Salinity Stress

A.A. Kandil[1], A.E. Sharief[1,*] and S.R.H. Ahmed[2]

[1]*Department of Agronomy, Faculty of Agriculture, Mansoura University, Egypt*

[2]*Central Administration for Seed certification (CASC), Variety Testing Administration, Ministry of Agriculture, Egypt*

Abstract: In order to study the response of some Chickpea (*Cicer arietinum* L.) cultivars i.e. Giza 1, Giza 2, Giza 3, Giza 3, Giza 4, Giza 195, Giza 531, and Chickpea stand1to germination under salinity concentrations i.e. control treatment, 4, 8, 12, 16, and 20 dSm^{-1} NaCl and to confirm the seedling growth performance. A laboratory experiment was laid out at Giza Central Seed Testing Laboratory of Central Administration for Seed Certification, Ministry of Agriculture, Egypt. Giza 3 cultivar exceeded other cultivars in germination percentage, germination index, seedling vigor index, shoot length, shoot and root dry weight followed by Giza 1 and Giza 2 cultivars. Giza 2 cultivar recorded highest mean germination time, followed by chickpea stand 1 and Giza 4 cultivars. Giza 195 cultivar exceeded other cultivars in root length and Giza 531 and Giza 1 cultivars surpassed other cultivars in shoot fresh weight. Chickpea stand 1 and Giza 195 cultivars surpassed other cultivars in seedling height reduction and Giza 1, Giza 2, Giza 3, and Giza 4, came in the second rank. However, the lowest percentages of seedling height reduction were obtained from Giza 531 cultivar. Increasing salinity levels from 0 to 20 dSm^{-1} significantly decreased germination percentage, germination index, seedling vigor index, shoot and root length, shoot and root fresh weight, shoot and root dry weight and relative dry weight. The control treatment recorded highest averages of these characters, vice versa mean germination time and seedling height reduction. Germination index, seedling vigor index, shoot and root length (cm), shoot and root fresh weight (mg), shoot and root dry weight (mg), seedling height reduction % and relative dry weight % significantly affected by the interaction between chickpea cultivars and salinity concentration. Giza 3, Giza 1 and Giza 2 cultivars were more tolerant to salinity and recommended to be used in breeding program for enhancing chickpea cultivation in newly reclaimed soils.

Keywords: Chickpea *(Cicer arietinum* L)., cultivars, salinity stress, germination parameters.

INTRODUCTION

Chickpea (*Cicer arietinum* L.) is one of the oldest crops grown mainly for their seed which contain 20.6 % protein, 2.2% fat and 61.2% carbohydrates [1]. In Egypt, people used chickpea as a source of protein in human diet particularly in developing countries. Salinity became a serious problem for agriculture all over the world. Salinity is one of the major stress factors which limit crop production in most of the arid and semi-arid regions of the world [2]. The extreme increase in population in Egypt needs to increase the total yield of legume crops in order to overcome the lack in protein through increase chickpea area of cultivation in the newly reclaimed lands especially under saline conditions of such soil. Under Egyptian conditions there was shortage in production of summer legumes crops. Increasing chickpea productivity could be achieved through sown promising cultivars and sand sowing of chickpea in new by reclaimed soils. Chickpea lines i.e. CSG 88101, CSG 8927, CSG 8977, CSG 8962 and CSG 8943 were varied in salt tolerant, uptake and spreading of Na^+ and Cl^- ions [3]. Chickpea C 727 cultivar showed better results in germination parameter under saline conditions as compared to CM 72 cultivar under salinity conditions [4]. Chickpea ILC 482 cultivar seemed to be more tolerant to salinity than Barka local, breeding programme involving regional exchange of germplasm may be cooperative [5]. [6] concluded that SG-11 and DHG-84-11 cultivars were identified as tolerant genotypes, whereas Pusa-256 and Phule G-5 cultivars were susceptible. Similar conclusions were reported by [7-11]. [12] reported that chickpea genotype (Pusa-329) salt tolerant, and (Pusa-240) salt sensitive and were differed in germination percentage, shoot and root dry matter accumulation.

Salinity is one of the major obstacles in increasing production in chickpea growing areas. Salinity stress is a major environmental factor that extremely affects crop production throughout the world, it is a danger to both agriculture and the soil body. Salinity is an a biotic hazard, induces numerous disorders in seeds and propagates during germination, it either completely inhibits germination at higher levels or induces a state of dormancy at lower levels [13]. Salt stress has been reported to decrease germination percentage, germination rate, shoot and root length as well as shoot and root fresh and dry weight [14-18]. [19] indicated that salinity imposes on plants other stresses such as ion toxicity, as a result of ion entry in excess of

*Address corresponding to this author at the Mansoura University, Egypt, 35516 El-Mansoura, Egypt; Tel: +201222986347; Fax: +22221688;
E-mail: sharief2005@yahoo.com

ISSN: 1814-8085 / E-ISSN: 1927-5129/12

appropriate compartmentation, and nutrient imbalances, as commonly seen in the displacement of potassium by sodium. Salinity harm is mainly due to different water relatives caused by high salt accretion in the intercellular spaces. [20] indicated that salt stress limits plant productivity in legumes through diminished germination, photosynthetic efficiency, nitrogen fixation and carbon metabolism. Salt in the germination medium showed a negative effect on all germination studies parameters. At highest salinity level reduction germination percentage was 66.01 %, pumule length, radical length, fresh and dry weight of radical and pumule also decreased under salt stress [4, 5, 21-25]. Moreover, [26-28] reported that germination of seeds one of the most critical phases of plant life is greatly influenced by salinity. [10, 29] indicated that salinity reduced germination percentage, root and shoot length, fresh and dry weight, germination index and plant growth.

With respect to the interaction, [30] found that all genotypes showed salt tolerance either at germination or seedling growth stage at low level of salinity (4 dSm-1). Genotypes C10, C14, C16, C17, C19 and C29 also showed tolerance to medium level of salinity (6 dSm-1). Only two salt tolerant genotypes out of those tested proved to be C28 and C29 which perform well both at germination and seedling stage under all salt levels. [25] reported that salinity significantly reduced dry matter accumulation in both roots and shoots in all cultivars, though declension was more pronounced in BG 267 (kabuli) and DCP 92-3 (desi). Root growth was more adversely affected than shoot growth, which also had an impact on the root to shoot ratio. CSG 9651 showed high levels of tolerance compared to the other cultivars. The objectives of this research were aimed to study the performance of chickpea cultivars under salinity stress and their interactions on germination parameters and seedling characters.

MATERIALS AND METHODS

This investigation was conducted at Giza Central Seed Testing laboratory of Central Administration for Seed Testing and Certification (CASC), Ministry Of Agriculture, Egypt during the period of March to April 2012. The objectives of this study was aimed to investigate the response of chickpea (*Cicer arietinum* L.) cultivars to germination and seedling characters under salinity stress and to examine a range of genetic variability for salinity tolerance among chickpea cultivars.

Treatments and Experimental Design

The experiment was arranged in factorial experiment in randomized complete block design (RCBD) with four replications. The first factor included 7 different chickpea cultivars i.e. Giza 1, Giza 2, Giza 3, Giza 4, Giza 195, Giza 531 and Chickpea Stand 1 which were obtained from Research Section Research Institute ARC, Ministry of agriculture, Egypt. All genotypes were stored under normal conditions in paper bags. The second factor included six salt concentrations of NaCl dSm^{-1} i.e., 8, 12, 16, and 20 dSm^{-1} NaCl. Seeds of studied cultivars were surface sterilized by immersion for 5 minutes in sodium hypochlorite solution, then repeatedly washed with deionized water. Fifty seeds of uniform size in each treatment for each cultivar were allowed to germinate on a filter paper in 9 cm diameter petre dishes. Each filter paper was moistened with a water solution at seven different NaCl concentrations. Thus, the whole experiment comprised 280 Petri dishes arranged in factorial experiment Randomized Complete Block Design (RCBD). The Petri dishes were placed in a growth chamber for 14 days at 28 ±1 ºc for germination.

Studied Characters

After 14 days ten seedlings were selected from each replicates and then seedlings were evaluated as follows:

1 Final Germination Percentage (FGP): according to the following equation described by [31]:

(FGP) = Number of germinated seed / Total Number of seed tested ×100.

2 Mean germination time (MGT): It was determined according to the equation of [31]:

$MGT= \sum dn/ \sum n$

Where (n) is the number of seeds which were germinated on day (d), and (d) is the number of days counted from the beginning of germination.

3 Germination Index (GI): according to the following equation described by [32] and it was calculated according the following equation.

(GI) = % Germination each treatment / % Germination in the control

4 Vigor index (VI): it was calculated according to [33] as the following equation:

(VI) = (Average shoot length + Average root length) × Germination percentage

5 Root length (cm).

6 Shoot length (cm).

7 Root fresh weight (mg).

8 Shoot fresh weight (mg).

9 Root dry weight (mg).

10 Shoot dry weight (mg).

11 Relative dry weight (RDW): It was calculated according to the following equation described by [34].

RDW (%) = Total dry weight under saline condition / Total dry weight under control condition × 100.

12 Seedling height reduction (SHR): It was calculated using the following equation described by [34].

SHR (%) = Plant height at control - Plant height at saline condition / Plant height at saline condition × 100.

Statistical Analysis

All obtained data were statistically analyzed according to the technique of analysis of variance (ANOVA) for the split-plot design as published by [35] by using means of “MSTAT-C” computer software package. Least Significant Difference (LSD) method was used to test the differences between treatment means at 5 % and 1% levels of probability as described [36].

RESULTS AND DISCUSSION

1. Performance of Cultivars

The results in Table **1** clearly showed that Giza 3 cultivar exceeded other cultivars in germination percentage, germination index and seedling vigor index. Moreover, Giza 1 and Giza 2 cultivars came in the second rank without significant differences between them. The lowest percentages of germination were recorded from chickpea Stand 1 and Giza 531 cultivars without significant differences between them. Giza 3 cultivar exceeded Giza 1, Giza 2, Giza 4, Giza 195, Giza 531 and chickpea Stand 1 in final germination percentage by 13.23, 9.33, 20.82, 18.44, 27.76 and 29.93%, respectively. Giza 2 cultivar recorded highest mean germination time, followed by chickpea stand 1 and Giza 4 cultivars came in the second rack without significant differences them. The lowest mean germination time was obtained from Giza 531 and Giza 3 cultivars without significant differences between them. Giza 3 cultivar surpassed Giza 1, Giza 2, Giza 4, Giza 195, Giza 531 and chickpea stand 1 in germination index by 9.16, 7.35, 14.71, 10.92, 19.56 and 19.46%, respectively. Moreover, Giza 3 cultivar surpassed other cultivars in shoot length. Giza 531 and Giza 4 came in the second rank without significant differences between them. The lowest shoot length was obtained from chickpea stand 1 cultivar. Giza 3 cultivar exceeded Giza 1, Giza 2, Giza 4, Giza 195, Giza 531and chickpea stand 1 cultivars in shoot length by 39.94, 26.97, 18.57, 40.71, 16.79 and 48.85%, respectively. Giza 195 cultivar exceeded other cultivars in root length and, Giza 1 and Giza 2 came in the second rank. The lowest root length was obtained from chickpea stand 1 and Giza 4 cultivars without significant differences between them. In addition, Giza 531 and Giza 1 cultivars surpassed other cultivars in shoot fresh weight without significant differences between them. The lowest shoot fresh weight was obtained from sown Giza 2 and chickpea Stand 1 cultivars without significant differences between them. Giza 1 cultivars exceeded other cultivars in root fresh weight and Giza 3 came in the second rank. The lowest weight of fresh root was obtained from Giza 2 and Giza 4 cultivars without significant differences between them. Giza 3 cultivar exceeded other cultivars in shoot dry weight and Giza 1 and Giza 4 and Giza 531 cultivars came in the second rank without significant differences between them. The lowest weight shoot dry was obtained from chickpea Stand 1, Giza 195 and Giza 2 cultivars without significant differences between them. Moreover, chickpea stand 1 and Giza 195 cultivars surpassed other cultivars in seedling height reduction and Giza 1, Giza 2, Giza 3, and Giza 4, came in the second rank without significant differences between them. The lowest percentages of seedling height reduction were obtained from Giza 531 cultivar. Giza 4 cultivar exceeded other cultivars in relative dry weight (RDW) and Giza 2 and Giza 531 came in the second rank without significant differences between them. The lowest relative dry weight was obtained from chickpea stand 1 cultivar. The differences in germination parameters due to chickpea cultivars may be due the genetically factors and heredity variation among the seven chickpea cultivars. [12] reported that chickpea genotype (Pusa-329) salt tolerant and (Pusa-240) salt sensitive and were differed in germination

Table 1: Averages of Final Germination Percentage (%), Mean Germination Time (Days), Germination Index, Vigor Index, Shoot Length, Root Length, Shoot Fresh Weight, Root Fresh Weight, Shoot Dry Weight, Root Dry Weight, Seedling Height Reduction and Relative Dry Weight as Affected by Chickpea Studied Cultivars

Characters Treatments	Final germination percentage (%)	Mean germination Time (days)	Germination index	Vigor index	Shoot length (cm)	Root length (cm)	Shoot fresh weight (g)	Root fresh weight (g)	Shoot dry weight (g)	Root dry weight (g)	Seedling height reduction (%)	Relative dry weight (%)
Cultivars performance:												
Giza 1	66.66	2.22	71.00	311.4	2.36	1.91	0.080	0.048	0.010	0.013	44.29	56.70
Giza 2	69.66	2.37	72.41	352.6	2.87	1.79	0.056	0.017	0.008	0.007	45.37	60.45
Giza 3	76.83	2.17	78.16	442.6	3.93	1.67	0.077	0.040	0.016	0.014	44.37	56.00
Giza 4	60.83	2.25	66.66	302.5	3.20	1.24	0.072	0.017	0.010	0.010	44.87	64.41
Giza 195	62.66	2.21	69.62	304.7	2.33	2.05	0.063	0.033	0.009	0.015	52.54	55.00
Giza 531	55.50	2.04	62.87	290.8	3.27	1.44	0.081	0.029	0.010	0.012	39.75	60.75
Chickpea stand 1	53.83	2.32	62.95	201.8	2.01	1.22	0.060	0.020	0.008	0.012	58.75	48.95
F. test	**	**	**	**	**	**	**	**	**	**	**	**
LSD at 5%	4.05	0.13	4.90	33.3	0.27	0.11	0.002	0.003	0.0027	0.003	3.97	3.38
LSD at 1%	5.32	0.17	6.44	43.8	0.36	0.14	0.003	0.004	0.0036	0.004	5.21	4.44

N. S.= Not significant, *= significant at 5%, **= significant at 1%.

percentage, shoot and root dry matter accumulation. [6] concluded that SG-11 and DHG-84-11 cultivars were identified as tolerant genotypes, whereas Pusa-256 and Phule G-5 cultivars were susceptible. These results are in good accordance with those obtained by [4, 5, 10, 25, 37].

2. Salinity Stress Effects

The results in Table **2** reported that highest salinity concentrations i.e. 20 dSm^{-1} NaCl recorded the lowest averages of these characters compared with control treatment. Increasing salinity concentrations from 0 to 20 dSm^{-1} NaCl gradually decreased averages of final germination percentage, germination index, seedling vigor index, shoot and root length, shoot and root fresh weight, shoot and root dry weight and relative dry weight, vice versa mean germination time and seedling height reduction were increased. Results indicated that increasing salinity concentrations up to 20 dSm^{-1} NaCl decreased final germination percentage, germination index, seedling vigor index, shoot length, root length, shoot fresh weight, root fresh weight, shoot dry weight, root dry weight, seedling height reduction and relative dry weight to 57.47, 32.6, 58.48, 86.05, 74.0, 54.43, 78.57, 76.66, 76.19, 72.95 and 67.18%, respectively compared with the control treatment. Increasing salinity up to 16 dSm^{-1} NaCl decreased final germination percentage, germination index, seedling vigor index, shoot length, root length, shoot fresh weight, root fresh weight, shoot dry weight, root dry weight, seedling height reduction and relative dry weight to 21.41, 24.89, 58.43, 74.53, 62.80, 48.79, 72.72, 66.66, 71.72, 28.0, 65378 and 60.61%, respectively compared with the control treatment. Increasing salinity up to 12 dSm^{-1} NaCl decreased final germination percentage, germination index, seedling vigor index, shoot length, root length, shoot fresh weight, root fresh weight, shoot dry weight, root dry weight, seedling height reduction and relative dry weight to 63.70, 18.22, 36.18, 70.37, 58.63, 44.75, 68.83, 66.66, 66.66, 60.86,57.35 and 54.0 %, respectively compared with the control treatment. Increasing salinity to 8 dSm^{-1} NaCl decreased final germination percentage, germination index, seedling vigor index, shoot length, root length, shoot fresh weight, root fresh weight, shoot dry weight, root dry weight, seedling height reduction and relative dry weight to 30.68, 14.13, 31.33, 60.4, 47.24, 37.09, 62.98, 50.0, 57.14, 56.52, 47.82 and 43.42%, respectively compared with the control treatment. Increasing salinity up to 4 dSm^{-1} NaCl decreased final germination percentage, germination index, seedling vigor index, shoot length, root length, shoot fresh weight, root fresh weight, shoot dry weight, root dry weight, seedling height reduction and relative dry weight to 16.03, 6.59, 15.25, 40.96, 32.82, 24.19, 50.0, 46.66, 52.38, 39.13, 39.39 and 30.0 %, respectively compared with the control treatment. Moreover, increasing salinity levels up to 20 dSm^{-1} increased mean germination time to 2.73 days. Increasing salinity up to 16 dSm^{-1} NaCl increased mean germination time to 2.45 day and increasing it up to 12 dSm^{-1} increased mean germination time to 2.25 day compared with the

Table 2: Averages of Final Germination Percentage (%), Mean Germination Time (days), Germination Index, Vigor Index, Shoot Length, Root Length, Shoot Fresh Weight, Root Fresh Weight, Shoot Dry Weight, Root Dry Weight, Seedling Height Reduction and Relative Dry Weight as Affected by Salinity Concentrations (dSm^{-1} NaCl)

Characters Treatments	Final germination percentage (%)	Mean germination Time (days)	Germination index	Vigor index	Shoot length (cm)	Root length (cm)	Shoot fresh weight (g)	Root fresh weight (g)	Shoot dry weight (g)	Root dry weight (g)	Seedling height reduction (%)	Relative dry weight (%)
Salinity stress (NaCl dSm^{-1}):												
O (control)	91.71	1.84	100.00	713.5	5.27	2.48	0.154	0.060	0.021	0.023	0.00	100.00
4 NaCl dSm^{-1}	77.00	1.97	84.75	421.2	3.54	1.88	0.077	0.032	0.010	0.014	39.39	70.07
8 NaCl dSm^{-1}	63.57	2.10	68.67	282.5	2.78	1.56	0.057	0.030	0.009	0.010	47.82	56.53
12 NaCl dSm^{-1}	58.42	2.25	63.82	211.4	2.18	1.37	0.048	0.020	0.007	0.009	57.35	46.00
16 NaCl dSm^{-1}	52.57	2.45	55.78	178.0	1.96	1.27	0.042	0.020	0.006	0.008	65.78	39.39
20 NaCl dSm^{-1}	39.00	2.73	41.57	99.5	1.37	1.13	0.033	0.014	0.005	0.006	72.95	32.82
F. test	**	**	**	**	**	**	**	**	**	**	**	**
LSD at 5%	3.75	0.12	4.53	30.8	0.25	0.10	0.002	0.002	0.002	0.002	3.67	3.13
LSD at 1%	4.92	0.16	5.96	40.5	0.33	0.13	0.003	0.003	0.003	0.003	4.83	4.11

N. S.= Not significant, *= significant at 5%, **= significant at 1%.

control treatment. Increasing salinity to 8 dSm^{-1} NaCl decreased mean germination time to 2.10 day and increasing it to 4 dSm^{-1} decreased mean germination time to 1.97 day. Increasing salinity levels decreased germination parameter and seedling growth of seeds which is directly related to the amount of absorbed water by the seeds. Moreover, [26-28] reported that germination of seeds one of the most critical phases of plant life is greatly influenced by salinity. [10, 29] indicated that salinity reduced germination percentage, root and shoot length, fresh and dry weight, germination index and plant growth. These results in agreement with those obtained by [4, 18, 20, 37, 38].

3. Interaction Effects

Results illustrated in Figure **1** clearly showed that highest germination index resulted percentages was obtained from sowing chickpea Giza 3 cultivar with control treatment followed by sowing Giza 4 with the control treatment without significant differences between them. In contrast, sowing chickpea stand1 cultivar or Giza 531 at 20 (dSm^{-1}) salinity stresses recorded the lowest percentages of germination index without significant differences between them. Moreover, highest percentages of seedling vigor index resulted from sowing chickpea Giza 3 cultivars with the control treatment compared with other treatment as shown in Figure **2**. However, all studied cultivars at higher salinity levels i.e. 20 dSm^{-1} was produced the lowest values of seedling vigor index without significant differences between them. In addition, results showed that maximum shoot length was obtained form sown Giza 3 cultivar at control treatment and sowing Giza 4 with control treatment came in the second rank without significant differences between them as shown in Figure **3**. Sowing chickpea stand 1 cultivar at 20 dSm^{-1} salinity stress recorded shortest shoot. Highest root length resulted from sowing chickpea Giza 1, Giza 3 and Giza 195 cultivars with the control treatment without significant differences between them as shown in Figure **4**. However, sown Giza 1, Giza 2 Giza 3, Giza 4 Giza 531 and chickpea stand 1 with high level of salinity, i.e. 20 dSm^{-1} significantly produced the lowest root length without significant differences between them. Moreover, results showed that highest weight of fresh shoot resulted from sowing chickpea Giza 1 cultivar with control treatment followed by sowing Giza 3 with control treatment as illustrated in Figure **5**. However, sowing chickpea stand 1 cultivar with 20 dSm^{-1} salinity levels recorded the lowest weight of fresh shoot. In addition, highest root fresh weight resulted from sowing chickpea Giza 3 cultivar with control treatment followed by sowing Giza 1 with the control treatment as illustrated in Figure **6**. However, sowing chickpea stand 1 cultivar with highest salinity level i.e. 20 dSm^{-1} recorded the lowest weight of fresh

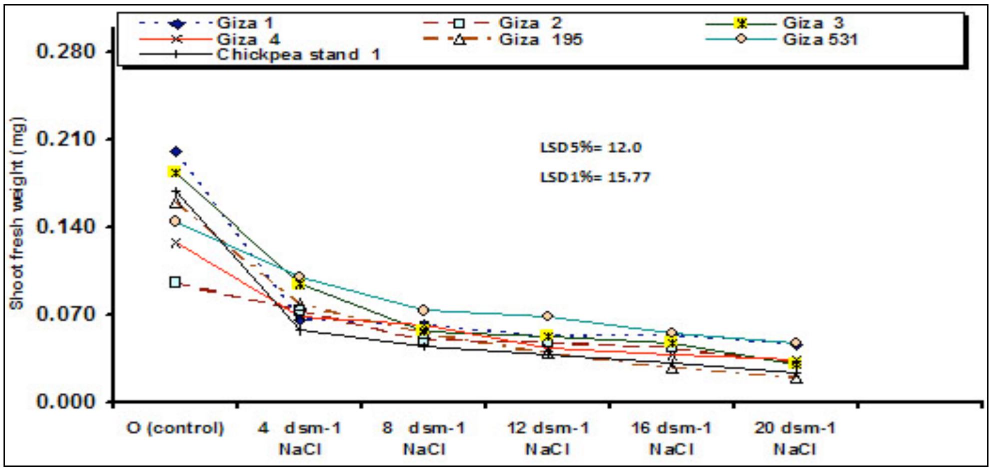

Figure 1: Averages of germination index as affected by the interaction between cultivars and salinity stress (NaCl dSm^{-1}).

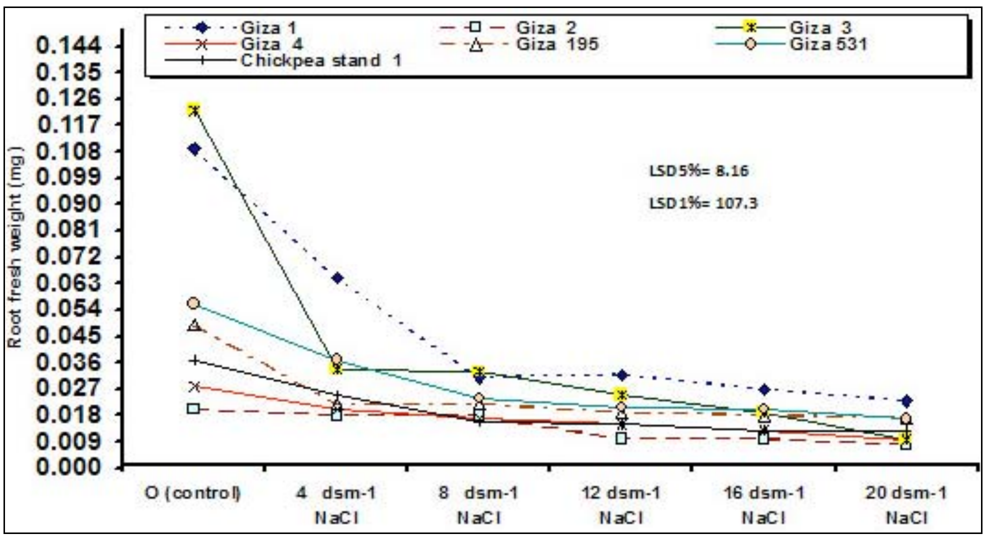

Figure 2: Averages of seedling vigor index as affected by the interaction between cultivars and salinity stress (NaCl dSm^{-1}).

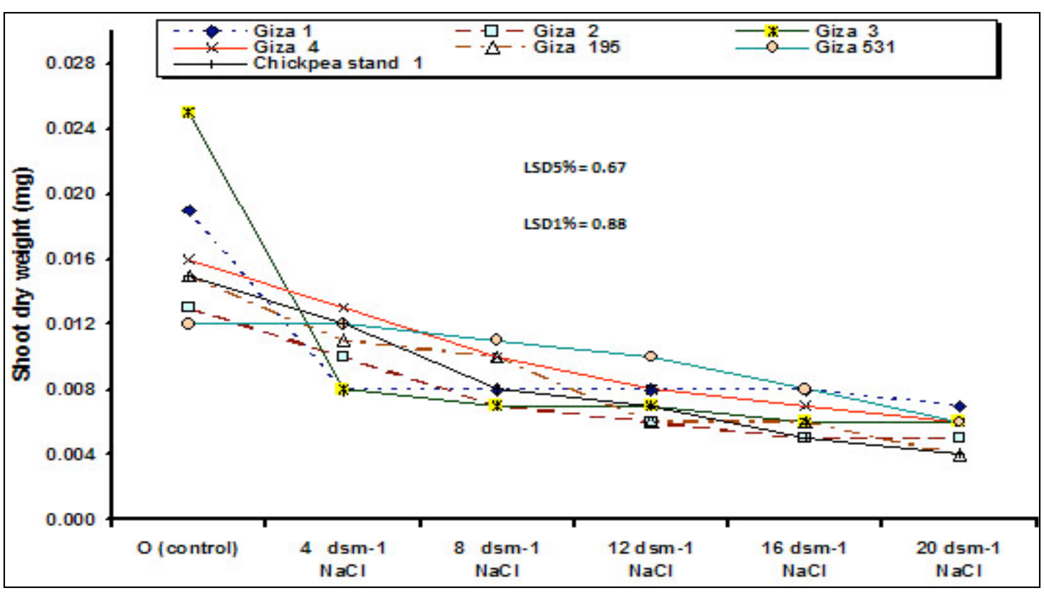

Figure 3: Averages of shoot length (cm) as affected by the interaction between cultivars and salinity levels (NaCl dSm^{-1}).

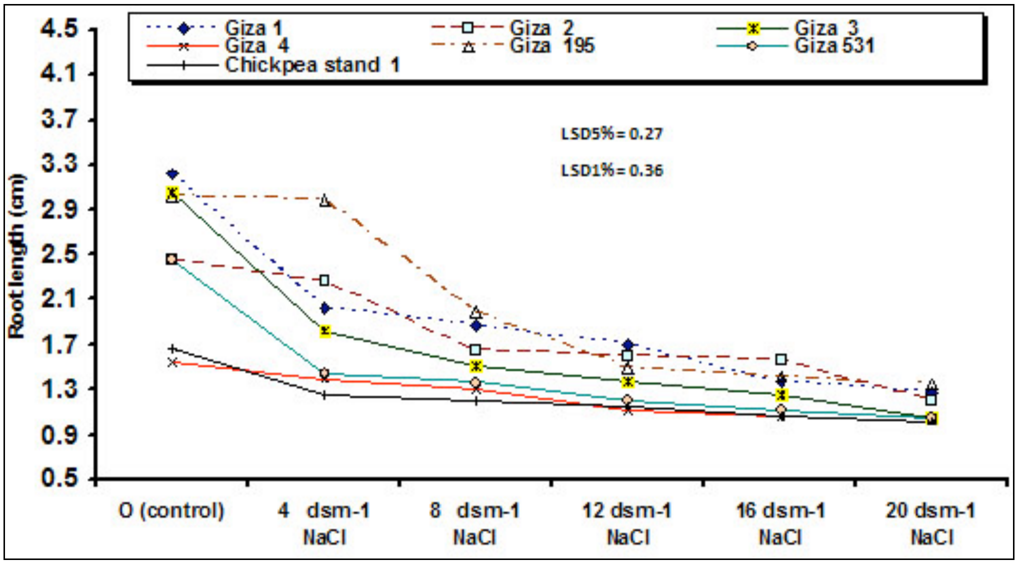

Figure 4: Averages of root length as affected by the interaction between cultivars and salinity levels (NaCl dSm^{-1}).

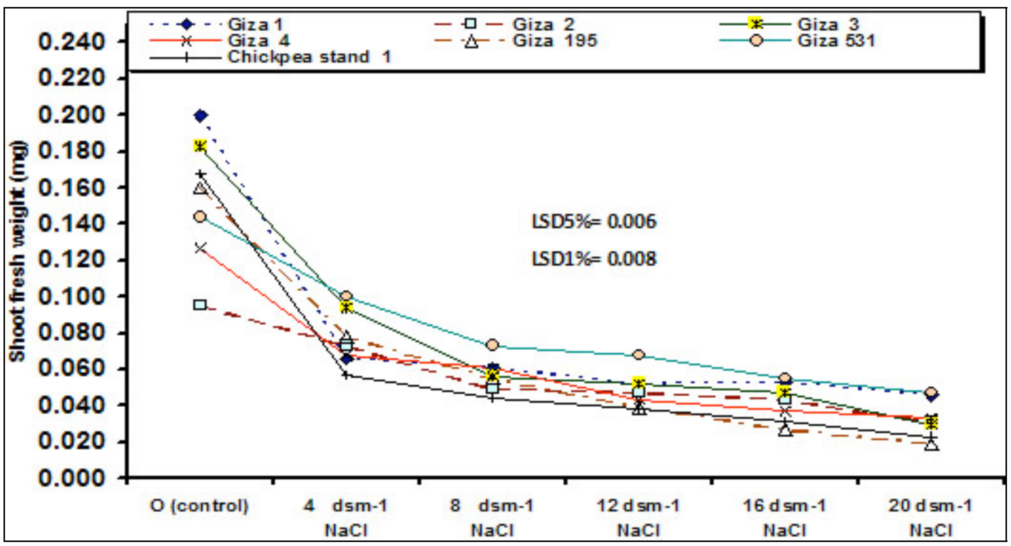

Figure 5: Averages of shoot fresh weight as affected by the interaction between cultivars and salinity levels (NaCl dSm^{-1}).

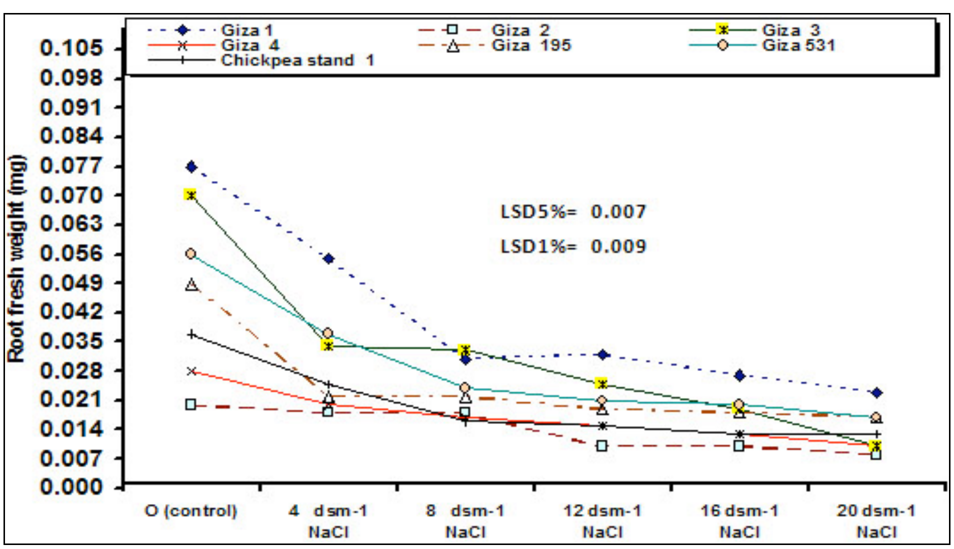

Figure 6: Averages of root fresh weight as affected by the interaction between cultivars and salinity levels (NaCl dSm^{-1}).

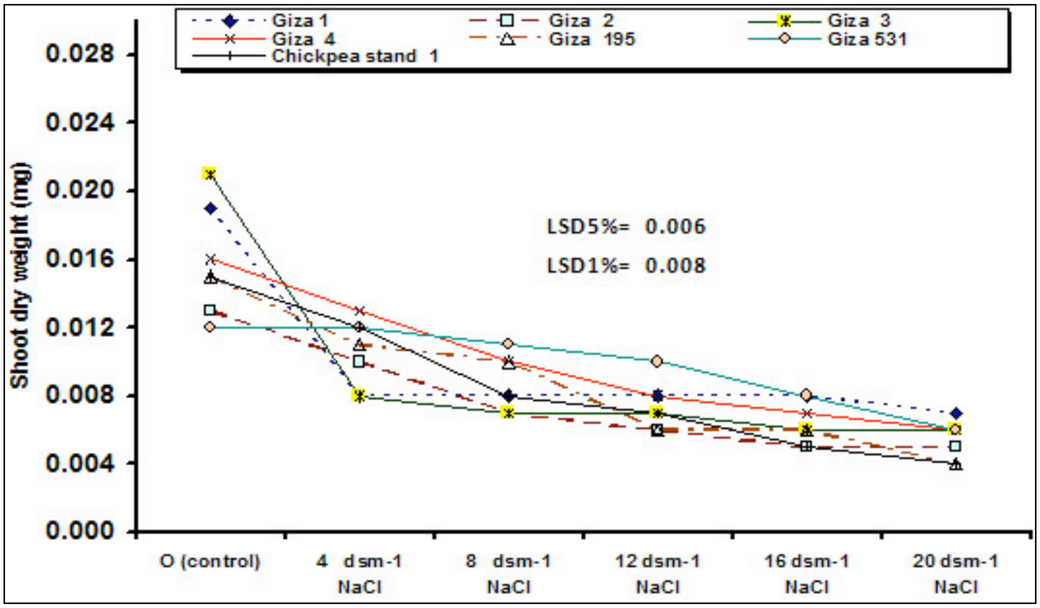

Figure 7: Averages of shoot dry weight as affected by the interaction between cultivars and salinity levels (NaCl dSm^{-1}).

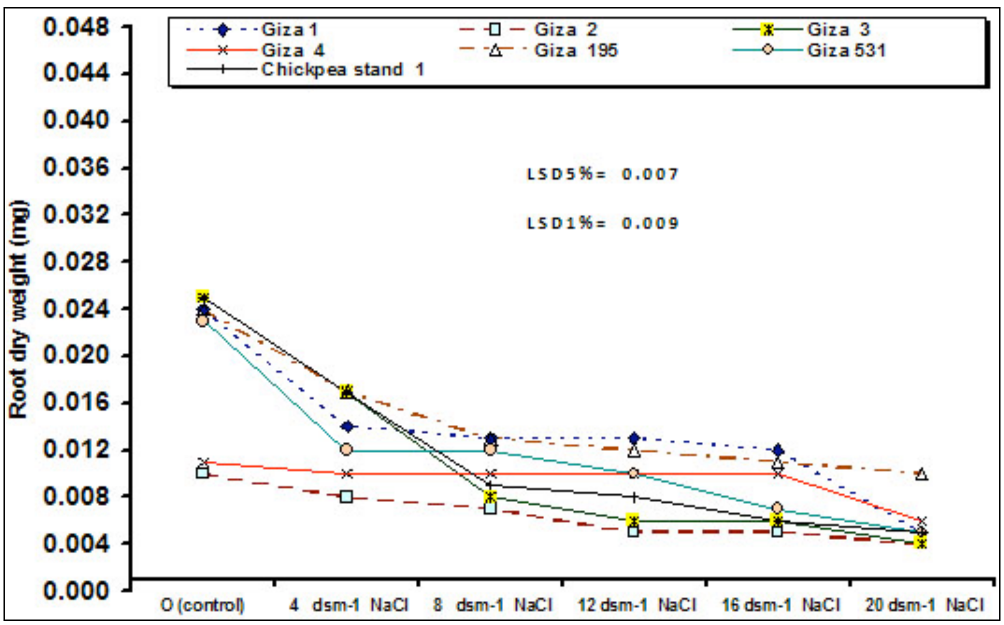

Figure 8: Averages of root dry weight as affected by the interaction between cultivars and salinity levels (NaCl dSm^{-1}).

root. Results showed that highest shoot and root dry weight resulted from sowing chickpea Giza 3 cultivar the with control treatment as illustrated in Figures **7** and **8**. However, sowing all studied cultivars under highest salinity levels significantly recorded the lowest shoot and root dry weight without significant differences between them. Furthermore, highest seedling height reduction (%) resulted from sowing all studied chickpea cultivars with levels of salinity levels i.e. 20 dSm^{-1} without significantly levels differences between them as shown in Figure **9**. However, the lowest averages of seedling height reduction (%) were produced from sown Giza 531 cultivar at i.e. 4 dSm^{-1}. Highest relative dry weight resulted from sowing chickpea stand 1 cultivars with the control treatment followed by sowing Giza 4 at salinity level of 4 dSm^{-1} NaCl as illustrated in Figure **10**. However, sowing all studied cultivars under highest salinity levels i.e. 20 dSm^{-1} NaCl produced the lowest percentages of relative dry weight. These results in agreement with those obtained by [5, 25, 30].

CONCLUSION

It could be summarized that for maximizing chickpea germination percentage and seedling

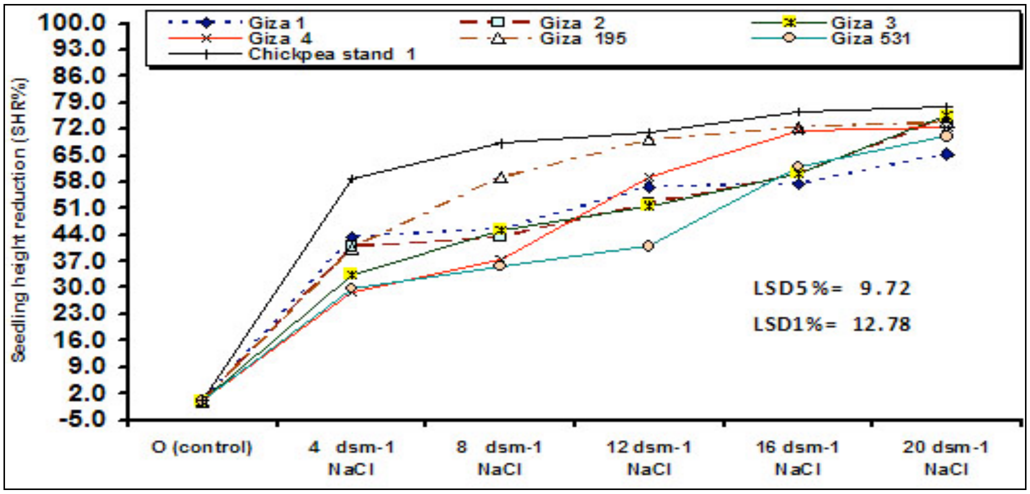

Figure 9: Averages of seedling height reduction (SHR%) affected by the interaction between cultivars and salinity stress (NaCl dSm^{-1}).

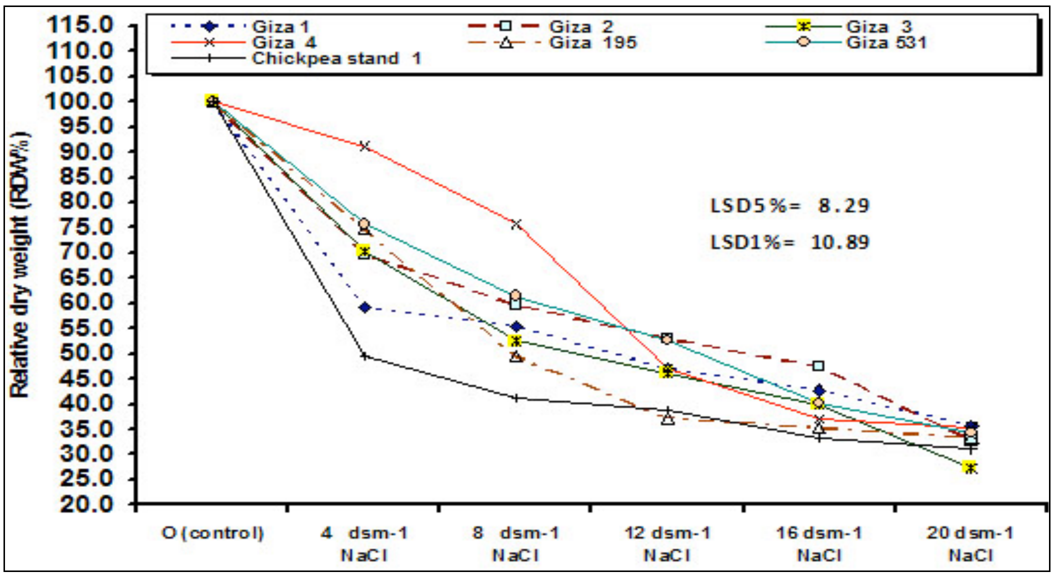

Figure 10: Averages of relative dry weight (RDW%) affected by the interaction between cultivars and salinity stress (NaCl dSm^{-1}).

parameters under salinity stress are producing by using chickpea Giza3, Giza2, Giza1 and Giza195 cultivars with increasing salinity concentrations levels up to 20 dSm^{-1}NaCl. These cultivars were more tolerant to salinity and recommended to use in breeding program for enhancing chickpea production in Egypt.

REFERNCES

[1] Gupta YP. Studies on chemical and nutritional changes in Bengal gram (*Cicer arietinum*) during storage caused by the attack of pulse beetle (*Callosobruchus macuatus* Fab). Plant Food Nutr 1987; 37: 201-28. http://dx.doi.org/10.1007/BF01091786

[2] Anwer M, Hussain I, Alam SS, Baig DF. Effect of NaCl Salinity on Seed Germination, Growth and Yield of two Varieties of Chickpea (*Cicer arietinum* L.). Pak J Biol Sci 2001; 4(2): 124-27. http://scialert.net/abstract/ http://dx.doi.org/10.3923/pjbs.2001.124.127

[3] Dua RP, Sharma PC. Salinity tolerance of Kabuli and Desi chickpea genotypes. International Chickpea and Pigeonpea Newsletter 1995; 2: 19-22. http://aob.oxfordjournals.org/content/89/5/563.full

[4] Khalid MN, Iqbal HF, Tahir A, Ahmad AN. Germination potential of chickpeas (*Cicer arietinum* L.) under saline conditions. Pak J Biol Sci 2001; 4(4): 395-96. http://scialert.net/qredirect.php?doi=pjbs.2001.395.396&linkid=pdf http://dx.doi.org/10.3923/pjbs.2001.395.396

[5] Esechie HA, Al-Saidi A, Al-Khanjari S. Effect of sodium chloride salinity on seedling emergence in chickpea. J Agron Crop Sci 2002; 188(3): 141-18. http://dx.doi.org/10.1046/j.1439-037X.2002.00554.x

[6] Singh AK. The physiology of salt tolerance in four genotypes of chickpea during germination. J Agric Sci Technol 2004; 6: 87-93. http://www.sid.ir/en/VEWSSID/J_pdf/84820040401.pdf

[7] Millan T, Clarke HJ, Siddique KHM, *et al*. Winter. Chickpea molecular breeding: New tools and concepts. Euphytica 2006; 147: 81-103. http://ukpmc.ac.uk/abstract/AGR/IND43816173

http://dx.doi.org/10.1007/s10681-006-4261-4

[8] Kaya M, Kaya G, Kaya MD, Atak M. Interaction between seed size and NaCl on germination and early seedling growth of some Turkish cultivars of chickpea (*Cicer arietinum* L.). J Zhejiang Univ Sci B 2007; 9(5): 371-77. http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2367375/ http://dx.doi.org/10.1631/jzus.B0720268

[9] Maliro M, McNeil D, Redden B, Kollmorgen JF, Pittock C. Sampling strategies and screening of chickpea (*Cicer arietinum* L.) germplasm for salt tolerance. Genet Resour Crop Evol 2007; DOI 10.1007/s10722-007-9214-9. http://ukpmc.ac.uk/abstract/AGR/IND43998981/reload=0;jsessionid=iTDENRZPSpcAZrqpPzgB.12

[10] Sohrabi Y, Heidari G, Esmailpoor B. Effect of salinity on growth and yield of Desi and Kabuli chickpea cultivars. Pak J Biol Sci 2008; 11(4): 664-67. http://eprints.icrisat.ac.in/2643/ http://dx.doi.org/10.3923/pjbs.2008.664.667

[11] Abdelmajid K. Differences in response of some Tunisian chickpea genotypes (*Cicer arietinum* L.) to salinity. Pak J Bot 2009; 41(6): 3081-91. http://www.pakbs.org/pjbot/PDFs/41(6)/PJB41(6)3081.pdf

[12] Garg N, Chandel S. Effect of mycorrhizal inoculation on growth, nitrogen fixation, and nutrient uptake in (*Cicer arietinum* L.) under salt stress Turk. J Agric 2011; (35): 205-14. http://journals.tubitak.gov.tr/agriculture/issues/tar-11-35-2/tar-35-2-11-0908-12.pdf

[13] Khan MA, Ungar IA. Effect of light, salinity and the thermoperiod on seed germination of halophytes. Can J Bot 1997; 75: 835-41. http://www.nrcresearchpress.com http://dx.doi.org/10.1139/b97-093

[14] Sharma SK, Manchanda HR, Singh JP. Note on the performance of some chickpea varieties grown on chloride-dominant saline soils. Indian J Agric Sci 1982; 52: 405-407.

[15] Geol N, Varshney KA. Note on seed germination and early seedling growth of two chickpea varieties under saline conditions. Legume Res 1987; 10: 34-36.

[16] Dubey RS, Sharma KN. Behavior of phosphatases in germinating chickpea in relation to salt tolerance. Plant Physiol Biochem 1990; 28: 17-26. http://www.cabdirect.org/abstracts/19900733445.html;jsessionid=D28C6B75DE2C8A2B9A83F4D737AF3312

[17] Kaur S, Anil KG Kaur N. Gibberellin A_3 reverses the effect of salt stress in chickpea (*Cicer arietinum* L.) seedlings by enhancing amylase activity and mobilization of starch in cotyledons. Plant Growth Regulators 1998; 26(2): 85-90. http://dx.doi.org/10.1023/A:1006008711079

[18] Ghoulam C, Fares K. Effect of salinity on seed germination and early seedling growth of sugar beet(*Beta vulgaris* L.). Seed Sci Technol 2001; 29: 357-64. http://cat.inist.fr/?aModele=afficheN&cpsidt=1112036

[19] Yadav HD, Yadav OP, Dhankar OP, Oswal MC. Effect of chloride salinity and boron on germination, growth and mineral composition of chickpea (*Cicer arietinum* L.). Ann Arid Zone 1989; 28: 63-67.

[20] Ferri A, Lluch C, Ocana A. Effect of salt stress on carbon metabolism and bacteroid respiration in root nodules of common bean (*Phaseolus vulgaris* L.). Plant Biol 2000; 2: 396-402. http://onlinelibrary.wiley.com http://dx.doi.org/10.1055/s-2000-5956

[21] Rout NP, Shaw BP. Salt tolerance in aquatic macrophytes: Ionic relation and interaction. Biol Plant 2001; 44: 91-95. http://www.springerlink.com/content/w2138743302uh738/?MUD=MP http://dx.doi.org/10.1023/A:1017978506585

[22] Munns R. Comparative physiology of salt and water stress. Plant Cell Environ 2002; 25: 239-250. http://faculty.ksu.edu.sa/EE5BDF68-F8DB-4B7D-B4C3-0D6938EF60B1/FinalDownload/DownloadId-8C9D5B447C2798032992239D64D13564/EE5BDF68-F8DB-4B7D-B4C3-0D6938EF60B1/Al-Whaibi/mhw%20documents/Coarses%20for%20the%20first%20tem%2031-32/671%20Bot/671%20Bot%20Course%20assignment/Translation%20assignment-1st%20Term-31-32/Assigned%20papers/10-Munns%202002%20comparativ%20d%20and%20s.pdf http://dx.doi.org/10.1046/j.0016-8025.2001.00808.x

[23] Delachiave MEA, De Pinho SZ. Germination of *Senna occidentalis* link: Seed at different osmotic potential levels. Braz Arch Biol Tech 2003; 46: 163-66. http://www.academicjournals.org/ajb/full%20text/2011/12Dec/Khodarahmpour.htm http://dx.doi.org/10.1590/S1516-89132003000200004

[24] Misra N, Dwivedi UN. Genotypic differences in salinity tolerance of green gram cultivars. Plant Sci 2004; 166: 1135-42. http://ukpmc.ac.uk/abstract/AGR/IND43633615%3Bjsessionid=A36A9C4693B12EE02D4BE7D1EE4FB30E http://dx.doi.org/10.1016/j.plantsci.2003.11.028

[25] Singla R, Garg N. Influence of salinity on growth and yield attributes in chickpea cultivars. Turk J Agric 2005; 231-35. http://journals.tubitak.gov.tr/agriculture/issues/tar-05-29-4/tar-29-4-1-0407-10.pdf

[26] Gunes A, Cicek N, Đnal A, *et al*. Genotypic response of chickpea (*Cicer arietinum* L.) cultivars to drought stress implemented at pre- and post-anthesis stages and its relations with nutrient uptake and efficiency. Plant Soil Environ 2006; 52(8): 368-76. http://www.agriculturejournals.cz/publicFiles/50746.pdf

[27] Soltani A, Gholipoor M, Zeinali E. Seed reserve utilization and seedling growth of wheat as affected by drought and salinity. Environ Exp Bot 2006; 55: 195-200. http://www.sciencedirect.com/science/article/pii/S0098847204001534 http://dx.doi.org/10.1016/j.envexpbot.2004.10.012

[28] Toker C, Lluch C, Tejera NA, Serraj R, Siddique KHM. Abiotic Stresses. In Chickpea Breeding and Management. Yadav SS, Redden R, Chen W, Sharma B, Eds. UK: CABI, 2007; pp. 474-496. http://dx.doi.org/10.1079/9781845932138.023

[29] Fatme K, Amooaghaie R, Mostajeran A, Emtiazi G. Effect of hydro and osmopriming in Two commercial chickpea cultivars on germination, growth parameters and nodules number in salt stress condition. Iranian J Plant Biol Winter 2010; 2(6): 71-86. http://www.academicjournals.org/EE5BDF68-F8DB-4B7D-B4C3-0D6938EF60B1/FinalDownload/DownloadId-60CA420C1FEF96C3611F67B607382A6D/EE5BDF68-F8DB-4B7D-B4C3-0D6938EF60B1/AjB/Ebooks/March/AJB-%206%20March,%202012%20Issue.pdf

[30] AL Mutawa M. Effect of Salinity on germination and seedling growth of Chickpea (*Cicer arietinum* L.) genotypes. Int J Agri Biol 2003; 5(3): 226-29. http://fspublishers.org/ijab/past-issues/IJABVOL_5_NO_3/2.pdf

[31] Ellis RA, Roberts EH. The quantification of ageing and survival in orthodox seeds. Seed Sci Technol 1981; 9: 373-409.

[32] Karim MA, Utsunomiya N, Shigenaga S. Effect of sodium chloride on germination and growth of hexaploid triticale at early seedling stage. Japanese J Crop Sci 1992; 61: 279-84. http://dx.doi.org/10.1626/jcs.61.279

[33] Abdul-Baki AA, Anderson JD. Vigor determination in soybean by multiple criteria. Crop Sci 1973; 13: 630-33. http://dx.doi.org/10.2135/cropsci1973.0011183X001300060013x

[34] Islam MM, Karim MA. Evaluation of Rice (*Oryza sativa* L.) genotypes at germination and early seedling stage for their tolerance to salinity. Agriculturists 2010; 8(2): 57-65. http://www.banglajol.info/index.php/AGRIC/article/view/7578

[35] Gomez AK, Gomez AA. Statistical Procedures for Agricultural Research. 2nd ed., John Willy and Sons, New York 1984; USA. http://www.google.com/books?hl=ar&lr=&id=PVN7_XRhpdUC&oi=fnd&pg=PA2&dq=Statistical+procedures+for+agricultural+research&ots=Hoa58prrl6&sig=-v65RCcVU8RUQjE_zfvGhSE5K3w#v=onepage&q=&f=false

[36] Snedecor GW, Cochran WG. Statistical Methods. 7th ed. The Iowa State Univ. Press, Iowa, USA. B0012S4NIE 1980.

[37] Zhang J, Jia W, Yang J, Ismail AM. Role of ABA integrating plant responses to drought and salt stresses. Field Crop Res 2006; 97: 111-19. http://courses.ttu.edu/bot3401-holaday/Role%20of%20ABA%20in%20integrating%20plant%20responses%20to%20drought%20and%20salt%20stresses.pdf http://dx.doi.org/10.1016/j.fcr.2005.08.018

[38] Jaiwal PK, Bhambie S, Mehta K. Effect of salinity on seed germination and seedling growth of chickpeas. International Crops Research Institute for the Semi-Arid Tropics, Andhra Pradesh, India 1983; 9: 15-16.

Received on 06-09-2012 Accepted on 04-10-2012 Published on 11-10-2012

http://dx.doi.org/10.6000/1927-5129.2012.08.02.49