Growth and accumulation of sodium in some genotypes of maize (Zea mays L) under salt stress and evaluate the correlation between them

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Abstract: High soil salinity is one of the important environmental factors that limit distribution and productivity of major crops. So the investigation of the plants and finding some method to resist the plants against salinity stress is very important. Considering Iran and Azerbaijan as origin countries in Astara region, and in order to study the effects of salt stress (NACL) on, Sodium content of leaves, proline, grain yield, plant height, Leaf chlorophyll content, leaf number and 100 grain weight of 8 maize cultivars were experimented in three replications on the basis of randomized complete block design in three years (2007-2009). Cultivars included K3615/1, S.C704, B73, S.C302, Waxy, K3546/6, K3653/2, and Zaqatala and they were cultivated in two pieces of land in Astara: one with normal soil and the other with salty soil. Results from the experiment showed that, between locations (normal and saline) in all traits, significant differences were seen. Between varieties in all traits, significant differences were seen. The interaction between years and varieties, years and varieties and locations for all traits was not significant. Comparison traits in different salinities showed that in most traits, there are significant differences between genotypes. Maximum of chlorophyll content was seen in S.C704, B73 and S.C302 under normal conditions. There was no significant difference between them. In the sodium content of leaves, a significant difference was seen between varieties at 1% level. The maximum amount of sodium was obtained In sc704 at salty conditions. The maximum of proline were measured In the S.C704 cultivar at salinity conditions. Grain yield was significantly negatively correlated with proline and showed a significant positive correlation with sodium. In normal conditions a significant negative correlation between the proline and sodium content were obtained with increasing salinity, between the leaves proline with the amount of sodium was significantly positive correlated.

[Davar Molazem, Jafar Azimi, Marefat Ghasemi, Mohsen Hanifi and Ali Khatami. **Growth and accumulation of sodium in some genotypes of maize (Zea mays L) under salt stress and evaluate the correlation between them.** *Life Sci J* 2013;10(1s):21-25] (ISSN:1097-8135). http://www.lifesciencesite.com. 3
Keywords: Salinity, accumulation of sodium, maize

INTRODUCTION

Abiotic stresses, such as drought, salinity, extreme temperatures, chemical toxicity and oxidative stress are serious threats to agriculture and the natural status of the environment. Salinity is one of the major environmental threats for agriculture and affects approximately 7% of the world's total land area (Ben-Salah et al, 2011) nearly 40% of the world land surface can be categorized as suffering from potential salinity problem. It has been estimated that over 25% of arable lands in Middle-East countries such as Iran is saline (El-Kader et al., 2006). Chloride and sodium ions enhancement in plant is one of the negative effects of salinity in plant parts which causes unfair condition for crop survival by stopping various mechanisms such as photosynthesis, stomata conductance and transpiration rate. Also, under saline condition, crop growth and development is affected by interaction of hormones, osmotic effects, specific ion effects and nutritional imbalances which take place all together (Shahid et al., 2011). Salinity causes oxidative stress that is outcome of induced active oxygen species formation. Furthermore, cellular metabolism is disturbed by active oxygen species via oxidative damage to membrane lipid, proteins and nucleic acids (Salama et al., 2011). It was reported by Collado et al., (2010) that after wheat and rice, Maize (Zea mays L.) is the third most important cereal in the world which has been cultivated under different climatic conditions. Since maize is a cross pollinated plant as a result, it has an extremely polymorphic for evolution and so includes huge diversity which cause it being tolerate to salinity (Collado et al., 2010). Maize has been classified as one of those plants which are sensitive to salinity moderately (Carpici et al., 2010). Akram et al., (2010) observed that yield reduction of corn varied from 10 percent at EC of 1/7 ds/m to 50 percent at EC 7 ds/m but there was diversity within the genotypes for accumulation of Na+. Due to the salinity, three kinds of different pressures will be produced in plants: osmotic stress, specific ion toxicities (e.g. Na + and Cl -) and ionic imbalance (e.g. Na+ versus K +; Na + versus Ca 2+) (Collado et al., 2011).

Soluble salts at higher concentrations in growth medium cause hyperosmolality and imbalance of nutrients in most plants that harmfully decline plant growth (Zhu, 2003; Turan et al., 2010). Many studies have shown that the height (jamil et al., 2007; Rui et al., 2009; Memon et al., 2010), growth index (Bandehhagh et al., 2008) and fresh and dry weights of the shoot and root system (Abdul Jaleel et al., 2007; Ashraf and Ali, 2008; Shahbaz et al., 2010) are affected negatively by changes in salinity concentration, type of salt present, or type of plant species. Numerous studies showed the affection of leaf area negatively by using different concentrations of

NaCl (Zhao et al., 2007; Yilmaz and Kina, 2008; Rui et al., 2009). Maize is of primary cultivated kinds that had been by mankind. Ghalinat believed that maize has originated from (Zea Mexicana) because of mankind's interference (Rahimian and Banayan,1996). Till a few years ago, maize had been cultivated in Iran as a secondary corn behind other cultivars, but fortunately chow it was placed as main cultivated product and high attention have been paid to its cultivation with a view to preparing the herbivorous animals food. Many studies have been done about maize. About 500 different genes were recognized in maize and the chromosome plan of each of them was analyzed. Mach of the maize is Hybrid cultivated kind that has high performance by considering the Heterosis phenomenon. The main goal in improving the gene of the maize is increasing the yield in level unite and compatibility with environment and the quality of the corn and resistance against diseases. Nowadays, we are witness of main changes in this field by relying on new methods in improving gene such as biotechnology and molecular markers and we hope that we can done our selection on the basis of the marker's related genotypes with special gene that can control the wanted characteristics by using molecular markers (abdmishani, 1997).

Materials and Methods:

Considering Iran and Azerbaijan as origin countries, and in order to study the effects of saltiness on growth and yield characteristics of maize plant, its different items were investigated in 2007-2009. Seeds of 8 maize cultivars including K3615/1, S.C704, B73, S.C302, Waxy, K3546/6, K3653/2, and Zaqatala were cultivated in two pieces of land in Astara, one with normal soil and the other with salty soil. Experiment was carried out in the form of randomized complete block design in three repetitions. During the experiment, morphological and physiological characteristics concerning the plant growth, such as plant height, leaf numbers, Sodium content of leaves, proline content, Leaf chlorophyll content and yield characteristics such as , 100 grain weight and grain yield, were measured. Free proline accumulation was determined using the method of Bates *et al.,* (1975). 0.04 gram dry weight of leafs was homogenized with 3% sulfosalicylic acid and after 72h that proline was released; the homogenate was centrifuged at 3000 g for 20 min. The supernatant was treated with acetic and acid ninhydrin, boiled for 1 hour and then absorbance at 520 nm was determined by Uv-visible spectrophotometer.

Sodium concentrations were determined by using Eppendorf Elex 6361 model flame photometry described by Miller (1998).Statistical analysis of the numbers was done on the basis of randomized complete block design. The average of attendances was calculated on the basis of Duncan method at 5% probability level.

Results and Discussion

Results from the experiment showed that, regarding the most of the characteristics, there were significant differences among cultivars and that, compared to normal conditions; saltiness had caused reduction in their values. Results from the analysis of variance showed that there were no significant differences between different years (Table 1). Between locations (normal and saline) in all traits, significant differences were seen. Between varieties in all traits, significant differences were seen. In the sodium content of leaves, a significant difference was seen between varieties at 1% level. The maximum amount of sodium was obtained in sc704 at salty conditions. That, with all varieties were significant differences (Table 2).In the chlorophyll content, a significant difference was observed in conditions (normal and saline), cultivars and interaction between cultivars and conditions. Maximum of chlorophyll content was seen in S.C704, B73 and S.C302 under normal conditions. There was no significant difference between them. Concerning the plant height under the normal and salty conditions, there were significant differences among the cultivars. In case of all cultivars, saltiness caused reduction in plant height. The greatest plant height was seen in S.C704 (275.6) and Zaqatala (268.8) under normal conditions. In case of both normal and salty conditions, the least amount of plant height was seen in K3545/6. That, with all varieties had significant differences (Table 2).Due to the saltiness; leaf numbers in case of all cultivars were reduced. Under normal and salty conditions, waxy had the least leaf numbers among the cultivars and there were significant differences among other cultivars under normal conditions. The greatest leaf numbers was seen in Zaqatala (13.96), K3653.2 (13.67) and S.C704 (13.28) and its least amount in Waxy (8.673) under the salty conditions. In an experiment done by Hussain et al(2007) on 4 items maize it was shown that together with increase in saltiness plant height, leaf numbers, length of cob, grain numbers and the whole grain in ear were reduced. It has been known that salty conditions causes decrease in water absorption in plants. For example, in an experiment done for the purpose of determining the relation between water and plant in tomato, it was shown that irrigating the plant with salty water caused decrease in case of both the amount of plant growth and the amount of absorbable water (Romero et al, 2001).

Weight of 100 grains was decreased due to the saltiness. The greatest weight of 100 grains was seen in Zaqatala cultivar and its least amount was seen in K3653.2. The maximum grain yield was obtained In S.C704, which with K3615.1 showed no significant difference. The lowest grain yield obtained at K3615.1 and of salinity condition. And indicates that this cultivar is sensitive to salinity. Proline content increased with increasing soil salinity. Proline increases plant resistance to salinity. The maximum of proline were measured In the S.C704 cultivar at salinity conditions. And there was a significant difference with other varieties (Table 2).

Simple correlation coefficients were calculated in normal and saline condition. Between the chlorophyll content and plant height were significant positive correlations. Significant positive correlation between the plant height with leaf number and yield were calculated. Between the number of leaves per plant with grain yield and leaf sodium content were significant positive correlations. A significant negative correlation Between the 100 seed weight with proline was

observed. Grain yield was significantly negatively correlated with proline and showed a significant positive correlation with sodium. In normal conditions a significant negative correlation between the proline and sodium content were obtained (Table 3). Between the chlorophyll content with the amount of sodium was significantly negatively correlated. Plant height with leaf number and leaf sodium content showed a significant positive correlation. Between the numbers of leaves per plant with the proline and sodium content were significantly positive correlated. With increasing salinity, between the leaves proline with the amount of sodium was significantly positive correlated (Table 4).

Table 1 - Analysis of variance for maize varieties

Source	DF	Mean Square						
		Na	Plant height	100-grain Weight	Leaf number	Grain yield	Chlorophyll content	proline
Year	2	0.0003ns	285.33ns	1.837 ns	0.193ns	0.0001ns	2.248ns	0.0005ns
Location	1	334.506**	69076.544**	59.640**	88.282**	16889.972**	66036.580**	405.720**
YL	2	0.0001ns	263.075ns	.035ns	0.004ns	0.0002ns	1.186ns	0.0001ns
R(LY)	12	0.007	1387.609	.495	2.001	108.598	617.444	0.001
Variety	7	1.838**	31638.024**	5.673**	23.359**	403.136**	851.123**	0.506**
YA	14	0.0002ns	212.301ns	.039ns	0.038ns	0.0001ns	0.112ns	0.0001ns
LA	7	1.567**	1762.906*	9.735**	1.715ns	259.220**	581.000**	1.668**
YLA	14	0.0002ns	216.318ns	.022 ns	0.018 ns	0.0003ns	0.101ns	0.001ns
Error	84	0.003	637.971	.709	1.216	72.088	84.110	0.028
	CV%	2.87%	12.82%	16.87%	9.34%	16.03%	19.66%	5.97%

ns. Non-significant
* significant at 5%
**, significant at 1%

Table 2- Mean comparison traits in eight varieties of maize

	Cultivars	Chlorophyll content	Plant height(cm)	Leaf number (unit/plant)	Grain yield (Kg/ha)	W100	Na mg g^{-1} DW	Proline µmol/g FW
Normal	1-Zaqatala	53.15 c	268.8 a	13.96 a	4489.167 bc	24.39 a	0.3300 hi	1.033 ij
	2-S.C302	78.49 ab	242.7 b	12.58 bc	3698.333 bcde	17.81 bcd	0.3010 hi	1.010 ij
	3-K3653.2	73.25 b	194.3 de	13.67 a	3429.167 de	15.67 cdef	0.2890 i	1.323 g
	4-B73	80.20 ab	239.3 bc	12.55 bc	3583.333 cde	17.88 bcd	0.2957 hi	1.300 gh
	5-S.C704	83.08 a	275.6 a	13.28 ab	5866.667 a	15.08 def	0.3497 h	1.150 hi
	6-Waxy	54.41 c	204.0 d	10.11 e	3069.167 ef	16.47 bcde	0.2730 j	1.430 g
	7-K3615.1	61.77 c	201.9 de	12.41 bc	4770.833 ab	16.08 bcde	0.3320 hi	0.9533
	8-K3545.6	60.24 c	125.5 h	12.18 bc	4339.167 bcd	19.04 b	0.3163 hi	0.9867ij
Salinity	1-Zaqatala	18.83 e	217.5 cd	12.44 bc	2162.500 gh	18.38 bc	4.094 b	4.847 b
	2-S.C302	27.23 de	165.9 f	11.05 de	2395.833 fg	14.35 ef	3.277 d	4.660 c
	3-K3653.2	29.60 d	150.9	10.92 de	1533.333 hi	12.95 f	2.840 e	3.910 e
	4-B73	27.54 de	206.6 d	12.02 cd	1737.500 ghi	16.40 bcde	2.753 f	4.443 d
	5-S.C704	21.20 de	212.6 d	11.89 cd	2604.167 fg	14.34 ef	4.215 a	5.067 a
	6-Waxy	23.67 de	162.0 f	8.673 f	1841.667 ghi	15.18 def	2.611 g	3.743 f
	7-K3615.1	27.89 de	177.5 ef	10.49 e	1241.667 i	15.60 cdef	3.769 c	4.663 c
	8-K3545.6	25.99 de	108.6 h	10.72 e	1312.500 i	13.72 ef	3.314 d	4.710 bc

* Different letters indicate significant differences at the level of 5%

Table 3 - Simple correlation coefficients between traits in normal conditions

	Chlorophyll content	Plant height	Leaf number	W100	Grain yield	proline	Na
Chlorophyll content	1	.319**	.024	-.198	.089	.034	-.028
Plant height		1	.285*	.122	.254*	.035	.206
Leaf number			1	.188	.260*	-.318**	.495**
W100				1	.173	-.272*	.078
Grain yield					1	-.301*	.545**
proline						1	-.655**

**. Correlation is significant at the 0.01 level (2-tailed).

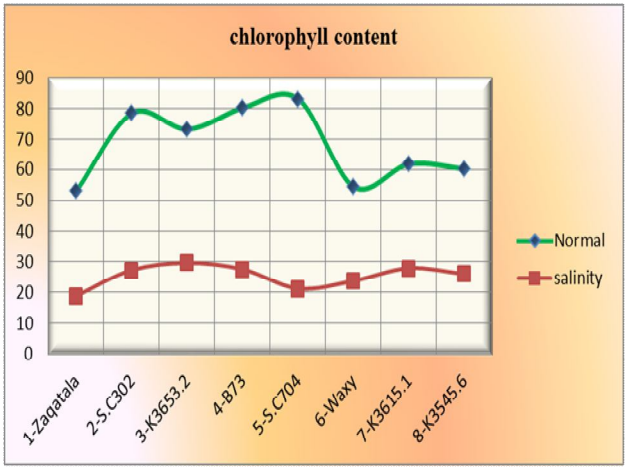
*. Correlation is significant at the 0.05 level (2-tailed).

Table 4 - Simple correlation coefficients between traits in saline conditions

	Chlorophyll content	Plant height	Leaf number	W100	Grain yield	proline	Na
Chlorophyll content	1	-.174	.049	-.087	-.036	-.035	-.291*
Plant height		1	.361**	.211	.209	.293*	.406**
Leaf number			1	.180	.196	.497**	.387**
W100				1	.205	.145	.165
Grain yield					1	.173	.199
proline						1	.793**

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).



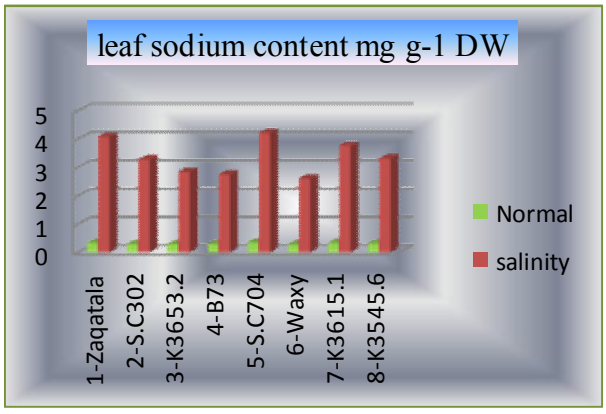


Figure 1 – Diagram of different understudy characteristics in eight cultivars of the maize under the normal and salty conditions

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