Is salinity tolerance related to Na accumulation in maize cultivars (*Zea mays* L.)?

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Abstract: Considering Iran and Azerbaijan as origin countries in Astara region, and in order to study the effects of salt stress (NACL) on morphological characteristics changes of 8 maize cultivars were experimented in three replications on the basis of randomized complete block design. 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. During the experiment, Salt accumulation in leaves, leaf numbers, Leaf length, and yield characteristics such as weight of 100 grains, proline and grain yield, were measured. Results from the experiment showed that, regarding the most of characteristics, there were significant differences among cultivars and that, compared to normal conditions; saltiness had caused reduction in their values Soil salinity reduces leaf length in most cultivars. Maximum leaf length was found in Zaqatala and Sc704 respectively. Lowest leaf length, was seen in K3545.6 (49.85). Proline content increased with increasing soil salinity. Proline increases plant resistance to salinity. With increasing salinity, salt accumulation in leaves severely increased. Biggest accumulation in S.C704 was observed. The highest amount of proline was measured in this variety. This variety showed resistance to salinity, and with all the varieties were significant difference.

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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. Increased salinisation of arable land is expected to have devastating global effects, resulting in 30% land loss within the next 25 years, and up to 50% by the year 2050 (Wang et al., 2003). The deleterious effects of salinity on plant growth are associated with (1) low osmotic potential of soil solution (water stress), (2) nutritional imbalance, (3) specific ion effect (salt stress), or (4) a combination of these factors (Ashraf, 1994b; Marschner, 1995; Zhu, 2003; Turan et al., 2010).

Salinity is known to adversely affect production of most crops worldwide (Hasegawa et al. 2000; Bayuelo-Jime´nez et al. 2002; Ashraf 2009). 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 characteristics concerning the plant growth, such as Salt accumulation in leaves, leaf numbers, Leaf length, and yield characteristics such as weight of 100 grains, proline 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. Interaction between year and location were no significant for all traits. Between varieties in all traits, were seen significant differences at 1%. Interaction between year and varieties were no significant for all traits. An interaction between locations and varieties for Na, leaf length, 100-seed weight, grain yield and proline were significant, but for the number of leaves was not significant. The highest coefficient of variation for seed weight was (16.87). The lowest values were obtained for Na (2.87). 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. Soil salinity reduces leaf length in most cultivars. Maximum leaf length was found in Zaqatala and Sc704 respectively. Lowest leaf length, was seen in K3545.6 (49.85).

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).

Together with the criticalness of vegetative growth in salty conditions, some physical parameters are also influenced. Some of the most important parameters are plant height, stem diameter, and yield characteristics of the plants (Blumwold, 2000). 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). Results from the experiments done by Hussein et al (2007) showed that increase in saltiness level in maize caused decrease in plant height, stem diameter, leaf numbers, leaf areas and dry mass of the plant. With increasing salinity, salt accumulation in leaves severely increased. Biggest accumulation in S.C704 was observed. The highest amount of proline was measured in this variety. This variety showed resistance to salinity, and with all the varieties were significant difference.

Table 1 - Analysis of variance for maize varieties

Source	DF	Mean Square					
		Na+	Leaf length	Leaf number	100-grain Weight	Grain yield	proline
Year	2	0.0003ns	0.106ns	0.193ns	1.837 ns	0.0001ns	0.0005ns
Location	1	334.506**	4263.654**	88.282**	259.640**	16889.972**	405.720**
YL	2	0.0001ns	1.353ns	0.004ns	0.035ns	0.0002ns	0.0001ns
R(LY)	12	0.007	149.063	2.001	0.495	108.598	0.001
Variety	7	1.838**	3217.854**	23.359**	85.673**	403.136**	0.506**
YA	14	0.0002ns	1.177ns	0.038ns	0.039ns	0.0001ns	0.0001ns
LA	7	1.567**	702.060**	1.715ns	19.735**	259.220**	1.668**
YLA	14	0.0002ns	0.685ns	0.018 ns	0.022 ns	0.0003ns	0.001ns
Error	84	0.003	88.468	1.216	7.709	72.088	0.028
	CV %	2.87%	12.44%	9.34%	16.87%	16.03%	5.97%

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

Table 2- Mean comparison traits in eight varieties of maize

	cultivars	Leaf length (cm)	Na mg g^{-1} DW	Leaf number (unit/plant)	100-grain Weight(g)	Grain yield (Kg/ha)	Proline µmol/g FW
Normal	1-Zaqatala	99.16 a	0.3300 hij	13.96 a	24.39a	4489.167 bc	1.033 ij
	2-S.C302	87.48 bc	0.3010 hij	12.58 bc	17.81bcd	3698.333	1.010 ij
	3-K3653.2	81.83 cd	0.2890 ij	13.67 a	15.67cdef	bcde	1.323 g
	4-B73	86.43 bc	0.2957 hij	12.55 bc	17.88bcd	3429.167 de	1.300 gh
	5-S.C704	95.74 ab	0.3497 h	13.28 ab	15.08def	3583.333 cde	1.150 hi
	6-Waxy	77.07 de	0.2730 j	10.11 e	16.47bcde	5866.667 a	1.430 g
	7-K3615.1	66.93 f	0.3320 hi	12.41 bc	16.08bcde	3069.167 ef	0.9533 i
-	8-K3545.6	53.54 gh	0.3163 hij	12.18 bc	19.04b	4770.833 ab	0.9867ij
Salinity	1-Zaqatala	92.88 ab	4.094 b	12.44 bc	18.38bc	4339.167 bcd	4.847 b
	2-S.C302	56.22 gh	3.277 d	11.05 de	14.35ef	2162.500 gh	4.660 c
	3-K3653.2	72.27 ef	2.840 e	10.92 de	12.95f	2395.833 fg	3.910 e
	4-B73	86.77 bc	2.753 f	12.02 cd	16.40bcde	1533.333 hi	4.443 d
	5-S.C704	69.47 ef	4.215 a	11.89 cd	14.34ef	1737.500 ghi	5.067 a
	6-Waxy	62.57 fg	2.611 g	8.673 f	15.18def	2604.167 fg	3.743 f
	7-K3615.1	71.08 ef	3.769 c	10.49 e	15.60cdef	1841.667 ghi	4.663 c
	8-K3545.6	49.85 h	3.314 d	10.72 e	13.72ef	1241.667 i	4.710 bc
						1312.500 i	

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

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