SALINITY AND NITROGEN LEVEL AFFECTS NUTRIENT COMPOSITION OF SOME TOMATO CULTIVARS

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ABSTRACT

Five commercial tomato cultivars; Pascal, Red Stone, Shohba, Super Marmand and Tanshet Star; were grown in a greenhouse to investigate the effects of four irrigation water salinity levels (0.5, 2.5, 5 and 10 dsm^{-1}), four nitrogen fertilizer rates (0, 5, 10 and 15 mML^{-1}) and their interactions on the leaves nutrient concentration of tomato seedlings. The study was carried out at the Experimental Farm of Faculty of Food and Agricultural Sciences, King Saud University, Riyadh, Saudi Arabia, during 2005, in a greenhouse through two identical trials. The results indicated marked cultivar differences with respect to Na and Cl contents were detected. The Pascal and Tanshet Star cultivars had significantly higher Na and Cl contents, however, the lowest Na and Cl contents were in cvs. Shohba and Super Marmand. Increasing salinity level seemed to be associated with higher Na and Cl, and lower Ca, Mn, K, N, and P contents. As nitrogen concentration increased from o to 10 mML^{-1}, the leaf's nutrient contents of Ca, Mn, K, N, and P were increased. Interaction effects between salinity × nitrogen levels for the different determined nutrients indicated that increasing nitrogen levels mitigated the negative effects of salinity levels.

Keywords: *Lycopersicon esculentum, mineral composition, salinity tolerant, ion concentration.*

INTRODUCTION

Salinity is one of the most important limiting factors to crop production (Munns 2002). Plants are stressed in saline soils due to water stress (low osmotic potential), toxic effects of ions, mainly Na and Cl, and nutrient imbalance, or a combination of these factors (Chapin, 1991, Marschner, 1995). Tomato (*Lycopersicon esculentum* Mill.) could act as a model crop for saline land recovery and use of poor-quality water as there is a wealth of knowledge of the physiology and genetics of these species, and it is already grown in large areas where saline conditions are a problem (Reina-Sanchrz *et a*l. 2005). Most commercial tomato cultivars are sensitive to moderate levels of salinity which means that it tolerates an E.C of the saturated soil extract up to about 2.5 dsm^{-1} without any yield reduction (Mass, 1986). However, large genetic variation exists among genotypes (Foolad and Lin, 1997, 1998).

Screening methods for salt tolerance and the physiological studies of salinity effects are based on the young plant (Al-Karaki, 2000; Alian *et al.*, 2000). Dasgan *et al.* (2002) reported that tomato genotypes differed greatly for shoot Na^+ concentration and salinity scale classes were significantly correlated with Na^+ concentrations. Salinity causes a nutrient imbalance in tomato plants which have lower concentrations of N, P, Ca and K when grown in a saline medium (Adams and Ho, 1989). The most direct way to reestablish normal N, P, Ca and K contents in plants would be by raising concentrations of these elements in the root zone with higher fertilizer rates (Cuartero and Fernandez-Munoz, 1999). Cerda and Martinez (1988) reported that addition of nitrogen fertilization in saline nutrient solution enhanced development of shoot and root dry weight of tomato and cucumber (*Cucumis sativus* L.) plants, and the optimum N concentration in the nutrient solution varied between 6 and 10 mML^{-1}. They ,also, reported that leaf Cl concentration decreased in both species when NO_3 was used as the N source, whereas, it increased in the leaves of plants fertilized with NH_4^+. Deleterious effects of salinity on tomato biomass production can be minimized with nutrient solutions containing higher NH_4 concentrations, since this seemed to be correlated with increases in nitrogen assimilation and the levels of Fe and chlorophyll (Flores *et al.*, 2001).

The objective of this study was to investigate the effects of water salinity under different nitrogen fertilizer rates on leaf nutrient concentration of some tomato cultivars.

MATERIALS AND METHODS

Plant material and culture condition: Plants of the tomato cvs. Pascal, Red Stone, Shohba, Super Marmand and Tanshet Star; were grown in a greenhouse to investigate the effect of irrigation with different levels of salinity (0.5, 2.5, 5 and 10 dsm^{-1}) in combination with four N levels (0, 5, 10 and 15 mML^{-1} N) on leaf nutrient concentration of tomato seedlings. Seeds of the tested tomato cultivars were sown in seedling trays(one seed/cell), with 209 cells, which were filled with sterilized peat-moss and vermiculite 1:1 v/v, and placed in a greenhouse at 25±0.5°C and 80±1% of relative humidity. The experiment was carried out in two trials on 5 March and 15 April 2007, respectively. Irrigation was begun immediately after sowing by adding 200 mL of NaCl solutions (0.5, 2.5, 5 and 10 dsm^{-1}) daily, and the nitrogen solutions (0, 5, 10 and 15 mML^{-1} N) every 2 days.

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The experimental design was split-split-plot system, in a randomized complete block design, with four replications. The cultivars were randomly arranged as the main plots, salinity levels were considered as the sub-plot; while , the N levels were taken as the sub-sub plots. Each experimental unit was represented by one tray in each replicate. Ten randomly selected seedlings were collected from each tray at 35 days after sowing to determine nutrient contents.

Minerals analysis: Dried plant material (leaves) was digested by perchloric sulfuric acid mixture according to the method described by Chapman and Pratt (1961). Phosphorus in the digested plant material was determined calorimetrically using Backman Spectronic20. Potassium and Na in the extraction were measured by a ATS 200 flame spectrophotometer. Manganese was measured by an Atomic Absorption Spectrophotometer (model 2380, Perkin-Elmer). Calcium was determined by the_versant method using ammonium purpurate indicators (Heng and Bray, 1951). Chloride was determined by titration with 0.05N silver nitrate using potassium chromate indicator (Chapman and Pratt, 1961)._Total nitrogen was determined by digesting 0.2 g of plant material using sulfuric and salicylic acid using a micro-Kjeldahal procedure (Chapman and Pratt, 1961). All nutrient concentrations were determined as mg/100 g dry matter.

Statistical Analysis: The combined data of the two trials were subjected to ANOVA using SAS (Ray and Sall, 1982, and_treatment means were compared with the Revised LSD test at 0.05 level (Steel and Torrie, 1980).

RESULTS AND DISCUSSION

Data presented in Table (1) indicated significant differences existed between each of the five tested cultivars, salinity levels, and nitrogen fertilization levels for leaf's nutrient composition of tomato seedlings. However, such an effect on %N for cultivars was not so high enough to be significant. The results in Table (1) revealed that both Pascal and Tanshet Star cultivars significantly contained higher Na , Cl and K contents , relative to the other cultivars, The lowest Na and Cl contents were reflected by cvs. Shohba and Super Marmand. These cultivar differences in leaves Na content of tomato seedlings are in accordance with those detected by Dasgan *et al.* (2002),who reported that tomato genotypes differed greatly for shoot Na^+ concentration. Large genetic variation exists among genotypes were recorded by Foolad and Lin(1997& 1998).

Regarding the significant differences in all determined chemical nutrients in response to salinity treatment, the results in Table (2) clarified that increasing salinity level in irrigation water from 0.5 to 10 dsm^{-1}, not only, increased Na and Cl contents but also, caused significant decreases in the other nutrients (Ca, Mn, K, N, NO_3 and P). The rise in Na and Cl concentrations in the leaves lowers the osmotic potential (Cuartero and Fernandez-Munoz, 1999); which, in turn, contributing to the maintenance of the water potential difference between the leaves and the soil required to obtain water from the saline solution. Accordingly, plants able to accumulate more Na and Cl (as observed by cvs. Pascal and Tanshet Star) would absorb water more easily and be more tolerant to salinity. The interaction between Na and K contributes to decreasing K uptake, however, inhibits P uptake by roots. Phosphorus translocation from root to shoot and re-translocation of P from old to young leaves as affected by salinity may be due to decreased mobility of P stored in vacuoles. _Also, uptake of NO_3 from roots was strongly inhibited by salinity, consequently NO_3 concentration in leaves was lower in plants treated with saline than in control (0.5 dsm^{-1}) plants. These results agreed with the findings of Gomez *et al*, (1992) and Al-Khayri (2002), who reported that salinity produced by the addition of NaCl to the irrigation water caused an increase of Na and decreasing concentration of K, P, N, and Ca ions. Similar findings were obtained by Adams and Ho(1989) who, stated that salinity causes a nutrient imbalance in tomato plants which have lower concentrations of N, P, Ca and K when grown in a saline medium. Ion absorption ability of the cells is considered one of the means of adaptation under saline conditions (Rus *et al.*, 1999).

Respecting the effects of N fertilization levels, it was noticed that the application of nitrogen fertilizer, irrespective the used level, significantly, increased all the determined nutrients compared to the unfertilized control. The higher the nitrogen level(15 mML^{-1} N) ,the higher was leaf's nutrient contents. These findings stated that applied N fertilization may reduce the negative effects of salinity. Similar results were reported by Cuartero and Fernandez-Munoz (1999), and Flores *et al.* (2001).

The interaction effects between cultivar and salinity level on leaf's nutrient contents of tomato seedlings were significant (Table 2). At the higher salinity level (10.0 dsm^{-1}) Pascal and Tanshet Star cultivars had significantly the highest Na content, however,_the lowest Na content was associated with the Tanshet Star and Super Marmand. It was observed that increasing salinity level was correlated with the lowest mean values of leaf's Ca, Mn, K, N and P contents for all tested cultivars. However, the magnitude among the five tested cultivars was different. This result are in general agreement with those found by_Dasgan *et al.* (2002), who reported that tomato genotypes differed greatly for shoot Na^+ concentration and salinity scale classes were significantly correlated with Na^+ concentrations.

Table 1. Chemical composition of tomato seedling leaves, as affected by cultivars, salinity levels, and nitrogen levels over the two trials.

Treatment	Na (mg)	Cl (mg)	Ca (mg)	Mn (mg)	N (%)	P (%)	K (%)
Cultivar							
Pascal	4217.4ab	2159.1a	3506.7c	617.1c	4.27	0.25b	5.38a
Red Stone	3891.2bc	1795.5ab	3917.5a	728.5a	4.25	0.25b	4.91c
Shohba	3844.2bc	1612.0c	3754.2b	541.2d	3.97	0.24c	5.04bc
Super Marmand	3729.7c	1903.6b	3443.1c	622.6c	4.30	0.23d	5.14b
Tanshet Star	4332.1a	1997.3ab	3804.6b	692.8b	4.17	0.27a	5.47a
LSD	**172.2**	**126.9**	**111.2**	**21.5**	**NS**	**0.005**	**0.218**
EC ($ds \cdot m^{-1}$)							
0.5	2497.4d	1837.4ab	4747.3a	866.3a	6.34a	0.32a	7.04a
2.5	3570.2c	1809.1ab	3661.8b	666.3b	3.80b	0.25b	5.42b
5	4323.6b	1974.0ab	3364.7c	552.2c	3.53c	0.22c	4.68c
10	5620.6a	1994.1a	2967.5d	477.8d	3.11d	0.21d	3.61d
LSD	**154.1**	**194.0**	**99.4**	**29.2**	**0.27**	**0.004**	**0.195**
N levels (mML^{-1})							
0	3084.4d	1646.2c	3590.3b	562.5d	3.76b	0.24c	4.74c
5	3808.2c	1967.0ab	3545.1b	606.8c	4.24a	0.25b	4.99b
10	3973.2b	1856.1b	3781.7a	745.8a	4.25a	0.25b	5.63a
15	4856.8a	2104.6a	3814.3a	646.5b	4.42a	0.26a	5.60a
LSD	**154.1**	**194.0**	**99.4**	**29.2**	**0.27**	**0.004**	**0.195**

[z] Values followed by the same alphabetical letter(s) are not significantly different; $P \leq 0.05$ revised LSD Test.

Table 2. Interaction effects of cultivars and salinity levels on chemical composition of tomato seedling leaves.

E.C. ($ds \cdot m^{-1}$)	Treatments Cultivar	Na ($mg \cdot L^{-1}$)	Cl ($mg \cdot L^{-1}$)	Ca ($mg \cdot L^{-1}$)	Mn ($mg \cdot L^{-1}$)	N (%)	P (%)	K (%)
0.5	Pascal	3277.6	2218.7	4672.1	870.3	6.52	0.32	7.47
	Red Stone	2221.3	1917.4	5232.4	1017.1	6.33	0.34	6.73
	Shohba	2254.7	1161.3	4716.9	627.5	5.97	0.30	6.47
	SuperMarmand	2170.6	1917.6	4267.8	770.3	6.58	0.28	7.00
	Tanshet Star	2563.0	1969.7	4847.6	1046.0	6.27	0.36	7.53
2.5	Pascal	3376.6	1811.6	3593.8	669.5	3.80	0.24	5.79
	Red Stone	4063.5	1129.7	4024.9	782.3	3.93	0.26	5.17
	Shohba	3268.5	2012.4	3678.4	482.7	3.65	0.23	4.98
	SuperMarmand	3671.8	1790.8	3282.9	592.6	4.08	0.23	5.38
	Tanshet Star	3470.7	2100.7	3728.9	804.6	3.50	0.28	5.79
5	Pascal	4441.5	2437.5	3063.4	493.8	3.70	0.22	4.64
	Red Stone	4034.9	2106.6	3295.3	662.0	3.78	0.21	4.22
	Shohba	4284.5	1055.7	3586.4	488.1	3.29	0.24	5.10
	SuperMarmand	3946.3	2106.2	3394.3	655.4	3.28	0.21	4.65
	Tanshet Star	4910.6	2163.8	3484.1	461.7	3.63	0.22	4.79
10	Pascal	5774.1	2168.7	2697.5	434.3	3.04	0.24	3.66
	Red Stone	5245.3	2027.9	3117.5	452.7	2.99	0.21	3.50
	Shohba	5569.8	2218.6	3037.3	566.4	2.98	0.19	3.60
	SuperMarmand	5130.2	1800.3	2827.3	472.1	3.23	0.22	3.52
	Tanshet Star	6383.7	1754.6	3157.9	458.7	3.28	0.22	3.76
L.S.D		242.9	434.7	222.8	46.1	NS	0.018	0.31

Table 3. Interaction effects of cultivars and nitrogen levels on chemical composition of tomato leaves.

Treatments N levels (mML⁻¹)	Cultivar	Na (mg·L⁻¹)	Cl (mg·L⁻¹)	Ca (mg·L⁻¹)	Mn (mg·L⁻¹)	N (%)	P (%)	K (%)
0	Pascal	3262.8	2200.9	3252.3	668.6	3.24	0.23	4.16
	Red Stone	2924.1	1950.2	4141.3	470.9	3.97	0.26	4.11
	Shohba	3071.1	1016.1	3550.9	565.4	3.42	0.26	4.65
	SuperMarmand	2886.4	1218.1	3321.6	568.7	3.87	0.29	4.79
	Tanshet Star	3277.5	1845.8	3685.7	538.6	4.31	0.21	5.97
5	Pascal	4002.2	2429.5	3075.0	735.1	3.83	0.25	5.18
	Red Stone	3612.1	1586.6	3717.8	809.0	4.92	0.28	5.12
	Shohba	3964.1	1556.7	3703.8	563.7	4.08	0.26	4.84
	SuperMarmand	3344.8	2445.0	3538.3	462.1	3.89	0.26	4.84
	Tanshet Star	4117.7	1817.2	3690.1	464.3	4.46	0.23	4.96
10	Pascal	3171.2	2158.8	3704.9	396.9	4.92	0.26	6.29
	Red Stone	4544.5	1407.7	4338.7	931.6	3.69	0.25	5.28
	Shohba	3643.2	1696.1	4036.3	469.9	4.19	0.23	5.79
	SuperMarmand	4287.9	2417.7	3070.8	683.3	4.64	0.26	5.16
	Tanshet Star	4218.8	1601.4	3757.8	1247.3	3.77	0.25	5.64
15	Pascal	4987.6	1847.7	3994.6	667.3	5.06	0.29	5.89
	Red Stone	4484.3	2237.3	3472.2	702.6	3.96	0.26	5.12
	Shohba	4698.4	2179.2	3678.1	565.6	4.19	0.24	4.88
	SuperMarmand	4399.7	1534.3	3841.5	776.1	4.77	0.29	5.78
	Tanshet Star	5714.0	2724.4	4084.9	520.9	4.13	0.28	6.81
	L.S.D	242.9	434.7	222.8	46.1	0.61	0.018	0.31

Table 4. Interaction effects of salinity and nitrogen levels on chemical composition of tomato leaves.

Treatments E. C. (ds·m⁻¹)	N levels (mML⁻¹)	Na (mg·L⁻¹)	Cl (mg·L⁻¹)	Ca (mg·L⁻¹)	Mn (mg·L⁻¹)	N (%)	P (%)	K (%)
0.5	0	1668.1	1373.0	4682.9	636.4	5.65	0.32	5.77
	5	2224.3	2059.1	4771.8	919.1	6.32	0.34	6.29
	10	2467.0	1938.5	4713.6	1232.0	6.78	0.30	8.19
	15	2909.8	1816.7	4820.9	677.4	6.60	0.32	7.92
2.5	0	3460.4	1785.1	3602.3	489.5	3.61	0.26	4.43
	5	4301.3	1553.6	3670.7	707.1	4.11	0.26	4.84
	10	3749.6	1327.2	3625.9	947.7	3.77	0.23	6.30
	15	2769.3	2570.3	3708.4	521.1	3.68	0.25	6.10
5	0	3134.3	1508.2	3250.6	549.3	3.14	0.20	4.80
	5	3785.6	2262.2	2869.8	425.8	3.16	0.20	5.20
	10	4396.8	2129.7	3521.1	372.4	3.41	023	4.36
	15	5977.4	1995.9	3817.3	861.3	4.03	0.25	4.37
10	0	4074.6	1918.6	2825.6	574.7	2.65	0.21	3.13
	5	4921.3	1993.1	2867.7	375.4	3.37	0.21	3.61
	10	5715.8	2029.1	3266.1	431.2	3.01	0.20	3.68
	15	7770.6	3035.3	2910.5	526.2	3.39	0.22	4.02
	L.S.D	217.0	388.8	199.2	38.5	0.55	0.016	0.27

The interaction effects between cultivars and nitrogen levels (Table 3) indicated that the highest mean value of leaf nitrogen content was resulted from the treatment combination having Pascal X 15 mML^{-1} N. However, the Tanshet Star cultivar which fertilized by 15 mML^{-1} recorded the highest mean values of Na, K and Cl followed by Super Marmand. X15 mML^{-1} N.

The effects of salinity × nitrogen level interaction on the different determined nutrients were found significant(Table 4).The results indicated that at any salinity level, increasing nitrogen level to 15 mML^{-1}, significantly, increased the leaf N content indicating that nitrogen fertilization mitigated the negative effects of salinity levels.

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الملخص العربي

تأثير مستويات الملوحة والتسميد النيتروجيني على العناصر الغذائية لبعض أصناف الطماطم

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استخدم خمسة أصناف تجارية من الطماطم (باسكال، رد ستون، شهبا، سوبر مارمند، و تنشيط ستار) وذلك لدراسة تأثير أربعة مستويات من الملوحة (وهي ٠,٥، ٢,٥، ٥,٠ و ١٠,٠ ديسيسيمنز/متر) وأربعة مستويات من التسميد النيتروجيني (وهي صفر و ٥ و١٠ و١٥ مليمول نيتروجين/لتر) على محتوى أوراق الطماطم من العناصر الغذائية.

أجريت الدراسة بالبيت المحمي التابع لكلية علوم الأغذية والزراعة جامعة الملك سعود بالرياض من خلال تجربتين متماثلتين. وقد تم تقدير محتوى الأوراق من العناصر الغذائية التالية: الصوديوم، الكلوريد، الكالسيوم، المنجنيز، النيتروجين، الفوسفور والبوتاسيوم.

وقد أوضحت النتائج وجود اختلافات صنفيه في محتوى الأوراق من العناصر الغذائية حيث احتوت أوراق الصنفان باسكال وتنشيط ستار على أعلى تركيز من عنصري الصوديوم والكلوريد واختلفا معنويا عن بقية الأصناف، في حين احتوت أوراق الصنفان شهبا وسوبر مارمند على اقل تركيز.كما أوضحت النتائج أن الزيادة في مستوي الملوحة يصاحبها زيادة محتوي الأوراق من عنصري الصوديوم والكلور، فضلا عن انخفاض محتوى الأوراق من عناصر الكالسيوم والمنجنيز والنيتروجين والفوسفور والبوتاسيوم. أظهرت النتائج أن زيادة مستويات النيتروجين بالمحلول المغذي قد صاحبها زيادة في محتوى الأوراق من الكالسيوم والمنجنيز والنيتروجين والفوسفور والبوتاسيوم. كما عكست النتائج أن الزيادة في مستويات النيتروجين قد أدت إلى خفض التأثير السلبي لارتفاع مستوى الملوحة .