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INDUCING SALINITY TOLERANCE IN ADULT TOMATO PLANTS BY DROUGHT AND HALOCONDITIONING PRETREATMENTS IN SEEDLING STAGE

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ABSTRACT: *In this experiment seedlings of tomato cv. Floradade at 5 true leaves stage were exposed either to drought or to some haloconditioning pretreatments i.e., irrigated daily with NaCl (100 mM for 15 days or 150 mM for 10 days). In addition roots of seedlings in this stage were immersed in poly-ethylene-glycol (PEG-6000 MW) with equivalent osmotic potential of -1 MPa for 6 hours. After terminated of the pretreatments all seedlings were picked up and roots were rinsed with tap water. Then seedling were transplanted to pots (30 cm in diameter contained 16 kg of soil + sand (1 : 3 by weight).. After establishment of transplanting they were either irrigated with NaCl solution (5 dSm-1) or tap water. All pretreatments enhanced root length, vegetative growth, total yield and fruit quality than those of the control (untreated seedlings) grown under saline condition. Pretreatments, particularly immersion seedlings roots in PEG for 6 hours and those were exposed to drought, reduced Na+ and Cl^- contents in young leaves but increased K+ / Na+ ratio of plants either irrigated with tap water or saline one. The results also shows that such pretreatments could altered dry matter devoted to different plant organs in a way that could improve plant withstanding under stress conditions. The reduction in osmotic pressure (OP) and the increase of relative water content (RWC) in leaves of pretreated plants, may explain the role of such pretreatments in reducing salinity hazard (by dilution salts) on growth and yield of plants, that grown under saline condition.*

Key words: *Salinity tolerance, drought , NaCl and PEG –pretreatments, RWC, K+/Na+ ratio, dry matter redistribution.*

INTRODUCTION

Tomato, *Lycopersicon esculentum* Mill., is one of the most leading vegetable in economic importance throughout the world including Egypt. In 2008 tomato acreage in Egypt was 571,844 feddans*† Tomato is a widely distributed annual vegetable crops which is consumed fresh, cooked or after processing: canning, making into juice, pulp, paste, or as a variety of sauces. More than 30% of world production comes from countries around the Mediterranean sea and about 20% from California (FAO, 1995).

One of the most serious problem currently facing countries of arid and semi-arid regions is how to balance the demands for fresh water between urban-domestic, industrial and agricultural needs. Increasing demands for irrigation water to provide food for rising populations must, in the face of limited water resources, lead to consideration of reuse of the available water, or use low quality water (such as saline water) in irrigation.The successful reuse of low-quality water requires the selection of salt tolerant crops and choosing of some cultural techniques such as pre-treatment of seedling with drought or other stress conditions which could ameliorate the adaptation of adult plants to salinity.

Some cultural techniques have proved useful in tomato to overcome in part, the effects of salinity: treatments of seedlings with drought (González-Fernández, 1996, Malash and Khatab (2008)), haloconditioning such as NaCl (Sherif, 1997, Cayuela *et al.*, 2001 and Flowers *et al.*,

* Feddan = 0.42 hectare = 4200 m^2
† Source: Division of vegetable and fruits statistics Department of Agriculure statistics, General Adminstration of Agricultural Economics and Statistics, Ministry of Agriculture. A.R. Egypt

2005), or PEG (Balibrea *et al.* (1999) of the young seedlings ameliorates the adaptation of adult plants to salinity. The most productive plants maintained low Na+ and Cl^{-} accumulation in their leaves until the end of growth cycle, which shows that adaptation is a long-term response (Cuartero *et al.,* 2006).

The induction of adaptation was only possible during specific times, called developmental windows (Amzallag *et al.,* 1993). Similar adaptive responses and developmental windows probably exist in some species, such as tomato.

The objective of this study was to evaluate; some pretreatments such as drought, haloconditioning and poly-ethylene-glycol (PEG) at seedling stage on salt tolerance of adult plants of tomato.

MATERIALS AND METHODS

A pot experiment was carried out at the Agricultural Experimental Farm of Faculty of Agriculture, Menoufia University in Shibin El-Kom in 2004 – 2005.

Seeds of cultivar "Floradade" which was mentioned to be relatively salt tolerance, was used in this experiment. Seeds of this cultivar were sown (on 23rd of December in 2004 and 2005) in speedling trays (84 holes) that were filled with mixture of peatmoss, vermiculite and fertilizers. The weight of peatmoss, vermiculite and mineral nutrients and penlet was applied according to the guidelines of Ministry of Agriculture. Seedlings at 5 true leaves stage grown in the above mentioned conditions were subjected to one of the following treatments:

A: Untreated seedlings (control); in this case the seedlings were irrigated with tap water as ordinary and were directly planted in the pots and used as a control.

B: Seedlings in this case were irrigated with saline solution (NaCl at 100 mM i.e., 9.14 dSm-1) daily for 15 days. At the end of salinity treatments (at time of transplanting) the transplants were picked up from the trays and the roots were washed by using weak stream of tap water to remove NaCl (and then were transplanted to the pots). This procedure was followed according to that described by Akinci and Akinci (2000) and Sherif (1997).

C: Seedlings in this case were irrigated with NaCl at 150 mM (13.71 dSm-1) daily for 10 days then roots of seedling (at time of transplanting) were washed by fresh water to remove NaCl (and then were transplanted to the pots). This procedure was followed according to that described by Akinci and Akinci (2000) and Sherif (1997).

D: Seedlings were exposed to drought treatment: by withholding irrigation water for the maximum period that permitted subsequent recovery of at least 90% of the pretreated plants. After recovery from welting by normal irrigation, seedlings were transplanted to the pots. This procedure was followed according to that described by Gonález-Fernández (1996).

E: Roots of the seedlings (at 5 true leaves stage) were immersed in PEG-6000 MW with equivalent osmotic potential of -1 MPa (296 g PEG + 1 L distilled water) in 25°C for 6 hours. PEG solution was aerated during the immersion treatment. At the end of the treatment roots were then washed by tap water, and the seedlings were transplanted to the pots which were previously prepared in the theram house. The idea of this experiment was taken from a similar work made by Balibrea *et al.* (1999).

Seedlings of the control and all other pretreatments were transplanted at the same time (68 days after sowing) in plastic pots; 30 cm diameter under theram greenhouse conditions. Growing media was a mixture of field soil (clay loam) and sand (1 : 3 by weight). Weight of soil was 16 kg in each pot. Each pot contained 10 seedlings.

To obtain good plant establishment, all pots were first irrigated with fresh water (tap water; 0.56 dSm-1). After seedlings establishment, (20 days after transplanting) two levels of water salinity i.e., 0.56 (tap water) and 5 dSm-1 were used in irrigation. Irrigation in all treatments {fresh water i.e., tap water (control treatment) or saline water received treatments} was applied when soil moisture content reached 60% of F.C. The time of irrigation was estimated by daily weigh of the pots. At irrigation time water was added to raise soil moisture to 100% field capacity. Pots were fertilized, as commonly practiced (as recommended by Ministry of Agriculture) in tomato farms; i.e.; 400 kg/fed super phosphate (15.5% P2O2), 450 kg/fed (NH4)2 (SO4)3 + 300 kg/fed calcium nitrate and 250 kg/fed potassium sulphate.

Two plant samples were taken at 35 and 50 days after transplanting (15 and 30 days after treatments initiation) but data of the second sample were only presented. Each sample consisted of 4 plants from each replicate (16 plants / treatment), then the plants were dissected into different organs and the following measurements were recorded: root length, plant height, dry weight of roots, stems, leaves and fruits (fruits that found on the plant at the time of the sample) and dry matter allocated to different plant organs(this was expressed as percent of dry weight for each plant organ to total plant dry weight).

Total nitrogen in young leaves (the 4th and 5th leaves from plant top) was determined by micro kjeldahl method, as described by Pergel (1945).Total phosphorus in young leaves was determined using the method described by Chapman and Pratt (1961).Potassium and sodium in young active leaves were determined photometrically using the Elmar-flame Photometer Model 149. Chloride in young leaves was extracted by boiled water, the clear solution was taken and titrated with silver nitrate (0.02 N) using potassium chromate as an indicator as described by Higinbothan *et al.* (1967).

In addition, osmotic pressure of leaf blade was calculated after determining the total soluble solids of the cell sap by using an Abbè Refractometer. The osmotic pressure values were then calculated by using special tables. Also relative water content (RWC): in the 5th leaf from the plant top at 15 and 30 days after treatments initiation. The RWC was calculated according to the equation as cited after Barrs and Weatherley (1962).

Yield and its components were calculated at the end of the harvesting season. TSS content was also determined in fruit samples taken three times throughout the harvesting season (at early, mid and late season) and the average value was only presented.

Randomize complete block design with four replications were used. The experimental design in all experiments was carried out according to the method described by (Snedecor, 1956). The data were subjected to the proper analysis of variance and the significance of differences between treatments was determined by least significant difference (Steel and Torrie, 1981).

RESULTS AND DISCUSSION

1. Vegetative growth characters:

Data in Table 1 elicit that, all pretreatments increased root length than the control (untreated seedlings) under saline and nonsaline conditions but the effect was more pronounced in plants irrigated with saline water. Roots of plants that previously exposed to drought or those immersed its roots in PEG for 6 hours gave the highest values of root length when compared with the other two pretreatments i.e., irrigation with saline solution (100 mM for 15 days or 150 mM for 10 days). Untreated seedlings (control) gave the lowest values of root length.

Also height of plants that pre-treated was significantly higher than those un-pre-treated. Better results, in terms of higher values of plant height were obtained by PEG, drought and 100 mM NaCl pre-treatments, even irrigated with saline and non-saline waters (Table 1).

Table 1. Effect of seedlings pretreatments and salinity of irrigation water on root length, plant height and plant dry weight at 50 days after transplanting in 2004 and 2005 seasons.

Pre-treatments	Salinity of irrigation water	2004 season			2005 season		
		Root length (cm)	Plant height (cm)	Plant dry weight (g)	Root length (cm)	Plant height (cm)	Plant dry weight (g)
Untreated seedlings (control)	Tap water	12.00	38.90	4.65	11.00	30.70	3.47
	Saline water	10.90	31.20	4.00	9.10	26.00	3.04
Drought pretreatment	Tap water	13.20	43.90	6.96	14.20	38.20	5.74
	Saline water	12.80	36.80	5.61	12.80	36.80	5.22
Pretreatment with 100 mM NaCl for 15 days	Tap water	13.00	45.30	7.16	12.50	35.10	3.90
	Saline water	12.00	39.30	5.49	11.70	28.70	3.65
Pretreatment with 150 mM NaCl for 10 days	Tap water	12.80	39.10	6.88	12.10	34.00	5.02
	Saline water	11.20	34.20	5.22	11.20	28.40	3.67
Roots were immersed in PEG for 6 hours	Tap water	18.80	40.00	8.38	13.00	32.30	5.68
	Saline water	14.90	37.00	7.54	11.50	30.80	4.55
LSD at 0.05		0.871	2.604	0.640	0.640	1.793	0.708

Data in Table 1 indicate that, plant dry weight decreased significantly as a result of irrigation with saline water regardless pre-treatment used. Similarly, Sherif (1997) indicated that dry weight of tomato shoots were decreased as salt concentration in soil was increased. Also, data in Table 1 show that total plant dry weight was higher in plants that pre-treatment than those un-pretreatment when irrigated with either saline or fresh waters. These results are in accordance with those obtained by Cayuela *et al.* (2001) who found positive effect on shoot and root DWs of adapted plants (pre-treated with 50 mM NaCl at 2-leaf stage for 15 days), when grown later under saline condition (100 mM NaCl), but the positive effect was higher and quicker on roots. While the pretreatment with NaCl solution alleviated this effect and gave more ability to growth in saline condition. Similarly, Flowers *et al.* (2005) mentioned that pre-treatment of seedlings with drought or salinity in the laboratory demonstrated that tomato plants haloconditioned at the 3 – 5 day-old stage produced more shoot and root biomass than non-conditioned control plants. In a similar study, Malash and Khatab (2008) indicated that tomato plants which were drought pre-treated had somewhat salt tolerance as they show less reduction percentages in all studied growth parameters as well as fruit yield than those un-pretreated when all irrigated with saline water, but differences were significant only in plant dry weight.

2. Dry matter percentage allocated to different plant organs:

At 50 days after transplanting (Table 2) plants that pretreated with NaCl either in 100 or 150 mM devoted (with one exception) the highest dry matter allocated to roots comparing with those of other treatments, whatever the salinity of irrigation water used.

However, there is a tendency that dry matter allocated to roots increased when plants irrigated with saline water than when received non-saline water. The enhancement effect of irrigation with saline water over fresh water in increasing dry matter allocated to roots was expected as it is well known that salinity increased the root to shoot ratio (Khaddar and Ray, 1993). Plants might respond to salinity mediated water stress by reducing water losses through ABA-regulated stomatal closure while, IAA may perform a complementary but independent (Dunlap and Binzel, 1996) function by increasing hydraulic conductance of the plant and especially of the root. Besides stomatal closure, the increased ABA concentration in leaves resulted in a reduction in leaf expansion while lower root IAA content promotes root growth. These two causes would partially explain the increased root / shoot ratio in tomato plants grown under saline conditions. However, dry matter allocated to stems decreased significantly in plants previously pre-treated, particularly when irrigated with saline water, in both years of study (Table 2).

Table 2. Effect of seedling pretreatments and salinity of irrigation water on dry matter percentage allocated to different plant organs at 50 days after transplanting in 2004 and 2005 seasons.

Pre-treatments	Salinity of irrigation water	2004 season				2005 season			
		Dry matter allocated to roots (%)	Dry matter allocated stems (%)	Dry matter allocated to leaves (%)	Dry matter allocated to fruits (%)	Dry matter allocated to roots (%)	Dry matter allocated stems (%)	Dry matter allocated to leaves (%)	Dry matter allocated to fruits (%)
Untreated seedlings (control)	Tap water	8.60	34.42	34.62	22.37	8.57	55.70	35.59	0.09
	Saline water	9.75	41.00	34.50	14.74	9.39	56.26	31.60	2.75
Drought pretreatment	Tap water	7.59	37.51	37.37	17.53	8.55	53.32	36.21	1.93
	Saline water	8.38	37.08	36.01	18.54	9.06	50.37	32.94	7.68
Pretreatment with 100 mM NaCl for 15 days	Tap water	10.00	37.35	38.57	14.07	10.46	46.47	42.81	0.22
	Saline water	9.32	32.71	36.28	21.69	13.84	41.56	43.47	1.13
Pretreatment with 150 mM NaCl for 10 days	Tap water	11.99	35.10	35.04	17.86	11.58	45.01	41.55	1.26
	Saline water	10.33	36.63	37.96	15.08	11.31	47.57	39.21	1.92
Roots were immersed in PEG for 6 hours	Tap water	11.03	36.61	32.94	19.75	6.87	41.28	33.24	18.61
	Saline water	9.08	37.54	30.44	22.94	8.40	41.03	28.35	22.23
LSD at 0.05		1.214	1.984	2.291	4.832	1.282	2.475	3.885	4.630

Drought and haloconditioning pretreatments except PEG pretreatment, enhanced dry matter allocated to leaves whatever, the irrigation water used (Table 2).

Data in Table 2 elicit that, plants which produced by immersion its seedlings roots in PEG, achieved significantly the highest dry matter (%) allocated to fruits compared with the other treatments. In addition, all pre-treatments (except only one case) enhanced dry matter allocated to fruits particularly in plants irrigated with saline water comparable to that devoted to fruits of un-pretreated plants.

Thus it seems that, pretreatments could influence dry matter devoted to different plant organs (by increasing dry matter devoted to roots, leaves and fruits on the expense of that devoted to stems) in a way that could improve plant withstanding under stress conditions.

3. Yield and its components:

Irrigation with saline water decreased fruit yield in all cases (Table 3) but the pretreatments used enhanced yield of those plants irrigated with either fresh or saline waters. Immersion seedlings roots in PEG for 6 hours gave the highest value of total yield / plant. Plants grown from seedlings which were exposed to drought treatment and those which were irrigated daily with saline solution (100 mM) for 15 days gave the second highest values of total yield (Table 3).

Table 3. Effect of seedling pretreatments and salinity of irrigation water on fruit yield and its components in 2004 and 2005 seasons.

Pre-treatments	Salinity level of irrigation water	2004 season				2005 season			
		Total yield (g/plant)	Number of fruits per plant	Average fruit weight (g)	TSS (%)	Total yield (g/plant)	Number of fruits per plant	Average fruit weight (g)	TSS (%)
Untreated seedlings (control)	Tap water	129.47	4.30	30.18	5.30	52.40	1.80	29.68	7.50
	Saline water	23.21	1.60	14.50	8.30	18.14	1.10	16.10	11.10
Drought pretreatment	Tap water	167.76	5.90	28.60	5.90	67.62	2.70	25.04	7.80
	Saline water	36.13	2.20	16.84	7.9	29.34	1.70	17.26	10.00
Pretreatment with 100 mM NaCl for 15 days	Tap water	160.06	4.90	32.80	6.10	64.44	2.10	30.69	7.30
	Saline water	35.76	2.40	14.93	8.20	29.00	1.80	16.11	9.00
Pretreatment with 150 mM NaCl for 10 days	Tap water	171.16	4.20	41.11	6.00	73.08	1.80	40.60	7.20
	Saline water	34.32	1.80	19.07	8.3	27.27	1.40	19.48	9.50
Roots were immersed in PEG for 6 hours	Tap water	181.12	5.60	32.34	5.70	83.98	2.60	32.30	8.10
	Saline water	39.65	2.30	17.24	8.20	31.48	1.90	16.57	10.40
LSD at 0.05		6.213	0.316	2.085	0.334	0.664	0.060	0.791	0.977

These results are in accordance with those obtained by Ojemakinde and Onwueme (1980) who found that subjected tomato seedlings to drought hardening increased the fruit weight and number of fruits / ha. In addition, Malash and Khatab (2008) showed that drought pre-treatment slightly enhanced yield of field grown tomato plants when irrigated with saline water than that of un-treated plants.

The role of PEG in enhancing salt tolerance in tomato was mainly due to its effect on the hexose contents in a similar way to salinity as it also significantly increased sucrose content (Balibrea *et al.,* 1997). However, Flores *et al.* (2000) found that, PEG was found to be more detrimental to seedling growth than isotonic Cl^{-} or SO_4^{2-} treatments. In addition, Perez-Alfocea *et al.* (2002) exposed tomato to some haloconditioning treatments applied at seedlings, they found that morphological alterations observed during the early plants development and differential expression of some proteins in adult plants support the idea that changes at genetic level occur. Moreover, the physiological responses of pre-treatment stress conditions concerning ionic, nutritional and osmotic regulation may responsible for enhancing salt tolerance in plants (Balibrea *et al.,* 1999). To further elucidate, plants express a number of genes in response to water deficit. Adaptation to water deficit brings about changes in the metabolic processes and perhaps in the structure of the cell that allows the cells to continue metabolism at low water potential (Ingram and Bartels, 1996).

It is obvious from data presented in Table 3 that, all pretreated plants gave higher fruit number than their counterparts unpretreated when either irrigated with fresh or saline waters. It is also clear that fruit number produced from plants irrigated with saline water were significantly fewer than those received tap water, regardless pretreatments used.

The data presented in Table 3 also show that plants pretreated at seedling stage (except in one case) and irrigated later with either tap or saline waters produced heavier fruits than their counterparts that not pretreated. These results are in accordance with those obtained by Ojemakinde and Onwueme (1980) who subjected tomato seedlings to drought hardening and found that, both fruit weight and number of fruits / ha were similarly increased by such hardening. The only exception for that result (in the recent study) was that fruit weight produced by plants which pretreated with drought were slightly lower (not significant) when irrigated with fresh water than its counterpart unpretreated.

It is clear from Table 3 that irrigation with saline water increased the TSS in tomato fruits comparable to those received tap water in each treatment. The increment of fruit TSS due to salinity has been previously reported by Cornish (1992), Caruso and Postiglione (1993) and Satti *et al.* (1994 & 1996). The increase in TSS under such conditions (salinity) may be attributed to the accumulation of organic compounds cuch as glucose and inorganic ions (mainly chlorides) (Plaut, 1997). In most cases there is a tendency that pretreatments enhanced TSS in fruits of plants irrigated with tap water comparing to their counterparts that unpretreated in both seasons (Table 3). TSS in fruits of plants pretreated was slightly lower (not significant in most cases) when irrigated with saline water than their counterparts unpretreated.

4. Mineral contents in young leaves:

It is obvious from results presented in Table 4 that pretreatments enhanced N content in leaves of plants either irrigated with tap water or saline water, than those unpretreated. However, N content (%) in leaves of plants that irrigated with saline water was lower than those irrigated with fresh water regardless pretreatment used.

Phosphorus content in young leaves followed a similar trend as that observed with N content with regard to their response to pretreatments and irrigation with saline water (Table 4). However, the enhancement of pretreatments on phosphorus content was more pronounced than that observed with N content. Again, all pretreatments enhanced P content in plant leaves than unpretreated plants, but 100 mM NaCl pretreatment gave the highest phosphorus content %.

Potassium content in young leaves followed a similar trend as that observed with N and P contents with regard to their response to pretreatments and irrigation with saline water (Table 4). Again, all pretreatments enhanced K content in plant leaves than unpretreated plants, 150 mM NaCl pretreatment (except in one case) gave the highest potassium content (%).

These results are in agreement with those obtained by Balibrea *et al.* (1999) who found that, after 6 weeks of salt treatment, the PEG-treated plants produced up to 50% more biomass and up to 25 mM more K+ in the actively growing leaves than did the non-treated control plants. Also, Cayuela *et al.* (2001) reported that K+ concentration increased in the young leaves of the adapted plants, with respect to unadapted plants, and these differences increased with the salinization period.

It is obvious from results presented in Table 4 that all pretreatments reduced Na+ and Cl^{-} contents in young leaves of plants either irrigated with tap water or saline water, than those unpretreated. But as expected, Na+ and Cl^{-} contents (%) in young leaves of plants, that irrigated with saline water, was higher than those irrigated with fresh water within each treatment used. In addition, there is a tendency that plants pretreated with drought or PEG gave the lowest values of both Na+ and Cl^{-} contents among pretreatments used. Thus, K+ / Na+ ratio was higher (even slightly) in drought and PEG pretreatments than those irrigated with NaCl solution all when irrigated later with saline or non-saline water.

Table 4. Effect of seedlings pretreatments and salinity of irrigation water on nitrogen, phosphorus, potassium, sodium and chloride in young leaves of tomato at 50 days after transplanting in 2004 and 2005 seasons.

Pre-treatments	Salinity of irrigation water	2004 season					2005 season				
		Nitrogen (%)	Phosphorus (%)	Potassium (%)	Sodium (%)	Chloride (%)	Nitrogen (%)	Phosphorus (%)	Potassium (%)	Sodium (%)	Chloride (%)
Untreated seedlings (control)	Tap water	3.29	0.308	3.95	1.480	2.574	3.42	0.345	4.14	1.766	1.953
	Saline water	2.63	0.325	3.56	2.960	3.772	3.15	0.305	4.04	2.466	2.663
Drought pretreatment	Tap water	3.89	0.374	4.16	1.220	1.731	4.41	0.360	4.28	1.648	1.509
	Saline water	2.87	0.359	3.83	2.693	3.373	3.50	.0354	4.23	2.220	2.219
Pretreatment with 100 mM NaCl for 15 days	Tap water	4.10	0.449	4.18	1.302	2.041	3.89	0.781	4.26	1.791	1.642
	Saline water	3.92	0.399	3.61	2.730	3.461	3.78	0.713	4.03	2.365	2.441
Pretreatment with 150 mM NaCl for 10 days	Tap water	3.99	0.297	4.17	1.230	1.820	3.78	0.458	4.60	1.780	1.598
	Saline water	3.92	0.290	3.75	2.705	3.417	3.78	0.429	4.40	2.350	2.352
Roots were immersed in PEG for 6 hours	Tap water	3.96	0.398	4.14	1.200	1.686	3.54	0.351	4.62	1.620	1.243
	Saline water	3.78	0.332	3.83	2.589	3.284	3.36	0.330	4.31	2.215	2.130
LSD at 0.05		0.398	0.048	0.135	0.040	0.086	0.183	0.024	0.021	0.165	0.048

These results are in agreement with those obtained by Flowers *et al.* (2005), who found that the haloconditioned plants had the lowest leaf Na and Cl concentrations. They added that haloconditioned plants showed 43% more K in the leaves than the non-adapted plants and the most effective treatments on this basis were those that reduced the toxic ions, and so the K / Na ratio increased in all the haloconditioned plants. In conclusion, the results presented indicate that seedling pre-treatment with haloconditioning is an interesting strategy to apply when the tomato plants have to be grown in a saline medium or when saline waters are used for irrigation. In this respect, Debouba *et al.* (2006) observed that, tomato maintained a high selectivity for K+ over Na+ under high salinity (50 and 100 mM). In addition, Parra *et al.* (2007) mentioned that, improving tolerance of salinity in most pre-treatments was related to lower Na+ and Cl^{-} concentrations in the leaves and increases in leaf K+ contents and K+ / Na+ ratio, but the contrary was also observed. In addition, Cayuela *et al.* (2001) found that, the most productive plants maintained low Na+ and Cl^{-} accumulation in their leaves until the end of growth cycle, which shows that adaptation is a long-term response during which the plants adjust their physiology to the environmental conditions.

5. Plant water relations:

In both seasons, results in Table 5 indicate that irrigation plants with saline water, regardless pretreatments used, resulted in an increase in the osmotic pressure (OP) of cell sap of leaf blade of such plants, than in leaves of plants irrigated with tap water. It is also obvious (Table 5) that OP in leaf blade of plants that pretreated and irrigated with saline water was lower than that in leaf blade of plants unpretreated and irrigated with saline water. This result may be due to lower solutes (salts) accumulated in pretreated plants when grown in saline conditions.

Thus, OP can be employed as a criteria for monitoring salt stress or as plant response mechanisms to salt tolerance. The increase in OP, may be due to the reduction in water content which was concomitant with increasing in the level of salinity due to the accumulation of salts inside the vacuoles (Sorial and Malash, 1997 and Mohammed *et al.,* 1998).

Data in Table 5 show also that RWC was significantly increased by application of all pretreatment. Immersion seedlings roots in PEG pretreatment gave the highest value of RWC in both seasons. The reduction in OP and the increase of RWC in leaves of pretreated plants, may explain the role of such pretreatments in reducing salinity hazard on plant growth and yield, that grown under saline condition.

Thus, it could be concluded that the hazard effect of salinity on plants could be alleviated by using some pretreatments such as drought, haloconditioning or osmoconditioning carried out at seedling stage.

Table 5. Effect of seedlings pretreatments and salinity of irrigation water on osmotic pressure (OP) and relative water content (RWC) in the upper 5th leaf blade at 35 days after transplanting in 2004 and 2005 seasons.

Pre-treatments	Salinity level of irrigation water	2004 season		2005 season	
		Osmotic pressure of leaf blade (-MPa)	Relative water content	Osmotic pressure of leaf blade (-MPa)	Relative water content
Untreated seedlings (control)	Tap water	11.11	74.60	11.63	69.40
	Saline water	12.79	63.40	12.92	59.00
Drought pretreatment	Tap water	9.18	77.20	11.24	68.70
	Saline water	11.11	68.00	11.36	62.70
Pretreatment with 100 mM NaCl for 15 days	Tap water	8.85	78.60	10.28	71.70
	Saline water	11.27	69.40	11.82	67.00
Pretreatment with 150 mM NaCl for 10 days	Tap water	8.40	78.60	11.32	69.60
	Saline water	10.77	69.40	12.75	74.50
Roots were immersed in PEG for 6 hours	Tap water	12.09	90.30	12.50	83.60
	Saline water	12.15	82.70	12.66	76.60
LSD at 0.05		1.116	3.464	1.369	3.839

REFERENCES

Akinci, S. and I. E. Akinci (2000). Responses of solanaceae species to salt in seelding stage. Bahce, 28 (1/2): 79 – 86 (C.F. Hort. Abstr., 68: 9497).

Amzallag, G. N., H. Seligmann and H. R. Lerner (1993). A developmental window for salt-adaptation in Sorghum bicolor. Journal of Experimental Botany, 44: 645 – 652.

Balibrea, M. E., A. M. Rus-Alvarez, M. C. Bolarin and F. Perez-Alfocea (1997). Fast changes in soluble carbohydrates and proline contents in tomato seedlings in response to ionic and non-ionic iso-osmotic stresses. Journal of Plant Physiology, 151 (2): 221 – 226.

Balibrea, M. E., M. Parra, M. C. Bolarín and F. Pérez-Alfocea (1999). PEG-osmotic treatment in tomato seedlings induces salt-adaptation in adult plants. Australian Journal of Plant Physiology, 26 (8): 781 – 786. (C.F. Hort. Abstr., 70: 4139).

Barrs, H. D. and P. E. Weatherley (1962). A re-examination of the relative turgidity technique for estimating water deficits in leaves. Aust. J. Biol. Sci., 15: 413 – 428.

Caruso, G. and L. Postiglione (1993). Effects of irrigation with different saline concentrations on soil and tomato (*Lycopersicon esculentum* L.) cultivars. Rivista di Agronomia, 27: 211 – 219. (C.F. Hort. Abstr., 65: 9822).

Cayuela, E., M. T. Estañ, M. Parra, M. Caro and M. C. Bolarin (2001). NaCl pre-treatment at the seedling stage enhances fruit yield of tomato plants irrigated with salt water. Plant and Soil, 230: 231 – 238.

Chapman, H. D. and D. F. Pratt (1961). Methods of analysis for soil, plants and water. Div. of Agric. Sci., Univ. of Calif.

Cornish, P. S. (1992). Use of high electrical conductivity of nutrient solution to improve the quality of salad tomatoes (*Lycopersicon esculentum*) grown in hydroponic culture. Australian Journal of Experimental Agriculture, 32: 513 – 520.

Cuartero, J., M. C. Bolarín, M. J. Asíns and V. Moreno (2006). Increasing salt tolerance in the tomato. Journal of Experimental Botany, 57 (5): 1045 – 1058.

Debouba, M., H. Gouia and M. H. Ghorbel (2006). NaCl effects growth, ions and water status of tomato (*Lycopersicon esculentum*) seedlings. Acta-Botanica-Gallica, 153 (3): 297 – 307.

Dunlap, J. R. and M. L. Binzel (1996). NaCl reduces indol-3-acetil acid levels in the roots of tomato plants independent of stress-induced abscissic acid. Plant Phsyiol., 112: 379 – 384.

FAO, (1995). Production Yearbook 1994, Vol. 48.

Flores, P., M. A. Botella, V. Martínez and A. Cerdá (2000). Ionic and osmostic effects on nitrate reductase activity in tomato seedlings. Journal of Plant Phsyiology, 156 (4): 552 – 557. (C.F. Hort. Abstr., 70: 8747).

Flowers, T. J., R. Ragab, N. Malash, G. A. Gawad, J. Cuartero and A. Arslan (2005). Sustainable strategies for irrigation in salt-prone Mediterranean. SALTMED. Agricultural-Water-Management, 78 (1/2): 3 – 14.

González-Fernández, J. J. (1996). Tolerancia a la salinided en el tomate en estado de plántula y en planta adulta. Tesis doctoral. Córdoba University, p. 269. In Cuartero J. and R., Fernandez-Muñoz. 1999. Tomato and Salinity. Scientia Horticulturae, 78: 83 – 125.

Higinbothan, N., B. Etherto and R. J. Foster (1967). Mineral ion contents and cell trans membrane electropotential of Pea and Oat seedling tissue. Plant Physiol., 42: 37 – 46. In Jakson, M. L. 1958. Soil chemical analysis constable Co., Ltd. London, p. 498.

Ingram, J. and D. Bartels (1996). Molecular basis of dehydration tolerance. Annu. Rev. Plant Physiol. Plant Mol. Biol., 47: 377 – 403.

Khaddar, V. K. and N. Ray (1993). Ameliorating effect of moisture regimes on salinity a case study with tomato. Advances in plant Sci., 6: 168 – 177.

Malash, N. M. and Entsar A. Khatab (2008). Enhancing salt tolerance in adult tomato plants by drought pretreatment applied at the seedling stage. Emirates Journal of Food and Agriculture, 20 (1): 84 – 88.

Mohammad, M., R. Shibli, M. Ajloun and L. Nimri (1998). Tomato root and shoot response to salt stress under different levels of phosphorus nutrition. Journal of Plant Nutrition, 21 (8): 1667 – 1680.

Ojemakinde, O. A. and I. C. Onwueme (1980). Heat and drought hardening of tomato (*Lycopersicon esculentum*) plants as an aid to field survival. Quarterly Journal of International Agriculture, 19 (Special issue): 25 – 28.

Parra, M., A. Albacete, C. Martinez-Andujar and F. Perez-Alfocea (2007). Increasing plant vigour and tomato fruit yield under salinity by inducing plant adaptation at the earliest seedlings stage. Environmental-and-Experimental-Botany, 60 (1): 77 – 85.

Pérez-Alfocea, F., M. E. Balibrea, M. Parra and M. C. Bolarin (2002). Increasing salt tolerance in tomato and lettuce by inducing plant adaptation: Haloconditioning. Acta-Horticutlurae, 573: 369 – 375.

Pergel, F. (1945). Quantitative organic Micro. Analysis, 4th Ed. J. & A. Chuch. 11, I td., London.

Plaut, Z. (1997). Irrigation with low-quality water: Effects on productivity, fruit quality and physiological processes of vegetable crops. Acta Horticulturae, 449: 591 – 597.

Satti, S. M. E., M. Lopez and F. A. Al-Said (1994). Salinity induced changes in vegetative and reproductive growth in tomato. Communication in Soil Science and Plant Analysis, 25 (5-6): 501 – 510. (C.F. Hort. Abstr., 65: 1319).

Satti, S. M. E., R. A. Al-Yahyai and F. Al-Said (1996). Fruit quality and partitioning of mineral elements in processing tomato in response to saline nutrients. Journal of Plant Nutrition, 19: 705 – 715.

Sherif, M. A. (1997). Adaptation of tomato plants to tolerate saline conditions in sand medium and in hydroponics. Zagazig J. Agric. Res., 24 (4): 727 – 739.

Snedecor, G. W. (1956). Statistical methods. 5th edn. Iowa State University Press. Ames. Iowa, p. 534.

Sorial, Mervat E. and N. M. Malash (1997). Physiological studies on salt tolerance at germination and seedling growth stages of tomatoes. Minufiya J. Agric. Res., 22 (5): 1247 – 1263.

Steel, R. G. D. and J. H. Torrie (1981). Principals and procedures of statistics, a biometrical approach. 2nd edn. By. Mc Grow. Hill International Book Company, Singapore, p. 633.

تحفيز مقاومة نباتات الطماطم البالغة للملوحة بتعريض شتلاتها للجفاف وبعض المعاملات الأولية

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الملخص العربى

فى هذه التجربة تم تعريض شتلات الطماطم صنف فلوراداد والمنزرعة فى صوانى إنتاج الشتلات للجفاف أو الرى اليومى بكلوريد الصوديوم (100 مللى مول لمدة 15 يوم أو 150 مللى مول لمدة 10 أيام) بالإضافة إلى غمس جذور الشتلات فى محلول البولى إيثيلين جليكول (6000) لمدة 6 ساعات وذلك فى مرحلة تكوين الورقة الحقيقية الخامسة, بعد إنتهاء هذه المعاملة تم غسيل الشتلات بماء الصنبور. ثم نُقلت جميع الشتلات المعاملة والغير معاملة (كونترول) إلى أصص قطرها 30 سم ملئت بمخلوط من التربة والرمل (16 كجم) بنسبة (1 : 3 بالوزن) . بعد ثبات الشتلات تم رى النباتات إما بمحلول كلوريد الصوديوم (5 ديسيسمنت / متر) أو بماء الصنبور حتي نهاية التجربة.

أدت كل المعاملات الأولية للشتلات إلى زيادة طول الجذر ، النمو الخضرى ، المحصول الكلى و تحسين جودة الثمار بالمقارنة بالشتلات الغير معاملة (كنترول) تحت ظروف الملوحة . المعاملات الأولية خاصةً غمس جذور الشتلات فى محلول البولى إيثيلين جليكول لمدة 6 ساعات وتلك التى سبق تعريضها للجفاف أدت إلى نقص محتوى الأوراق الحديثة لنباتاتها البالغة من كلٍ من الصوديوم والكلوريد ، كما أدت ايضا إلى زيادة نسبة البوتاسيوم / للصوديوم تحت الظروف الملحية والغير ملحية . أوضحت النتائج أيضاً إلى أن كل المعاملات الأولية أثرت فى إعادة توزيع المادة الجافة علي الأعضاء المختلفة للنبات بطريقة أدت إلى زيادة تحمل النباتات للظروف الملحية . كذلك فإن نقص الضغط الإسموزى وزيادة محتوى الماء النسبى فى أوراق النباتات التى سبق معاملة شتلاتها بالمعاملات الأولية في هذه التجربة يُوضح دورهذه المعاملات فى تقليل ضرر الملوحة (بتخفيف تركيز الأملاح) على النمو والمحصول تحت ظروف الملحية .