

## IMPROVING GROWTH AND PRODUCTIVITY OF TOMATO UNDER SALINE CONDITIONS BY FERTILIZATION AND SALINITY HARDENING

Shafshak, Nadia S.<sup>1</sup>; S. M. Aid<sup>1</sup>; H .S. Khafaga<sup>2</sup> and Y. A. M. Salama <sup>2</sup>

1- Horticulture Dept., Faculty of Agric., Moshtohor , Benha University

2- Plant Adaptation Unit, Genetic Resource Dept.. Desert Res. Center

### ABSTRACT

This study aimed to investigate some possible approaches to alleviate the negative effects of salinity on tomato plant growth and productivity. Seeds of tomato (*Lycopersicon esculentum* Mill) hybrid VT737 were sown and seedling were exposed to hardening treatments using four levels of saline irrigation (control 250 ppm, low 1500 ppm, medium 3000 ppm and high 4500 ppm) during nursery stage. After transplanting in the open field, all plants were irrigated with saline water with 5500±500 ppm and the standard recommended fertilization dose. Plants were also receiving four experimental fertilization treatments namely control (no additional fertilization), mono potassium phosphate, potassium humate and amino acids.

Recorded data showed that all vegetative and reproductive parameters responded positively to the individual effect of hardening and fertilization treatments and their interactions. The hardening level of 3000 ppm showed the best effect followed by the 4500 level and the least for 1500pp. Meanwhile the fertilization of mono potassium phosphate gave the best results followed by potassium humate then the amino acids. The interactive effect of the treatments appeared to be cumulative on plant response.

**Keywords:** tomato, salinity, hardening, mono potassium phosphate, humate, amino acids.

### INTRODUCTION

Salt stress is a common consequence of insufficient water supply and/or using poor quality water. Salinity may be naturally exist particularly in arid and semi arid regions such as Egypt. According to Gehad, 2003 most of the saline affected soil is located in the northern middle Nile Delta as well as its eastern and western sides. This problem is usually counteracting the expansion in land reclamation. Salinity is a well known factor affecting negatively growth and production of many crops such as tomato (Hayward and Long, 1943; Sanchez Conde and Azuara,1979; Li, 2000; Tantawy, 2007) and sweet pepper (Pitacco *et al.*, 1990; Zabri *et al.*, 1997; Chartzoulakis and Klapaki, 1998; Abdel-Mawgoud 2002) and their productivity, for tomato (Ehret and Ho, 1986; Ho and Adams, 1989; Li, 2000; Tantawy, 2007) and sweet pepper (Sonneveld, 1979; Abdel-Mawgoud, 2002). The main negative effect of salinity comes from the osmotic effect on plant water uptake which eventually affects growth and yield (Livett, 1980; Abdel-Mawgoud, 2002). The result is the well-known yield reduction. Many trails have been made to alleviate salinity effects with partial success or non-applied results.

The aim of this study is to find an applied, environmental-friendly products such as potassium humate and amino acids to improve alleviate the negative effects of salits tomato crop grown under saline conditions.

## **MATERIALS AND METHODS**

The experiments were conducted in Agric. Research stations location in Ras Sedr, South Sinai governorate. Tomato hybrid VT737 was used in the experimental work of this study to test the proposed treatments in different growth condition. The first was carried out under nursery while the other under the field conditions

### **I. Nursery stage (Hardening treatments):**

The experiment was started on the 15<sup>th</sup> February during the two growth seasons of 2005 and 2006. Seeds of tomato hybrid were sown in foam trays having 209 holes filled with a growing media having moisture of 60%. The growing media was prepared by mixing 300 liters peatmoss, 100 kg vermiculite, 500 gm ammonium phosphate, 400 gm ammonium nitrate, 300 gm potassium sulfate, 150 gm micro nutrients mixture (Tradecorp A-Z), 100 cm<sup>3</sup> fungicide (Maxium), and 4 kg Calcium Carbonate. Seed trays were irrigated with tape water for 15 days after which the experimental treatments were applied.

Four salinity levels of irrigation water were applied namely control (tape water  $\approx$  250 ppm), 1500, 3000 and 4500 ppm. At each week and for five weeks period, irrigation with the above mentioned salinity levels were applied as follow: First day: irrigation with proposed salinity levels, Second day: Irrigation Fasting, Third day: irrigation with proposed salinity levels, Fourth day: Irrigation Fasting, Fifth day: Leaching with tape water and Six day: Irrigation Fasting. No other treatments were applied in this experiment.

### **II. Open field stage (fertilization treatments)**

Plants grown in the nursery and treated with the above mentioned hardening treatments were transplanted into the open field at Ras Sedr Research Station in South Sinai. Mechanical (Table 1) and chemical (Table 2) analyses of soil used were determined at two depths, 0-15 and 15-30 cm. Mechanical analysis of soil was performed according to Piper (1950) and Jackson (1958), while the chemical analysis of water and soil was carried out according to Jackson (1958) and Chapman and Pratt (1961).

The irrigation was carried out using water from underground well. The chemical analysis of the irrigation water is shown in Table (3).

Soil was prepared before transplanting by adding cattle manure at 20m<sup>3</sup>/feddan and calcium super phosphate (15.5% P<sub>2</sub>O<sub>5</sub>) at a standard rate of 350 kg/feddan. Chemical fertilizers were applied twice before transplanting and near to flowering stage. Ammonium nitrate (33.5% N) and potassium sulfate (48% k<sub>2</sub>O) were added at the rate of 50 and 70 kg/feddan respectively as two equal portions at 15 and 30 days after transplanting.

Individual transplants were grown at the bottom of ridges 100 cm width at 40 cm apart. Plot area was 1X12= 12 m<sup>2</sup>. The drip irrigation system of GR 16 was used and plants were irrigated daily using saline-well water.

**Table (1): Soil mechanical analysis and soil properties of the experimental farm, at Wadi Sedr, South Sinai.**

Soil depth (cm)	Total sand (%)	Silt (%)	Clay (%)	Texture
0-15	59.0	10.5	30.5	Sandy
15-30	56.0	12.0	32.0	Sandy

**Table (2): Soil chemical analysis of the experimental farm, at Wadi Sedr, South Sinai.**

Soil depth (cm)	EC (dS/m)	pH	Soluble anions (ppm)			Soluble cations (ppm)			
			HCO <sub>3</sub> <sup>-</sup>	Cl <sup>-</sup>	SO <sub>4</sub> <sup>-</sup>	Ca <sup>++</sup>	Mg <sup>++</sup>	Na <sup>+</sup>	K <sup>+</sup>
0-15	10.00	7.5	11.0	1210	5.0	270	144	685	13
15-30	9.00	7.2	13.3	1200	4.8	220	110	670	15

**Table (3): Chemical analysis of irrigation water (underground well) of the experimental farm, at Wadi Sedr, South Sinai.**

Water sample	EC (dS/m)	pH	Soluble anions (ppm)			Soluble cations (ppm)			
			HCO <sub>3</sub> <sup>-</sup>	Cl <sup>-</sup>	SO <sub>4</sub> <sup>-</sup>	Ca <sup>++</sup>	Mg <sup>++</sup>	Na <sup>+</sup>	K <sup>+</sup>
Average	8.59*	7.4	0.50	1540	6.1	518	275	807	9

\* EC X 640 = ppm 8.59 X 640= 5500 ppm.

Fertilization treatments with specific compounds were applied with irrigation water every ten days. Fertilization treatments were as follow: Potassium humate (Humic acid 85% - 12 % K<sub>2</sub>O) in a rate of 4 gm/liter water, Mixture of amino acids in a rate of 2 gm/liter, Mono potassium phosphate in a rate of 3 gm/liter and control.

**Measurements:**

Vegetative, physiological and chemical measurements were recorded at 75 days after transplanting in the open field.

**Vegetative measurements:-**

Plant height (cm) was measured from cotyledons level to plant top, Number of branches, Leaf area (cm<sup>2</sup>) was determined using leaf area meter machine model ADC Bioscientific Ltd., Japan, Fresh weight (g) of aerial part (stem and leaves) was determined in gm/plant, Dry weight (g): Sample of plant shoot per replicate was dried in oven (70°C) until a constant dry weight was reached.

**Physiological measurements:-**

Stomatal conductance, Leaf temperature and Transpiration rate using Porometer machine model LI-COR., USA. Osmotic pressure of cell sap at 70 days after transplanting was estimated with relationship between total soluble solids and osmotic pressure according to Gosev (1960). Total Soluble Solids (T.S.S.%) in leaves at 70 days after transplanting was determined by using hand refractometer according to A.O.A.C. (1990).

**Yield measurements:-**

Number of fruits per plant, Weight of fruits per plant, Average of individual fruit, Total yield, Total Soluble Solids (T.S.S.%) in fruits was determined by using hand refractometer according to A.O.A.C. (1990).

**Statistical design and analysis:**

A total of 16 treatments were a result of a combination of 4 salinity hardening treatments x 4 fertilization treatments. Treatments were arranged in a split plot design with three replicates. Fertilization were placed in the main plot and hardening in the sub-plot. Analytical procedures were as described by Snedecore and Cochran (1991).

## **RESULTS AND DISCUSSION**

### **I. Vegetative growth:**

#### **Effect of fertilization treatments:**

Table (4) shows the effects of salinity and fertilization treatments on plant vegetative growth. In this study as previous studies, salinity reduced plant height (Achilea, 2002; Agong *et al.*, 2004 and Hajer *et al.*, 2006) and leaf area (Li and Stanghellini, 2001; Mulholland *et al.*, 2002; Maggio *et al.*, 2004; and Agong *et al.*, (2004), fresh weight (Hassan, 1999; Li, 2000; Sonneveld, 2000, Amico *et al.*, 2003 and Hajer *et al.*, 2006) as well as dry weight (Li, 2000; and Yurtseven *et al.*, 2003). However the application of fertilizers such as mono potassium phosphate and potassium humate overcame this negative effect probably due to the presence of potassium as reported by Eata (2001) and Achilea (2002). Leaf area reduction was also overcome by K application under saline conditions (Al-Karaki, 2000; Eata, 2001; Ahmed, 2003). This may be due to the competition between potassium and Sodium for absorption and/or the regulation of K to plant water relation which reflects on cell elongation. The same explanation can be held true for the effect of K on a higher leaf area of the plant under saline conditions. Mono potassium phosphate was superior in its positive effect followed by potassium humate while amino acid had the lowest positive effect in improving plant height, number of branches and leaf area compared to control treatment (Table 4). These effects were significantly higher compared to control as well as among the fertilization treatments themselves. Similar trend was observed in both seasons for the fresh and dry weight of the shoot with one exception in the fresh weight of the shoots, where there was no significant difference between the positive effects of potassium humate and amino acid treatments. Using K fertilizer under saline condition alleviated saline effect and improved plant fresh weight as reported by Soubeih, 1998; Hassan, 1999. As the fresh weight depends mainly on plant water status and K has a major role in controlling this status, therefore this can be the explanation for the role of K in improving this parameter. Since potassium is the main nutrient in controlling stomatal behavior hence plant water status and photosynthesis, it can be expected that it may improve plant dry matter production which has been observed. The presence of phosphate in the same fertilizer enhanced the response of the plant to the applied dose and this may be the reason for the highest response to mono potassium phosphate application compared to other treatments. P was reported to decrease as salinity increased (Ahmed, 1998; Nofual *et al.*, 2000; Eata, 2001; and Shibli *et al.*, (2007) But K increased P content in the plants (Eata, 2001; Ahmed, 2003) which means that the presence of the two elements enhance each other which eventually reflect on plant growth and production.

Vegetative growth was positively correlated with dry matter production, as well as phosphorus level in plant (Valenzuela and Gallardo, 2001). The effect of P may come from its essential role in energy compounds in the plants as well as in the phospholipids which is the main component of cell walls.

**Effect of hardening treatments:**

Hardening treatments, generally, improved plant vegetative growth parameters compared to control as shown in Table (4). The medium hardening level of 3000 ppm showed superiority in its positive effect on plant growth followed by the high level of 4500 ppm then the low level of 1500 ppm. All vegetative parameters studied, plant height, number of branches, total leaf area and shoot fresh and dry weight responded similarly to the hardening treatments. Hardening increased plant tolerance to salinity which reflected on better plant growth and production. Salinity hardening treatments it was for the mung bean increased plant height, leaf area and fresh weight (Ahmed, 2003) as well as dry weight (Taha, 1978). This effect of hardening may come from the effect of hardening on plant osmotic adjustment to higher osmotic pressure in the root zone. This adjustment can be brought about by accumulating nutrients in the plant as hardening was found to increase P and K content (Taha, 1978 and Ahmed 2003).

**Effect of interaction:**

Table (4) shows the interaction between the two treatments which showed a cumulative positive effect on plant height where the combination between mono potassium phosphate and the hardening with medium level (3000 ppm) gave the highest effect allover the treatments. The difference among the treatments was significant. The same trend was observed for the parameters of fresh and dry weights of the shoots. Meanwhile only in the season of 2005 differences resulted from the interaction between the fertilization and hardening treatments on number of branches and total leaf area were not significant at  $p < 0.05$ .

**II. Physiological parameters**

**Effect of fertilization treatments:**

TSS of the leaves and osmotic pressure as shown in Table (5) for the two seasons of 2005 and 2006 responded positively to the treatments of fertilization. As observed in the vegetative growth, the treatment of mono potassium phosphate resulted in the highest response in those recorded parameters compared to the control. Other fertilization treatments gave also significant positive results compared to control but not as of mono potassium phosphate. Stomatal conductance, transpiration rate and leaf temperature decreased in response to the fertilization treatments. Mono potassium phosphate treatment resulted in the lowest values for the three mentioned parameters. For all physiological parameters studies, the Fertilization treatments can be arranged according to their degree of effect in the following order, mono potassium phosphate, potassium humate and finally amino acid treatment. All these findings can be explained as results of K application which is considered the main key for stomatal behavior which reflects on all measured physiological parameters.

**Table (4): Effect of fertilization and salinity hardening treatments on growth characters of V.T. 737 tomato hybrid in the first and second seasons (2005 and 2006)**

Treatments		Plant height (cm)		No. of branches / plant		Leaf area / plant (cm <sup>2</sup> )		Shoot fresh weight/ plant (gm)		Shoot dry weight/ plant (gm)	
Fertilization (A)	Salinity hardening (B)*	1 <sup>st</sup>	2 <sup>nd</sup>	1 <sup>st</sup>	2 <sup>nd</sup>	1 <sup>st</sup>	2 <sup>nd</sup>	1 <sup>st</sup>	2 <sup>nd</sup>	1 <sup>st</sup>	2 <sup>nd</sup>
<b>Seasons</b>											
Control	Control	54.33	55.33	8.00	8.33	9.23	9.97	206.00	230.00	158.00	163.00
	Low (1500 ppm)	56.33	57.33	8.33	8.67	11.67	12.33	246.00	288.67	169.00	174.00
	Medium(3000 ppm)	63.67	64.67	9.00	9.00	14.70	14.93	286.00	338.67	180.67	186.33
	High (4500 ppm)	61.67	62.67	8.67	8.67	12.00	12.73	262.00	311.33	166.00	171.67
Mean		59.00	60.00	8.50	8.67	11.90	12.49	250.00	292.17	168.42	173.75
Potassium Humate	Control	59.00	61.00	9.33	10.00	11.23	11.57	251.00	281.67	169.00	176.00
	Low (1500 ppm)	61.00	63.33	10.33	11.67	13.23	14.40	309.00	456.33	187.33	197.33
	Medium(3000 ppm)	71.67	74.00	11.67	13.00	17.08	18.07	406.33	560.33	206.67	216.67
	High (4500 ppm)	67.00	68.67	10.67	12.00	13.97	15.17	396.67	536.00	200.33	209.00
Mean		64.67	66.75	10.50	11.67	13.88	14.80	340.75	458.58	190.83	199.75
Mono Potassium Phosphate	Control	60.67	63.67	10.00	11.00	12.00	12.53	292.00	303.00	181.67	183.00
	Low (1500 ppm)	64.00	67.00	11.33	12.67	14.07	16.07	420.33	593.67	211.00	221.00
	Medium(3000 ppm)	75.67	78.67	13.00	15.67	19.30	21.30	576.67	763.33	274.67	283.00
	High (4500 ppm)	74.33	77.00	12.00	14.00	16.93	18.97	514.33	663.67	226.67	235.33
Mean		68.67	71.58	11.58	13.33	15.58	17.22	450.83	580.92	223.50	230.58
Amino Acid	Control	56.67	57.67	9.00	9.67	9.57	10.23	234.67	270.33	164.33	166.33
	Low (1500 ppm)	60.33	62.33	10.00	11.00	12.03	13.00	299.67	399.67	172.67	182.00
	Medium(3000 ppm)	70.33	72.33	10.67	11.67	15.57	16.47	388.33	488.33	199.00	203.33
	High (4500 ppm)	66.00	68.00	9.67	11.33	12.57	13.73	373.00	473.00	188.00	197.67
Mean		63.33	65.08	9.83	10.92	12.43	13.36	323.92	407.83	181.00	187.33
General mean for (A) treatments	Control	57.67	59.42	9.08	9.75	10.51	11.08	245.92	271.25	168.25	172.08
	Low (1500 ppm)	60.42	62.50	10.00	11.00	12.75	13.95	318.75	434.58	185.00	193.58
	Medium(3000 ppm)	70.33	72.42	11.08	12.33	16.66	17.69	414.33	537.67	215.25	222.33
	High (4500 ppm)	67.25	69.08	10.25	11.50	13.87	15.15	386.50	496.00	195.25	203.42
L.S.D at 0.05 for	A	0.90	0.92	0.44	0.63	0.84	0.69	20.88	9.60	5.08	5.56
	B	0.76	0.75	0.53	0.63	0.71	0.58	9.38	9.13	4.08	3.59
	AxB	1.51	1.50	N.S	1.26	N.S	1.17	18.76	18.26	8.17	7.18

\*ppm for salinity

**Effect of hardening treatments:**

The salinity hardening treatments showed the same trend observed earlier with other parameters. The medium hardening level 3000 ppm showed the highest positive response on the TSS and osmotic pressure of the leaves followed by the high level of hardening 4500 ppm then the lowest level of 1500 ppm compared to control treatment (Tables 5). Stomatal conductance, transpiration rate and leaf temperature showed a negative response compared to the control treatment. The lowest recorded values for the three parameters were recorded with the medium level of 3000 ppm followed by the high hardening level of 4500 ppm then the 1500 ppm level compared to the control treatment.

**Effect of Interaction:**

Data in table (5) showed that the interaction between treatments resulted in a cumulative effect on the observed parameters during the two

growth seasons. Fertilization treatments enhanced the effect of the hardening treatments which resulted in a higher plant response. The mono potassium phosphate treatment in combination with the hardening level of 3000 ppm gave the best results compared to the control and all other treatments.

**Table 5): Effect of fertilization and salinity hardening treatments on some physiological characters on V.T. 737 tomato hybrid in the first and second seasons (2005 and 2006)**

Treatments		TSS % of leaves		Osmotic pressure (A.P)		Stom. Cond. (cms <sup>-1</sup> )		Trans. (mg cn <sup>-2</sup> s <sup>-1</sup> )		Leaf temp. (C°)	
Fertilization (A)	Salinity hardening (B)*	1 <sup>st</sup>	2 <sup>nd</sup>	1 <sup>st</sup>	2 <sup>nd</sup>	1 <sup>st</sup>	2 <sup>nd</sup>	1 <sup>st</sup>	2 <sup>nd</sup>	1 <sup>st</sup>	2 <sup>nd</sup>
<b>Seasons</b>		1 <sup>st</sup>	2 <sup>nd</sup>	1 <sup>st</sup>	2 <sup>nd</sup>	1 <sup>st</sup>	2 <sup>nd</sup>	1 <sup>st</sup>	2 <sup>nd</sup>	1 <sup>st</sup>	2 <sup>nd</sup>
Control	Control	10.07	10.13	8.17	8.20	27.97	27.50	29.63	29.17	38.83	38.47
	Low (1500 ppm)	10.57	10.63	8.60	8.70	25.03	24.63	25.23	25.07	37.60	37.33
	Medium(3000 ppm)	10.80	10.93	9.20	9.30	22.33	21.80	24.13	23.70	36.47	36.13
	High (4500 ppm)	10.63	10.73	8.87	9.00	22.93	22.43	24.57	24.10	36.73	36.57
Mean		10.52	10.61	8.71	8.80	24.57	24.09	25.89	25.51	37.41	37.13
Potassium Humate	Control	10.57	10.60	8.47	8.47	23.83	23.60	26.47	26.13	37.77	37.47
	Low (1500 ppm)	10.77	10.87	9.23	9.33	21.97	21.50	24.10	23.70	37.17	36.83
	Medium(3000 ppm)	12.20	12.30	10.23	10.33	19.70	19.27	22.60	22.10	35.17	34.93
	High (4500 ppm)	11.40	11.63	9.53	9.63	20.10	19.67	23.30	22.83	36.07	35.87
Mean		11.23	11.35	9.37	9.44	21.40	21.01	24.12	23.69	36.54	36.28
Mono Potassium Phosphate	Control	10.70	10.80	8.57	8.57	23.03	22.83	25.53	25.43	37.23	37.07
	Low (1500 ppm)	10.87	11.00	9.17	9.27	19.97	19.50	22.77	22.30	35.07	34.80
	Medium(3000 ppm)	12.50	9.37	10.60	10.73	18.50	18.07	19.60	19.10	34.00	33.77
	High (4500 ppm)	11.73	11.87	9.87	10.00	19.23	18.77	20.10	19.63	34.20	34.07
Mean		11.45	10.76	9.55	9.64	20.18	19.79	22.00	21.62	35.13	34.93
Amino Acid	Control	10.43	10.83	8.40	8.40	24.83	24.70	27.13	26.80	37.87	37.57
	Low (1500 ppm)	10.63	10.80	9.02	9.03	22.93	22.43	24.80	24.27	37.57	37.47
	Medium(3000 ppm)	11.53	11.63	9.47	9.60	20.10	19.70	22.63	22.43	35.60	35.47
	High (4500 ppm)	11.67	11.33	9.27	9.37	20.70	20.20	23.63	23.03	36.47	36.33
Mean		10.94	11.08	9.04	9.10	22.14	21.76	24.55	24.13	36.88	36.71
General mean for (A) Treatments	Control	10.44	10.52	8.40	8.41	24.92	24.66	27.19	26.88	37.93	37.64
	Low (1500 ppm)	10.71	10.83	9.01	9.08	22.48	22.02	24.23	23.83	36.85	36.61
	Medium(3000 ppm)	11.76	11.06	9.88	9.99	20.16	19.71	22.24	21.83	35.31	35.08
	High (4500 ppm)	11.23	11.39	9.38	9.50	20.74	20.27	22.90	22.40	35.87	35.71
L.S.D at 0.05 for	A	0.11	N.S	0.10	0.08	0.18	0.26	0.34	0.22	0.09	0.17
	B	0.09	N.S	0.07	0.07	0.16	0.21	0.26	0.20	0.04	0.12
	A x B	0.17	N.S	0.13	0.15	0.33	0.43	0.52	0.41	0.09	0.23

\*ppm for salinity

### III. Reproductivity

#### Effect of fertilization treatments:

Li ( 2000) as well as others (Ragab *et al.*, 2005; and Krauss *et al.*, 2006) found that salinity decreased tomato yield and this what has been observed in this study but potassium application either as mono potassium phosphate or potassium humate increased yield under saline condition (Table 6). This is also supported by the finding of Eata (2001) and Economakis and Daskalaki, (2003) who reported an increment in total yield by increasing K application under salinity. Total yield increment may be brought about by increment in average fruit weight and/or increment in fruit number per plant. Average fruit weight improved by K under salinity (Soubeih, 1998; Eata,

2001) and this what has been observed in this study also (Table 6). As potassium plays a role in assimilates translocation, the application of K can be expected to improve TSS in the fruits. This is supported by the findings of (Soubeih, 1998; Eata, 2001) who found that TSS of fruit improved by K under salinity. Moreover, salinity reduces the amount of water going to the fruits which means a more concentrated solids in the fruits. This was observed earlier as TSS in fruits increased as salinity increased (Stamatakis *et al.*, 2003; and Olympios *et al.*, 2003).

**Effect of hardening treatments:**

Salinity hardening treatments as shown in Table (6) for the two seasons of 2005 and 2006 increased plant tolerance to salinity as expressed in the increment in the recorded reproductive growth parameters. The differences among the means of the treatments were significant with the superiority of the medium level hardening of 3000 ppm followed by the high level of 4500 ppm and the least effect but still significantly higher the low level of 1500 ppm compared to control. Ahmed, 2003 reported improvement in mung bean which received salinity hardening.

**Table (6): Effect of fertilization and salinity hardening treatments on yield and yield components of V.T. 737 tomato hybrid in the first and second seasons (2005 and 2006)**

Treatments		No. of fruits /plant		Total yield / plant (gm)		Average fruit weight (gm)		Total yield / fed. (ton)		TSS% for fruit	
Fertilization (A)	Salinity hardening (B)*	1 <sup>st</sup>	2 <sup>nd</sup>	1 <sup>st</sup>	2 <sup>nd</sup>	1 <sup>st</sup>	2 <sup>nd</sup>	1 <sup>st</sup>	2 <sup>nd</sup>	1 <sup>st</sup>	2 <sup>nd</sup>
<b>Seasons</b>											
Control	Control	18.33	19.33	672.67	685.33	73.67	74.67	5.53	5.70	7.87	7.90
	Low (1500 ppm)	23.00	31.00	757.33	804.00	89.00	95.00	7.63	7.60	8.19	8.24
	Medium(3000 ppm)	28.33	30.67	1157.67	1207.00	113.33	116.67	9.23	9.43	8.54	8.70
	High (4500 ppm)	26.00	28.67	1038.67	1100.00	96.67	100.00	8.63	8.83	8.35	8.45
Mean		23.92	27.42	906.58	949.08	93.17	96.58	7.76	7.89	8.24	8.32
Potassium Humate	Control	23.33	23.67	823.33	823.33	85.33	91.00	6.10	6.23	7.92	7.94
	Low (1500 ppm)	32.00	33.33	1283.33	1333.33	109.33	115.33	8.20	8.63	8.68	8.72
	Medium(3000 ppm)	37.00	39.67	1643.33	1690.00	127.67	133.00	10.27	10.60	9.08	9.22
	High (4500 ppm)	36.00	38.00	1550.00	1607.67	121.00	123.33	9.67	10.10	8.95	9.03
Mean		32.17	33.67	1325.00	1363.58	110.83	115.67	8.56	8.89	8.66	8.73
Mono Potassium Phosphate	Control	25.67	26.33	1063.33	1053.00	89.33	96.33	7.50	7.40	8.07	8.07
	Low (1500 ppm)	39.00	41.00	1546.67	1610.00	125.00	133.00	9.80	10.43	8.84	8.96
	Medium(3000 ppm)	57.33	60.00	2750.00	2783.33	155.00	162.00	14.83	15.33	9.67	9.85
	High (4500 ppm)	49.33	53.00	2033.33	2072.00	141.67	149.67	13.30	14.27	9.39	9.98
Mean		42.83	45.08	1848.33	1879.58	127.75	135.25	11.36	11.86	8.99	9.11
Amino Acid	Control	22.00	22.67	790.00	798.33	83.00	89.67	5.90	6.00	7.89	7.90
	Low (1500 ppm)	30.33	32.33	1183.33	1243.33	106.33	109.67	7.97	8.27	8.55	8.65
	Medium(3000 ppm)	33.33	38.33	1523.33	1563.33	121.67	122.67	9.67	10.03	8.98	9.07
	High (4500 ppm)	32.67	36.67	1443.33	1491.67	119.00	118.67	9.77	9.93	8.87	9.00
Mean		29.58	32.50	1235.00	1274.17	107.50	110.17	8.33	8.56	8.57	8.66
General mean for (A) Treatments	Control	22.33	23.00	837.33	840.00	82.83	87.92	6.26	6.33	7.94	7.95
	Low (1500 ppm)	31.08	34.42	1192.67	1247.67	107.42	113.25	8.40	8.73	8.56	8.64
	Medium(3000 ppm)	39.08	42.17	1768.58	1810.92	129.42	133.58	11.00	11.35	9.07	9.21
	High (4500 ppm)	36.00	39.08	1516.33	1567.83	119.58	122.92	10.34	10.78	8.89	9.01
L.S.D at 0.05 for	A	0.84	2.93	86.58	97.11	5.90	5.30	0.32	0.34	0.04	0.05
	B	1.27	2.17	79.20	75.13	3.52	3.35	0.19	0.24	0.06	0.05
	A x B	2.54	4.34	158.39	150.26	7.04	6.69	0.37	0.49	0.12	0.11

\*ppm for salinity

**Effect of Interaction:**



Similar to the trends observed in the vegetative growth, the interaction effect of the combined fertilization and hardening treatments showed a cumulative positive effect compared to the control treatment as shown in Tables (6) for the two seasons 2005 and 2006 respectively. The combination of the treatments of mono potassium phosphate and the hardening with the medium level 3000 ppm had the best effect on improving the productivity of tomato plants grown under saline condition. Fruit characteristics also showed a positive and the highest response to the same treatment. All other combinations were also significantly higher compared to control however not as high as the combination of mono potassium phosphate and the hardening level of 3000 ppm.

In addition, the application of potassium in other forms such as potassium humate, improved plant growth under saline conditions due to the presence of humic. Humic was reported to increase plant vegetative growth (Turkmen *et al.*, 2004; Dursun *et al.*, 2002; and Arancon *et al.*, 2003) and total plant dry mater production (Arancon *et al.*, 2003; Bohme, 1999). Amino acids improved also plant growth and production under saline conditions. Amino acids were found to increase number of flowers, fruit setting and fruit yield (Neeraja *et al.*, 2005).

All above mentioned explanation are expected to give cumulative effects on plant growth and production as both techniques (fertilization and hardening) are acting in two complementary pathways and these what have been observed in the interaction of the treatments.

### **Conclusion**

It can be concluded that using hardening techniques at nursery as well as at field condation stage can improve plant tolerance to salinity after transplanting to the open field in salt affected soils. However, using other fertilizers such as mono potassium phosphate can improve this tolerance to a further degree.

### **REFERENCES**

- Abdel-Mawgoud, A.M.R. (2002). Growth and production of greenhouse sweet pepper in relation to root zone conditions. Ph.D. thesis, Humboldt University in Berlin, Germany. 115 pp.
- Achilea, O. (2002). Alleviation of salinity induced stress in cash crops by Multi-K (Potassium Nitrate), five cases typifying the underlying pattern. *Acta Horticulturae*. 573: 43-48.
- Agong, S.G.; Y. Yoshida; S. Yazawa and; M. Masuda (2004). Tomato response to salt stress. *Acta Horticulturae*, 637: 93-97.
- Ahmed, Y.M.A. (2003). Adaptation studies on increasing salt tolerance of mung bean plants. M.Sc.Thesis, Fac.Agric Zagazing Univ. (Benha Branch).
- Ahmed, Y.M.A. (1998). Response of tomato plants to the salinity of irrigation water. Ph.D. Thesis, Fac. Agric. Zagazig Univ. Benha Branch,.

- Al-Karaki, G.N. (2000). Growth, sodium, and potassium uptake and translocation in salt stressed tomato. *Journal of Plant Nutrition*, 23 (3): 369-379.
- Amico, M.L.; R. Izzo; F. Tognoni; A. Pardossi and F.Navari (2003). Application of diluted Seawater to soilless culture of tomato (*Lycopersicon esculentum* Mill.): Effect on plant growth, yield, and fruit quality and antioxidant capacity. *Journal of food Agriculture and Environment*, 1 (2): 112-116.
- A.O.A.C. (1990). Official methods of analysis. Association of official analytical chemists. 15<sup>th</sup> ed. Washington D.C., USA.
- Arancon, N. Q.; S. Lee; C.A. Edwards; R. Atiyeh (2003). Effects of humic acids derived from cattle, food and paper-waste vermicomposts on growth of greenhouse plants. *Pedobiologia*. 47(5/6): 741-744
- Bohme, M. (1999). Effects of lactate, humate and *Bacillus subtilis* on the growth of tomato plants in hydroponic systems. *Acta-Horticulturae*. (481): 231-239
- Chapman, H.D. and P.F. Pratt (1961). *Methods of analysis for soils, plant and water*. Univ. of Calif. Division of agriculture science, August 2<sup>nd</sup> printing.
- Chartzoulakis, K.S. and G. Klapaki (1998). Effects of NaCl salinity on growth and yield of two pepper cultivars. *Acta Hort*. 511, p. 143-149
- Dursun, A.; I. Guvenc; M. Turan (2002). Effects of different levels of humic acid on seedling growth and macro and micronutrient contents of tomato and eggplant. *Acta-Agrobotanica*. 55(2): 81-88
- Eata, A.E.K. (2001). Response of some tomato cultivars to natural soil salinity and use of some treatments to reduce salt injury. Ph.D. Thesis, Faculty of Agric. Mansoura Univ.
- Economakis, C. and A. Daskalaki (2003). Effect of potassium nutrition on yield and quality of tomato plants grown with nutrient film technique under sodium chloride saline conditions. *Acta Horticulturae*, 609 : 337-339.
- Ehret, D.L. and L.C. Ho (1986). The effect of salinity on dry matter partitioning and fruit growth in tomatoes in nutrient film culture. *Journal Horticultural Science*, 61: 361-367.
- Gehad, A. (2003). *Deteriorated Soils in Egypt: Management and Rehabilitation*. EXECUTIVE AUTHORITY FOR LAND IMPROVEMENT PROJECTS (EALIP), Ministry of Agriculture, Egypt.
- Gosev, N.A. (1960). Some methods in studying plant water relations, Leningrade Acad of Scienc, USSR.
- Hajer, A.S.; A.A. Malibari; H.S. Al-Zahrani and O.A. Almaghrabi (2006). Responses of three tomato cultivars to seawater salinity 1- Effect of salinity on the seedling growth. *African J. of Biotechnology*, 5 (10): 855-861. (CAB Abstr. 2004-2006).
- Hassan, E.H.A. (1999). Physiological studies on the adaptation of some tomato varieties under saline condition. M.Sc. Thesis, Fac. Agric. Ain Shams Univ.
- Hayward, H.E. and E.M. Long (1943). Some effects of sodium salts on the growth of tomato. *Plant physiology*, 18, 556-569.

- Ho, L.C. and P. Adams (1989). Effects of Diurnal changes in the salinity of the nutrient solution on the accumulation of calcium by tomato fruit. *Ann. Bot.*, 64, 373-382.
- Jackson, M.L. (1958). *Soil chemical analysis*. Constable and Co., Ltd., London, 38, 325.
- Krauss, S.; W.H. Schnitzler; J. Grassmann and M. Voitke (2006). The influence of different electrical conductivity values in a simplified recirculating soilless system on inner and outer fruit quality characteristics of tomato. *J. of Agric. and Food Chemistry*, 54 (2): 441-448.
- Li, Y. and C. Stanghellini (2001). Analysis of the effect of EC and potential transpiration on vegetative growth of tomato. *Scientia Horticulturae*, 89 (1): 9-21.
- Li, Y. (2000). Analysis of greenhouse tomato production in relation to salinity and shoot environment. Ph.D. thesis, Wageningen Agricultural university. 95pp.
- Livett, J. (1980). *Responses of plants to environmental stresses*. 2nd ed. Academic Press New York.
- Maggio, A.; S. Pascale; G. Angelino; C. Ruggiero and G. Barbieri (2004). Physiological response of tomato to saline irrigation in long-term salinized soils. *European Journal of Agronomy*, 21 (2): 149-159. (CAB Abstr. 2004-2006).
- Mulholland, B.J.; M. Fussell; R.N. Edmondson; J. Basham; J.M. Mckee and N. Parsons (2002). The effect of split-root salinity stress on tomato leaf expansion, fruit yield and quality. *Journal of Horticultural Science and Biotechnology*, 77 (5): 509-519. (CAB Abstr. 1998-2003).
- Neeraja, G.; I. P. Reddy; B. Gautham (2005). Effect of growth promoters on growth and yield of tomato cv. Marutham. *Journal-of-Research-ANGRAU.*; 33(3): 68-70
- Nofual, E. H. A.; M. K. Sadik; M.F. Attia (2000). Studies on tolerance of some plants to salinity. *Annals-of-Agricultural-Science,-Moshtohor.*; 38(2): 1329-1346
- Olympios, C. M.; I. C. Karapanos; K. Lionoudakis; I. Apidianakis (2003). The growth, yield and quality of greenhouse tomatoes in relation to salinity applied at different stages of plant growth. *Acta-Horticulturae*. (609): 313-320
- Piper, C.S. (1950). *Soil and plant analysis*. Inter Science Publishers, New York, 213-217.
- Pitacco, A.; O. Lain and C. Giulivo (1990). Gas exchange and architecture of sweet pepper as affected by water stress. First congress of the European Society of Agronomy, Colmar, France.
- Ragab, R.; N. Malash; G.A. Gawead; A. Arslan and A. Ghaibeh (2005). A holistic generic integrated approach for irrigation, crop and field management 2-The SALTMED model validation Using field data of five

- growing seasons from Egypt and Syria-Agricultural Water Management, 78(1-2): 89-107. (CAB Abstr. 2004-2006).
- Sanchez Conde, M.P. and P. Azuara (1979). Effect of balanced solutions with different osmotic pressure on tomato plant. J. plant Nutrition, 1, 297-307.
- Shibli, R.A.; M. Kushad; G.G. Yousef; M.A. Lila (2007). Physiological and biochemical responses of tomato microshoots to induced salinity stress with associated ethylene accumulation .Plant-Growth-Regulation. 51(2): 159-169
- Snedecore, G.W. and Cochran (1991). Statistical methods. 8<sup>th</sup> ed., Iowa State Univ. press, Iowa, USA.
- Sonneveld, C. (1979). Effects of salinity on the growth and mineral composition of sweet pepper and eggplant grown under glass. Acta Horticulturae, 89: 71-78.
- Sonneveld, C. (2000). Effect of salinity on substrate grown vegetables and ornamentals in greenhouse horticulture. Ph.D. dissertation, Wagenignen Agric. Univ., 151 pp.
- Soubeih, K.A.A. (1998): Productivity improvement of tomato crop under environmental saline conditions. M. Sc. Thesis, Fac. Agric. Ain Shams Univ.
- Stamatakis, A.; N. Papadantonakis; N. Lydakias Simantiris; P. Kefalas; D. Savvas (2003). Effects of silicon and salinity on fruit yield and quality of tomato grown hydroponically. Acta-Horticulturae. (609): 141-147
- Taha, E.M.E. (1978): Physiological studies on the hardening process in vegetable crops. Ph. D. Thesis, Fac. Agric., Ain Shams univ. Cairo, Egypt.
- Tantawy, A. (2007). Effect of some mineral and organic compounds on salinity tolerance in tomato. Ph.D. thesis. Fac. Agric. Al-Azhar Univ.
- Turkmen, O.; A. Dursun; M. Turan; C. Erdinc (2004). Calcium and humic acid affect seed germination, growth, and nutrient content of tomato (*Lycopersicon esculentum* L.) seedlings under saline soil conditions. Acta-Agriculturae-Scandinavica-Section-B,-Soil-and-Plant-Science. 2004; 54(3): 168-174
- Valenzuela, O. R.; C.S. Gallardo (2001). Production of tomato seedling in growing medium formulated with soil .Horticultura-Argentina.; 20(48): 5-10
- Yustseven, E.; G.D. Kesmez and A. Unlukara (2003). The effect of potassium on salinity tolerance, fruit quality and water consumption for tomato (*Lycopersicon esculentum*) under saline conditions. Sustainable Strategies for irrigation in salt prone Mediterranean Region. a: system approach proceeding of an International Woshop, Cairo, Egypt, 8-10 December,; 192-203.
- Zabri, A.W.; S.W. Burrage; K.S. Chartzoulakis (1997). The effects of vapour pressure deficit (VPD) and enrichment with CO<sub>2</sub> on water relations, photosynthesis, stomatal conductance and plant growth of sweet

pepper (*Capsicum annuum* L.) grown by NFT. Acta Horticulturae. No. 449, 561-567.

## تحسين نمو وإنتاجية الطماطم تحت ظروف الملوحة باستخدام التسميد والتقسية الملحية

نادية سعد شفشق<sup>١</sup>، سعيد معوض عيد<sup>١</sup>، حسين سعيد خفاجة<sup>٢</sup> و ياسر عبد الحكيم محمد سلامة<sup>٢</sup>

1- قسم البساتين - كلية الزراعة بمشتهر - جامعة بنها

2- مركز بحوث الصحراء - قسم الأصول الوراثية - وحدة أقلمة نبات

تهدف هذه الدراسة الى تحرى بعض الاساليب والطرق لتخفيف التأثير السلبى للاملاح على نمو وإنتاجية الطماطم . تم غرس بذور طماطم هجين V.T.737 فى المشتل وتمت معاملة الشتلات باربعة مستويات من الرى المالح طول فترة المشتل: كنترول ( ماء الصنبور، ٢٥٠ جزء /مليون ملوحة) ، منخفض (١٥٠٠ جزء / مليون ملوحة)، متوسط (٣٠٠٠ جزء / المليون ملوحة)، عالى (٤٥٠٠ جزء / المليون) . بعد نقل الشتلات للارض المستديمة ، تمت معاملة جميع النباتات وريها بماء بئر مالح حوالى ٥٥٠٠ جزء / المليون ( $\pm$  ٥٠٠ جزء فى المليون) وتم تسميدها بالتسميد الموصى به للطماطم . تم معاملة النباتات أيضا باربعة معاملات سمادية من الاسمدة التجريبية وهى بدون تسميد ، فوسفات احادى البوتاسيوم ، هيومات بوتاسيوم ، أمماض امينية . أظهرت النتائج إستجابة المجموع الخضرى والثمرى إيجابيا لتأثير التقسية الملحية ومعاملات التسميد . أظهرت التقسية على مستوى ٣٠٠٠ جزء / المليون أحسن تأثير يليها ٤٥٠٠ جزء فى المليون والاقبل تأثير كان لمعاملة ١٥٠٠ جزء فى المليون. فى نفس الوقت أظهر التسميد بفوسفات احادى البوتاسيوم احسن نتائج ثم تبعه معاملة هيومات البوتاسيوم ثم الاحماض الامينية . يظهر التأثير التفاعلى للمعاملات انه تأثير تراكمى على إستجابة النبات .