Effect of Salinity, Boron and Nitrate Concentrations in Irrigation Water on the Growth and Elemental Composition of Tomato Plants

Nasseem, M.g., H.A. Zeid, Wafaa. H.Mohamed. and A.M.Abo Jadeda
Soil & Agricultural Chemistry Dept., Faculty of Agriculture (Saba Bacha), Alexandria University

ABSTRACT

The effects of salinity, boron and nitrate concentrations in the irrigation water on the growth, elemental composition of tomato plants and accumulation of salinity, boron and nitrate in the soil were studied in a pot experiment.

The data showed that increasing salinity of the irrigation water from 0.44 to 1.0 dS/m significantly increased the dry weights, and the total uptake of Na, K, N, P and B in the shoot of tomato plants However nitrate uptake was significantly decreased with increasing salinity level. On the other hand, increasing salinity level from 1.0 to 2.0 or 4.0 dS/m significantly decreased the dry weight, and the total uptake of Na, K, N, P, NO_3 and B. Also, increasing boron levels in the irrigation water to 4.0 or 8.0 mg/l caused a significant decrease in the dry weights and the total uptake of K and B. Besides, the total uptake of Na, N, P and NO_3 in the shoot of tomato plants were increased significantly as compared to the control treatment. Increasing nitrate level in the irrigation water from 0.43 to 15.0 mg/l significantly increased the dry weights of shoot of tomato plants and the uptake of Na, K, N, P, NO_3 and B. Subsequent increase of nitrate in the irrigation water to 30.0 mg/l exerted marked increase on dry weight and the total uptake of Na, K, N, NO_3 and B, accompanied by a remarkable drop in P uptake compared with control. The interaction between salinity, nitrate, and boron, showed significant effect on Na, B, NO_3, and N uptake. In addition, the 3-way interaction imposed significant performance on NO_3-N and B accumulation without any detrimental effects on soil salinity.

On the assessment of water quality, the irrigation water containing EC of 0.44 dS/m, 30 mg NO_3-N/l and 0.02 mg B/l was suitable since it gave the highest growth (shoot dry weight). Meanwhile, the water containing EC 1.02 dS/m, 30.0 mg NO_3-N/l and 0.02mg B/l, can be used without serious problems.

INTRODUCTION

Increasing efficiency and utilization of different fertilizers for crop production in soil are dependent on the interaction between soil fertility, irrigation water salinity, and other variables. Water used for irrigation is greatly varied in quality, depending upon type and quantity of dissolved salts. Whenever salts are presented in irrigation water at lower concentrations, significant amounts may be developed during the long-term application. Perez Alfocea *et al.* (1993) attributed the inhibition of tomato growth is due to the toxicity of Cl^-, Na^+ ions and also to the nutritional imbalance induced by salinity revealing a direct a relationship between growth and the Cl^- and/or Na^+, K, Ca and Mg concentration in plant parts. When certain ions are absorbed in access by plant roots system toxicity may results and accumulated in the plants during water transpiration to an extent that damage the plant and reduce the yield. The damage depends on the duration of salt exposure concentration, crop sensitivity and crop water requirements.

Boron concentrations below ~ 0.5 mg/liter in soil solution are probably safe for most plants, but many plants are affected by when its concentrations is in the creased within the range of 0.5 to 5 mg/liter (Wilcox, 1960). Such toxic concentrations of boron have been found in the soils and irrigation waters of many arid regions.

The most readily available forms of nitrogen are nitrate and ammonium but nitrate (NO_3-N) occurs most frequency in irrigation water. Ayers and Westcot (FAO, 1985) reported that the concentration in most surface and ground water is usually less than 5 ppm NO_3-N but some unusual ground water may contains quantities exceed 50 ppm. Sensitive crops may be affected by nitrogen concentrations above 5 ppm, while most other crops are relatively unaffected up to 30 ppm. High nitrogen concentration in the water which supplies nitrogen to the crop, may cause excessive vegetative growth, lodging and delayed crop maturity. The objectives of this study are to provide further details on the effects of salinity, boron and nitrate concentrations in the irrigation water on the growth, elemental composition of tomato plants and to follow up the soil salinity, boron and nitrate accumulation in soil.

MATERIALS AND METHODS

Pot experiment was carried out during 2002 season under greenhouse conditions at Faculty of Agriculture, Saba Bacha, Alexandria University. Plastic pots of 25cm diameter and 30 cm deep with a hole in the bottom for drainage, were uniformly packed with 3 Kg air- dried calcareous soil. The soil samples were collected from Bangr El-Sukar physical and chemical properties of the calcareous soil used were 51.62% Sand, 25.50% silt, 22.88% clay, pH 7.9(1:1 soil :H_2O suspension); 22% $CaCO_3$, 0.092 mg l^{-1} NO_3^- and 0.067 mg l^{-1} B. Four week-old seedling of tomato (Strain B), were transplanted into each pot, and the irrigation treatments were started on August 7th ,2002 after seven days from transplanting and continued until harvesting on November 11th, 2002. The plants were irrigated with different water quality, keeping the moisture content near by the field capacity of the soil.

Thirty six types of irrigation waters containing different concentrations of NaCl ،NO_3-N as KNO_3 and B, as boric acid were prepared. The irrigation water treatments consisted of four levels of salinity (0.44, 1.0, 2.0 and 4 dS/m), three concentrations of B (0.02, 4.0 and 8.0 mg/l) and three concentrations of NO_3-N (0.43, 15 and 30 mg/l). The chemical composition of the irrigation waters are shown in Table (1).

The pots were arranged in a split-split plot design with three replicated. The four levels of salinity were assigned as the main plots, the three concentrations of boron were the sub-plot and the three concentrations of nitrate

Table (1). Chemical analysis of water types used for irrigation.

No. of water	Water treatments			EC_W dS/m	B mg/L	NO_3-N mg/L	SAR	pH
1	S	B	N	0.44	0.02	0.43	2.20	7.46
2	S_1	B_1	N	0.44	0.02	15.00	2.27	7.22
3	S_1	B_1	N	0.44	0.02	30.00	2.05	7.65
4	S_1	B_2	N	0.44	4.00	0.43	2.17	7.12
5	S_1	B_2	N	0.44	4.00	15.00	2.13	6.68
6	S_1	B_2	N	0.44	4.00	30.00	2.23	7.03
7	S_1	B_3	N	0.44	8.00	0.43	2.23	7.09
8	S_1	B_3	N	0.44	8.00	15.00	2.23	7.09
9	S_1	B_3	N	0.44	8.00	30.00	2.23	7.09
10	S	B	N	1.01	0.02	0.43	5.02	7.02
11	S_2	B_1	N	1.00	0.02	15.00	4.89	7.21
12	S_2	B_1	N	1.02	0.02	30.00	4.99	7.41
13	S_2	B_2	N	1.00	4.00	0.43	4.99	7.20
14	S_2	B_2	N	1.01	4.00	15.00	4.94	7.40
15	S_2	B_2	N	1.02	4.00	30.00	5.01	7.60
16	S_2	B_3	N	1.03	8.00	0.43	4.93	7.10
17	S_2	B_3	N	1.00	8.00	15.00	4.89	7.20
18	S_2	B_3	N	1.00	8.00	30.00	4.89	7.40
19	S	B	N	2.00	0.02	0.43	6.40	7.20
20	S_3	B_1	N	2.00	0.02	15.00	6.43	7.30
21	S_3	B_1	N	2.00	0.02	30.00	6.54	7.35
22	S_3	B_2	N	2.01	4.00	0.43	6.50	7.35
23	S_3	B_2	N	2.00	4.00	15.00	6.51	7.29
24	S_3	B_2	N	2.00	4.00	30.00	6.53	7.15
25	S_3	B_3	N	2.07	8.00	0.43	6.50	7.32
26	S_3	B_3	N	2.00	8.00	15.00	6.54	7.29
27	S_3	B_3	N	2.00	8.00	30.00	6.54	7.28
28	S	B	N	4.00	0.02	0.43	10.98	7.37
29	S_4	B_1	N	4.00	0.02	15.00	11.01	7.43
30	S_4	B_1	N	4.00	0.02	30.00	10.99	7.42
31	S_4	B_2	N	4.00	4.00	0.43	10.96	7.46
32	S_4	B_2	N	4.01	4.00	15.00	10.96	7.49
33	S_4	B_2	N	4.01	4.00	30.00	11.03	7.49
34	S_4	B_3	N	4.01	8.00	0.43	10.96	7.31
35	S_4	B_3	N	4.00	8.00	15.00	11.01	7.55
36	S_4	B_3	N	4.00	8.00	30.00	11.01	7.38

* S, B and N represent the water salinity, boron and NO_3-N concentrations, respectively.

nitrogen were the sub-sub plots. At the end of the growing season, representative soil sample were taken and analyzed to determine some chemical properties. The soil chemical analysis was carried out as described below:

Electrical conductivity (EC) in the soil: water extract (1/1 w/v) according to Jackson (1973), available boron was determined using curcumin method according to Jackson (1973), and available NO_3-N was extracted and determined according to the methods described by Boyd (1984).

The shoot of the plants were harvested, and washed with tap water and then by distilled water and weighed for fresh weight and dried for 24 h in an oven at 70°C and then weighed for the dry weight. Samples of the dried plant materials (0.5 g) were wet-digested with H_2SO_4 - H_2O_2 (Lowther, 1980) for chemical analysis: Sodium and potassium were determined using flame spectrophotometer (Jackson, 1973). Nitrogen was determined by Nessler's method (Chapman and Pratt,1978). Phosphorus was determined using Vanadomolybdophosphoric method (Jackson, 1973). Boron was determined by curcumin method (Black, 1965). Nitrate was determined by phenol disulphonic acid methods (Boyd, 1984).

The data obtained were statistically analyzed for ANOVA and the treatment means were compared to fulfil the significant according to procedures outlined by Steel and Torrie (1982) using least significant difference test (LSD) at 5% probability.

RESULTS AND DISCTION

Plant dry weight:

The effects of salinity, B and NO_3-N levels in the irrigation waters on shoot dry weight are presented in Tables (2 and 3).

The obtained results given in Table (3) show that increasing the level of salinity in the irrigation water from 0.44 to 4.0 dS/m significantly decreased the dry weight. The shoot dry weight was dramatically affected at the higher level of salinity (4.0 dS/m). This depressive effect could be attributed to the decrease of water availability and uptake as a result of reducing the condition in root pressure driven xylem, that transport water and solute. Kafkafi (1991) found that in salt/treated tomato plants of 27 days (50 m M NaCl), the xylem exudation flow decreased by a factor of 17-20 compared with the non salinized plants, and ion concentrations in xylem sap increased only by a factor of 2-3.

The data presented in Table (3) reflect clearly the influence of Boron levels in irrigation water on the dry weight. It is evident that increasing B rates from 0.02 to 4.0 or 8.0 mg/l significantly decreased the dry weight. The relative decrease in dry weight yield associated with increasing B rates of 4.0 and 8.0 mg/l were, 28.4 and 71.6% respectively. This trend indicates that tomato plants have a rather low requirement for boron. Wilcox (1960) reported that boron might be toxic if its concentration is increased only several fold above the rang from 0.2 to 0.5 mg/l that is required for optimum growth. Also, Ayers and Westocot (FAO, 1985) showed that, B concentration of 0.2 mg/l boron in irrigation water is essential for some crops, 1 to 2 mg/l may be toxic.

Increasing NO_3-N rates from 0.43 to 15.0 or 30.0 mg/l induced significant increase in dry weight (Table 3). The relative increase over the control treatments due to increasing NO_3-N rates to 15.0 and 30.0 mg/l, were 5 and 26%, respectively providing, a highly significant correlation between nitrate content of irrigation water and dry weight was observed ($r = 0.95$). previous studies (Gomez and Ulrich,1974) have shown that that the increase in fresh and dry weight of the shoots or the roots of tomato was positively correlated with NO_3-N supply. This would indicate that high NO_3 concentration is not sufficient to compensate the yield potential. Bar-Tal-A *et al.* (1994) showed that the lower NO_3 solution concentration significantly reduced the dry weight of the vegetative organs, but had no significant effect on fruit yield and quality.

The interaction effect between nitrate rates and salinity levels in the irrigation water on vegetative growth was significant at $P = 0.05$ (Table 2). The obtained data indicated that there is a possible yield reduction, due to salt injury, as a result increasing NO_3 content in the irrigation water (Fig. 1). These results are similar to findings by Kafkafi *et al.* (1982) who found a decline in dry matter yield of tomatoes with increasing Cl^- concentration in solution at all NO_3^- levels.

Regression analysis was carried between the dry weight of tomato plants (Y) and the salinity levels (X_1), Boron (X_2) and NO_3-N concentrations in the irrigation water (X_3). The regression equation for the relationship was:

$$Y = 40.34 + 3.84 X_1 + 2.96 X_2 + 0.197 X_3$$

The efficiency of each of the above variables differed considerably as they can be represented by the slope ratio method as 3.84: 2.96: 0.197 or 1: 0.77: 0.05. This analyses indicated that the dry weight of tomato plants was affected by the three variables especially by the salinity of the irrigation water.

Nutrients status

The effects of salinity, B and NO_3-N levels in the irrigation waters on Na, K, N, P, NO_3 and B uptake presented in Tables (4 and 5).

The results have shown that Na uptake by shoots tended to increase with increasing the water salinity from 0.44 to 1.0 dS/m, followed by a marked drop as the salinity levels increased from 1.0 to 4.0 dS/m. this could be ascribed to the inhibitory effect of increasing salt stress on growth performance and dry matter yield. The regression analysis showed that the relationship between dry matter yield and salinity exposure was defined by:

$$Y = 500.08+69.012 X - 28.07 X^2$$

Table (2): Effect of irrigation water composition on the dry weight of shoot of tomato plants.

Irrigation water No.	Treatments			Dry weight (mg/plant)
1	S_1	B_1	N_1	7.44
2	S_1	B_1	N_2	7.36
3	S_1	B_1	N_3	9.93
4	S_1	B_2	N_1	1.00
5	S_1	B_2	N_2	4.52
6	S_1	B_2	N_3	5.69
7	S_1	B_3	N_1	0.99
8	S_1	B_3	N_2	0.96
9	S_1	B_3	N_3	2.73
10	S2	B1	N1	7.01
11	S2	B1	N2	8.38
12	S2	B1	N3	8.90
13	S2	B2	N1	4.43
14	S2	B2	N2	4.38
15	S2	B2	N3	5.08
16	S2	B3	N1	0.84
17	S2	B3	N2	1.10
18	S2	B3	N3	1.85
19	S_3	B_1	N_1	3.57
20	S_3	B_1	N_2	5.19
21	S_3	B_1	N_3	5.36
22	S_3	B_2	N_1	5.14
23	S_3	B_2	N_2	4.61
24	S_3	B_2	N_3	4.85
25	S_3	B_3	N_1	1.49
26	S_3	B_3	N_2	1.16
27	S_3	B_3	N_3	1.12
28	S_4	B_1	N_1	1.76
29	S_4	B_1	N_2	1.49
30	S_4	B_1	N_3	2.26
31	S_4	B_2	N_1	2.10
32	S_4	B_2	N_2	1.98
33	S_4	B_2	N_3	2.18
34	S_4	B_3	N_1	1.94
35	S_4	B_3	N_2	2.51
36	S_4	B_3	N_3	2.50
ANOVA				
Salinity (S)			**	
Boron (B)			**	
Nitrate (N)			**	
B x S			**	
Nx S			**	
N x B			n.s.	
N x B x S			n.s.	

** Significant at P = 0.01 n.s : not significant at P=0.05 * Significant at P = 0.05

Table (3): The main effect of irrigation water composition on the dry weight of shoot of tomato plants.

Treatments	Dry weight (g/plant)
Water salinity (dS/m)	
0.44 (control)	4.74
1.00	4.78
2.00	3.61
4.00	2.07
L.S.D.$_{0.05}$	0.45
Boron(mg/l)	
0.02	5.70
4.00	4.08
8.00	1.62
L.S.D. 0.05	0.513
Nitrate rates (mg/l)	
0.43 (Control)	3.44
15.00	3.63
30.00	4.33
L.S.D. 0.05	0.34

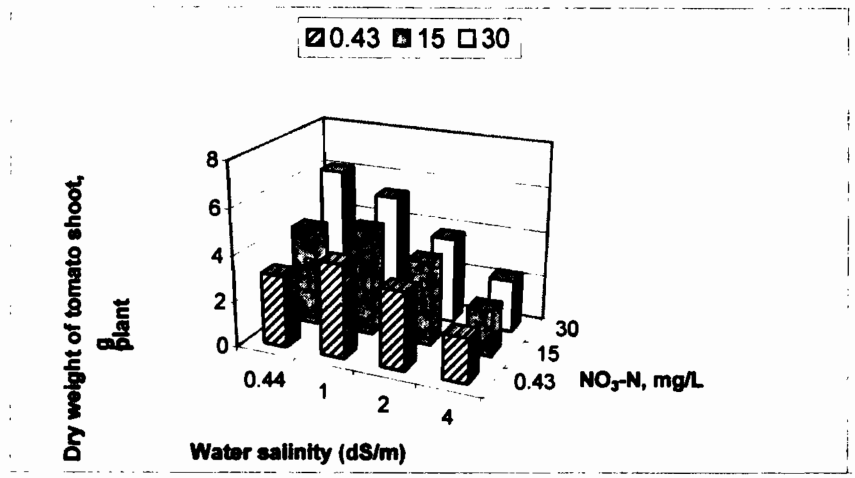

Fig. (1): The interaction effect between water salinity and NO_3-N content on the dry weight of tomato shoot (g/plant).

Increasing NO_3-N rates from 0.43 to 15.0 or 30.0 mg/l induced significant increase in dry weight (Table 3). The relative increase over the control treatments due to increasing NO_3-N rates to 15.0 and 30.0 mg/l, were 5 and 26%, respectively providing, a highly significant correlation between nitrate content of irrigation water and dry weight was observed (r = 0.95). previous studies (Gomez and Ulrich,1974) have shown that that the increase in fresh and dry weight of the shoots or the roots of tomato was positively correlated with NO_3-N supply. This would indicate that high NO_3 concentration is not sufficient to compensate the yield potential. Bar-Tal-A *et al.* (1994) showed that the lower NO_3 solution concentration significantly reduced the dry weight of the vegetative organs, but had no significant effect on fruit yield and quality.

The interaction effect between nitrate rates and salinity levels in the irrigation water on vegetative growth was significant at P = 0.05 (Table 2). The obtained data indicated that there is a possible yield reduction, due to salt injury, as a result increasing NO_3 content in the irrigation water (Fig. 1). These results are similar to findings by Kafkafi *et al.* (1982) who found a decline in dry matter yield of tomatoes with increasing Cl^- concentration in solution at all NO_3^- levels.

Regression analysis was carried between the dry weight of tomato plants (Y) and the salinity levels (X_1), Boron (X_2) and NO_3-N concentrations in the irrigation water (X_3). The regression equation for the relationship was:

$$Y = 40.34 + 3.84 X_1 + 2.96 X_2 + 0.197 X_3$$

The efficiency of each of the above variables differed considerably as they can be represented by the slope ratio method as 3.84: 2.96: 0.197 or 1: 0.77: 0.05. This analyses indicated that the dry weight of tomato plants was affected by the three variables especially by the salinity of the irrigation water.

Nutrients status

The effects of salinity, B and NO_3-N levels in the irrigation waters on Na, K, N, P, NO_3 and B uptake presented in Tables (4 and 5).

The results have shown that Na uptake by shoots tended to increase with increasing the water salinity from 0.44 to 1.0 dS/m, followed by a marked drop as the salinity levels increased from 1.0 to 4.0 dS/m. this could be ascribed to the inhibitory effect of increasing salt stress on growth performance and dry matter yield. The regression analysis showed that the relationship between dry matter yield and salinity exposure was defined by:

$$Y = 500.08+69.012 X - 28.07 X^2$$

Potassium and Phosphorus uptake by shoot of tomato plants was affected also by water salinity. Increasing salinity level from 1.0 to 2.0 or 4.0 dS/m significantly decreased the uptake of K (r=-0.70) and P (r=-0.970. The greater reduction in K uptake could be attributed to the greater reductions of dry matter yield and the high Na^+ concentration in the irrigation water that might interferes K^+ uptake, even though the uptake of K^+ and Na^+ are apparently occur through independent pathways. Despite the reduction of P uptake due to increasing salinity(r=-0.97), it is unlikely that Cl^- and $H_2PO_4^-$ ions are competitive in terms of plant uptake (Champagnol 1979). It was also clear from Table (5) that increasing salinity levels in the irrigation water from 0.44 to 1.0 dS/m caused an increase in N-uptake by tomato shoot, but increasing the salinity level from 1.0 to 2.0 or 4.0 dS/m caused a decrease in N-uptake. Generally, the differences between all treatments were not significant. These data are in harmony with those of Abou El-Soud *et al.*, (1990) and Francois (1982) who mentioned that decreasing N uptake in plants at different stages of growth, with increasing salinity levels, may be due to the competition between chloride in soil solution.

The data in Table (5) elucidated that NO_3-uptake by shoot was significantly decreased with increasing salinity in the irrigation water, as compared to the control treatment (r=- 0.96). Thus, the decreased of because all pots were subjected to receive adequate amount of irrigation water within 60 % of soil water holding capacity.

Table (4): Effect of irrigation water quality on Na, K, N, P, NO_3 and B uptake by shoots of tomato plant.

Irrigation water sample No.	Na	K	N	P	NO_3	B
	(gm/kg dry matter)				(mg/kg dry matter)	
1	350.53	73.27	82.80	42.55	312.90	209.91
2	313.04	102.55	66.75	43.64	882.90	258.34
3	381.56	135.82	94.07	27.71	1604.31	329.70
4	50.20	31.92	27.21	5.31	52.62	120.40
5	222.31	75.50	85.97	10.44	487.66	566.22
6	290.21	112.19	142.53	14.28	759.04	811.96
7	51.16	32.20	27.98	5.51	53.55	123.39
8	53.03	32.07	13.24	4.89	62.38	117.06
9	153.10	76.16	56.18	7.15	306.79	378.10
10	362.08	78.17	86.36	25.44	191.44	210.79
11	434.15	100.40	99.72	55.81	607.55	411.60
12	450.12	136.65	129.49	14.77	978.82	469.83
13	223.43	80.32	83.95	17.18	112.52	653.63
14	221.14	83.20	74.19	14.89	365.02	584.42
15	256.39	87.22	88.03	9.24	572.87	699.61
16	47.63	14.51	16.54	2.78	16.25	111.21
17	66.05	20.59	31.86	3.64	79.52	164.61
18	98.62	33.99	45.86	6.16	177.48	262.82
19	205.23	76.20	77.75	9.38	58.26	144.29
20	290.59	57.40	61.44	17.28	392.10	286.06
21	285.60	64.64	84.84	22.78	558.35	305.89
22	288.32	46.51	119.50	19.89	254.22	638.49
23	249.06	55.75	89.11	9.22	334.13	551.49
24	271.23	33.20	108.15	8.00	510.65	592.67
25	83.22	29.53	30.38	4.05	59.09	194.51
26	75.06	30.98	24.44	3.70	72.51	155.19
27	75.54	25.94	31.92	3.94	72.51	161.60
28	116.88	45.08	84.09	5.12	84.36	90.67
29	110.97	39.47	33.34	3.94	98.50	81.51
30	141.77	45.03	52.97	10.014	154.49	125.33
31	131.54	60.80	39.87	7.37	52.62	294.86
32	96.42	40.97	24.05	6.08	67.56	227.55
33	143.11	49.80	48.07	7.31	153.69	290.12
34	137.61	40.14	49.53	4.73	34.69	286.22
35	159.66	50.03	75.60	7.15	128.23	348.21
36	161.56	63.71	59.71	4.13	237.86	279.08
ANOVA						
Salinity (S)	*	*	n.s	n.s	**	*
Boron (B)	**	**	**	**	**	**
Nitrate (N)	**	**	n.s	n.s	**	*
B x S	**	**	*	*	**	**
N x S	**	**	n.s	n.s	**	n.s
N x B	n.s	*	n.s	n.s	**	n.s
S x N x B	**	**	n.s	n.s	**	**

* Significant at P = 0.05   ** Significant at P = 0.01

n.s not significant at P=0.05

shoot growth observed in this cultivar at high salinity could be attributed not only to the greater amount of the toxic ions accumulated in the shoot but also due to the decrease of NO^-_3 in shoot.

Data in Table (5) showed that increasing salinity levels decreased B uptake (r=-0.95). The decrease of shoot boron uptake, relative to the control treatment accounted 38.7 % at 4.0ds/m salinity level. Also, increasing boron levels in the irrigation water from 0.02 to 4.0 or 8.0 mg/l imposed a significant decrease in the total uptake Na. The regression equation for the relationship between Na uptake (Y) and boron concentration in the irrigation water (X) was:

$$Y = 681.45-30.337X- 3.008 X^2$$

The data of Table (5) indicated that K uptake increased significantly with increasing B concentration in the irrigation water from 0.02 to 4.0 mg/l. subsequent increase in B rate to 8.0 mg/l significantly decreased potassium uptake . Also, the data showed that increasing boron levels in the irrigation water decreased nitrogen, phosphorus and NO_3 uptake. The decrease in uptake due to B treatment could be attributed to the effect of B on water absorption and transpiration in plants (Stiles, 1961), absorption of cations and disruption in metabolic of carbohydrate and nitrogen assimilation (Gauch and Dugga, 1954). Documented data revealed that increasing B in the irrigation water from 0.02 to 4.0 mg/l exhibited significant increase in boron uptake by shoots. On the other hand increasing B concentration in the irrigation water from 4.0 to 8.0 mg/l decreased significantly boron uptake. This may be due to reduction in dry weight with increasing B in the irrigation water.

Table (5) indicated that Na uptake increased significantly by increasing NO_3 concentration in the irrigation water from 0.43 to 15.0 or 30.0 mg/l(r=0.97). Carter (1986) reported that both K and Na uptake were affected by N-uptake. They also added that the increase of N-application rates resulted in an increase in the concentrations of N, K and Na in the harvested roots. Similarly, increasing NO_3^- -N rates promoted K accumulation in shoots. This increase could be inferred to the stimulatory effect of increasing NO_3-N rates on the vegetative growth and dry matter yield production. The data documented on N- uptake behaved similarly as for Na and K uptake. Similar results were obtained by Singh *et al.* (1979) and Abd El-Nour (1981). Also, Increasing rates of NO_3-N from 0.43 to 15.0 or 30.0 mg/l in the irrigation water produced remarkable increase in NO_3-N uptake as compared with the control treatment. The relative increases of NO_3 accumulation in tomato shoots treated with 15 and 30 mg/l NO_3-N were 3.99 and 5.09 times the NO_3-N relative to the control treatment, respectively. It is also clear that boron uptake by shoots was increased but significantly by increasing NO_3-N rates in the irrigation water. The differences in boron uptake between the control and 15.0 mg/l NO_3-N were insignificant.

In conclusion the data obtained showed that Na, NO_3, N, and uptake by Tomato shoots was significantly affected by the interaction between salinity levels and nitrate rate in the irrigation water. Also, NO_3-uptake by tomato shoot was significantly affected by the interaction between Nitrate and boron rates in the irrigation water. The interaction between salinity levels, nitrate, and boron rates showed significant trend on Na, B, NO_3, and N uptake.

Accumulation of salts, boron and NO_3-N in soil.

The data in Table (6) showed that the EC values of soil had increased significantly from 4.05 to 15.37 dS/m as the salinity of irrigation water increased from 0.44 to 4.0 dS/m. These results indicate the serious effect saline water application on soil salinization. Also, the results shown in (Table 7) indicated that, EC of the soil tended to increase as the boron level in the irrigation water was increased. The interaction between salinity and nitrate levels (S x N) or between salinity and boron level (S x B) in the exhibited a significant performance on the accumulation of salts in the soil.

Investigating the effect of salinity levels, in the irrigation water, on nitrate accumulation in soil (Tables 6 and 7) data indicated that nitrate accumulation in soil decreased with increasing the level of salinity or B in the irrigation water. On the other hand, the accumulation of NO_3-N in soil significantly increased as a result of increasing NO_3-N up to 30 mg/l in the water. The results in Table (7) showed that, on the average, the accumulation of boron in soil was increased significantly with increasing salinity levels or B in the irrigation water.

The two way interaction (B x S), (N x B), (N x S) or the three way interaction (N x B x S) exerted a significant effect on the accumulation of NO_3-N. Also, the two way interaction (B x S) or the three way interaction (N x B x S) were conductive for a marked B accumulation in soil.

It becomes evident that the established soil salinity was positively correlated with the salt concentration of the irrigation water. Furthermore, the EC values of the soil at the different levels of salinity, NO_3-N or boron were relatively higher than its original value (0.72). The increase of the EC values of soil is apparently due to the soil permeability because of its higher clay content or due to the absence of introducing the leaching fraction into consideration. This fact holds true because all pots were subjected to receive adequate amount of irrigation water within 60 % of soil water holding capacity.

Table (4): Effect of irrigation water quality on Na, K, N, P, NO_3 and B uptake by shoots of tomato plant.

Irrigation water sample No.	Na	K	N	P	NO_3	B
	(gm/kg dry matter)				(mg/kg dry matter)	
1	350.53	73.27	82.80	42.55	312.90	209.91
2	313.04	102.55	66.75	43.64	882.90	258.34
3	381.56	135.82	94.07	27.71	1604.31	329.70
4	50.20	31.92	27.21	5.31	52.62	120.40
5	222.31	75.50	85.97	10.44	487.66	566.22
6	290.21	112.19	142.53	14.28	759.04	811.96
7	51.16	32.20	27.98	5.51	53.55	123.39
8	53.03	32.07	13.24	4.89	62.38	117.06
9	153.10	76.16	56.18	7.15	306.79	378.10
10	362.08	78.17	86.36	25.44	191.44	210.79
11	434.15	100.40	99.72	55.81	607.55	411.60
12	450.12	136.65	129.49	14.77	978.82	469.83
13	223.43	80.32	83.95	17.18	112.52	653.63
14	221.14	83.20	74.19	14.89	365.02	584.42
15	256.39	87.22	88.03	9.24	572.87	699.61
16	47.63	14.51	16.54	2.78	16.25	111.21
17	66.05	20.59	31.86	3.64	79.52	164.61
18	98.62	33.99	45.86	6.16	177.48	262.82
19	205.23	76.20	77.75	9.38	58.26	144.29
20	290.59	57.40	61.44	17.28	392.10	286.06
21	285.60	64.64	84.84	22.78	558.35	305.89
22	288.32	46.51	119.50	19.89	254.22	638.49
23	249.06	55.75	89.11	9.22	334.13	551.49
24	271.23	33.20	108.15	8.00	510.65	592.67
25	83.22	29.53	30.38	4.05	59.09	194.51
26	75.06	30.98	24.44	3.70	72.51	155.19
27	75.54	25.94	31.92	3.94	72.51	161.60
28	116.88	45.08	84.09	5.12	84.36	90.67
29	110.97	39.47	33.34	3.94	98.50	81.51
30	141.77	45.03	52.97	10.014	154.49	125.33
31	131.54	60.80	39.87	7.37	52.62	294.86
32	96.42	40.97	24.05	6.08	67.56	227.55
33	143.11	49.80	48.07	7.31	153.69	290.12
34	137.61	40.14	49.53	4.73	34.69	286.22
35	159.66	50.03	75.60	7.15	128.23	348.21
36	161.56	63.71	59.71	4.13	237.86	279.08
ANOVA						
Salinity (S)	*	*	n.s	n.s	**	*
Boron (B)	**	**	**	**	**	**
Nitrate (N)	**	**	n.s	n.s	**	*
B x S	**	**	*	*	**	**
N x S	**	**	n.s	n.s	**	n.s
N x B	n.s	*	n.s	n.s	**	n.s
S x N x B	**	**	n.s	n.s	**	**

* Significant at P = 0.05 ** Significant at P = 0.01

n.s not significant at P=0.05

Table (5): The main effect of irrigation water salinity, boron and Nitrate on Na, K, N, P, NO_3 and B uptake by shoots of tomato.

Treatments	Na	K	N	P	NO_3	B
Water salinity (ds/m)	(g/shoot)			(mg/shoot)		
0.44 (control)	493.94	196.05	31.45	8.29	249.50	182.81
1.00	598.54	261.13	36.34	8.58	170.60	197.27
2.00	494.83	228.96	34.41	5.40	128.70	168.67
4.00	331.44	142.94	23.14	3.02	53.44	112.11
L.S.D. 0.05	96.97	37.91	10.14	n.s.	33.18	49.31
Boron (mg/l)						
0.02 Control	680.84	148.61	37.91	11.44	246.53	142.84
4.0	511.97	336.21	37.25	5.05	149.98	246.23
8.0	246.23	137.00	18.84	2.48	55.17	106.58
L.S.D. 0.05	66.18	32.39	4.70	2.78	28.78	28.81
Nitrate(mg/l)						
0.43 (Control)	407.60	139.50	27.03	6.01	49.79	142.18
15.00	454.43	163.46	27.8	7.41	198.56	158.13
30.00	577.01	194.96	39.17	5.54	253.33	195.33
L.S.D. 0.05	54.98	23.55	5.45	n.s	20.64	37.54

Table (6): The effect of irrigation water quality on the accumulation of salts, nitrate and boron in soil.

Irrigation water No.	Soil salinity(EC) dS/m	Nitrate conc. in soil mg/kg	Boron conc. in soil, mg/kg
1	3.15	3.21	32.86
2	3.83	10.50	36.32
3	3.88	12.85	32.27
4	3.92	0.92	101.13
5	5.17	7.43	102.22
6	4.22	9.47	101.41
7	5.22	0.90	97.29
8	5.46	4.32	96.75
9	5.25	7.78	96.76
10	5.89	2.83	36.74
11	6.04	10.39	32.89
12	5.21	13.51	32.27
13	5.32	1.60	99.75
14	5.01	7.51	101.37
15	5.14	9.90	100.90
16	8.82	0.97	99.13
17	8.12	4.22	100.27
18	8.06	6.16	98.48
19	7.94	2.67	34.48
20	8.22	10.28	32.02
21	8.67	13.58	33.52
22	7.31	1.57	101.39
23	8.02	7.03	100.21
24	8.37	9.49	100.84
25	10.48	1.20	96.35
26	9.02	4.09	100.98
27	11.25	7.04	89.77
28	15.33	0.87	10.86
29	15.07	4.18	11.34
30	15.04	7.21	11.82
31	14.95	0.89	51.93
32	16.00	3.93	51.56
33	15.06	7.00	53.37
34	15.22	1.09	94.56
35	15.40	4.23	95.87
36	16.41	5.68	99.04
ANOVA			
Salinity (S)	**	**	**
Boron (B)	**	**	**
Nitrate (N)	n.s	**	n.s
B x S	**	**	**
N x B	n.s	**	n.s
N x S	*	**	n.s
N x B x S	n.s	**	*

* Significant at P = 0.05 ** Significant at P = 0.01 n.s not significan

Table (7): The main effect of irrigation water on the accumulation of salts, nitrate and boron in soil.

Treatment	Soil salinities, dS/m	Nitrate conc. in soil, mg/kg	Boron conc. in soil, mg/kg
Water salinity (dS/m)			
0.44	4.05	67.09	77.54
1.00	6.40	63.49	77.99
2.00	8.81	63.32	76.62
4.00	15.37	39.03	53.38
L.S.D	0.35	2.56	1.37
Nitrate (mg/l)			
Control	8.65	18.21	71.45
15.0	8.78	65.06	71.82
30.0	8.87	91.42	70.88
L.S.D	0.36	1.50	1.21
Boron (mg/l)			
Control	8.18	76.69	28.12
4.0	8.21	58.22	88.92
8.0	9.91	39.78	97.11
L.S.D	0.36	2.25	1.17
ANOVA			
Salinity (S)	**	**	*
Boron (B)	**	**	**
Nitrate (N)	n.s	**	n.s
B x S	**	**	**
N x B	n.s	**	n.s
N x S	*	**	n.s
N x B x S	n.s	**	*

* Significant at S = 0.05

** Significant at S = 0.01

n.s not significant

In conclusion saline irrigation water, containing NO_3 and /or B could be applied to tomato plants in course or moderate soil texture in excessive amounts to meet the leaching requirement in order avoid soil salinization and B toxicity. In view of water quality assessment irrigation water comprising of EC 0.44 dS/m, 30 mg NO_3-N/l and 0.02 mg B/l was superior since it gave the highest growth (shoot dry weight). Also, the water containing 1.02 dS/m of total soluble salts , 30.0 mg NO_3-N/l and 0.02mg B/l can be used without any detrimental effects.

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الملخص العربي

تأثير الملوحة وتركيزات البورون والنترات في ماء الري على النمو والمحتوى المعدني للطماطم

ا.د. ماهر جورجى نسيم ، ا.د.حسين أحمد زيد، د. وفاء حسن محمد، عبد القادر محمد

قســـم الأراضــــي و الكيمـــياء الزراعـــية-كلية الزراعة (سابا باشا)- جامعة الإسكندرية

اجريت هذه الدراسة بغرض معرفة تأثير تركيزات من الملوحة و البورون و النترات فـــي ماء الري على النمو و المحتوى المعدني لنبات الطماطم وكذلك على تراكم الملوحة و البورون و النترات في التربة.

أشـــارت النـــتائج إلى أن زيادة مستوى الملوحة في ماء الري من 44و. إلى 0و 1 ديسيسيمنز/ متر زادت معنويا من الوزن الجاف و من الممتص من عناصر Na, K, N, P, B بالمجموع الخضري لنبات الطماطم ، لكن الممتص من NO_3 انخفض معنويا مع زيادة مستوى الملوحة في ماء الري . كما أن زيادة مستوى الملوحة من 0و1 إلى .و2 أو 0 و4 ديسيســـيمنز/ متر أدى إلى انخفاض معنوي في الوزن الجاف وكذا الممتص من عناصر . K, , Na, N, P, NO_3, B

زيـــادة مســـتويات الـــبورون في ماء الري إلى 0و4 أو .و8 مليجرام/لتر أدى إلى انخفـــاض معـــنوي فـــي الوزن الجاف و كذلك الممتص من عناصر K , B . ومن ناحية أخرى فأن الممتص من عناصر (Na, N, P, NO_3) بواسطة المجموع الخضري لنباتات الطماطم ازداد معنويا مقارنة بالكنترول.

كذلك وجد أن زيادة مستويات النترات في ماء الري الى43و. إلى .و15 مليجرام/لتر زاد معنويا من الوزن الجاف و كذلك الممتص من عناصر Na, K , N, P, NO_3, B . ومـــن ناحـــية أخرى فأنّ الممتص من (NO_3) في ماء الري إلى .و 30 مليجرام/لتر زادت معنويا من الوزن الجاف و من الممتص من عناصر N a, K, N, NO_3, B و انخفاض الفوسفور مقارنة بالكنترول.

الـــتداخل بيـــن الملوحة-النترات-البورون أدى إلى تأثير معنوي على Na, N, NO_3, B الممتص.

التداخل بين الملوحة-النترات-البورون أدى إلى تأثير معنوي على تراكم النترات و البورون ولم يؤثر معنويا على تراكم الملوحة في التربة.

أشارت النتائج أن الري بعينات الماء التي تحتوي على ملوحة 44و. ديسيسيمنز/ متر و مستوى نترات .و30ملجرام/لتر و 2.و. مليجرام/لترمن البورون أعطت أعلى وزن جاف للمجمـــوع الخضـــري. أيضا استعمال الري بعينات الماء والتي تحتوي على ملوحة 2.و1 ديسيســـيمنز/ متر و مستوى نترات .و30ملجرام/لتر و 2.و. مليجرام/لترمن البورون يمكن استخدامها بدون حدوث مشاكل.