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MAIZE TOLERANCE TO DIFFERENT LEVELS OF BORON AND SALINITY IN IRRIGATION WATER.

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ABSTRACT

Plants are likely to be affected by simultaneous boron (B) toxicity and salinity. Stresses on plants due to exposure to soils with high levels of naturally occurring salinity and boron, or due to irrigation with water containing high levels of salts and B can be done. For this reason, a greenhouse study was conducted at Soils Department, Faculty of Agriculture, Mansoura University in two different soils (alluvial and sandy soil) during two successive summer seasons 2013 and 2014 to determine the interactive effects of salinity and varying concentrations of boron on growth, yield and ion relations of maize (Zea mays L.var.s.c.10). The experimental design was split plot with 3 replicates. Boron and salinity were applied with irrigation water. Boron levels were 0, 1, 2 and 3 mg L-1, while salinity levels were 0.4, 2.4, 4.4, 6.4, and 8.4 dSm−1. The average values of fresh and dry weight of shoot and root yield of maize (g/pot) as well as plant height (cm) during both seasons of 2013 and 2014 increased with increasing of B levels from 0 to 1ppm under S1 treatment (0.4 dSm−1), and then significantly decreased with any increasing in boron element under all different levels of irrigation water salinity for both soils under study. On the other hand, the average values of B concentration in maize plant for both seasons significantly decreased as salinity of irrigation water increase with constant of B level but it was significantly increase with increasing of B level and constant level of salinity in irrigation water. For example, the boron concentration in shoot were 28.75, 23.0, 19.1, 13.7 and 7.8 mg/kg ,respectively using irrigation water having EC 0.4,2.4,4.4,6.4 and 8.4 dSm-1,respectively and constant B concentration of 2 ppm, while the boron concentration of maize shoot were 0.9,15.65,23.0and 26.4mg/kg, respectively at using irrigation water having EC 2.4 dSm-1 and B concentration were zero,1,2 and 3 ppm , respectively . Also, the average values of nitrogen, phosphorus, potassium, sodium, chloride and calcium contents in maize were evaluated under the effect of different levels of boron and salinity in irrigation water at the same time.
Keywords: alluvial soil; Sandy soil; Salinity; Boron; Maize; Tolerance.

INTRODUCTION

Agricultural production in arid and semi-arid regions, such as Egypt, relies mainly on irrigation, and, since the water resources in these regions are scarce, the use of marginal water sources (saline water and treated sewage effluent) for irrigation is increasing. These marginal waters contain relatively high salt levels and, in some cases, high boron concentrations (Feigin et al., 1991). Moreover, weathering of minerals could increase the salt and boron concentration in the soil solution (Bresler et al., 1982and Keren and Bingham, 1985). Boron (B) is an essential micronutrient that plays a major role in crop production and crop quality. Although boron (B) is a micronutrient, it is frequently found at toxic concentrations in soils, irrigation water and ground waters in arid and semi-arid conditions worldwide. B is now recognized as a toxic component of the saline milieu which interacts with salinity and further aggravates its toxic effects (Keren 1990, Mola-Doila et al. 1998; Wimmer et al., 2001and Ismail, 2004). In view of the gravity of the problem, breeding for B tolerance has become an objective of some laboratories (Paull et al., 1991). For this an understanding of the mechanism of B toxicity particularly under saline conditions is considered vital (Wimmer et al., 2001and Läuchli, 2002). Whereas the effects of excess boron concentration on crop yields are well documented, the interaction between the effects of excess boron and salinity on growth and yield of crops was much less studied. Under salt affected soil conditions, boron toxicity is considered a major problem, even after reclamation of high salinity levels. Therefore, the focus on boron toxicity is crucial during the management of soil salinity stages. Generally salinity reduces the B uptake, however, contradictory results revealed that salinity can decrease or enhance the B toxicity in wheat (Wimmer et al., 2001). Under salinity hazard, B deteriorates the activity of various membrane functions, which defect water status in plant (Martínez-Ballesta et al., 2008). Besides, salinity and boron stresses have a harmful affect on germination, shoot and root elongation and metabolism of plant (Ismail, 2004and Molassiotis et al., 2006). At higher B levels, B enters the plant cell to cause severe disturbances in the physiological functions of plant leading to dramatic reduction in net yield of crops (Gupta, 1982 and Nable et al., 1997). Growth and biochemical reactions in sunflower are negatively affected by foliar application of B under saline conditions (Jabeen and Ahmad, 2011). Ferreyra et al. (1997) found that the behavior of 42 crop species grown on high boron saline soils had a positive interaction effect. Separately, plants grown under high boron and salinity would produce little to no growth; however, the interaction that occurred seemed to increase individual tolerance coefficients when exposed to both soil constraints at one time. Smith et al., (2013) studied the combined effect of salinity, pH and B on broccoli growth and found a significant decrease in the produced yield by the combined effect of salinity and B application. Meanwhile, this negative effect was more pronounced at high pH values. In addition, it is observed that reduction in biomass yield, and the increase in total antioxidative capacity (TAC) and Luminol-converting peroxidase (LUPO) was more recognized under combined stress of salinity and B as compared with the sole salinity stress (Masood et al., 2012).

Despite the intensive research concerning the individual effects of either salinity or born stress, little is known about their combined effect on growth, yield and biochemical attributes on plant. Therefore, this research aims to study the tolerance of maize crop to different salinity and boron levels in irrigation water.

MATERIALS AND METHODS

To achieve the goal of this study, a pot experiment was conducted at the green house of soils Dept, Fac. Of Agric., Mansoura Univ. during the two summers successive seasons of 2013 and 2014 to investigate tolerance of maize (Zea mays L.var.s.c.10) to different levels of boron and salinity of irrigation water using alluvial and sandy soil conditions. The combined effects of boron and salinity on growth and yield maize plants were investigated by combining four boron rates and five salinity levels in the irrigation water under a split plot design, with three replicates (three pots) for each treatment. The salinity levels were: (S1) EC 0.4 dS m−1 (Tap water), (S2) EC 2.4 dS m−1, (S3) EC 4.4 dS m−1, (S4) EC 6.4 dS m−1and (S5) EC 8.4 dS m−1, representing saline water. As well as four rates of boron at the same irrigation water: (B1) 0ppm, (B2) 1ppm, (B3) 2ppm and (B4) 3ppm, added as boric acid (H_3BO_3). Boric acid was chosen as the source of boron as it contains no sodium. Synthetic saline water was prepared by dissolving natural salt (El-Rashidi) in tap water according to the required salinity level. The philosophy of using this natural salt instead of NaCl is to prepare a representative saline water source and to avoid the ionic effect associated with the sole presence of sodium or chloride. Table 1 shows the soluble cations and anions in the natural salt.

Table 1: Chemical analysis of anions and cations in salt as meq/100g salt:

Con.	Ca++	Mg++	Na+	K+	Cl-	HCO3-	SO4--
(Meq/100g)	75	85	1500	15	1570	25	80

The concentration of the element in salt extract were calculated to find out the forms of salt, so it was found that,100 g from salt contains 2g $Ca(HCO_3)_2$, 3.4g $CaSO_4$, 1.8g $MgSO_4$, 2.6g$MgCl_2$, 1.0g KCl, 87.7gNaCl and 1.5g impurities.

Irrigation salinity levels were selected according to FAO (1985) standards taking into account the yield reduction associated with increasing water salinity levels.

Two surface soil samples (0-30 cm) were collected, the first was from a private Farm in Talkha District, Dakahlia Governorate to represent alluvial soil and the other sample was collected from Kalabsho District, Dakahlia Governorate to represent a sandy soil. The obtained samples were air dried, crushed and passed through a 2-mm sieve. Some Physical and chemical analysis of soil samples (Table 2) were carried out according to the standard methods as mentioned down. Plastic pots having 25cm in diameter and 30cm deep were used. Each pot was filled with 10Kg soil .Three maize seeds were sown in each pot and were thinned to one healthy plant per pot after 20 days from planting in the two seasons. Irrigation was carried out every 2 days to reach the soil field capacity by weight. Planting date was 10th of July. Plants were harvested after 120 days from planting. Super phosphate (7 % P) was applied at a rate of 200 Kg fed-1 which was added at 15 days from planting and all the agricultural operations were performed according to the usual local agriculture management.

Table 2. Some soil physical and chemical characteristics.

Soil characteristics			Alluvial soil	Sandy soil
Sand (%)			23.05	90.5
Silt (%)			25.05	2.7
Clay (%)			50.00	6.8
Soil texture			Clay	Sand
Field capacity (%)			35.0	15.0
Saturation (%)			70.0	30.0
Calcium carbonate (%)			4.00	0.00
OM(%)			1.10	0.30
pH*			7.80	7.91
EC** (dSm-1)			1.50	1.11
soluble ions**	Soluble cations (meq L-1)	Ca++	2.50	2.12
		Mg++	0.70	2.61
		Na+	3.10	3.16
		K+	1.00	3.21
	Soluble anions (meq L-1)	CO3--	0.00	0.00
		HCO3-	0.40	3.34
		Cl-	3.40	4.55
		SO4--	3.60	3.21
Available boron (ppm)			0.30	0.09

***Soil pH was determined in soil paste.**
****Soil Electrical Conductivity (EC) and soluble ions were determined in soil paste extract..**

Nitrogen fertilization was done in three equal doses at 15,30 and 45 days from sowing using urea fertilizer (46 % N) at the rate of 120 and 150 kg N/fed for maize planted in alluvial and sandy soil, respectively. Potassium sulphate (48 % K2O) was applied at a rate of 50 Kg fed-1 at 60 days from planting. Particle size distribution of the soil was carried out using the pipette method (Dewis and Fertias, 1970). Soil field capacity was determined by the method described by Richards (1954). Soil reaction (pH), and soil electrical conductivity (EC) was determined in the saturated soil paste, and the saturated soil paste extract, respectively, according to Richards (1954). Total carbonate was estimated gasometrically using Collin's Calcimeter and calculated as calcium carbonate according to Dewis and Fertias (1970). The amounts of soluble ions meq L-1 in the soil were determined in saturation extract by method according to (Hesse, 1971). Available soil B was determined by hot water extract method as described by Dewis and Freitas (1970). To determine the concentrations of nutrients in plant tissues, 0.2 g from each sample (shoot or root) was digested using 5 cm3 from the mixture of sulphuric (H2SO4) and perchloric (HClO4) acids (1:1) as described by Peterburgski (1968). Nitrogen was determined by micro-Kjeldahl method as explained by Hesse (1971). Phosphorus was determined colorimetrically at wavelength 680 nm using Spekol spectrophotometer as described by Jackson (1967). Potassium was determined by using Gallen Kamp flame photometer as mentioned by Jackson (1967). B concentration was determined in clear digested solution by colorimetric method as mentioned by Bingham (1982).

RESULTS AND DISCUSSION

1-Shoots and roots of maize as affected by different levels of boron and salinity in irrigation water.

Data of Table (3) show the effect of B levels , irrigation water salinity and their interactions on the average values of fresh and dry weight (g/pot) of shoot and root maize grown on alluvial and sandy soil during both seasons of 2013and 2014 . Data in Table (3) show that the decreases resulting from the individual effect of different boron levels on the values of fresh and dry weight of shoot and root maize in alluvial and sandy soil were significant. The highest values of fresh and dry weight for shoots were at control treatment, it was 255.04and 153.44g in alluvial soil and it was 235.38and132.40 in sandy soil, respectively, while the lower values were obtained at B4 treatment for both soils under study, it was241.29and 138.5g in alluvial soil and it was 217.73and 116.06 in sandy soil, respectively, the decreasing rate of fresh and dry weight of shoot maize in alluvial soil from B1 to B4 was (5.4%) and (9.7%), respectively, while the decreasing rate of fresh and dry weight of shoot maize in sandy soil from B1 to B4 was (7.5%) and (12.34%) ,respectively. This trend was the same for fresh and dry weight of maize root yield. The highest values of fresh and dry weight for roots were at control treatment, it was 15.56 and 12.55 g in alluvial soil and it was 13.74and 10.76g in sandy soil respectively, while the lower values were obtained at B4 treatment for both soils under study, it was 14.58 and 10.46 g in alluvial soil and 12.34 and 7.94g in sandy soil, respectively. It can be concluded that raising the boron level from 0 to 3 ppm led to a significant decrease in shoot fresh and dry weight of maize plant grown in both soils.

Data in Table (3) reveal that shoot fresh weight (g/pot), significantly decreased with increasing irrigation water salinity level. The decrease in alluvial soil is from 341.49 g/pot for control treatment (S1) to 318.75,238.95,191.28 and 155.58 g/pot for S2, S3, S4 and S5,respectively, while the decrease in sandy soil is from 306.44 g/pot for control treatment (S1) to,283.59,224.3,175.8 and 146.75 g/pot for S2, S3 , S4 and S5 ,respectively.

Data of the same Table show that dry weight (g/pot), significantly decreased with increasing irrigation water salinity level. The decrease for alluvial soil is from 240.20 g/pot for control treatment (S1) to 218.45, 134.53, 89.23and 54.08 g/pot for S2, S3, S4 and S5 ,respectively, while the decrease for sandy soil is from 204.78 g/pot for control treatment (S1) to 180.23, 122.53, 75.53and 42.99 g/pot for S2, S3, S4 and S5 respectively. This trend was the same for fresh and dray weight of maize root.

The decreasing rate of fresh and dry weight of shoot maize in alluvial soil from S1 to S5 was (54.4%) and (77.4%), respectively, while the decreasing rate of fresh and dry weight of shoot maize in sandy soil from S1 to S5 was (52.1%) and (79%), respectively, This trend was the same for fresh and dry weight of maize root .

The interaction effect between boron levels and irrigation water salinity was significant for both soils under study. As shown in Table (3), the values of fresh and dry weight of shoot and root of maize (g/pot), significantly increase with raising of B level from 0 to 1ppm under S1treatment and insignificantly increase under S2. Significantly decreased was found with any increase in boron level under all different levels of irrigation water salinity for both soils under study. The highest values of fresh and dry weight for maize shoot were at treatment (B2 S1), it was 346.1 and 247.10 g/pot in alluvial soil while it was 309.4 and 207.90g/pot in sandy soil. On the other hand, the data of the same Table show that the lower values of fresh and dry weight of maize shoot were at (B4 S5), it was 139.9 and 38.50 g/pot in alluvial soil while it was 129.5 and 27.60 g/pot in sandy soil .This trend was the same for fresh and dry weight of maize root. Similar results are in agreement and showed that fresh and dry weight yield decreased by significant values as a results of salinity stress (Abou El-Nour 2002; Ismail, 2004; Molassiotis et al. 2006;).

Table 3. Fresh and dry weights (g/pot) (means of the two seasons) of maize shoot and root as affected by different levels of boron and salinity in irrigation water and their interactions.

Treat.	Char.	SHOOTS				ROOTS			
		Alluvial Soil		Sandy Soil		Alluvial Soil		Sandy Soil	
		Fresh weight	Dry weight	Fresh weight	Dry weight	Fresh weight	Dry weight	Fresh weight	Dry weight
Boron levels									
B1 0 (control)		255.04	153.44	235.38	132.40	15.56	12.55	13.74	10.76
B2 1 ppm		253.01	151.74	231.58	129.17	15.80	12.30	13.76	10.24
B3 2 ppm		247.49	145.50	224.82	123.20	15.24	11.38	13.18	9.08
B4 3 ppm		241.29	138.50	217.73	116.06	14.58	10.46	12.34	7.94
LSD at 5%		0.43	0.08	1.49	0.12	0.08	0.05	0.08	0.16
Salinity levels									
S1 (0.4 dS.m-1)		341.49	240.20	306.44	204.78	22.98	16.76	20.70	14.47
S2 (2.4 dS.m-1)		318.75	218.45	283.59	180.23	18.18	15.15	16.23	12.28
S3 (4.4 dS.m-1)		238.95	134.53	224.30	122.53	13.63	13.00	11.43	9.88
S4 (6.4 dS.m-1)		191.28	89.23	175.80	75.53	11.70	8.88	10.15	6.95
S5 (8.4 dS.m-1)		155.58	54.08	146.75	42.99	10.00	4.58	7.78	3.95
LSD at 5%		1.14	0.10	1.06	0.08	0.10	0.09	0.09	0.14
Interaction									
B1 0(control)	S1 (0.4 dS.m-1)	336.70	235.70	304.50	202.20	21.90	16.55	19.50	14.68
	S2 (2.4 dS.m-1)	318.60	219.80	284.90	181.50	18.30	15.50	16.50	12.90
	S3 (4.4 dS.m-1)	246.10	142.70	234.10	132.50	14.20	14.00	12.30	11.20
	S4 (6.4 dS.m-1)	201.90	99.50	190.30	89.90	12.40	10.50	11.20	9.10
	S5 (8.4 dS.m-1)	171.90	69.50	163.10	55.90	11.00	6.20	9.20	5.90
B2 1ppm	S1 (0.4 dS.m-1)	346.10	247.10	309.40	207.90	24.30	17.10	22.00	14.70
	S2 (2.4 dS.m-1)	320.53	220.00	285.50	182.00	18.50	15.70	16.50	13.00
	S3 (4.4 dS.m-1)	242.30	139.60	228.50	127.20	13.90	13.80	11.80	10.80
	S4 (6.4 dS.m-1)	196.00	93.50	181.20	80.50	12.00	9.70	10.40	8.10
	S5 (8.4 dS.m-1)	160.10	58.50	153.30	48.27	10.30	5.20	8.10	4.60
B3 2ppm	S1 (0.4 dS.m-1)	343.20	241.50	306.30	205.50	23.50	16.90	21.30	14.50
	S2 (2.4 dS.m-1)	318.57	217.50	283.10	179.50	18.10	15.20	16.20	12.20
	S3 (4.4 dS.m-1)	237.30	132.70	222.30	119.90	13.40	12.70	11.10	9.50
	S4 (6.4 dS.m-1)	188.00	86.00	171.30	70.90	11.50	8.40	9.80	6.40
	S5 (8.4 dS.m-1)	150.40	49.80	141.10	40.20	9.70	3.70	7.50	2.80
B4 3ppm	S1 (0.4 dS.m-1)	339.95	236.50	305.57	203.50	22.20	16.50	20.00	14.00
	S2 (2.4 dS.m-1)	317.30	216.50	280.87	177.90	17.80	14.20	15.70	11.00
	S3 (4.4 dS.m-1)	230.10	123.10	212.30	110.50	13.00	11.50	10.50	8.00
	S4 (6.4 dS.m-1)	179.20	77.90	160.40	60.80	10.90	6.90	9.20	4.20
	S5 (8.4 dS.m-1)	139.90	38.50	129.50	27.60	9.00	3.20	6.30	2.50
LSD at 5%		2.28	0.21	2.11	0.17	0.20	0.18	0.18	0.29

2- Plants growth parameter.

Data in Table (4) show the effect of different levels of boron and salinity in irrigation water and their interactions on plant growth parameters of maize plant in expression of plant height(cm) at harvest, ear weights (g/pot) ,100-seed weight (g) as well as grain yield(g/pot) for maize .

Data in Table 4 show that all the studied plant growth parameters were significantly decreased with raising the B level from 0 to 3ppm (means of the two seasons) whatever the maize plant grown under alluvial or sandy soil. The plant height was decreased from 157.5 at zero ppm B to 122.73 cm at 3 ppm B for alluvial soil and from 137.30 to 104.56 cm for sandy soil, respectively. The other parameters went in the same line for example grain yield was 73.91, 67.58, 64.20 and 58.57(g/pot) in alluvial soil and 41.42, 40.94, 38.38 and 34.16(g/pot) for sandy soil when B was added at zero, 1,2 and 3 ppm, respectively.

Data in Table (4) indicate also that, using of different levels of irrigation water salinity led to significant decrease in all plant growth parameters of maize plant as compared to tap water S1 (0.4dSm-1).The plant height decreased from 193.93cm at S1 treatment (0.4dsm-1) to 94.2cm at S5 treatment in alluvial soil and from 173.55cm at S1 treatment (Tap water) to 72.85cm at S5 treatment in sandy soil. The decreasing rate was 51.9%for alluvial and it was57.5% for sandy soil. The same trend was found for all plant growth parameters.

As shown from Table (4), the interactions effect between boron levels and irrigation water salinity on plant growth parameters of maize were significant for both soils under study. the values of plant height (cm) , ear weights (g/pot), 100-seed weight (g) and grain yield(g/pot) of maize increase with increasing of B treatment from 0 to 1ppm under S1treatment and then significantly decreased with any increasing in boron element under all different levels of irrigation water salinity for both soils under study, It can be said that adding 1ppm B in irrigation water having EC of 0.4dSm-1 induced favoring effect and significantly increased the all studied growth parameters of maize plant , but raising B level more than 1ppm had a negative effect on maize plant. Data in Table (4) stated also that adding 1, 2 and 3ppm B in irrigation water having EC value of 6.4 and 8.4d Sm-1 did not result in any grain yield under sandy soil. Under alluvial soil, adding 1, 2 and 3 ppm B to irrigation water with 8.4dSm-1 did not give any grain yield. The highest mean values were at (B2 S1) and the lower mean values were at (B4 S5) for all plant growth parameters in alluvial and sandy soil. The present results in Table 3and 4 agree with El-Shebiny and sharaf (2000) who they found that the dry weights of shoot and grains (g), plant height (cm), ear weights (g/pot), 100-seed weight (g) of maize grown increased and then decreased with increasing of B treatments from 1 to 4 mg B/Kg-1 soil but the changes were not significant. The continuous decline in grains yield of maize become significant at the 8, 16 and 32 (mg B/Kg-1 soil) with 7.78, 11.98 and 17.51 per cent reduction of grains yield, respectively.

The results showed that the toxic levels of B concentration of maize shoots were 59.9 and 119.57 mg B kg-1 fresh and dry shoot, which resulted in reducing the grains maize grain yield by 25and 50 % from the maximum yield ,respectively.

Table 4. plant height (cm), ear weights (g/pot), 100-seed weight (g) and grain yield (g/pot) of maize (means of the two seasons) as affected by different levels of boron and salinity in irrigation water and their interactions.

Treat. \ Char.		plant heights (cm)		Ear weights (g/pot)		100-seed weight (g)		Grain yield (g/pot)	
		Alluvial	Sandy	Alluvial	Sandy	Alluvial	Sandy	Alluvial	Sandy
B levels									
B1 0 (control)		157.50	137.30	97.92	56.06	14.24	6.86	73.91	41.24
B2 1 ppm		151.02	130.78	95.58	55.84	11.98	7.49	67.58	40.94
B3 2 ppm		139.69	119.72	89.94	52.02	11.44	7.14	64.20	38.38
B4 3 ppm		122.73	104.56	81.96	46.32	7.84	6.57	58.57	34.16
LSD at 5%		3.13	2.74	0.09	0.05	0.09	0.06	0.16	0.17
Salinity levels									
S1 (0.4 dS.m-1)		193.93	173.55	185.54	131.95	22.85	20.06	134.38	95.88
S2 (2.4 dS.m-1)		168.65	148.35	140.35	92.98	18.48	15.01	98.63	69.63
S3 (4.4 dS.m-1)		141.35	121.10	88.69	37.87	12.05	0.00	68.13	27.90
S4 (6.4 dS.m-1)		116.55	98.88	42.18	0.00	3.50	0.00	29.20	0.00
S5 (8.4 dS.m-1)		94.20	72.58	0.00	0.00	0.00	0.00	0.00	0.00
LSD at 5%		1.36	1.64	0.07	0.06	0.06	0.05	0.15	0.14
Interaction									
B1 0 (control)	S1 (0.4 dS.m-1)	190.30	170.20	183.57	130.30	21.40	18.10	133.09	95.00
	S2 (2.4 dS.m-1)	186.50	166.30	145.50	99.50	18.90	16.20	100.10	72.30
	S3 (4.4 dS.m-1)	161.10	140.90	100.65	50.48	16.90	0.00	96.16	38.90
	S4 (6.4 dS.m-1)	150.50	130.40	59.90	0.00	14.00	0.00	40.20	0.00
	S5 (8.4 dS.m-1)	99.10	78.70	0.00	0.00	0.00	0.00	0.00	0.00
B2 1ppm	S1 (0.4 dS.m-1)	199.70	179.80	188.00	134.50	25.30	21.90	136.01	97.50
	S2 (2.4 dS.m-1)	188.20	167.90	145.90	99.70	18.60	15.55	100.50	72.50
	S3 (4.4 dS.m-1)	151.30	130.90	95.00	45.00	16.00	0.00	66.30	34.70
	S4 (6.4 dS.m-1)	120.30	100.00	49.00	0.00	0.00	0.00	35.10	0.00
	S5 (8.4 dS.m-1)	95.60	75.30	0.00	0.00	0.00	0.00	0.00	0.00
B3 2ppm	S1 (0.4 dS.m-1)	194.10	173.40	186.60	132.10	23.50	21.30	134.50	95.90
	S2 (2.4 dS.m-1)	171.30	150.90	140.00	92.50	18.40	14.40	98.50	69.50
	S3 (4.4 dS.m-1)	137.50	117.30	86.10	35.50	15.30	0.00	60.00	26.50
	S4 (6.4 dS.m-1)	105.10	85.00	37.00	0.00	0.00	0.00	28.00	0.00
	S5 (8.4 dS.m-1)	90.43	72.00	0.00	0.00	0.00	0.00	0.00	0.00
B4 3ppm	S1 (0.4 dS.m-1)	191.60	170.80	184.00	130.90	21.20	18.93	133.90	95.10
	S2 (2.4 dS.m-1)	128.60	108.30	130.00	80.20	18.00	13.90	95.40	64.20
	S3 (4.4 dS.m-1)	115.50	95.30	73.00	20.50	0.00	0.00	50.07	11.50
	S4 (6.4 dS.m-1)	90.30	80.10	22.80	0.00	0.00	0.00	13.50	0.00
	S5 (8.4 dS.m-1)	87.67	68.30	0.00	0.00	0.00	0.00	0.00	0.00
LSD at 5%		2.73	2.72	0.14	0.11	0.12	0.11	0.29	0.28

3 - Boron concentrations (mg/kg) in shoots and roots of maize plant as affected by different levels of boron and salinity in irrigation water.

Data in Table (5) show that B concentration in shoots and roots of maize (mg/kgDM) significantly increased with increasing B application levels. The values of shoot B concentration were 0.71, 12.31, 18.47and 20.63(mg/kgDM) at zero, 1, 2 and3ppm levels for alluvial soil, respectively, whereas the values for root B concentration for alluvial soil were 0.48, 2.93, 8.48 and 10.58(mg/kgDM) at the mentioned B level, respectively. The same trend was found in sandy soil.

From the data in Table (5) B concentration of maize shoots and roots significantly decreased with increasing of salinity level in irrigation water. The highest value was 20.29 at 0.4dSm-1 and then decreased to 5.31(mg/kg) at8. 4 dSm-1 for shoot. On the other hand B concentration was 7.36 at 0.4 dSm-1 and then decreased to 2.97(mg/kg) at8. 4 dSm-1 for root in alluvial soil. Similar trend was found for sandy soil.

It can be noticed that B concentrations in shoot or roots of maize grown on sandy soil are higher than in plants grown on alluvial soil as a result of increasing B level or salinity in irrigation water .It can be attributed to low dry matter accumulation under sandy soil compared to alluvial one (Table 3) which led to dilution of B concentration under alluvial soil. Or maybe to the low concentration of B and salinity in the soil solution of alluvial soil compare with sandy soil . in this content the mechanism of B in alluvial adsorption and/ or absorption colloides complex may take please.

Data in Table 5 reveal also that the interaction effect between boron levels and irrigation water salinity was significant for both soils under study. It can be stated that under any B level, the concentration of B in maize plant significantly decreased with increasing the salinity level of irrigation water and this trend was found under the both soils. For example, the B concentrations in shoots of maize grown on alluvial soil with no addition of B to irrigation water were 1, 0.9, 0.75, 0.55and 0.33mg/ kg whereas they were 31.9, 26.4, 21.45, 15.2and 8.2 (mg/ kgDM)when B was added at the level of 3ppm to irrigation water (B4) under irrigation salinity of 0.4,2.4,4.4,6.4and 8.4dSm-1 ,respectively. It can be concluded that increasing salinity of irrigation water significantly decreased the concentration of B in maize plant .The highest values of B concentration of maize shoots and roots were at (B4 S1) under both studied soils, they were 31.90 and 33.73 for shoot in alluvial and sandy soil, respectively, as well as they were 13.0 and 15.0 for root in alluvial and sandy soil, respectively, while the lower values of B concentration of maize shoots and roots were at (B1S5) under both studied soils.

Table 5. Boron concentration (mg/kg) in shoot and root of maize (means of the two seasons) as affected by different levels of boron and salinity in irrigation water and their interactions.

Treat. / Char.		Boron concentration (mg/ kg)			
		shoots		roots	
		Alluvial	Sandy	Alluvial	Sandy
B levels					
0 (control)		0.71	0.10	0.48	0.06
1 ppm		12.31	14.10	2.93	4.49
2 ppm		18.47	20.18	8.48	9.87
3 ppm		20.63	22.30	10.58	12.58
LSD at 5%		0.58	0.40	0.12	0.15
Salinity levels					
S1 (0.4 dS.m-1)		20.29	21.29	7.36	8.46
S2 (2.4 dS.m-1)		16.49	17.56	6.48	7.62
S3 (4.4 dS.m-1)		13.45	14.66	5.89	6.90
S4 (6.4 dS.m-1)		9.61	10.81	5.39	6.53
S5 (8.4 dS.m-1)		5.31	6.53	2.97	4.24
LSD at 5%		0.50	0.63	0.39	0.20
Interaction					
B1 0 (control)	S1 (0.4 dS.m-1)	1.00	0.25	0.75	0.15
	S2 (2.4 dS.m-1)	0.90	0.15	0.60	0.08
	S3 (4.4 dS.m-1)	0.75	0.07	0.45	0.05
	S4 (6.4 dS.m-1)	0.55	0.02	0.30	0.02
	S5 (8.4 dS.m-1)	0.33	0.01	0.29	0.01
B2 1 ppm	S1 (0.4 dS.m-1)	19.50	21.30	4.80	6.20
	S2 (2.4 dS.m-1)	15.65	17.10	3.30	5.00
	S3 (4.4 dS.m-1)	12.50	14.40	3.00	4.35
	S4 (6.4 dS.m-1)	9.00	10.90	2.67	4.10
	S5 (8.4 dS.m-1)	4.90	6.80	0.90	2.80
B3 2 ppm	S1 (0.4 dS.m-1)	28.75	29.90	10.90	12.50
	S2 (2.4 dS.m-1)	23.00	25.00	9.50	10.90
	S3 (4.4 dS.m-1)	19.10	21.00	9.00	10.10
	S4 (6.4 dS.m-1)	13.70	15.50	8.10	9.50
	S5 (8.4 dS.m-1)	7.80	9.50	4.90	6.35
B4 3 ppm	S1 (0.4 dS.m-1)	31.90	33.73	13.00	15.00
	S2 (2.4 dS.m-1)	26.40	28.00	12.50	14.50
	S3 (4.4 dS.m-1)	21.45	23.18	11.10	13.10
	S4 (6.4 dS.m-1)	15.20	16.80	10.50	12.50
	S5 (8.4 dS.m-1)	8.20	9.80	5.80	7.80
LSD at 5%		1.15	1.27	0.78	0.41

4. N, P, K, Na, Cl and Ca percentage in shoots and roots of maize plant as affected by different levels of B and salinity in irrigation water.

Nitrogen, Phosphorus and potassium concentration (%) in shoot and root maize plants as influenced by boron element, irrigation water salinity and their interactions in alluvial and sandy soil are presented in Table (6).

In regard to the effect of boron element, data presented in Table 6 show a superior effect for boron element on the mean values of N (%) in maize plants. The N (%) of maize shoot and root increased with increasing of B from 0 to 1and 2 ppm and then significantly decreased with raising B level to 3ppm. P% in shoots of maize grown on alluvial or sandy soil insignificantly affected by raising the B level in irrigation water. No clear trend was found for K concentration in maize organs whatever grown on alluvial on sandy soils .For the K (%), the values for shoot and root were not significant.

Table 6. N, P and K percentage in shoots and roots of maize plant as affected by different levels of B and salinity in irrigation water and their interactions.

Treat.	Char.	N (%)				P (%)				K (%)			
		shoot		root		shoot		root		shoot		root	
		Alluvial	Sandy	Alluvial	Sandy	Alluvial	Sandy	Alluvial	Sandy	Alluvial	Sandy	Alluvial	Sandy
B levels													
B1 0 (control)		1.88	1.47	0.49	0.41	0.24	0.26	0.10	0.12	1.80	1.55	0.72	0.48
B2 1 ppm		2.01	1.59	0.52	0.45	0.26	0.28	0.11	0.13	1.85	1.54	0.72	0.49
B3 2 ppm		1.98	1.56	0.61	0.43	0.27	0.29	0.11	0.13	1.78	1.53	0.73	0.53
B4 3 ppm		1.69	1.36	0.45	0.37	0.23	0.26	0.09	0.11	1.54	1.37	0.67	0.41
LSD at 5%		0.12	0.12	0.06	n.s	n.s	n.s	0.01	0.01	0.19	0.09	n.s	0.03
Salinity levels													
S1 (0.4 dS.m-1)		2.68	2.25	0.78	0.67	0.38	0.39	0.16	0.18	2.40	2.07	0.89	0.70
S2 (2.4 dS.m-1)		2.13	1.72	0.63	0.53	0.33	0.35	0.13	0.14	2.07	1.79	0.82	0.62
S3 (4.4 dS.m-1)		1.82	1.41	0.50	0.44	0.27	0.28	0.09	0.12	1.75	1.56	0.73	0.47
S4 (6.4 dS.m-1)		1.55	1.17	0.37	0.30	0.19	0.22	0.07	0.10	1.43	1.25	0.63	0.37
S5 (8.4 dS.m-1)		1.27	0.93	0.32	0.16	0.08	0.13	0.06	0.08	1.08	0.80	0.49	0.22
LSD at 5%		0.10	0.11	0.05	0.03	0.02	0.03	0.01	0.01	0.13	0.13	0.05	0.04
Interaction													
B10 (control)	S1 (0.4 dS.m-1)	2.45	2.00	0.64	0.55	0.34	0.35	0.14	0.15	2.20	1.90	0.85	0.60
	S2 (2.4 dS.m-1)	2.05	1.61	0.58	0.51	0.31	0.32	0.12	0.13	2.06	1.80	0.81	0.55
	S3 (4.4 dS.m-1)	1.85	1.42	0.51	0.46	0.26	0.28	0.08	0.12	1.86	1.65	0.74	0.50
	S4 (6.4 dS.m-1)	1.60	1.21	0.40	0.35	0.19	0.22	0.08	0.10	1.60	1.40	0.66	0.43
	S5 (8.4 dS.m-1)	1.43	1.10	0.30	0.20	0.10	0.15	0.07	0.09	1.30	1.00	0.55	0.32
B2 1ppm	S1 (0.4 dS.m-1)	2.75	2.30	0.75	0.71	0.38	0.39	0.17	0.18	2.40	2.00	0.90	0.73
	S2 (2.4 dS.m-1)	2.25	1.86	0.66	0.55	0.34	0.35	0.14	0.15	2.20	1.90	0.83	0.58
	S3 (4.4 dS.m-1)	2.00	1.53	0.53	0.47	0.28	0.29	0.11	0.13	1.90	1.66	0.75	0.50
	S4 (6.4 dS.m-1)	1.63	1.26	0.40	0.33	0.20	0.23	0.08	0.11	1.56	1.30	0.64	0.38
	S5 (8.4 dS.m-1)	1.40	1.00	0.28	0.18	0.09	0.15	0.06	0.09	1.20	0.82	0.50	0.24
B3 2ppm	S1 (0.4 dS.m-1)	2.95	2.45	1.00	0.74	0.42	0.43	0.19	0.20	2.66	2.43	0.95	0.80
	S2 (2.4 dS.m-1)	2.30	1.92	0.72	0.58	0.36	0.38	0.15	0.16	2.10	1.77	0.85	0.81
	S3 (4.4 dS.m-1)	1.83	1.40	0.50	0.43	0.29	0.29	0.09	0.13	1.75	1.50	0.72	0.45
	S4 (6.4 dS.m-1)	1.55	1.15	0.35	0.27	0.18	0.22	0.07	0.09	1.40	1.20	0.62	0.35
	S5 (8.4 dS.m-1)	1.25	0.90	0.50	0.15	0.08	0.13	0.05	0.07	1.00	0.74	0.49	0.22
B4 3ppm	S1 (0.4 dS.m-1)	2.55	2.25	0.73	0.69	0.37	0.38	0.15	0.18	2.35	1.95	0.87	0.65
	S2 (2.4 dS.m-1)	1.90	1.50	0.55	0.46	0.32	0.33	0.12	0.13	1.90	1.70	0.79	0.52
	S3 (4.4 dS.m-1)	1.62	1.29	0.46	0.38	0.25	0.27	0.08	0.10	1.50	1.43	0.70	0.45
	S4 (6.4 dS.m-1)	1.40	1.05	0.32	0.24	0.17	0.20	0.06	0.08	1.15	1.10	0.61	0.33
	S5 (8.4 dS.m-1)	1.00	0.70	0.21	0.10	0.06	0.10	0.05	0.06	0.80	0.65	0.40	0.10
LSD at 5%		0.21	0.22	0.11	0.06	n.s	n.s	n.s	0.02	0.26	0.26	0.10	0.07

Data in Table (6) show the effect of salinity in irrigation water on N, P and K (%) in maize, the percentage of N,P and K(%) in maize shoot and root significantly decreased with increasing salinity level in irrigation water from S1 to S5 . The values of N, P and K(%) for shoots of maize grown on alluvial soil were 2.68,0.38 and 2.4 for control (S1),while the lowest values were 1.27,0.08 and 1.08% at S5 treatment, respectively . The values of N,P and K(%)for roots of maize grown on alluvial soil were 0.78,0.16 and 0.89 for control (S1),while the lowest values were 0.32, 0.06 and 0.49% at S5 treatment , respectively . Similar trend was found for the concentration of N, P and K shoot and root of maize grown on sandy soil. As shown from Table 6 the interactions between B and salinity of irrigation water were significant on the N and K %of shoots and roots of maize grown on both soils. Raising the B added to 1 or 2 ppm in irrigation water having EC 0.4or 2.4 dSm-1 induced an increase in N and K % in shoots and roots of maize grown on both soils .The highest N and K %in shoots were 2.95 and 2.66% for alluvial soil and 2.45and 2.43% for sandy soil which were obtained due to adding 2ppm B to irrigation water having EC of 0.4 dSm-1 .No significant interactions were found between B and salinity of irrigation water on P %in maize plant organs (shoot and roots). The present result is in accordance with Ferreyra *et al* (1997).

Data in Table (7) show the effect of boron element, irrigation water salinity and their interactions on Na, Cl and Ca percentage in maize shoot and root grown on alluvial and sandy soil.

Data demonstrate that the increase in B level had no significant effect on Na% in shoots or roots of maize grown in both soils, while the Cl (%) of maize shoot and root significantly decreased with increasing B level, As well as the Ca (%) of maize shoot and root significantly increased with increasing B level. This trend was for both of soils under study.

Table 7.Na, Cl and Ca percentage in shoots and roots of maize plant as affected by different levels of B and salinity in irrigation water and their interactions.

Treat.	Char.	Na (%)				Cl (%)				Ca (%)			
		shoot		root		shoot		root		shoot		root	
		Alluvial	Sandy	Alluvial	Sandy	Alluvial	Sandy	Alluvial	Sandy	Alluvial	Sandy	Alluvial	Sandy
B levels													
B1 0 (control)		0.13	0.16	0.18	0.18	0.67	0.73	1.02	1.09	0.49	0.33	0.12	0.10
B2 1 ppm		0.14	0.16	0.19	0.18	0.60	0.67	0.90	1.00	0.50	0.36	0.13	0.11
B3 2 ppm		0.14	0.16	0.18	0.18	0.48	0.63	0.82	0.95	0.57	0.39	0.15	0.12
B4 3 ppm		0.14	0.16	0.20	0.18	0.51	0.60	0.73	0.92	0.59	0 .43	0.16	0.15
LSD at 5%		n.s	n.s	n.s	n.s	0.14	0.08	0.12	0.07	0.03	0.03	0.02	0.01
Salinity levels													
S1 (0.4 dS.m-1)		0.03	0.07	0.10	0.03	0.06	0.07	0.06	0.06	0.62	0.17	0.16	0.09
S2 (2.4 dS.m-1)		0.08	0.09	0.12	0.14	0.40	0.43	0.63	0.67	0.61	0.53	0.18	0.17
S3 (4.4 dS.m-1)		0.16	0.17	0.19	0.21	0.65	0.72	0.98	1.09	0.55	0.47	0.15	0.14
S4 (6.4 dS.m-1)		0.18	0.22	0.25	0.24	0.81	0.90	1.22	1.36	0.50	0.39	0.12	0.11
S5 (8.4 dS.m-1)		0.23	0.25	0.28	0.28	0.88	1.19	1.43	1.79	0.42	0.32	0.10	0.10
LSD at 5%		0.02	0.02	0.02	0.01	0.11	0.06	0.13	0.11	0.04	0.03	0.02	0.01
Interaction													
B1 0 (control)	S1 (0.4 dS.m-1)	0.01	0.07	0.10	0.04	0.08	0.10	0.07	0.08	0.50	0.15	0.13	0.07
	S2 (2.4 dS.m-1)	0.08	0.08	0.12	0.13	0.48	0.57	0.82	0.86	0.55	0.43	0.15	0.13
	S3 (4.4 dS.m-1)	0.15	0.17	0.18	0.21	0.74	0.77	1.11	1.17	0.51	0.41	0.12	0.11
	S4 (6.4 dS.m-1)	0.18	0.20	0.23	0.23	0.89	0.97	1.35	1.46	0.47	0.35	0.10	0.09
	S5 (8.4 dS.m-1)	0.23	0.26	0.27	0.28	1.16	1.26	1.74	1.89	0.40	0.30	0.09	0.08
B2 1ppm	S1 (0.4 dS.m-1)	0.02	0.08	0.10	0.02	0.07	0.09	0.06	0.06	0.56	0.17	0.15	0.08
	S2 (2.4 dS.m-1)	0.09	0.09	0.11	0.13	0.42	0.40	0.63	0.66	0.53	0.49	0.17	0.15
	S3 (4.4 dS.m-1)	0.15	0.17	0.20	0.20	0.71	0.73	1.08	1.11	0.54	0.44	0.14	0.13
	S4 (6.4 dS.m-1)	0.19	0.21	0.24	0.24	0.84	0.92	1.26	1.38	0.48	0.37	0.11	0.10
	S5 (8.4 dS.m-1)	0.23	0.24	0.29	0.29	0.98	1.20	1.47	1.80	0.41	0.31	0.09	0.09
B3 2ppm	S1 (0.4 dS.m-1)	0.03	0.06	0.09	0.03	0.04	0.05	0.05	0.06	0.71	0.18	0.17	0.09
	S2 (2.4 dS.m-1)	0.07	0.09	0.12	0.14	0.38	0.38	0.57	0.59	0.64	0.55	0.19	0.17
	S3 (4.4 dS.m-1)	0.16	0.16	0.19	0.22	0.60	0.69	0.94	1.05	0.55	0.48	0.16	0.14
	S4 (6.4 dS.m-1)	0.18	0.22	0.25	0.24	0.80	0.88	1.21	1.32	0.50	0.40	0.12	0.11
	S5 (8.4 dS.m-1)	0.24	0.25	0.27	0.27	0.58	1.17	1.32	1.74	0.43	0.33	0.10	0.10
B4 3ppm	S1 (0.4 dS.m-1)	0.04	0.08	0.11	0.03	0.03	0.03	0.04	0.05	0.70	0.18	0.19	0.10
	S2 (2.4 dS.m-1)	0.08	0.10	0.13	0.14	0.32	0.35	0.46	0.56	0.71	0.65	0.21	0.21
	S3 (4.4 dS.m-1)	0.17	0.17	0.20	0.21	0.53	0.67	0.80	1.01	0.59	0.54	0.18	0.17
	S4 (6.4 dS.m-1)	0.19	0.23	0.26	0.25	0.70	0.84	1.06	1.26	0.53	0.44	0.13	0.13
	S5 (8.4 dS.m-1)	0.22	0.24	0.28	0.29	0.80	1.12	1.20	1.72	0.44	0.35	0.11	0.12
LSD at 5%		n.s	n.s	n.s	n.s	0.22	0.13	0.26	n.s	n.s	n.s	n.s	n.s

Data in Table (7) show the effect of salinity in irrigation water on Na, Cl and Ca (%) in maize. The percentage of Na and Cl (%) in shoot and root of maize plant significantly increased with increasing of salinity level in irrigation water from s1 to S5 . The values of Na, Cl (%) were 0.03 and 0.06 at control (S1),while the highest values were 0.23 and 0.88% at S5 treatment for shoots in alluvial soil, respectively ,.as well as the values of Na and Cl (%) were 0.07 and 0.07% at control (S1),while the highest values were 0.25and 1.19% at S5 treatment for shoots in sandy soil, respectively. For Ca (%), the values for shoot and root were significantly decreased with increasing salinity level in irrigation water from S2 treatment to S5 treatment under both of studied soils. This trend was found for root in alluvial and sandy soil.

Data in Table 7 state also that there were no significant interactions between B and salinity of irrigation water on Na and Ca% of shoots and roots of maize cultivated on alluvial or sandy soils. The interaction was significant for Cl % in shoots of maize grown on both soils.

CONCLUSION

Based on the obtained results of this study it could be detect that maize resist the boron concentration even 3ppm B in irrigation water having EC of 0.4dSm-1(tap water) without a crop decrease . The decrease of crop occur at 1,2and 3ppm B in irrigation water having

EC of 2.4, 4.4, 6.4and 8.4 dSm-1, so that the grain yield disappear when that level of boron was added to irrigation water having EC 8.4 dSm-1 under both used soils .It can be concluded that the salinity of irrigation water reduced the tolerance of maize to different B levels in irrigation water.

The concentration of B in maize does not reflect the extent of maize tolerance to boron element because the boron concentration in maize plant decreased with increasing of irrigation water salinity with inducing harmful effects of boron on crop at the same time.

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تحمل الذرة لتركيزات مختلفة من البورون وملوحة ماء الري

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غالبا ما تواجهَ النباتات المنزرعةَ بالمناطق الجافةَ وشبه الجافةَ مثل مصر الإجهاد الملحي و الذي قد يكون مصحوباً بتركيزات عاليةَ من عنصر البورون في نفس الوقت .وقد يحدث الإجهاد نتيجةَ الزراعةَ بتربةَ عاليةَ الملوحةَ و البورون او يحدث نتيجةَ الري بمياه ذات تركيز عالي من البورون والملوحةَ في نفس الوقت . لهذا الغرض أجريت تجربة اصص بقسم الأراضي – كلية الزراعة – جامعة المنصورة حيث تم استخدام نوعين من التربةَ (طينيةَ ورمليةَ) لدراسة مدي تحمل محصول الذره لتركيزات مختلفه من البورون تحت مستويات ملوحه مختلفه خلال الموسم الصيفي لاعوام 2013و2014 . لدراسه تاثير التداخل بين تركيزات البورون العاليه والاجهاد الملحي علي محصول الذره وقد استخدم تصميم القطع المنشقه. تم اضافه البورون والملح معا في مياه الري وكانت مستويات البورون (0و1و2و3 ملجرام /لتر) ومصدره حمض البوريك اما معدلات الملح فكانت (0.4و2.4و4.4و6.4و8.4 ديسيمنز). وكان مصدره ملح طبيعي (الرشيدي) حيث اضيف الملح لماء الصنبور(0.4 ديسيمنز) .
أوضحت النتائج ان متوسط قيم الوزن الطازج والجاف لكل من المجموع الخضري والجذري وكذالك ارتفاع نبات الذره للموسمين زاد مع زياده البورون من (0ملجرام /لتر) حتي (1 ملجرام /لتر) تحت مستوي الملوحه (0.4ديسيمنز) ثم يلي ذلك نقص معنوي مع اي زياده للبورون تحت جميع مستويات الملوحه الاخري لكل من التربه الرمليه والطينيه .علي جانب اخر وجد ان متوسط قيم تركيز البورون بالنبات للموسمين نقص معنويا مع زياده الملوحه تدريجيا وثبات مستوي البورون وزاد مع زياده تركيز البورون في ماء الري وثبات مستوي الملوحه فعلي سبيل المثال تركيز البورون بالمجموع الخضري كان 28.75و23و19.1و13.7و7.8 ملجرام / كجم علي الترتيب عند استخدام مياه ري تركيز البورون بها (2 ملجرام/ لتر) وملوحتها (0.4و2.4و4.4و6.4و8.4 ديسيمنز علي الترتيب) في حين ان تركيز البورون بالمجموع الخضري كان 9.و15.65و23و26.4 ملجرام /كجم علي الترتيب عند استخدام مياه ري ملوحتها ثابته (2.4.ديسيمنز) وتركيزات البورون بها 0و1و2و3ملجرام/لتر علي الترتيب .كذلك تم تقيم تركيز كل من النيتروجين والفوسفور والبوتاسيوم والكلور والصوديوم كذلك الكالسيوم تحت المستويات المختلفه لكل من البورون والملوحه.