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Effect of Urea and Potassium Sulfate Fertilizers Combined with Boron on Soil Fertility and Sugar Beet Productivity in Salt Affected Soil

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A FIELD experiment was conducted an saline sodic soil at El-Quntra Shark, Ismailia governorate, Egypt, during two successive winter seasons of 2012/2013 and 2013/ 2014. It amid to evaluate the effect of urea and potassium sulfate fertilizers at different rates alone or combined with boron on some soil properties and its content of available nutrients and sugar beet productivity as well as the roots content of macronutrients and yield quality in salt affected soil. The soil has a sandy loam texture and is saline sodic (EC_e = 12.18 dS/m, SAR= 22.78 and pH = 8.13). The experimental design was randomized complete block with three replicates. Urea and potassium sulfate fertilizers at three different rates, were arranged in the main treatment and applied in three equal doses after 30, 50 and 75 days from planting. The boron rates at 0.0 and 0.5 kg boric acid fed^{-1} in three doses at the same periods of N, K application then randomly distributed in sub treatments.

Results showed that increasing $N+K_2O$ fertilizers rates up to 150 kg N and 100 kg $K_2O.fed^{-1}$ combined with B significantly decreased soil salinity, and significantly increased the available N and K, while P was not significantly affected. Sugar beet yield and yield quality as well as the nutrients content in root of sugar beet increased with increasing the rates of $N+K_2O$ combined with B. The maximum sugar beet yield of root (15.96 ton/fed), sugar yield (2.26 ton/fed), sucrose (16.07 %) and protein percentage (13.13%) were achieved with 150 kg N + 100 kg K_2O / fed combined with 0.5 kg B. fed^{-1}. Also, application of $N+K_2O$ rates had a significant positive effect on root fresh weight/plant, root diameter, and juice purity percentage in both seasons. Raising the $N+K_2O$ fertilizers rates combined with B significantly augmented the content of N, P and K in roots during the two growing seasons. The observation which ought to be mentioned herein that, the combination of 150 kg N + 100 kg $K_2O.fed^{-1}$ with B at rate of 0.5 kg B. fed^{-1} as foliar spray could be recommend to obtain economical yield with satisfactory quality and to improve the soil fertility under the conditions of the studied area.

Keywords: Saline sodic soil, Sugar beet, Urea fertilizer, Potassium sulfate , Boron.

Sugar beet could be extensively grown under the Egyptian condition because of its adaptation to a wide range of climate, tolerance to salinity and productivity which make it a good cash crop. Recently, in Egypt, sugar beet crop had an important role in the Egyptian crop rotation as a winter crop in poor sand, salt affected and calcareous soils. It is one of the most salt tolerant crop. But it is reported to be less tolerant of salinity during germination emergence and in the seedling stage (Maas, 1986). Also, it is far better than sugar can when water use efficiency is concerned, on kilogram of sugar needs about 1.4 and 4.0 m^3 water by sugar beet and sugar cane, respectively, (Ouda, 2011). The productivity of crops and plants is severely limited under the saline soil conditions. It is demonstrated that the fertilization practices is an increasingly important tool for improving the salt affected soil and crop productivity in many areas of the world (Jordan *et al.,* 2004). Adding suitable fertilizers, such as macro and or/micronutrients is one of the favorite factor for soil fertility and crop productivity.

Nitrogen and potassium fertilizers are essential for high root and sugar yields. Nitrogen is an essential element of bio-molecules such as amino acids, proteins, nucleic acids, phytohormones and a number of enzymes and coenzymes (Ashraf and Khan, 1993). Management of soil fertility especially for N and K in salt–affected soils is essential because these nutrients are required in high amounts for good crop growth and high production (Noaman, 2004). Amin (2005) reported that increasing N levels significantly increased root length and its diameter, root fresh weight, top, root and sugar yield. Seadh *et al*. (2007) found that the different combination levels between potassium sulfate and nitrogen increased significantly the concentration of nitrogen, potassium and phosphorus in sugar beet root. El-Sarag and Moselhy (2013) indicated that the application of 211 kg N and 180 kg K_2O ha^{-1} gave the highest top and root yields (19.21 and 50.59 t ha^{-1}). On other hand, Buskiene and Uselis (2008) found that the nitrogen content in the soil increased by approximately 25 %. When the rate of potassium fertilizer was increased from 90 to 240 kg ha^{-1}, potassium content in the soil increased to 33 %. Mahmoud (2011) found that the soil pH and EC decrease with increasing potassium sulfate rate. Shaban *et al*. (2012) showed that, the micronutrient (Fe, Mn and Zn) content in soil increased with increasing rates of N combined with K fertilizers,

Potassium fertilization for sugar beet crop became indispensable particularly in the saline soils. Potassium plays an important role to overcome the high concentration of sodium which has a deteriorating effect on root quality of sugar beet. The influence of K on sugar beet is a function of its root in several individual biochemical and biophysical processes. It directly and indirectly affects photosynthesis, movement and utilization of assimilates, water transport and osmoregulation turgor. The combined effects of which are manifested in both crop yield and quality. Therefore, sugar beet, has a high K requirement (Herlihy, 1989). Ibrahim *et al*. (2002) showed that the highest percentage of root yield (22% and 24%) and that of white sugar yield (25.4% and 37.7%) was obtained at addition of 96 kg K_2O. fed^{-1}, proving that K-fertilization increment improve sugar quality more than that production quantity.

Boron (B) is the most important of the trace elements needed sugar beet because, without an adequate supply, the yield and quality of roots is very depressed (Cooke and Scott, 1993). Soil application, as well as, a foliar spray of boron is equally effective, hence the root fresh weight, sucrose %, root and top yields significantly increased by increasing boron levels (Jaszczolt, 1998). It plays important role in water relations, cell wall formation; cations and anions absorption, pollen viability and metabolism of N, P, carbohydrates and fats in the plant (Oyinlola, 2007). Kristek *et al*. (2006) studied the effect of foliar fertilization with B element (1.0 kg B/ha) on sugar beet root yield and quality compared to the control. They found that root yield is higher by 13.86 t/ha (19.4%), sugar concentration higher by 1.46 % (relative 10.8%) and sugar yield higher by 3.15 t/ha (39.5%). Azzazy (2004) found that the combined Boron and Nitrogen treatments at the rate of 100 kg N + 5 kg borax are recommended to maximize quality and yield of sugar beet under the new reclaimed soil. Hellal *et al*. (2009) showed that the positive effect of increasing N doses on shoot and root weight may be due to the role of nitrogen in development and survival of new tillers, through synthesis of nucleic acids and other organelles. Boron found, also, to interact positively with nitrogen to affect yield and yield components of sugar beet. Combination of 50 ppm B plus 100 mg N kg^{-1} soil led to the highest values of shoot and root yield of sugar beet and nutrient balance whereas increasing the B application until 100 ppm appeared to have a toxic effect on plant growth.

Therefore the current work was carried out to study the effect of potassium and nitrogen fertilization rates alone or combined with boron on yield and quality of sugar beet and on some soil properties and its content of available nutrients under saline sodic condition.

Materials and Methods

Two field experiments were conducted at El-Quntra Shark, Ismailia governorate, Egypt (latitude 30^o 80`N and longitude $32^o$ 28`E), during two successive winter seasons 2012/2013 and 2013/ 2014. The experimental area is characterized by Mediterranean climate which is hot dry summer and relative cold winter. The mean annual rainfall is about 200 mm mostly fell in January and February. The soil has a sandy loam texture and is saline sodic (EC_e =12.18 dS/m, SAR= 22.78 and pH (1:2.5) = 8.13). The nutritional status of the soil is generally low. Level of soil organic matter content (0.45) is very low due to the climatic conditions of the studied area which favor its rapid decomposition. The N, P and K contents are also little, Table 1. Some physical and chemical properties of the experimental soil were determined according to Kim (1996) and presented in Table 1.

The experiments were set up in a randomized complete block design with three replicates. Urea (46% N) and potassium sulfate (48% K_2O) fertilizers at three different rates (75 kg N+ 50 kg K_2O, 100 kg N+ 75 kg K_2O and 150 kg N+ 100 kg $K_2O.fed^{-1}$) in three equal doses after 30, 50 and 75 days from planting and arranged as a main treatments. The control received the recommended doses of N and K fertilizer. While the boron rates at 0.0 and 0.5 kg fed^{-1} boric acid (17.0% B) were applied as a foliar spray in three doses after 30, 50 and75 days from planting and randomly distributed sub treatments.

Super phosphate (15.5 % P_2O_2) was applied at a rate 31kg $P_2O_2.fed^{-1}$ during soil preparation.

TABLE 1. Soil physical and chemical properties of the studied soil (0-30 cm) before planting

Particle size distribution								
Coarse sand (%)	**Fine sand (%)**	**Silt (%)**	**Clay (%)**	**Texture**	**O.M (%)**	**$CaCO_3$ (%)**	**SAR**	
8.99	67.11	10.39	13.51	Sandy loam	0.45	7.00	22.78	
pH (1:2:5)	EC (dS/m)	Cations (mmole/l)				Anions (mmol/l)		
		Ca^{++}	Mg^{++}	Na^{+}	K^{+}	HCO^{-}_3	Cl^{-}	SO^{--}_4
8.13	12.18	10.39	20.83	90.0	0.88	7.93	80.0	34.17
Macronutrients (mg/kg)			Micronutrients (mg/kg)					
N	P	K	Fe	Mn	Zn	Cu		
33.0	3.68	190	1.22	2.11	0.62	0.007		

Sugar beet (*Beta vulgaris* L.), Mirador sugar beet variety was shown on October 28th in growing seasons 2012 and 2013 respectively at rate of 4 kg seeds/fed and harvested after 170 days from sowing (on April 20th in the two seasons). Each experimental plot consisted of 6 rows each of 4 m in length and 50 cm in width. The growth area plot was 12 m^2 (4.0 X 3.0 m). Three seeds were sown in each hill, thinned after 30 days to one plant per hill. Sugar beet was irrigated by the furrow method and the irrigation water salinity was about 1.7 dS/m. Water was applied immediately after sowing for 4 hours and then the excess water was drained. On day after the soil received the same amount of irrigation. After that, irrigation water was added every 12 days until the end of the growing seasons. This was done in order to get rid of a large part of the soluble salts in the soil (Shaban *et al*., 2012).

One day before harvesting, 5 plants with soil surrounding roots are taken from each plot. The plants were get rid of surrounding soil layer, washed, divided into roots and shoots and weighed. The yield of each plot was recorded as described by Shaban and Negm (2008). The root total soluble solids (T.S.S %) was determined using hand refractometer. Sucrose percent (%) was determined in fresh samples of sugar beet root by using saccharometer according to the method described by AOAC (1995). Purity percentage was computed according to the equation:

$$\text{Purity } \% = \frac{\text{Sucrose } \%}{\text{T.S.S } \%} \times 100$$

Total chlorophyll (mg/g f.w) was determined using spectrophotometric method described by Metzner *et al.* (1965).

Sugar beet plant samples were oven-dried at 70ºC till a constant weight and the dry weight was recorded. The plant material was ground to a fine powder and sub sample of 0.2 g was wet disgusted using a mixture of $HClO_4$ and H_2SO_4 acids to determine the concentration of N P K in the dry matter of plants as described by Cottenie *et al*. (1982).

Soil sample were collected at harvest from the surface layer (0-30 cm) to determine the salinity, pH and the available macronutrients N P K in the soil according to Kim (1996)

At harvest, random samples of sugar beet plants were taken from each plot to determine: Root length and diameter (cm), as well as, root weight (kg/plant.). Root yield and Top yield (ton/fed). Sugar yield was also calculated by multiplying root yield (ton/fed) by Sucrose %.

The obtained data of yield and nutrients analysis were statistically analyzed for the two seasons separately according to procedure of Snedecor and Cochran (1980).

Results and Discussion

Soil salinity (EC dSm^{-1})

Soil salinity after harvesting sugar beet decreased significantly with increasing potassium sulfate combined with urea fertilizers compared with the control treatment, Table 2. Overall the average values of soil EC of soil treated with N+K_2O ranged from 5.91 to 7.51 dS m^{-1} was lower than that of the control treatment (8.62 ds/m). This means that potassium sulfate combined with urea fertilizers decreased EC values by about 12.8 – 30.7% relative to the control. The highest decrease induced with the highest rate. This may be resulted from the applied K-fertilizer which increase soil solution by $SO_4^=$ after its dissolution by the applied irrigation water (Khalifa and Ibrahim, 1995). These results are in agreement with Mahmoud (2011) who reported that the EC values decreased with increasing rates of potassium sulfate with the highest reduction at the highest rate, where a pronounced amount of salts leached out from the treated soil reflected on the associated soil properties. The obtained data showed, also, that EC values reduced by about 45% as compared with the corresponding initial soil before cultivation, and the EC values decline was more pronounced under the treatment of N + K_2O combined with boron. I.e., boron application enhanced the soil salinity reduction. These results are in agreement with those of Shaban *et al*. (2009) who found showed that the soil electrical conductivity (EC) values were reduced as compared with the corresponding initial soil before cultivation. Increasing the rate of nitrogen was associated with significant reduction in EC values. Tarek *et al.* (2008) found that the soil EC was significantly reduced from 60 dSm^{-1} to about 17dSm^{-1}, for the soil cultivated with fodder beet, and the harvested above ground biomass fodder beet removed 156 kg Na^+ ha^{-1} from topsoil (0-10 cm deep).

TABLE 2. EC and the available macronutrients contents as affected by N+K fertilizers combined with boron treatment

Fertilizer Treatments (F) (kg/fed^{-1})	Season 2012/2013			Season 2013/2014			Mean of two seasons
	Boric acid (kg/fed^{-1})		Mean F	Boric acid (kg/fed^{-1})		Mean F	
	Non	0.5		Non	0.5		
EC							
Control	9.17	8.94	9.06	8.79	7.58	8.19	8.62
75N +50K$_2$O	8.44	7.48	7.96	7.86	6.25	7.06	7.51
100N+75K$_2$O	7.59	7.14	7.37	6.02	5.88	5.95	6.66
150N+100K$_2$O	6.71	6.10	6.41	5.83	5.22	5.53	5.97
Mean B	7.98	7.42		7.13	6.23		
LSD. %5 F	0.66			0.25			
LSD. %5 B	ns			ns			
F × B	ns			**			
Available Macronutrients (mg kg-1)							
N							
Control	36.25	38.21	37.23	37.02	40.10	38.56	37.90
75N +50K$_2$O	38.91	41.39	40.15	39.47	42.05	40.76	40.46
100N+75K$_2$O	41.19	43.18	42.19	41.66	43.59	42.63	42.41
150N+100K$_2$O	42.57	43.89	43.23	41.66	43.59	42.63	42.93
Mean B	39.73	41.67		43.01	44.28		
LSD. %5 F	1.46			ns			
LSD. %5 B	ns			ns			
F × B	ns			ns			
P							
Control	3.82	3.89	3.86	3.85	3.92	3.89	3.87
75N +50K$_2$O	3.88	3.97	3.93	3.92	3.99	3.96	3.94
100N+75K$_2$O	3.96	4.05	4.01	3.98	4.09	4.04	4.02
150N+100K$_2$O	3.97	4.12	4.05	3.99	4.19	4.09	4.07
Mean B	3.91	4.01		3.94	4.05		
LSD. %5 F	ns			ns			
LSD. %5 B	ns			ns			
F × B	ns			ns			
K							
Control	192	195	194	196	198	197	195
75N +50K$_2$O	198	201	200	201	204	203	201
100N+75K$_2$O	203	208	206	206	213	210	208
150N+100K$_2$O	208	215	212	212	219	216	214
Mean B	200	205		204	209		
LSD. %5 F	3.76			2.62			
LSD. %5 B	3.11			2.50			
F × B	ns			ns			

The effect of interaction between the fertilizers was only significant in the 2*nd* season, and the lowest EC value was obtained under the treatment of N + K_2O at the highest rate with boron, whereas the highest one was recorded for the same treatment without boron. This may be ascribed to the ability of sugar beet to remove more of Na from the soil consequently decrease EC in the sodic saline soil (Tarek *et al*., 2008)

Content of the available macronutrients in soil under study

The data representing available N, P and K as affected by N + K_2O rates applied alone or in combination with boron after sugar beet harvest are shown in Table 2. The available soil N and K increased significantly with the application of the N + K_2O fertilizers rates alone or combined with boron in both seasons, except the increment of N was not significant in the first season.

The available P increased also under all treatments but the increment was not significant in both seasons. However, the application of N + K_2O fertilizers at the high rates in combination with boron gave the highest soil available N, P and K .The interaction between different rates of N + K and B were not significant in both season for available N, P and K content in soil. The corresponding relative increase resulted from the fertilizers rates were 6.54, 10.80 and 12.61 % for the available N with boron, while it was 6.95; 13.07 and 16.78 % without boron compared with the control, respectively, for the treatment of (75 kg N+ 50 kg K_2O, 100 kg N+ 75 kg K_2O and 150 kg N+ 100 kg $K_2O.fed^{-1}$). The corresponding relative increase for the same fertilizers rates were 1.79, 4.09 and 8.93 % for P content in soil with boron, and 1.56, 3.38 and 3.65 % without boron compared with control , respectively. Concerning, the relative increase of the available K as affected by the fertilizers rates, were 3.04; 7.11 and 10.14% for soil treated with boron, while it was 3.09; 5.07 and 8.25 % for soil without boron compared with control, respectively for the same fertilizer treatments. These finding indicate either that more N+ K_2O applications, the more available nutrients increases, since the highest increase was noticed at the highest rates and these increments were enhanced with boron or to decline the pH that augment the availability of nutrients in the soil. Similar results were obtained by Shaban *et al*. (2013) who found that the rates of N + K were significantly affected soil contents of K, while the P was not significantly affected. Helmy and Shaban (2007) indicates that the applied K fertilizer as well as foliar application with B increased the available N, P and K contents in soil as compared to the control. Singh and Sharma (2001) indicated that application of N and K fertilizers led to an increase of available N and K in surface soil. Also, Buskiene and Uselis (2008) reported that increasing the application rates of nitrogen fertilizer from 60 to 90 kg ha^{-1}, increased nitrogen content in the soil by approximately 25 %. When the rate of potassium fertilizer was increased from 90 to 240 kg K_2O ha^{-1}, potassium content in the soil increased up to 33%.

Macronutrients (N, P and K) concentration in sugar beet root

The obtained results presented in Table 3 showed that the application of N+ K_2O fertilizers alone or with boron caused a positive effect on N, P and K concentration in sugar beet root as compared with the control treatment. N concentration of roots significantly increased in the 1*st* season only, whereas the increase of K content was significant only in the 2*nd* season. The P concentration significantly increased in both seasons. However, the highest increases of N, P and K concentrations were noticed at the highest rate of N + K_2O fertilizers in combination with boron. Overall average, N concentration in sugar beet roots increased by 22.7 and 11.7% over the control treatment at the highest and lowest rate of N + K_2O, respectively. The corresponding values of P increase were 55.3 and 32.1% for the same treatments, respectively, while those of K were 27.2 and 10.7%, respectively for the same treatments. In the same context, the relative increase of the N, P and K concentration in sugar beet roots due to boron application were 8.47, 22.4 and 9.15%, respectively. These results indicate that P responses more than N and K to the applied fertilizers. The interaction between N + K_2O fertilizers and B application significantly increased the N, P and K concentration of roots in the two seasons of the study, except the increment of N concentration was significant only in the 2*nd* season, with the highest values at the highest rate of N + K_2O in combination with boron. This may be attributed to the beneficial and mutual affect applied nutrients on its availability in soil consequently, enhance its uptake and concentration in plant roots. These results are in agreement with thoses of Seadh *et al*. (2007) Salem and Khaled, (2012) and Shaban *et al*. (2013) who found that the different combination levels between potassium sulfate and nitrogen increased significantly the concentration of nitrogen, potassium and phosphorus in sugar beat root in two seasons of study. Also, Mehran and Samad (2013) showed that increasing N and K fertilization had a significant effect on nutrients content and uptake of roots and foliage over two seasons of study. In the same context, Hellal *et al*. (2009) found that the highest levels of boron and N application led to increase the N, P and K contents in root of sugar beet.

TABLE 3. Macronutrients concentration in root sugar beet as affected by N+K fertilizers combined with boron treatment

Fertilizer Treatments (F) (kg/fed^{-1})	Season 2012/2013			Season 2013/2014			Mean of two seasons
	Boric acid (kg/fed^{-1})		Mean F	Boric acid (kg/fed^{-1})		Mean F	
	Non	0.5		Non	0.5		
N							
Control	1.52	1.69	1.61	1.60	1.72	1.66	1.63
75N +50K_2O	1.74	1.85	1.80	1.79	1.90	1.85	1.82
100N+75K_2O	1.82	1.98	1.90	1.88	2.03	1.96	1.93
150N+100K2O	1.87	2.08	1.98	1.92	2.12	2.02	2.00
Mean B	1.74	1.90		1.80	1.94		
LSD. %5 F	0.05			ns			
LSD. %5 B	0.018			ns			
F × B	**			ns			
P							
Control	0.39	0.69	0.54	0.43	0.72	0.58	0.56
75N +50K_2O	0.67	0.77	0.72	0.71	0.81	0.76	0.74
100N+75K_2O	0.76	0.83	0.80	0.81	0.87	0.84	0.82
150N+100K_2O	0.79	0.89	0.84	0.85	0.96	0.91	0.87
Mean B	0.65	0.80		0.70	0.84		
LSD. %5 F	0.010			0.014			
LSD. %5 B	0.008			0.015			
F × B	**			**			
K							
Control	2.79	2.94	2.87	2.83	3.05	2.94	2.90
75N +50K_2O	2.98	3.34	3.16	3.07	3.46	3.27	3.21
100N+75K_2O	3.22	3.55	3.39	3.48	3.74	3.61	3.50
150N+100K_2O	3.47	3.77	3.62	3.69	3.82	3.76	3.69
Mean B	3.12	3.40		3.27	3.52		
LSD. %5 F	ns			0.019			
LSD. %5 B	0.007			0.020			
F × B	**			**			

Yield and yield component of sugar beet

The obtained results showed that N + K_2O fertilizers with or without boron had a significant positive effect on sugar beet yield and its component such as roots, top yield and sugar yield, (Table 4,) as well as, root fresh weight and root diameter, (Table 5). These parameters of yield and its component were found to be increased significantly with the incremental addition of applied fertilizers. The interaction effect between N + K_2O combined with boron fertilizers was found to be significant in respect to root and sugar yield in both seasons, but not significant in the 1st season in respect to the root fresh weight and root diameter. A gradual increase was observed in root yield, top yield, sugar yield, root fresh weight and root diameter as reason of increasing nitrogen and potassium combination rates from 75 kg N +50 kg K_2O fed^{-1} to 150 kg N +100 kg K_2O fed^{-1} alone or combined with B in both seasons. The highest increase occurred at the highest rates of the applied fertilizers. Average values of root fresh weight and root diameter increased by 40.5 and by 45.5% for the root fresh weight and by 57.3 and 36.3% for the root diameter, relative to the control treatment, affected by the treatment of the highest fertilizers rates with and without boron, respectively. Likewise, the average values, over the two seasons, increased from 10.13 to 15.96, from 12.7 to 14.35 and from 1.98 to 2.56 $Mg.fed^{-1}$, for root, top and sugar yield compared with the control treatment 7.6, 14.3 and 1.11 $Mg.fed^{-1}$, respectively, under the treatment of the highest fertilizers rates with boron,. The corresponding values at the same treatment without boron were varied from 8.08 to 13.21, from 12.7 to 14.35 and from 1.12 to 1.97 $Mg.fed^{-1}$, respectively, for the same traits compared with the control treatment 6.98, 10.45 and 0.92 $Mg.fed^{-1}$, respectively. Such as effect of nitrogen and potassium on these parameters may be returned to its role in building up metabolites and activation of enzymes that associate with accumulation of carbohydrates, which transported from leaves to developing roots. These results means that root yield at the highest application rate 150kg N + 100 kg K_2O /fed increased by 109.86% and 89.33 %, respectively, with and without boron relative to the control. The corresponding values for the sugar yield at the same treatment with and without boron were 130.6% and 114.1 %, respectively. As for the top yield, the relative increase, over the two season at the highest application rate 150kg N + 100 kg K_2O /fed with and without boron were 17.5% and 37.3%, respectively. These results emphasize the beneficial role of boron in improving the productivity of sugar beet crop.

The same trend of the obtained results was reported by El-Sarag and Sameh (2013) who found that application of 211 kg N and 180 kg K_2O ha^{-1} gave the highest top and root yields (19.21 and 50.59 ton ha^{-1}) while, the lowest quantities of sugar beet top and root (9.71 and 25.43 ton ha^{-1}) were achieved by adding 105 kg N and 60 kg K_2O ha^{-1}. On other hand, the obtained increases with K application could be due to its effective role on carbohydrate and N-metabolism, water absorption and transpiration in plant. Abdel- Mawly and Zanouny (2004) indicated that application of K tends to accelerate photosynthetic activity, translocation of sucrose from the leaves and its accumulation in roots. The beneficial effects of K in improving sugar beet productivity may be attributed to its enhancement effects on increasing plant metabolic activity.

TABLE 4. Yield and yield component as affected with N+K combined with or without boron

Fertilizer Treatments (F) (kg/fed^{-1})	Season 2012/2013			Season 2013/2014			Mean of two seasons
	Boric acid (kg/fed^{-1})		Mean F	Boric acid (kg/fed^{-1})		Mean F	
	Non	0.5		Non	0.5		
Weight root yield ($Mg\ fed^{-1}$)							
Control	6.71	7.38	7.05	7.25	7.83	7.54	7.29
75N +50K_2O	7.82	9.68	8.75	8.34	10.59	9.47	9.11
100N+75K_2O	9.60	12.95	11.28	11.52	15.74	13.63	12.45
150N+100K_2O	12.74	14.98	13.86	13.69	16.94	15.32	14.59
Mean B	9.22	11.25		10.20	12.78		
LSD. %5 F	0.64			1.90			
LSD. %5 B	0.45			1.34			
F × B	**			ns			
Top yield ($Mg\ fed^{-1}$)							
Control	10.25	14.12	12.19	10.66	14.55	12.61	12.40
75N +50K_2O	12.54	14.97	13.76	12.86	15.05	13.96	13.86
100N+75K_2O	13.14	15.77	14.46	13.82	16.43	15.13	14.79
150N+100K_2O	13.96	16.46	15.21	14.74	17.23	15.99	15.60
Mean B	12.47	15.33		13.02	15.82		
LSD. %5 F	1.92			1.75			
LSD. %5 B	1.36			1.24			
F × B	ns			ns			
Sugar yield ($Mg\ fed^{-1}$)							
Control	0.87	1.07	0.97	0.97	1.15	1.06	1.02
75N +50K_2O	1.08	1.46	1.27	1.16	2.51	1.84	1.55
100N+75K_2O	1.37	2.06	1.72	1.70	2.51	2.11	1.91
150N+100K_2O	1.89	2.40	2.15	2.05	2.72	2.39	2.27
Mean B	1.30	1.75		1.47	2.22		
LSD. %5 F	0.07			0.05			
LSD. %5 B	0.05			0.03			
F × B	**			**			

The positive effect of N fertilizer might be due to the increased efficiency of N-fertilization in building up metabolites translocations from leaves to developing roots, thus increases dry matter accumulation.

TABLE 5. Root fresh weight and root diameter as affected with N+K combined with or without boron

Fertilizer Treatments (F) (kg/fed^{-1})	Season 2012/2013			Season 2013/2014			Mean of two seasons
	Boric acid (kg/fed^{-1})		Mean F	Boric acid (kg/fed^{-1})		Mean F	
	Non	0.5		Non	0.5		
Root fresh weight (g/plant)							
Control	512	559	536	529	573	551	543
75N +50K$_2$O	573	637	605	596	720	658	632
100N+75K$_2$O	637	748	693	649	793	721	707
150N+100K$_2$O	720	788	754	791	803	797	776
Mean B	611	683		641	722		
LSD. %5 F	41.46			41.65			
LSD. %5 B	29.32			29.46			
F × B	ns			**			
Root diameter (cm)							
Control	6.14	6.27	6.21	7.15	7.33	7.24	6.72
75N +50K$_2$O	8.04	8.35	8.20	8.15	8.67	8.41	8.30
100N+75K$_2$O	8.38	8.96	8.67	8.91	9.28	9.10	8.88
150N+100K$_2$O	8.96	10.53	9.75	9.15	10.88	10.02	9.88
Mean B	7.88	8.53		8.34	9.04		
LSD. %5 F	0.65			0.55			
LSD. %5 B	0.44			0.39			
F × B	ns			*			

According to the above mentioned results, the combination of 150 kg N + 100 kg K_2O fed^{-1} with boron at rate of 0.5 kg B fed^{-1} as foliar spray could be recommended to maximize the sugar beet productivity and to improve the soil fertility under the conditions of the studied area.

Yield quality of sugar beet

The studied sugar beet quality such as sucrose percentage, purity (%), protein percentage and total chlorophyll (mg/g) are shown in Table 6. Results revealed that all sugar beet quality parameters were significantly increased as affected by the different application rates of N + K_2O in both seasons, with the highest increase at the highest application of fertilizers rates, except sucrose (%) which was not significantly affected. Also, the application of boron affected significantly the studied quality traits. The interaction between the N + K_2O different rates and B was not significantly affected the studied quality parameters in both seasons, except of the total chlorophyll which was affected significantly in the 1st season only.

TABLE 6. Effect of mineral nitrogen and potassium fertilizers alone or combined with boron on sugar beet quality under saline soil

Fertilizer Treatments (F) (kg/fed^{-1})	Season 2012/2013 Boric acid (kg/fed^{-1}) Non	0.5	Mean F	Season 2013/2014 Boric acid (kg/fed^{-1}) Non	0.5	Mean F	Mean of two seasons
Total Chlorophyll (mg/g F.W)							
Control	569	579	574	573	583	578	576
75N +50K_2O	689	720	705	702	735	719	712
100N+75K_2O	743	758	751	759	782	771	761
150N+100K_2O	743	812	778	759	820	790	784
Mean B	686	717		698	730		
LSD. %5 F	8.34			42.16			
LSD. %5 B	5.9			29.15			
F × B	**			ns			
Sucrose (%)							
Control	13.22	14.52	13.87	13.39	14.80	14.10	13.98
75N +50K_2O	13.92	15.10	14.51	14.02	15.59	14.81	14.66
100N+75K_2O	14.37	15.95	15.16	14.80	15.99	15.40	15.28
150N+100K_2O	14.90	16.06	15.48	15.02	16.08	15.55	15.52
Mean B	14.10	15.41		14.31	15.62		
LSD. %5 F	ns			ns			
LSD. %5 B	1.16						
F × B	**			ns			
Purity (%)							
Control	73.55	75.96	74.76	75.18	78.14	76.66	75.71
75N +50K_2O	77.96	82.53	80.25	82.60	83.10	82.85	81.55
100N+75K_2O	85.17	87.21	86.19	86.77	89.25	88.01	87.10
150N+100K_2O	82.15	86.14	84.15	84.09	88.02	86.06	85.10
Mean B	79.71	82.96		82.16	84.63		
LSD. %5 F	1.85			1.72			
LSD. %5 B	1.31			1.22			
F × B	ns			ns			
Protein (%)							
Control	9.50	10.56	10.03	10.00	10.75	10.38	10.20
75N +50K_2O	10.88	11.56	11.22	11.19	11.88	11.54	11.38
100N+75K_2O	11.38	12.38	11.88	11.75	12.69	12.22	12.05
150N+100K_2O	11.69	13.00	12.35	12.00	13.25	12.63	12.49
Mean B	10.86	11.88		11.24	12.14		
LSD. %5 F	0.63			0.94			
LSD. %5 B	0.68			0.74			
F × B	ns			ns			

The sucrose (%) varied between 15.3–16.07% and from 13.97 to 14.96 %, respectively under the N+ K_2O fertilizers rates with and without boron. The highest increase of sucrose (%) compred to the control treatment was obtained at the highest N+ K_2O rates combined with boron, whereas the lowest one was recorded under the lowest N+ K_2O rates without boron application. This means that the best treatment is that of the highest N+ K_2O rates combined with boron.

It increased sucrose (%) in root of sugar beet by 9.4% over the control, and by 15.0 % compared with the treatment received no boron addition. The increase of sucrose (%) at the lowest N+ K_2O rates with boron was about 4.6% compared with that of without boron addition treatment (5.0%).

As for protein (%), the obtained results showed that it varied between 10.88 – 13.13% and from 9.75 to 11.85%, respectively under the N+ K_2O fertilizers rates with and without boron. The highest increase of protein (%) was obtained at the highest N+ K_2O rates combined with boron compared with the control treatment, whereas the lowest one was recorded under the lowest N+ K_2O rates without boron application. This proves that the best treatment is that of highest N+ K_2O rates combined with boron. It increased the protein (%) in root of sugar beet by 21.3% over the control, and by 10.8% compared with the treatment of without boron addition. The increase of the protein (%) at the lowest N+ N+ K_2O rates with boron was about 6.1% compared with that of without boron addition treatment. The results indicate that boron increased the protein content of root by about 6.1- 10.8%.

Likewise, average values, over the two seasons, of the purity (%) and total chlorophyll increased from 82.8% to 87.08% and from 727.5 to 816 mg/g, respectively, with increasing N+ K_2O rates from 75N + 50 K_2O Kg fed^{-1} to 150N + 100 K_2O Kg fed^{-1} with boron application, compared to the control treatment (77.05% and 581 mg/g), respectively. The corresponding values for the same treatments without boron application were from 80.28 to 83.12% and from 702 to 816 mg/g compared to the control treatment 74.36% and 571 mg/g, respectively, for the purity (%) and total chlorophyll.

The increase of the above mentioned yield quality traits as a result of increasing N + K_2O fertilizers rates may be due to the importance of nitrogen and potassium role in increasing vegetative growth through enhancing leaf initiation, increment chlorophyll concentration in leaves which may reflected in improving photosynthesis process and increasing fresh root weight. The obtained increases with K application could be due to its role on carbohydrate and N-metabolism, water absorption and transpiration in plant.

Mehran and Samad (2013) indicated that adding the highest level of K (114 kg K_2O ha^{-1}) under different rates of N significantly increased sucrose contents, recoverable sugar yield and some quality traits. . Increasing N and K fertilization had a significant effect on nutrients content and uptake of roots and foliage over two seasons.

These results are in the same trend of those of El-Sarag and Moselhy (2013) who showed that the maximum sucrose percent (18.64 and 18.87% was achieved by adding 100 Kg K_2O and 141 Kg N ha^{-1}. Ali (2015) found that highest averages of purity were obtained from 140 kg N /fed with 120 and 150 ppm boron. It could be noticed that increasing N and K fertilizers rates significantly increased root growth and quality. Armin and Asgharipour (2011) reported that the highest root yield and sucrose concentration were obtained by spraying plants with 12% boric acid at 60 days after planting.

Conclusion

Application of urea + potassium sulfate fertilizers at high rates to soil alone or combined with boron foliar spry improved the soil properties (EC and pH) of the saline sodic soil. It also increased the available nutrients in the soil as well as the macronutrients concentrations in sugar beet roots, which reflected on increasing root yield and its component, top and sugar yield and yield quality such as sucrose percent, sugar purity (%), total chlorophyll content and protein percent in roots. The maximum yield and yield quality of sugar beet crop was obtained at application rate of 150 kg N fed^{-1} + 100 kg K_2O fed^{-1}, with boron foliar spry at rate of 0.5 Kg fed^{-1}. Therefore this treatment could be recommended to obtain economical yield with satisfactory quality and to improve the soil fertility under the conditions of the studied area.

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تأثيرالتسميد باليوريا وسلفات البوتاسيوم مع البورن على خصوبة التربة وانتاجية محصول بنجر السكر فى الاراضى المتأثرة بالاملاح

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أجريت تجربة حقلية في القنطرة شرق، محافظة الإسماعيلية، مصر، خلال موسمي شتاء لعامى 2013/2012 و 2013 / 2014 على بنجر السكر بهدف دراسة تقييم تأثير مستويات مختلفة من سمادى اليوريا وكبريتات البوتاسيوم مع الرش بالبورون او بدون على بعض خواص التربة ومحتواها من العناصر الغذائية وعلى انتاجية البنجر ومحتوى الجذور من العناصر الغذائية وجودة المحصول فى الاراضى المتأثرة بالاملاح.

واجريت التجربة فى ارض ملحية صودية (EC_e = 12.18 dS/m, SAR= 22.78 and pH = 8.13)ونفذت التجربة فى قطاعات كاملة العشوائية فى ثلاث مكررات واشتملت معاملات التجربة على ثلاث معدلات مختلفة من اليوريا وكبريتات البوتاسيوم وهى
(75 kg N+ 50 kg K_2O, 100 kg N + 75 kg K_2O and 150 kg N + 100 kg $K_2O.fed^{-1}$)

و اضيفت الاسمدة على فترات 30و50و75 يوم من الزراعة بالاضافة الى الكنترول واضيفت بالكميات الموصى بها من وزارة الزراعة الى كل المعاملات لكل من النتروجين والبوتاسيوم واضيف البورون بمعدل صفر و0.5 كحم حمض بوريك رشا على الاوراق.
واوضحت النتائج انه بزيادة معدلات تسميد النيتروجين الى 150 كجم و البوتاسيوم الى100كحم K_2O للفدان وذلك مع الرش البورون ادى الى انخفاض معنوى فى ملوحة التربة وزيادة معنوية للنيتروحين والبوتاسيوم الميسر فى التربة بينما لم يتأثر الفوسفورمعنويا وايضا ازداد محصول انتاج البنجروجودتة ومحتوى الجذور من العناصر الغذائية بزيادة معدلات اضافة النيتروجين والبوتاسيوم مع البورون وكان اعلى انتاج لجذور بنجر السكر (15.96 طن /فدان) وانتاج السكر (2.26 طن /فدان) ونسبة السكروز (16.07%) ونسبة البروتين (13.3%) وذلك عند معدل تسميد (150 كجم نيتروجين + 100كجم، K_2O مع 0.5كجم بورون/ فدان)

وايضا وجد ان اضافة معدلات الاسمدة من النيتروجين والبوتاسيوم كان لها تأثير ايجابى معنوى على كلا من جذور النباتات وقطر الجذر ونسبة نقاوة العصير فى كلا من الموسمين محل الدراسة و بزيادة معدلات تسميد النيتروجين والفوسفور مع البورن كانت هنال زيادة معنوية لمحتوى الجذور من النيتروجين والبوتاسيوم والفوسفور خلال موسمى النمو.

وفى ضوء هذة الدراسة فانه يوصى بالتسميد بمعدل 150كجم نيتروجين+ 100كجم اكسيد بوتاسيوم /فدان مع الرش بمعدل 0.5 كجم بورن /فدان للحصول على محصول اقتصادى ذو نوعية جيدة وتحسين خصوبة التربة تحت طروف منطقة الدراسة.