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Response of Sugar Beet to Continuous Deficit Irrigation and Foliar Application of some Micronutrients under Sandy Soil Conditions.

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ABSTRACT

Two field experiments were conducted at El-Bostan area at Aly Mubark experimental farm southern EL-Tahrir region (latitude of 30.57^0 N and longitude of 30.71^0 E) El-Beheira Governorate, Egypt, during the two winter growing seasons 2014/2015 and 2015/2016 to study the effect of foliar application of boron and iron on growth parameters, yield and quality of sugar beet under continuous deficit irrigation condition in sandy soil. A split plot design with three replicates was used. The present work included three irrigation regimes (100%, 75% and 50% ET_c), three boron treatments (0, 0.5 and 1.0 g boric acid/l) and three iron treatments (0, 0.5 and 1.0 g chelated iron EDTA "13% Fe"/l). The treatments of irrigation were lay in main plots, whereas boron and iron treatments were in sub-plots. Sugar beet "Sara" multi-germ variety was sown in both seasons. Data reveled that irrigating sugar beet with 100 ET_c significantly increased root diameter and fresh weight; leaf area index (LAI), chlorophyll b, Na, α-amino N and top, root and sugar yields/fed in the two growing seasons. Root length, chlorophyll a, carotenoids, sucrose%, extractable sugar% and purity% significantly increased with irrigating sugar beet at 75% ET_c. Increasing foliar application rate of boric acid and chelated iron significantly increased root length and diameter, LAI, top and root yields, chlorophyll a and b, carotenoids, sucrose%, and extractable sugar%. Increasing foliar rates of boric acid and chelated iron led to decreasing sugar impurities. The interaction effect between irrigation regimes and foliar of boric acid were significant for root length, top yield, sucrose%, extractable sugar%, meanwhile the interaction between irrigation regimes and foliar of chelated iron were only significant for top yield, in both seasons. Decreasing amount of applied irrigation water as well as foliar application of boric acid and chelated iron increased water utilization efficiency (WUtE) for root and sugar yields/fed in both seasons. Results summarized that irrigating sugar beet with 100% ETc with foliar application of boron and iron at rate of 1g/l were recommended to obtain high root and sugar yield. While, irrigating sugar beet with 75% ETc and foliar application of boron and iron at rate of 1g/l were recommended to obtain the higher sugar quality under drip irrigation in sandy soil at El-Bostan, El-Beheira Governorate.

INTRODUCTION

Water scarcity in Egypt is a major challenge in agriculture development. Without maximizing the water use efficiency by the crops to save water, developments in agriculture sector will be limited. Deficit irrigation and cultivated a drought tolerant crops are the main strategies for water saving under these condition with the optimum fertilization. Sugar beet is the second important sugar crops in Egypt after sugar cane and will be the major sugar crop under the new strategies in the Egyptian agriculture sector for saving irrigation water. Deficit irrigation is a good tool to increased irrigation water use efficiency and reduced water supply costs (English *et al*., 1996). In arid and semi-arid regions, the increase in the irrigation and water opportunity costs and the decrease in the amount of available water get deficit irrigation techniques into focus in these regions (Winter, 1990). Low irrigation, during which water deficit stress is applied either at a certain growth stage or during the whole growing season, is a technique for maximizing water usage efficiency (WUE), and increasing the yield per unit of applied water (Kirda, 2002). There are many deficit irrigation strategies could be applied, such as continuous deficit irrigation (CDI,) and regulated deficit irrigation (RDI,) to save water without major effects on yield (lniesta *et al*., 2009 and Chalmers *et al*., 1981). RDI requires precise knowledge of the crop response to water stress at different physiological growth stages to identify the stage when the plant are less sensitive (Fereres and Goldhamer, 1990, FAO.2002).

Moursi, *et al*., 2014, indicated the highest mean values of water productively (WP) and productivity of irrigation water (PIW) were recorded under I1 (55 % depletion of available soil moisture), but the lowest mean values were recorded under I3 (85% depletion of available soil moisture). Sugar beet root yield, top yield and root diameter were highly significant affected by irrigation treatments in the two growing seasons, where, the mean values for the abovementioned studied parameters were increased with increasing water applied, Although root length increased with decreasing amount of irrigation water applied. Sugar yield, purity, nitrogen concentration in tops and roots increased with increasing irrigation water. On the other hand, sucrose percentage increased with decreasing irrigation water (70 and 85 % depletion of available soil moisture). Water stress had significant effect on foliage height, root length, total plant height and root diameter of sugar beet plants (Pawar , *et al*., 2015 and Tognetti *et al*., 2002).

Masri, *et al*., 2015 study the effect of water stress (100%, 75% and 50% of irrigation water requirements based on ETc) on growth, yield and quality of sugar beet plants and reported that drip irrigated sugar beet plants with 75% of irrigation water requirements (IWR) recorded the highest significant leaf area index, sucrose%, purity% and extractable sugar% in both seasons and white sugar yield in the second season. Also, Hussein *et al*., 2015 mointied that the highest values of all growth parameters were obtained by irrigation sugar beet plants with 75% of the ETc. On contrary, the lowest values of all growth parameters were gained under the highest treatment of water stress (50% of the ETc,). In to decrease with 50% ETc water irrigation treatment Yield decreased as the water quantity decreased. The highest water use efficiency (WUE) values, the best quality parameters (N, P, K, Na and Protein) were determined in the treatment of the 75% ETc. On the other hand Mehrandish *et al*., 2012 and Sadeghi-Shoae *et al*., 2013 illustrate that deficit irrigation significantly decreased root yield, shoot yield and sugar yield. However, irrigation treatments had no effect on impure sugar percent, pure sugar percent and root dry matter. Esmaeili, 2011 investigate the response of three irrigation regimes I1: Irrigation at 50% of available moisture around the root, (treatment without stress). I2: Irrigation at 90% of available moisture around the root and (initial stress or irrigation stress at the first of season after sprouting and settling of plant). I3: Irrigation at 80% of available moisture around the root (continuous stress, stress during growth season) on sugar beet growth and yield and indicate that effects of water treatments on root yield and gross sugar content was significant also, Water use efficiency for root (WUEr) and for sugar (WUEs) were significant with irrigation amounts ($P < 0.05$).

Boron is one of the important micronutrient among essential elements for plant growth, and plays a significant role in the physiological and biochemical processes within plants. Several reports in the literature indicated that the supply of B in the substrate may affect the behavior of other micronutrients in plants. It is evident from the literature that B induced changes of other micronutrients in soil-plant system, but still it is not clear whether the effects of B on the behavior of other micronutrients are based on the physiology of plants (Tariq and Mott 2006). Abido, 2012 mentioned that foliar spraying of boron at rate of 80 ppm increased total chlorophyll, leaf area/plant, foliage fresh weight, foliage length, root fresh weight, root length, root diameter, total soluble solids, sucrose (%), apparent purity percentages, root yield/ha, top yield/ha and sugar yield/ha by 12.77, 9.53, 31.34, 10.83, 9.72, 16.68, 15.24, 2.48, 9.75, 7.39, 11.27, 19.01 and 20.14%, respectively as an average of two seasons compared with the control treatment.

In addition to the major nutrient elements, sugar beet, in common with other crops needs very small amounts of other elements. These micronutrients, or trace elements, essential for plants are boron, chlorine, cobalt copper, iron, manganese molybdenum and zinc. Boron is by far the most important of the trace elements needed by sugar beet because, without an adequate supply, the yield and quality of roots is severely depressed. (Draycott, 1996).

Masri and Hamza, 2015 revealed that increasing micronutrients mixture concentration significantly increased sugar beet root weight by 21.54% and 23.81%, root yield by 28.00% and 24.40% and sugar yield by 76.50% and 60.61% in the first and second growing seasons, respectively. Quality attributes, in terms of total soluble solids (TSS), sucrose%, purity% and extractable sucrose% were significantly increased by increasing concentration of micronutrients in the two growing seasons and the highest values of these attributes resulted from highest concentration (150 Zn + 150 Mn + 150 Fe + 1500 B in ppm/L). Application of high rates of micronutrients produced the highest dry matter par plant root and sugar yield of sugar beet plants; on the other hand it produced the lowest values of quality traits such as sucrose, TSS and purity percentages, this may be that micronutrients such as, Fe Zn, Mn and B that have an vital metabolic role in plant development. (Abd El-Gawad *et al*.,2004, Yarnia *et al*.,2008, Amin *et al*.,2013, Nemeat-Alla *et al*.,2009 and Mousavi *et al*., 2013)

Sugar beet has high positive response to external supply of micronutrients (Grzebisz, *et al*., 2010). Foliar application with micronutrients (Fe, Zn, Mn and B) twice (60 and 90 days) after sowing significantly increased root, top and recoverable sugar yield and improved sucrose % and purity % in both seasons (Gobarah, Mirvat E. *et al*.2014). Allen, *et al*., 2007 reported that for highly sugar beet yield has high requirements of boron (B) are required. They cleared that boron increases the rate of transport of sugars from mature plant leaves to actively growing regions. A work by Hellal, *et al*., 2009 also stated that application of 50ppm boron significantly increase yield of roots and above ground and nutrient contents of sugar beet.

This work aimed to investigate the effect of foliar application of boron and iron on sugar beet yields (root and sugar) and quality (sucrose % and purity %), growth parameters (root length, root diameter and leaf area index) under continuous deficit irrigation condition in sandy soil at El-Bostan region to find out the optimal water regime and the best foliar application rate of iron and boron to obtain the higher root and sugar yields with the best quality traits of sugar beet under these certain condition.

MATERIALS AND METHODS

A field experiment was carried out at El-Bostan area - Aly Mubark experimental farm (30.570 N latitude and 30.710 E longitude), South El-Tahrir region, El-Behera Governorate, Egypt, during the two successive winter seasons of 2014/2015 and 2015/2016 to study the response of sugar beet yields (top, root and sugar), quality (sucrose %, impurities % and purity %), growth parameters (root length, root diameter, root fresh weight and leaf area index) to foliar application of boron and iron under continuous deficit irrigation condition in sandy soil. Soil samples were collected before cultivation to determine main soil physical and chemical characteristics (Black, 1965 and Page *et al.* 1982) at the experimental site (Table 1).

Experimental design and tested variables:

A split plot experimental design with three replications was used to implement the field experiment. Three deficit irrigation treatments occupied the main plots and nine boron+ chelated irons foliar application occupied the sub-plots as follows:

Table 1. Main soil physical and chemical characteristics of the experimental site.

Soil depth	Particle size distribution (%)			Texture	Available nutrients (mg/kg soil)					F.C.	W.P.	A.W.
(cm)	Sand	Silt	Clay	class	N	P	K	Fe	B	(%)	(%)	(%)
0-20	90.9	4.7	4.4	Sandy	22.4	7.2	70.2	3.5	0.50	13.4	5.5	7.9
20-40	91.8	5.1	3.1	Sandy	25.8	6.2	65.1	2.00	0.46	11.5	5.0	6.5

Soil depth	B.D.	EC	pH	Soluble cations and anions (meq/l)						
(cm)	gm/cm^3	dS/m		Ca^{+2}	Mg^{+2}	Na^+	K^+	HCO_3^-	SO_4^{-2}	Cl^-
0-20	1.45	0.61	8.21	2.03	0.98	2.56	0.48	3.05	1.17	1.93
20-40	1.60	0.67	8.27	2.18	0.94	3.15	0.45	3.01	0.90	2.80

1. Irrigation treatments (main plots):

I_1: irrigation with amounts of water equal to 50% of crop evapotranspiration (ETc).

I_2: irrigation with amounts of water equal to 75% ETc.

I_3: irrigation with amounts of water equal to 100% ETc.

2. Foliar application treatments (sub-plots):

Foliar application treatment consist of boric acid "17 % B" levels at three concentration (0.0, 0.5 and 1.0 g/liter), chelate iron (EDTA-Fe 13%) levels at three concentration (0.0, 0.5 and 1.0 g/liter), and combination between the three concentration of boric acid and chelate iron. These resulted in nine foliar application treatments which were randomly distributed in sub-plots for each replicate. Iron was sprayed at age of 75 days, while boron was sprayed at 90 days from sowing.

Cultural practices:

The drip irrigation system used to conduct the experiment consisted of a main delivery pipeline (PE, 32mm) and a sub-main line (PE, 25mm). The drip laterals were of polyethylene material (16mm diameter), with inline emitters spaced at 0.25 meters apart. The discharge rate of the emitter was 4 liters/hour.

Sugar beet seeds (variety *viz.* SARA) were sown on the 4th week of September in both seasons. It was sawn in ridges of 0.6m in width and 6 m in length and the distance between hills was 0.25m, each sub-plot area was 10.8 m^2.Phosphorous in the form of super phosphate (12.5% P_2O_5) at rate of 30kg P_2O_5/fed was added during land preparation. Nitrogen fertilizer was added in form of ammonium nitrate (33.5% N) in 6 equal doses; the 1st one was added after thinning (4 true-leaf stage) and the other doses were applied at 2-week interval after the first application. Potassium in form of potassium sulfate (48% K_2O) was added in 4 equal doses at the same time of applying nitrogen fertilizers. Harvesting took place after 205 days from sowing in both seasons. All other field practices were done as recommended by Sugar Crop Research Institute, Agriculture Research Center. After sowing sugar beet seeds, a total amount of 45 mm water was daily applied at four irrigations to ensure full emergence of sugar beet plants, thereafter, the studied irrigation regimes were applied.

Measurements and calculations:

1. Reference evapotranspiration (ET_o):

The values of ET_0 were calculated using average of the previous five years of weather data obtained from southern El-Tahrir metrological station using Penman-Monteith equation, CROPWAT model (Allen *et al.*, 1998). The crop evapotranspiration values were calculated according to the following equation:

$$ET_c = ET_o * K_c$$

Where:

ET_c = crop evapotranspiration (mm/day)

ET_o = reference evapotranspiration (mm/day)

K_c = crop coefficient values for sugar beet crop (Table 2).

2. Applied Irrigation Water:

The amounts were calculated according to the equation given by Vermeirer and Topling (1984) as follows:

$$AIW = \frac{ET_c * K_r * I}{E_a (1-LR)}$$

Where:

AIW: head of applied irrigation water (mm),

ETc: crop evapotranspiration (mm/day),

Kr: evaporation reduction coefficient, that depends on ground cover. A value of 1.0 was used "where the spacing between drip lines is less than 1.8m, FAO,56",

I: irrigation intervals (day),

E_a: irrigation efficiency of the drip irrigation system, "an average value of 0.85 was used", and

LR: leaching requirements, "10% of the calculated applied irrigation water was additionally applied per-irrigation during the growing season for leaching purposes".

Table 2. Sugar beet crop coefficients values (FAO, 24, 1975).

Growth stage		Crop coefficient
Stage	Period (day)	(Kc)
Initial stage	35	0.40
development	60	0.80
Midi stage	70	1.05
End stage	40	0.60
Total	205	--

The calculated amount of applied irrigation water were 2550, 1915 and 1275 m^3/fed for I_1 (100% ET_c), I_2 (75% ET_c) and I_3 (50% ET_c), respectively for the two growing season.

Irrigation time was determined before each irrigation event by measuring the actual emitter discharge according to the equation given by Ismail, (2002) as follows:

$$t = \frac{AIW * A}{q}$$

Where;

t: irrigation time (h), AIW: applied irrigation water (mm), A: wetted area (m^2), and q: emitter discharge (liter/h).

3. Irrigation Water Utilization Efficiency (IWUtE):

Irrigation water utilization efficiency was calculated according to Jensen (1983) as follows:

$$IWUtE = \frac{\text{root or sugar yield (kg/fed)}}{\text{Applied irrigation water (m3/fed)}}$$

Where:

$IWUtE_{root\ yield}$ = root yield (kg/fed)/applied irrigation water (m^3/fed)

$IWUtE_{sugar\ yield}$ = sugar yield (kg/fed) / applied irrigation water (m^3/fed)

4. Measurements related to sugar beet crop:

A representative sample of five guarded plants was randomly taken from each sub-plot to determinate the following characters:

a. Leaf area index (LAI): Leaf area was measured after 120 days from sowing by the disk method using 10 disks at 1.0cm diameter according to Watson (1958) equation:

$$LAI = \frac{\text{Unit leaf area per plant(cm2)}}{\text{Plant ground area (cm2)}}$$

b. Photosynthetic pigments were determined in the fresh leaves after 120 days from sowing according to Wettestien (1957). The following equations were used:

Chl. "a" mg/g.f.w. = 9.684 (A 662) – 0.99 (A 644).

Chl. "b" mg/g.f.w. = 21.426 (A 644) – 4.65 (A 662).

Carot. mg/g.f.w. =4.695 (A 440)–0.268 (chl."a"+chl. "b").

Where : chl. "a", "b" and carot. = concentrations of chlorophylls "a", "b" and carotenoids, respectively, and A = optical density at the wave length indicated.

c. At harvest, a sample of five guarded plants was randomly taken from each sub-plot to determine the following traits:

1- Root length (cm).
2- Root diameter (cm).
3- Root fresh weight (g/plant).
4- Potassium and sodium concentrations (meq/100 g beet) in roots were determined using "flame photometer" according to Brown and Lilliland (1964). Alpha amino nitrogen concentration determined using Hydrogenation method according to Pergel (1945).
5- Extractable sugar% (ES) was calculated according to Dexter *et al.* (1967) as follows: ES % = sucrose % - sugar lost to molasses - 0.6
6- Sucrose percentage was determined as described by Le Docte (1927).
7- Purity percentage was calculated according to the following equation:

Purity %= (sucrose %/ total soluble salts %)*100

d. Plants from each sub-plot area were uprooted, topped, cleaned and weighed to estimate the following yields:

1- Top yield (ton/fed).
2- Root yield (ton/fed).
3- Sugar yield was calculated according to the following equation: Sugar yield (ton/fed) = extractable sugar% x root yield (ton/fed).

Statistical analysis:

The collected data were statistically analyzed according to Snedecor and Cochran (1982). Least Significant Difference (LSD) method was used to compare the differences between treatment means at 5% level of probability as mentioned by Waller and Duncan (1969).

RESULTS AND DISCUSSION

1. Agronomical and physiological characteristics:

a. Root length (cm), root diameter (cm) and root fresh weight (g/plant)

Data in Table (3) cleared that the difference among water regimes treatments significantly affected on roots length, diameter and fresh weight/plant in the 1st and 2nd seasons. Results cleared a positive response to increase the irrigation water regime to 75% ET_c which was enough to produce the significant values and tallest root length.

Decreasing irrigation water regime from 100% ETc to 75% ETc led to significant increments amounted to 2.9 and 1.83 cm for root length for 1st and 2nd seasons, respectively. Meanwhile, increasing irrigation water regime to 75% and 100% ETc caused significant increases amounted to (0.58 and 2.25 cm) and (0.75 and 3.7 cm) in root diameter, corresponding to (267 and 507 g) and (173 and 312 g) in root fresh weight/plant, in the 1st and 2nd season, respectively, compared to that water regime at 50% ET_c. In this respect, Bnhassan-Kesri *et al.* (2002) reported that environmental stresses, in particularly drought stress, represent the main limiting factors of plant cell growth. Drought stress induces several effects including reduced cell division and growth rates.

Regarding to boron effects, results in Table (3) cleared that there were significant positive increments in root dimensions as well as root fresh weight/plant due to the gradual increase in the foliar application of boron. Spraying sugar beet foliage by 1.0 g boric acid/l produced the highest values of these traits, in both seasons. Increasing the concentration of boron to 0.5 and 1.0 g boric acid/l caused an increase in root fresh weight/plant amounted to 145 and 252 g in the 1st season, corresponding to 124 and 304 g, in the 2nd one, respectively, compared to the control. The positive effect of boron may be due to its effective role in cell elongation of root, finally due to increases in root size. These results are in line with those confirmed by Dewdar *et al.*, (2015) and El-Geddawy and Makhlouf (2015).

Table 3. Root length (cm), root diameter (cm) and root fresh weight (g/plant) as affected by foliar application of boron and iron under water regimes in 2014/2015 and 2015/2016 seasons

Treatments	Root length (cm) 1st season	Root length (cm) 2nd season	Root diameter (cm) 1st season	Root diameter (cm) 2nd season	Root fresh weight (g/plant) 1st season	Root fresh weight (g/plant) 2nd season
Water regimes (A)						
50 % ETc	20.56	20.96	9.82	9.15	698	682
75 % ETc	25.12	25.57	10.40	9.90	965	855
100 % ETc	22.22	23.74	12.07	12.85	1205	994
LSD at 0.05	0.48	0.75	1.25	0.42	85	92
Boric acid levels (B)						
Without(control)	21.34	21.94	10.06	8.99	824	701
0.5 (g/liter)	22.91	23.04	10.62	10.27	969	825
1.0 (g/liter)	23.65	25.29	11.62	11.64	1076	1005
LSD at 0.05	0.20	0.24	0.34	0.38	50	24
Chelate iron levels (C)						
Without (control)	21.20	22.11	10.12	9.61	857	768
0.5 (g/liter)	23.09	23.27	10.80	10.48	989	848
1.0 (g/liter)	23.62	24.88	11.38	10.81	1023	914
LSD at 0.05	0.20	0.22	0.32	0.35	46	22
A x B	*	*	NS	NS	*	NS
A x C	*	NS	NS	NS	NS	NS
B x C	NS	NS	*	NS	NS	NS
A x B x C	NS	NS	NS	NS	NS	NS

***: significant and NS: insignificant.**

Concerning the significant influence of iron, the gradual increase in concentrations of iron on sugar beet foliage up to 1.0 g/l produced the significant positive increase and maximum values in root dimensions as well as root fresh weight/plant. Raising iron concentrations to 0.5 and 1.0 g/l caused an increase in root fresh weight/plant of 132 and 166 g in the 1st season, corresponding to 80 and 146 g in the 2nd one, respectively compared to the control. These results are agreement with Soudi, *et al.*(2008), and Makhlouf, *et al.* (2015).

b. Leaf area index (LAI) and top and root yields (ton/fed).

Data in Table (4) clear that the difference among water regimes on sugar beet plants resulted in significant increases in LAI, top and root yields/fed for 1st and 2nd season. The highest values of top and root yields were achieved with 100 % ET_c, meanwhile the lowest values in these traits were recorded by amount of irrigation water 50% ET_c. Increasing the amount of irrigation water to 75 % and 100 % ETc caused an increase amounted to (2.12 and 3.87 tons) and (2.22 and 3.07 tons) in top yield/fed, corresponding to (2.63 and 4.95 tons) and (0.42 and 4.98

tons) in root yield/fed, in the 1st and 2nd seasons, respectively, compared to that water regime at 50% ET_c. In this regard, Milford *et al.* (1985) reported that the difference of yield between different water treatments is related to decreasing pressure potential stomatal conductivity and relative water content of leaf in water stress that cause lower growth of leaves and root because of less development of cells. In addition, Jaggard *et al.* (1998) and Wittenmayer and Schilling (1998) mentioned that if sugar beet is subjected to water stress, the root yield decreased.

Concerning the influence of boron foliar application, Table (4) show that there was a positive and significant response in LAI, top and root yields/fed with increasing the applied dose of boron. Spraying sugar beet plants by 1.0 g boric acid/l achieved the highest significant values of these traits, in both seasons. Increasing boron levels to 0.5 and 1.0 g boric acid/l gave increments in root yield/fed amounted to 0.44 ton (2.27%) and 0.75 ton (3.87%) in the 1st season, corresponding to 0.46 ton (2.56%) and 1.3 ton (7.26%) in the 2nd one, respectively, as well as, the increments of top yield/fed amounted to 1.13 and 2.97 tons in the 1st season, corresponding to 0.95 and 2.95 tons in the 2nd one, respectively, compared to the control. The advantage of boron application may be due to important function of boron in increasing plant metabolism, development and growth (Abido, 2012, Gobarah and Mekki 2005).

Table 4. Leaf area index (LAI) and top and root yields (ton/fed) as affected by foliar application of boron and iron fertilizers under water regimes in 2014/2015 and 2015/2016 seasons

Treatments	LAI		Top yield (ton/fed)		Root yield (ton/fed)	
	1st season	2nd season	1st season	2nd season	1st season	2nd season
Water regimes (A)						
50 % ETc	2.87	2.74	8.06	7.78	17.21	16.85
75 % ETc	3.24	3.48	10.18	10.00	19.84	17.27
100 %ETc	3.60	3.45	11.93	10.85	22.16	21.83
LSD at 0.05	0.13	0.59	1.04	0.94	1.48	0.72
Boric acid levels (B)						
Without(control)	2.68	2.88	8.69	8.24	19.34	17.90
0.5 (g/liter)	3.26	3.24	9.82	9.19	19.78	18.36
1.0 (g/liter)	3.59	3.55	11.66	11.19	20.09	19.20
LSD at 0.05	0.12	0.16	0.18	0.21	0.40	0.32
Chelate iron levels (C)						
Without (control)	2.85	2.91	9.42	8.91	19.01	17.22
0.5 (g/liter)	3.20	3.19	10.00	9.56	19.75	18.46
1.0 (g/liter)	3.66	3.58	10.73	10.15	20.44	19.77
LSD at 0.05	0.11	0.14	0.17	0.19	0.37	0.30
A x B	NS	NS	*	*	NS	*
A x C	*	NS	*	*	NS	*
B x C	NS	NS	NS	NS	NS	NS
A x B x C	NS	NS	NS	NS	NS	NS

*: significant and NS: insignificant.

Table (4) show that increasing iron levels up to 1.0 g/l led to gradual and significant increases in the values of LAI, top and root yields/fed in both seasons. Raising concentration of iron to 0.5 and 1.0 g/l caused an increase in root yield/fed amounted to 0.74 ton (3.89%) and 1.43 ton (7.52%) in the 1st season, corresponding to 1.24 ton (7.20%) and 2.55 ton (14.80%) in the 2nd one, respectively, as well as, the increments of top yield/fed amounted to 0.58 and 1.31 tons in the 1st season, corresponding to 0.65 and 1.24 tons in the 2nd one, respectively, compared to the control.

The increases in these traits back to the role of microelements in increasing volume and elongation of roots, therefore increasing leaf area/plant, finally due to increases in top and root size. These observations coincide with those found by Yarnia *et al*., 2008, Amin *et al*., 2013, and Mousavi *et al*., 2013).

c. Chlorophyll a (mg/g.f.w), Chlorophyll b (mg/g.f.w) and Carotenoids (mg/g.f.w)

The importance of chlorophyll is not only to give the green color of the plant, but also to chlorophyll is responsible for photosynthesis in plants, where the carbon dioxide in the air and water to sugar and starch by solar photovoltaic energy. Table (5) clear that the examined water regimes gave a significant effect in the values of chlorophyll a in the two growing seasons. Chlorophyll b and carotenoids were significantly affected by water regime treatments in the 1st season only. Irrigation water at 75% ETc over passed other two water regimes under study, in both seasons. In this respect, Xiang *et al.* (2013) mentioned that the drought stress led to a significant decrease and degradation in chlorophyll a and b as well as total chlorophyll content. The sugar yield is the product of the total amount of dry matter accumulated in the plant during growth, the percentage allocated to the storage root, and the proportion of accumulated dry matter (Bell *et al*., 1996).

Table 5. Photosynthetic pigments (mg/g.f.w) as affected by boron and iron fertilizers under water regimes in 2014/2015 and 2015/2016 seasons

Treatments	Chlorophyll a (mg/g.f.w)		Chlorophyll b (mg/g.f.w)		Carotenoids (mg/g.f.w)	
	1st season	2nd season	1st season	2nd season	1st season	2nd season
Water regimes (A)						
50 % ETc	4.29	4.61	2.14	2.41	1.33	1.56
75 % ETc	4.50	5.24	2.44	2.97	1.61	1.94
100 % ETc	5.08	4.87	2.73	2.77	1.85	1.54
LSD at 0.05	0.30	0.12	0.44	NS	0.21	NS
Boric acid levels (B)						
Without (control)	4.27	4.39	2.22	2.38	1.38	1.48
0.5 (g/liter)	4.63	5.02	2.34	2.76	1.56	1.61
1.0 (g/liter)	4.97	5.31	2.75	3.00	1.85	1.95
LSD at 0.05	0.09	0.11	0.06	0.11	0.09	0.15
Chelate iron levels (C)						
Without (control)	4.30	4.44	2.06	2.51	1.36	1.44
0.5 (g/liter)	4.72	4.85	2.47	2.73	1.65	1.65
1.0 (g/liter)	4.85	5.43	2.79	2.90	1.79	1.95
LSD at 0.05	0.09	0.10	0.06	0.10	0.09	0.14
A x B	NS	NS	NS	NS	NS	NS
A x C	*	NS	*	NS	NS	NS
B x C	*	*	NS	NS	*	*
A x B x C	NS	NS	NS	NS	NS	NS

*: significant and NS: insignificant.

Table (5) showed that increasing boron levels up to 1.0 g boric acid/l led to_significant increases in photosynthetic pigments. Spraying sugar beet plants with boron of 1.0 g boric acid/l resulted in the highest chlorophyll "a" and "b" as well as carotenoids in both seasons. The advantage of boron application may be due to its important function_in increasing plant metabolism, development and growth. These results are in line with those confirmed by Abido (2012).

Regarding to the effects of foliar application of iron on photosynthetic pigment values, Table (5) cleared a significant and positive response with the gradually increase in doses of chelated iron, in the two growing seasons. The maximum values of chlorophyll a and b as well as carotenoids were achieved with the highest doses of iron (1.0 g chelated iron/l). These findings may be returned to that iron may have effective role in increasing chlorophyll pigmentation of leaves and thus induced photosynthetic capabilities of plants (Gyana and Sahoo, 2015). In addition, iron serves as a catalyst in chlorophyll synthesis. These results were in agreement with those reported by Makhlouf, *et al.* (2015).

2. Juice quality and chemical constituents:

a. Sucrose %, Extractable sugar % and sugar yield (ton/fed)

Sucrose and extracted sugar percentages are the important characteristics in sugar beet because the final goal of sugar beet production depends on sucrose% as well as root and sugar yields.

Data in Table (6) pointed out that irrigation water at 75% ETc gave the highest and significant increase in the values of sucrose (17.90 and 20.81 %) and (15.32 and 18.33 %) in extractable sugar, in the 1st and 2nd seasons, respectively, while, irrigation water at 100% ETc came in the second rank with respect to these traits. Meantime, the maximum sugar yield/fed was recorded with water regime 100% ETc, may be back to the high root yield (Table 3). In addition, water deficit decreased the photosynthetic, transpiration rates and stomatal conductance of sugar beet, which resulted in a reduction in sugar contents (Bloch *et al.*, 2006 and Sadeghi-Shoae *et al.,* 2013).

Results in Table (5) also, showed that increasing boron levels to 0.5 and 1.0 g boric acid/l caused significant increases amounted to 1.34 and 2.02 in sucrose%, corresponding to 1.45 and 2.25 in extractable sugar%, in the 1st season, as well as, 1.03 and 2.28 in sucrose%, corresponding to 1.16 and 2.48 in extractable sugar%, in the 2nd one, respectively, compared to the control treatment. These results assured the importance role of boron element in metabolic translocation process. Concerning the increments in sugar yield, raising boron concentrations to 0.5 and 1.0 g boric acid/l led to significant increases in sugar yield/fed amounted to 0.35 and 0.55 tons in the 1st season, corresponding to 0.28 and 0.69 tons in the 2nd one, respectively, compared to the control. This finding is in line with that found by Gobara and Mekki (2005) and Armin and Asgharipour (2011) who stated that sucrose% significantly increased with increasing boron doses.

Regarding iron effects, results in Table (6) cleared a statistical positive response to the foliar application of iron in both seasons. Raising concentrations of iron to 0.5 and 1.0 g chelated iron/l caused significant increases in sucrose% amounted to (0.9 and 1.23) and (0.57 and 1.68), corresponding to (0.78 and 1.33) and (0.63 and 1.78) in extracted sugar%, in the 1st and 2nd seasons, respectively, compared to the control. These results are in line with these obtained by Moustafa, Zeinab *et al.* (2011). These results were in coinciding with Makhlouf, *et al.*, (2015), who stated that treating sugar beet plants with trace elements have a considerable influence on the metabolic activities and in turn exert an increase in its sugar content.

Table 6. Sucrose %, Extractable sugar % and sugar yield (ton/fed) as affected by boron and iron fertilizers under water regimes in 2014/2015 and 2015/2016 seasons

Treatments	Sucrose %		Extractable sugar %		Sugar yield (ton/fed)	
	1st season	2nd season	1st season	2nd season	1st season	2nd season
Water regimes (A)						
50 % ETc	16.58	18.60	13.95	16.00	2.41	2.63
75 % ETc	17.90	20.81	15.32	18.33	3.05	3.18
100 % ETc	17.02	19.83	14.10	17.06	3.13	3.74
LSD at 0.05	0.46	0.52	0.52	0.58	0.18	0.12
Boric acid levels (B)						
Without (control)	16.05	18.64	13.22	15.92	2.56	2.86
0.5 (g/liter)	17.39	19.67	14.67	17.08	2.91	3.14
1.0 (g/liter)	18.07	20.92	15.47	18.40	3.11	3.55
LSD at 0.05	0.26	0.32	0.26	0.33	0.09	0.08
Chelate iron levels (C)						
Without (control)	16.52	19.01	13.75	16.33	2.61	2.82
0.5 (g/liter)	17.42	19.58	14.53	16.96	2.88	3.14
1.0 (g/liter)	17.75	20.65	15.08	18.11	3.10	3.59
LSD at 0.05	0.24	0.30	0.24	0.30	0.08	0.08
A x B	*	*	*	*	NS	*
A x C	*	NS	*	NS	*	NS
B x C	NS	NS	NS	NS	NS	NS
A x B x C	NS	NS	NS	NS	NS	NS

*: significant and NS: insignificant.

b. Impurities (meq/100 g beet) and purity percentage.

Data listed in Table (7) clear that the tested water regimes led to significant effects in the values of α-amino N and sodium contents, meanwhile the difference between water regimes did not reach the level of significance on potassium content in both seasons as well as purity in the 2nd season. The amount of irrigation water 75% gave the lowest and the best values of impurities%, meantime the same water regime gave the highest and the best values of purity% over passed the other two water regimes, in both seasons.

Data also, showed that the values of impurities and purity percentages were significantly affected by increasing boron levels, in both seasons. It can be noticed that the spraying sugar beet foliage by 1.0 g boric acid/l produced the lowest values of impurities contents and the maximum values of purity (86.99 and 88.05%) in the 1st and 2nd seasons, respectively. Decreasing the impurities contents in sugar beet roots produce good results in sugar extraction and purity percentages. These results are in line with these obtained by Gobara and Mekki (2005) and Armin and Asgharipour (2011).

Foliar application of high level of iron (1.0 g chelated iron/l) had a significant affect impurities contents (Table 7). Spraying sugar beet plants by 1.0 g chelated iron/l gave the lowest values of K and Na as well as α-amino N percentages compared to the other two levels, in the two growing seasons. These findings are in agreement with that mentioned by Makhlouf, *et al*., (2015),

In this regard, the efficiency of the sugar extraction process is dependent on the concentration of solutes other than sucrose (K, Na and α-amino N) and the interrelationships among accumulation of sucrose and these so-called impurities are important determinants of root quality.

Table 7. Impurities (meq/100 g beet) and purity percentage as affected by foliar application of boron and iron fertilizers under water regimes in 2014/2015 and 2015/2016 seasons

Treatments	Impurities (meq/100 g beet)						Purity %	
	K		Na		α-amino N			
	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season
Water regimes (A)								
50 % Etc	5.22	5.63	2.43	2.55	1.86	1.41	86.12	86.94
75 % ETc	5.17	5.43	2.04	2.26	1.88	1.18	86.92	88.23
100 % Etc	5.93	6.20	2.87	2.71	2.38	1.69	84.97	86.63
LSD at 0.05	NS	NS	0.15	0.19	0.18	0.20	1.37	NS
Boric acid levels (B)								
Without (control)	5.63	5.99	2.68	2.66	2.27	1.66	84.90	86.40
0.5 (g/liter)	5.45	5.71	2.42	2.48	2.07	1.38	86.13	87.36
1.0 (g/liter)	5.25	5.57	2.23	2.38	1.78	1.22	86.99	88.05
LSD at 0.05	0.11	0.11	0.08	0.06	0.12	0.16	0.18	0.20
Chelate iron levels (C)								
Without (control)	5.56	5.96	2.52	2.55	2.14	1.55	85.42	86.73
0.5 (g/liter)	5.46	5.72	2.46	2.51	2.00	1.46	86.05	87.22
1.0 (g/liter)	5.30	5.60	2.36	2.47	1.98	1.26	86.55	87.85
LSD at 0.05	0.10	0.10	0.07	0.06	0.11	0.15	0.16	0.18
A x B	NS	*	NS	NS	NS	*	NS	*
A x C	NS	NS	NS	NS	*	NS	*	NS
B x C	NS	NS	NS	NS	NS	NS	NS	NS
A x B x C	NS	NS	NS	NS	NS	NS	NS	NS

***: significant and NS: insignificant.**

3. Significant interaction effect between water regimes and foliar application of boron.

The interaction between water regimes and boron levels significantly affected root length, top yield/fed, sucrose and extractable sugar percentages in both seasons, however, the same interaction significantly affected root fresh weight/plant in the 1st season, and yields of root and sugar/fed and K, α-amino N and purity percentages in the 2nd season only (Table 8). Furthermore, the maximum values of root length and fresh weight/plant, top, root and sugar yields/fed were between 100% of irrigation water regime with foliar application of 1.0 g boric acid/l.

Table 8. Significant interaction effect between water regimes and foliar application of boron on sugar beet yield and some of its attributes.

Water regimes	Boric acid (g/l)	Root length (cm)	Root fresh weight (g/plant)	Top yield (ton/fed)		Root yield (ton/fed)	Sugar yield (ton/fed)
		1st season	1st season	1st season	2nd season	2nd season	2nd season
50 % ETc	Without	19.24	521	6.78	6.25	15.86	2.41
	0.5	20.70	763	7.90	7.64	16.34	2.68
	1.0	21.74	811	9.51	9.46	16.86	2.80
75 % ETc	Without	20.74	841	8.58	9.01	17.01	2.92
	0.5	22.67	985	10.07	9.63	17.17	3.12
	1.0	23.26	1070	11.78	11.36	17.64	3.50
100 % ETc	Without	24.04	1111	10.70	9.48	20.82	3.25
	0.5	25.37	1158	11.47	10.32	21.57	3.63
	1.0	25.96	1346	13.61	12.75	23.10	4.35
LSD at 0.05		0.37	86	0.32	0.36	0.55	0.15

Water regimes	Boric acid (g/l)	K (meq/ 100 g beet)	α-amino N (meq/100 g beet)	Sucrose %		Extractable sugar %		Purity %
		2nd season	2nd season	1st season	2nd season	1st season	2nd season	2nd season
50 % ETc	Without	5.92	1.78	15.44	17.86	12.72	15.11	86.02
	0.5	5.58	1.43	16.63	18.91	13.98	16.32	87.14
	1.0	5.40	1.00	17.67	19.02	15.14	16.57	87.67
75 % ETc	Without	5.53	1.43	16.47	19.63	13.76	17.07	87.58
	0.5	5.49	1.02	18.40	20.56	15.80	18.12	88.25
	1.0	5.28	1.07	18.83	22.22	16.40	19.81	88.86
100 % ETc	Without	6.52	1.77	16.23	18.43	13.17	15.56	85.60
	0.5	6.07	1.69	17.14	19.55	14.24	16.81	86.69
	1.0	6.02	1.60	17.70	21.51	14.88	18.81	87.61
LSD at 0.05		0.19	0.28	0.45	0.55	0.45	0.57	0.34

On the other hand, both of sucrose, extractable sugar and purity percentages recorded the highest values when sugar beet planted with 75% of irrigation water regime and foliar application of 1.0 g boric acid/l. The lowest values of K and α-amino N contents were recorded with application of 0.5 and/or 1.0 g boric acid/l under any the examined water regimes compared to the control of boron.

The interaction between water regime 100% ET_c and boron foliar application of 1.0 g boric acid/l caused significant increases in root yield amounted to 23.10 tons/fed, corresponding to 4.35 tons/fed in sugar yield in the 2nd season, compared to the same boric acid level with 50% or 75% of irrigation water regime, respectively. In addition, the interaction between irrigation water regime of 75% ETc and application of 1.0 g boric acid/l achieved the highest values of sucrose (18.83 and 22.22%) and extracted sugar (16.40 and 19.81%), in the 1st and 2nd season, respectively over passed other two irrigation regimes.

4. Significant interaction effect between water regimes and foliar application of iron.

Results in Table (9) indicate that sugar beet root length, sugar yield, Chlorophyll a and b, α-amino N, sucrose%, extractable sugar % and purity% were significantly affected by the interaction between the examined water regimes and application of iron levels in the 1st season only. Likewise, the same interaction significantly affected roots yield/fed in the 2nd season, and top yield/fed in the both seasons. In addition, the highest values of root length, Chlorophyll a and b as well as top, root and sugar yields/fed were observed by the combination between the application of irrigation water at 100% ET_c and 1.0 g chelated iron/l.

Sucrose, extractable sugar and purity percentages achieved the maximum values when sugar beet plant irrigated with 75% of ETc and foliar application of 1.0 g chelated iron/l compared to the other treatments in the 1st season. The lowest value of α-amino N content was recorded with foliar application of 1.0 g chelated iron/l and water regime at 75% ET_c in the 1st season.

The interaction between water regime at 100% ET_c and iron foliar application of 1.0 g chelated iron/l led to significant increases in root yield of 5.23 and 3.94 tons/fed, in the 2nd season, corresponding to 0.88 and 0.21 tons/fed in sugar yield in the 1st season, compared to the same chelated iron level with 50% and/or 75% of irrigation water regime, respectively. In addition, the interaction between irrigation water regime at 75% ET_c and application of 1.0 g chelated iron/l achieved the highest values of sucrose (18.24%) and extracted sugar (15.72 %), in the 1st season, over passed other two irrigation regimes.

Table 9. Significant interaction effect between water regimes and foliar application of iron on sugar beet yield and some of its attributes.

Water regimes	Chelated iron (g/l)	Root length (cm)	Top yield (ton/fed)		Root yield (ton/fed)	Sugar yield (ton/fed)
		1st season	1st season	2nd season	2nd season	1st season
50 % ETc	Without	19.59	7.18	6.98	15.06	2.27
	0.5	20.80	8.14	7.69	16.39	2.38
	1.0	21.30	8.88	8.69	17.60	2.58
75 % ETc	Without	21.18	9.68	9.45	15.56	2.83
	0.5	22.56	10.15	10.13	17.37	3.06
	1.0	22.93	10.70	10.40	18.89	3.25
100 % ETc	Without	22.82	11.39	10.31	21.04	2.72
	0.5	25.93	11.79	10.86	21.63	3.21
	1.0	26.63	12.60	11.38	22.83	3.46
LSD at 0.05		0.34	0.30	0.34	0.51	0.14

Water regimes	Chelated iron (g/l)	Chl. a (mg/g.f.w)	Chl. b (mg/g.f.w)	α-amino N (meq/100 g beet)	Sucrose %	Extractable sugar %	Purity %
		1st season	1st season	1st season	1st season	1st season	1st season
50 % ETc	Without	3.89	1.82	1.96	16.41	13.72	85.85
	0.5	4.44	2.17	1.87	16.38	13.73	85.95
	1.0	4.54	2.43	1.75	16.97	14.39	86.58
75 % ETc	Without	4.25	2.05	2.10	17.52	14.86	86.40
	0.5	4.61	2.48	1.82	17.94	15.38	87.02
	1.0	4.65	2.80	1.74	18.24	15.72	87.34
100 % ETc	Without	4.75	2.30	2.37	15.62	12.67	84.00
	0.5	5.11	2.76	2.32	17.42	14.50	85.19
	1.0	5.37	3.14	2.44	18.04	15.13	85.73
LSD at 0.05		0.15	0.10	0.19	0.42	0.42	0.29

Chl. a: Chlorophyll a and Chl. b: Chlorophyll b.

5. Significant interaction effect between foliar application of boron and iron.

Results in Table (10) show that sugar beet root diameter (in the 1st season), Chlorophyll a and Carotenoids (in both seasons) were significantly affected by the interaction between the foliar application of boron and iron levels.

Spraying sugar beet plants in combination between boron of 1.0 g boric acid/l and 1.0 g chelated iron/l resulted in the highest chlorophyll a (in both seasons) and root diameter (in the 1st season). The positive effect of boron may be returned to its effectiveness role in cell elongation of root, in addition, the important role that iron may have been effective in increasing chlorophyll pigmentation of leaves and thus induced photosynthetic capabilities of plants (Gyana and Sahoo, 2015).

Table 10. Significant interaction effect between boron and iron fertilizer levels on significant sugar beet yield and some of its attributes.

Boric acid (g/l)	Chelated iron (g/l)	Root diameter (cm)	Chlorophyll a (mg/g.f.w)		Carotenoids(mg/g.f.w)	
		1st season	1st season	2nd season	1st season	2nd season
Without	Without	9.22	4.02	3.80	1.12	1.18
	0.5	9.95	4.39	4.40	1.49	1.56
	1.0	11.02	4.40	4.96	1.55	1.69
0.5	Without	9.89	4.24	4.56	1.38	1.49
	0.5	10.67	4.77	4.91	1.63	1.59
	1.0	11.30	4.89	5.61	1.67	1.75
1.0	Without	11.26	4.62	4.97	1.57	1.66
	0.5	11.78	5.00	5.24	1.82	1.79
	1.0	11.81	5.27	5.73	2.14	2.40
LSD at 0.05		0.56	0.15	0.18	0.15	0.24

Under water shortages, water utilization efficiency (WUtE) is a good evident for the best water management under certain condition. Figure (1 and 2) illustrate the corresponding WUtE for the studied irrigation water regimes. It is clear that WUtE for the 50 Etc catches the highest value flowed by 75% and 100%.

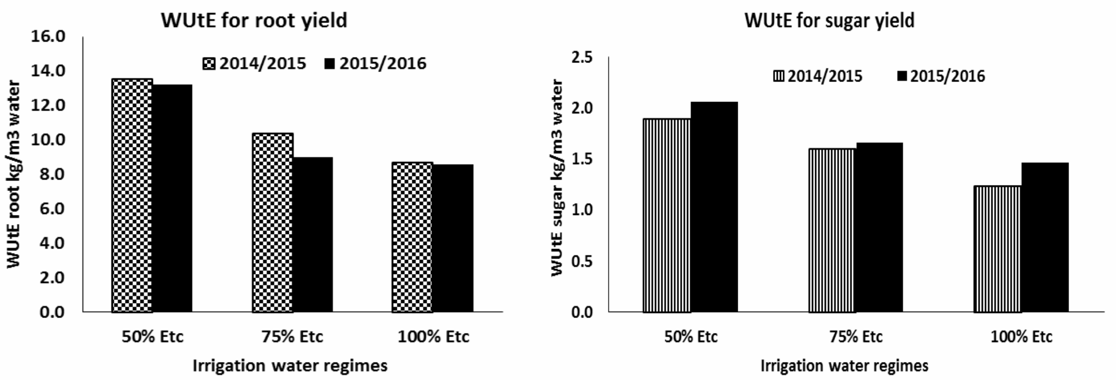

Figure 1. water utilization effeciency for sugar and root yield as affected by different irrigation regime.

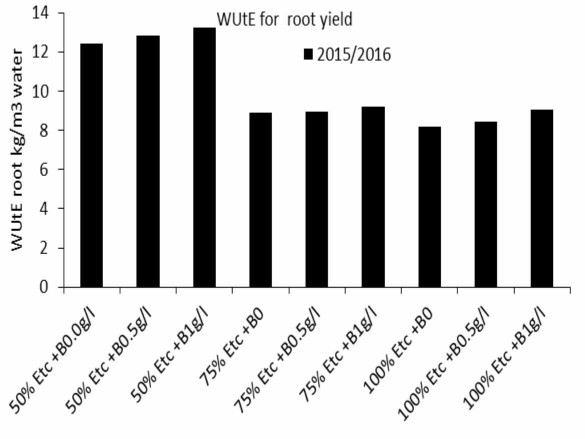

Fig. 2. water utilization effeciency for root yield as affected by the interaction effect between irrigation regime and boric foliar application.

Water utilization effeciences for suger and root yield were calculated for the significant values only (seconed season), figures 2, 3 indicate the interaction effect between irrigation rgimes and foliar application of boric acids, its clear that WUtE were higher for irrigation rigmes that recives the highest boric acid level as a foliar application 1 g/l where it were 13.22, 9.21 and 9.06 kg root/m^3 and were 2.20, 1.83 and 1.71 kg sugar/m^3 for 50 % ETc, 75 % ETc and 100 ETc , respectivelly.

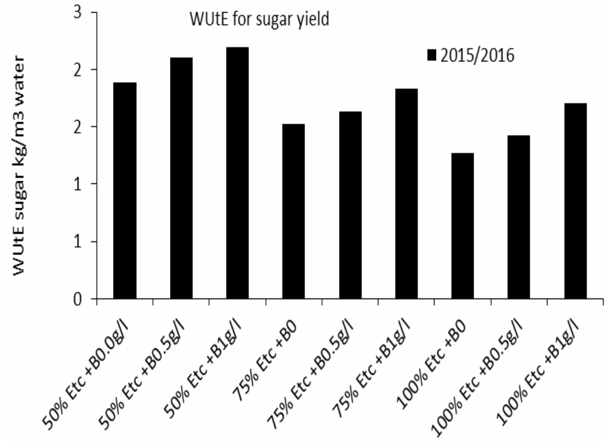

Fig. 3. water utilization effeciency for sugar yield as affected by the interaction effect between irrigation regime and boric foliar application.

Figures 4, 5 indicate the interaction effect between irrigation rgimes and foliar application of iron, its clear that WUtE were higher for irrigation rigmes that recives the highest boric acid level as a foliar application 1 g/l where it were 13.80, 9.86 and 8.95 kg root/m^3 and were 2.02, 1.70 and 1.36 kg sugar/m^3 for 50 % ETc, 75 % ETc and 100 ETc , respectivelly.

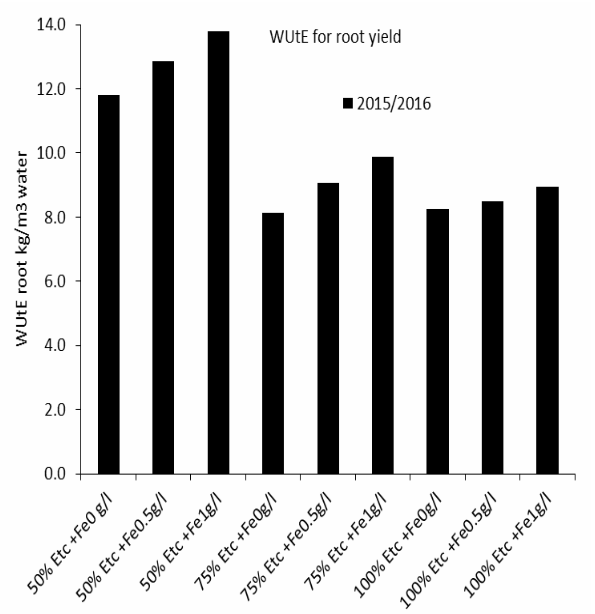

Fig. 4. water utilization effeciency for root yield as affected by the interaction effect between irrigation regime and iron foliar application.

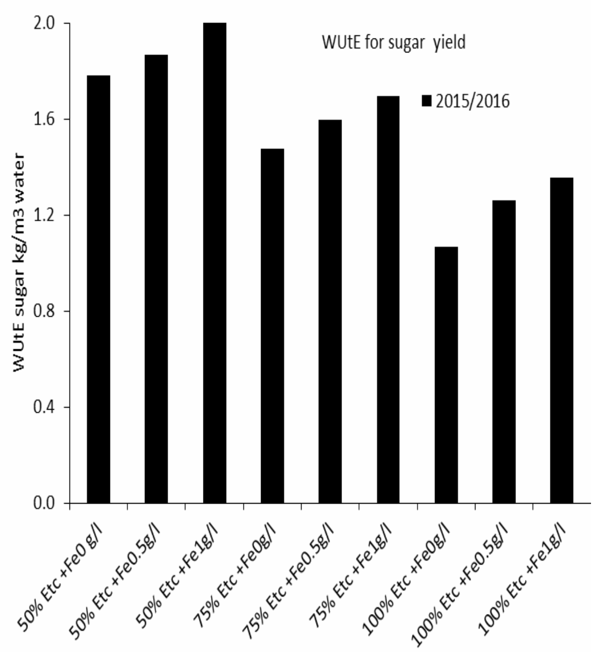

Fig. 5. water utilization effeciency for sugar yield as affected by the interaction effect between irrigation regime and boric foliar application.

CONCLUSION

Under drip irrigation in El-Bostan area, El-Beheira Governorate irrigating sugar beet, variety Sara, with amount of 2550 m^3/fed with combination of foliar application of 1 g chelated iron EDTA"13%Fe" /l + 1g boric acid/l can be recommended to get the highest sugar beet root and sugar yields, however for getting high sugar quality, it can be recommended to irrigate sugar beet with 1915 m^3/fed with combination of foliar application of 1 g chelated iron EDTA"13%Fe" /l + 1g boric acid/l.

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إستجابه بنجر السكر للرى بالعجز و الرش الورقى ببعض العناصر الصغرى تحت ظروف الأراضى الرملية

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أقيمت تجربتان حقليتان في أرض رملية بمزرعة علي مبارك التجريبية - منطقة البستان - جنوب التحرير- محافظة البحيرة في موسمي 2015/2014 و 2016/2015 لدراسة تأثير الري بالعجز و الرش الورقى بكل من الحديد المخلبي وحمض البوريك على إنتاجية و جودة محصول بنجر السكر ، اشتملت الدراسة على ثلاث مستويات من الري وهى 100% و 75 % و 50 % من البخر نتح المحصولى وثلاث مستويات من الرش الورقى (بدون رش و 0.5 جم /لتر و 1جم/لتر) لكل من الحديد المخلبى "EDTA 13%" وحمض البوريك (بورون17%) وذلك لتحديد أفضل كمية من مياة الري وكذلك أفضل تركيز للرش الورقى من الحديد و البورون للحصول علي أعلي محصول مع أعلي جودة لبنجر السكر النامي تحت ظروف الري بالتنقيط فى الأراضى الرمليه بمنطقة البستان. استخدم تصميم القطع المنشقه مرة واحدة حيث وزعت معاملات الري فى القطع الرئيسية في حين وزعت مستويات الرش الورقى بالحديد المخلبي و البورون فى القطع تحت الشقية. وكانت النتائج المتحصل عليها كالأتى: 1- أدي زيادة كميات المياة المضافة من 50% إلى 100% علي أساس البخر نتح المحصولى ETc إلى زيادة معنويه فى كل من قطر الجذر ووزن الجذر لكل نبات و معامل مساحة الورقة ومحصول العروش ومحصول الجذور وكللوروفيل ب ومحصول السكر وزادت نسبة الشوائب بالسكر مما أدي إلى انخفاض نسبة النقاء للسكر وكان الإنخفاض معنوى فقط فى السنه الأولى.2- أدى الري 75% من البخر نتح المحصولى إلى زيادة معنوية فى طول الجذر وكذلك نسبة السكر ونسبة السكر المستخلص خلال موسمى الدراسة بينما كانت الزيادة فى نسبة النقاء للسكر معنوية فقط للسنة الأولى.3- أدى الرى 50% من البخر نتح المحصولى إلى انخفاض فى قيم المحصول وكذلك خصائص الجودة المقاسة خلال موسمى النمو ماعدا نسبة الصوديوم فى السكر حيث كان ترتيب المعاملات 100% >50% >75 % وكذلك نسبة نقاء السكر فى موسم النمو الأول فقط حيث كان 75% > 50% > 100% %.4- أدى زيادة تركيز الرش بالبورون من 0.5 جم/لتر الى 1 جم/لتر إلى زيادة معنويه فى كل من طول الجذر و قطر الجذر ووزن الجذر لكل نبات و معامل مساحة الورقة ومحصول العروش ومحصول الجذور وكللوروفيل أ و ب الكاروتينات و نسبة السكر ونسبة السكر المستخلص ومحصول السكر خلال موسمى الدراسة.5- أدى زيادة تركيز الرش بالبورون من 0.5 جم/لتر الى 1 جم/لتر إلى حدوث إنخفاض معنوي فى تركيز الشوائب فى السكر (البوتاسيوم والصديوم وألفا-أمينو نتروجين) مما أدى إلى حدوث زيادة معنويه فى نسبة نقاء السكر خلال موسمى الدراسة.6- أدى زيادة تركيز الرش بالحديد المخلبى من 0.5 جم/لتر الى 1 جم/لتر إلى زيادة معنويه فى كل من طول الجذر و قطر الجذر ووزن الجذر لكل نبات و معامل مساحة الورقة ومحصول العروش ومحصول الجذور وكللوروفيل أ و ب الكاروتينات و نسبة السكر ونسبة السكر المستخلص ومحصول السكر خلال موسمى الدراسة.7- أدى زيادة تركيز الرش بالحيد المخلبى من 0.5 جم/لتر الى 1 جم/لتر إلى حدوث إنخفاض معنوي فى تركيز الشوائب فى السكر (البوتاسيوم والصديوم وألفا-أمينو نتروجين) مما أدى إلى حدوث زيادة معنويه فى نسبة نقاء السكر خلال موسمى الدراسة. تحت ظروف الأراضى الرمليه بمنطقة البستان بمحافظة البحيرة توصى الزراعة بزراعة بنجر السكر تحت مستوى ري 2550 م3 /فدان مع الرش الورقى بتركيز 1 جم حديد المخلبى 13%/لتر + 1 جم حديد حمض البوريك/ لتر للحصول على أعلى محصول للجذور والسكر , كما توصى الدراسة انه للحصول على أعلى نقاوة للسكر فإنه يمكن الرى بمستوي 1915 م3 /فدان مع الرش الورقى بتركيز 1 جم حديد المخلبى 13%/لتر + 1 جم حمض البوريك/ لتر.