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Influence of Sowing Dates and Foliar Spraying of Iron and Zinc on Sugar Beet Productivity in Salt Affected Soil

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ABSTRACT

The objectives of this study were to determine the effects of sowing dates and foliar spraying of the micronutrients Iron and Zinc on productivity of the sugar beet variety Halawa (multigerm) in salt affected soil. Therefore field experiments were carried out at the area of Sahl-Eltina south of Port Said, Egypt which known by its salt affected soil during the two growing seasons of 2015/2016 and 2016/2017. Each sowing date was allocated in a separate experiment. The experiments were laid out in randomized complete block design having three replications. The treatments consisted of two sowing dates (August 1st and October 1st) and for micronutrients, without micronutrients, Zinc-EDTA (16 %) in concentration of 1g/l and Fe-EDTA (14 %) in concentration of 1.5 g/l were applied three times at 60, 75 and 90 days after planting. The combined analysis showed that the first sowing date (August 1st) surpassed the second one (October 1st) in all studied characters. Foliar application of Fe-EDTA at concentration of (1g/l) was more effective than foliar spray of Zn-EDTA at concentration of (1.5g/l) in improving root performance (length, diameter and fresh weight/plant) and juice quality as well as increasing root, top and sugar yields/fed compared with without treatment (control). The effect of interactions between sowing dates and foliar application of micronutrients were not statistically significant on the all studied characters.

INTRODUCTION

Sugar beet (*Beta vulgaris* L.) is the second important sugar crops after sugar cane in the world and in Egypt too. In Egypt, sugar beet crop is grown not only in fertile soils, but also in poor, saline, alkaline and calcareous soils. This gives us the opportunity to cultivate enough area of sugar beet to fill the gap between the sugar production and sugar consumption without competing with other winter crops. Sugar beet is a salt tolerant plant (Maas, 1986 and Grieve *et al*., 2012).

North to Nile Delta and south of Port Said city, there is a large area known as Sahl-Eltina region. It classified as salt affected soil. Source of irrigation water for this area is El-Salam Canal; its water is mixed water (1:1 fresh water to drainage water). The water of this canal tends to be saline (Mohamed, 2013 and Ahmed, *et al*., 2018). According to Rhoades and Loveday (1990) salinity up to an electrical conductivity value of soil paste extract (ECe) of 7dSm^{-1} would not affect the yield of sugar beet.

Foliar application of micronutrients has become an established procedure for increasing yield and improving the quality of sugar beet and become target to many investigators especially in alkaline soils. It was found that that foliar spray of micronutrients mixture is significantly increased growth, yield and quality of sugar beet (Nemeat-Alla and El-Geddawy, 2001; Abd El-Gawad *et al*., 2004; Nemeat-Alla *et al*., 2009; Nemeat-Alla *et al*., 2014 and Rassam *et al*., 2015).

Lucena (2000) reported that in high pH soils, iron, an essential element for plant growth and development, is inaccessible for plant metabolism. Most field crops in soils exhibit high pH induced iron deficiency, known as iron chlorosis, although there is enough iron in the soil and plant leaves. Iron deficiency is known to weaken physiological processes in plant as it is important for chlorophyll and protein synthesis (Fahad *et al*., 2014).

Approximately10% of the proteomes in eukaryotic cells is Zn binding proteins not only this but also 36% of the eukaryotic Zn-proteins are involved in gene expression (Cakmak, 2008).

The presence of Zn is essential for many plant biological processes. These processes include: involvement in biosynthesis of tryptophan which is the precursor of auxins; cytoplasmic membranes stability; carbonic anhydrase control; RNA polymerase activation; management of oxidative stress through the enzyme superoxide dismutase and augmented plants resistance to water stress (Khan *et al.*, 2004 and Hafeez *et al.*, 2013). In alkaline soils, Zinc could be considered a limiting factor for beet yield (Neamatollahi *et al*., 2013 and Goborah *et al*., 2014).

Apart from pH, in the temperate countries, high repeat of susceptible crops cultivation; deficiency of organic manure and so high phosphorus (P) rates may be the causes of Zn deficiency in sugar beet (Barker and Eaton, 2015). In addition, Zn positively enhance the distribution of assimilates and plants maturation processes (Barłóg *et al*., 2016).

Accurate sowing date in cultivated soil affected by salinity is important to gain economical production and enhance sugar yield quality. Taha *et al*. (1985) and Badawi (1985) found that sowing sugar beet early (10th Sep.) gave the largest number of leaves/plant, top yield, root weight, root yield/fed and TSS%. Metwally (1998) observed that the highest values of root length, root diameter and yield of roots, tops and sugar/fed as well as juice purity and sucrose % were obtained by early planting (25th Sep.) while, the heaviest roots were obtained at middle planting date (10th Oct.). Total soluble solids (T.S.S.), sucrose percentage and purity were significantly increased by early planting date in both seasons (El-Shouny *et al*., 2003)

Improvement of sugar beet productivity under Sahl-Eltina area can be done by adopting one or more of the following strategies: fertilization management (especially foliar application of micronutrients) and adjustment of sowing dates which produced economical yield with satisfactory quality. Herein, it was intended to investigate response of sugar beet plants grown under Sahl-Eltina region to two sowing dates and foliar spraying of iron and zinc.

MATERIALS AND METHODS

Field experiments were carried out at the area of Sahl-Eltina south of Port Said, Egypt which known by its salt affected soil during the two growing seasons of 2015/2016 and 2016/2017. Each sowing date was allocated in a separate experiment. The experiments were laid out in randomized complete block design having three replications. The treatments consisted of two sowing dates (August 1st and October 1st) and for micronutrients, without micronutrients, Zinc-EDTA (16 %) in concentration of 1g/l and Fe-EDTA (14 %) in concentration of 1.5 g/l were applied three times at 60, 75 and 90 days after planting. Each plot consisted of 6 ridges 4 m in length and 70 cm in width (4 × 4.2 = 16.8 m^2). Seed of sugar beet variety Halawa (multigerm) was sown 20 cm between hills.

Physiochemical properties of the soil of the experimental sites as well as chemical analysis of irrigation water are stated in Table 1. Some of meteorological data for south of Port-Said area during the two growing seasons are given in Figure 1.

Thinning to one plant/hill was done after 4 weeks from planting (4-leaves age). Phosphorous in form of super phosphate (15.5 % P_2O_5) at the rate of 30 kg P_2O_5/fed was added before sowing and during soil preparation. Nitrogen in a form of ammonium nitrate (33.5 % N) at rate of 100 kg/fed as well as potassium sulfate (48 %) at a rate of 50 kg/fed were added in three equal doses at 60, 75 and 90 days after sowing. At harvest (210 days after planting), for each sowing date, plants of two inner rows in each experimental plot were harvested by hand and cleaned, then roots and tops were separated. The following characters: root length, root diameter and root fresh weight/plant, total soluble solids (TSS), sucrose % and purity % in root juice were determined. Also, root, top and sugar yields/fed as well as extractable sucrose % were calculated.

Table 1. Physical and Chemical properties of the experimental soil sets and irrigation water (El-Salam Canal).

	First season 2015/2016	Second season 2016/2017
Experimental soil sites		
Physical analysis		
Coarse sand (%)	6.80	6.30
Fine sand (%)	25.40	25.53
Silt (%)	34.20	35.50
Clay (%)	33.60	34.80
Texture grade	Clay loam	Clay loam
Chemical properties:		
pH	7.93	7.82
EC dsm^{-1}	1.4	1.2
Soluble cations m eq/100 g soil		
Ca^{2+}	3.4	3.2
Mg^{2+}	2.7	2.9
Na^{+}	5.3	5.5
K^{+}	0.6	0.8
Soluble anions m eq/100 g soil		
CO_3^{2-}	-	-
HCO_3^{-}	0.8	0.7
Cl-	7.5	7.9
SO_4^{2-}	3.3	3.5
Available Fe and Zn (ppm)		
Fe	8.41	7.92
Zn	9.24	9.55
Irrigation water :		
pH	7.16	7.30
EC dsm^{-1}	1.82	1.70

TSS was determined by using hand refract meter model PR-1, ATAGO, Japan. Sucrose % was determined polarimetrically on a lead acetate extract of fresh macerated roots according to Carruthers and Oldfield (1960). Purity was calculated using the following equation:

Purity % = Sucrose % / TSS % × 100.

Statistical analysis of the data obtained from each trial was subjected to the analysis of variance of randomized block design. The combined analysis of the data of the two seasons was performed as described by Leclery *et al.*, 1966. Micronutrient treatments means were compared using the least significant difference (LSD) test developed by Waller and Duncan (1969) at the 5% level.

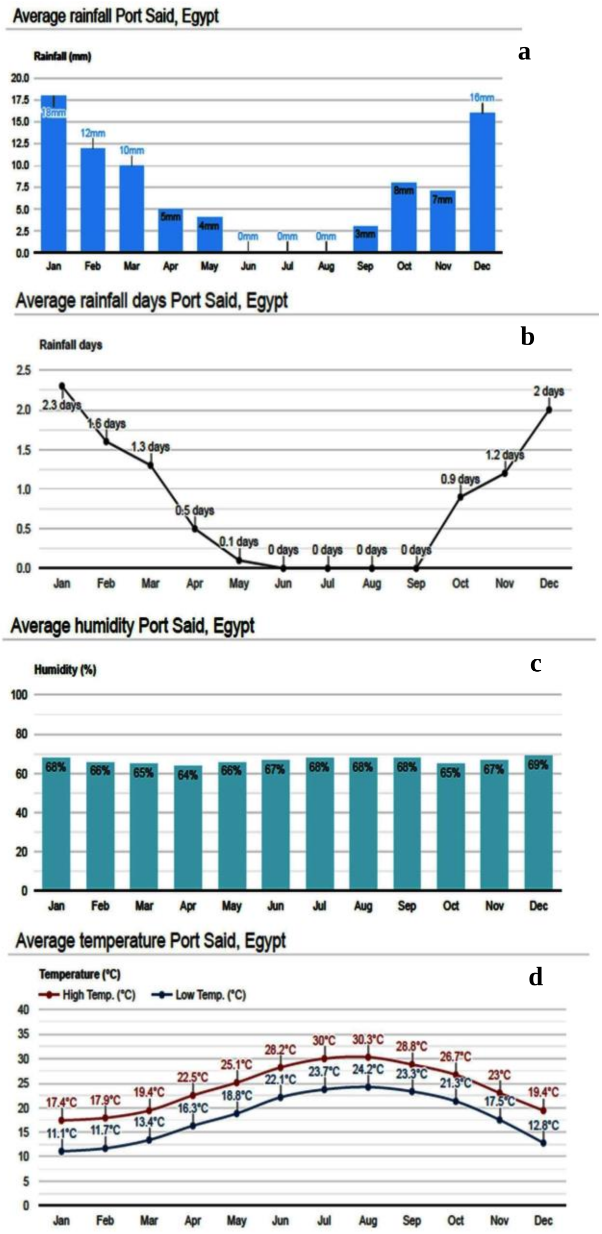

Figure 1. Monthly average of some meteorological data of Port-said area. (a) average rainfall (mm), (b) Average rainfall days, (c) Average humidity % and (d) Average temperature (°C). (From: https://www.weather-atlas.com/ en/ egypt/port-said-climate).

RESULTS AND DISCUSSION

1-Effect of sowing dates:

Data in Table 2 shows that sugar beet plants sowing at 1st August significantly surpassed those sowing at 1st October in root diameter and root weight/plant, while, root length not affected by sowing dates. Root weight/plant for early sowing date significantly increased by 15.56% and 10.75% compared with late date in the two seasons, respectively. This result might be due to more favorable environment was given by early sowing date, where gave good germination and establishment of seedlings, consequently produced bigger and heavier roots comparing with later date.

Also, Table 2 illustrates that sucrose percentage in root juice for early sowing date gave higher values (18.93% and 18.33%) comparing with the later sowing date (18.08% and 17.48%) in the two seasons, respectively. When sugar beet plants sown early (1st August), the moderate temperature during storing sugar period (December, January and February) might be enhanced higher root sucrose content comparing with late sowing date (meteorological data in Figure 1). Moreover, both TSS% and purity% not affected significantly by sowing dates.

Concerning root yield, the analysis of variance stated that first sowing date (1st August) recorded higher values of root yield (19.91 and 20.6 t/fed.) comparing with the later one (17.59 and 18.23 t/fed.) in the two growing seasons. The increases in root yields due to cultivate sugar beet two months early were 13.19% and 13% in the both seasons, respectively. The proper temperature during vegetative growth period (August, September, October and November) produced increases in root weight and root diameter per plant, consequently increases in root yield per feddan.

Top yield/fed recorded high values in the two seasons when sow was early at August ,but the differences between the two sowing dates not reach the significant level in the second season. While the increase in top yield was 13.21 % in the first season as a result to sow sugar beet at the early date (1st August).

Productivity of sugar yield per feddan significantly increased by cultivation beet early two months, the first sowing date produced an increase in sugar yield by 15.05% and 13.16% in the two growing seasons, respectively comparing with the late date. Practically, the increase in sugar yield is related to the increases in both root yield and sucrose content (%).

The above mentioned results are in agreement with those obtained by Taha *et al.* (1985), Badawi (1985), Metwally *et al.* (1998) and El-Shouny *et al.* (2003).

Table 2. Effect of sowing dates on yield, yield component and quality of sugar beet during 2015/2016 and 2016/2017 seasons.

Characters	Root length (cm)	Root diameter (cm)	Root weight (g/plant)	TSS %	Sucrose %	Purity %	Root yield (t/fed)	Top yield (t/fed)	Sugar yield (t/fed)
Sowing dates					2015/2016 season				
1st August	19.33 a	12.67 a	1906.77 a	22.38 a	18.93 a	82.84 a	19.91 a	8.91 a	3.44 a
1st October	18.33 a	11.89 b	1650.00 b	22.31 a	18.08 b	82.83 a	17.59 b	7.87 b	2.99 b
Significance	NS	*	*	NS	**	NS	*	*	*
					2016/2017 season				
1st August	20.03 a	13.26 a	1956.67 a	22.42 a	18.33 a	78.61 a	20.60 a	6.73 a	3.61 a
1st October	18.64 a	12.13 b	1766.67 a	22.23 a	17.48 b	78.20 a	18.23 b	6.23 a	3.19 b
Significance	NS	*	NS	NS	**	NS	*	NS	*

NS= not significant, *= significant and * *= high significant.

2-Effect of micronutrients:

Foliar application of micronutrients (iron at rate of 1 g/l or Zn at rate of 1.5 g/l) had positive and significant effect on root length, root diameter and root weight per plant comparing with control treatment and that was true in the two growing seasons, except, root diameter in the first season only (Table 3). Data revealed that foliar spray of iron surpassed foliar spray of Zn concerning root length by 7.96% and 4.46% and concerning root weight by 17.49% and 16.89% in the two growing seasons, respectively. While foliar spray of iron at rate 1g/l surpassed control treatment by 17.33% and 11.93% concerning root length and by 72.02% and 62.39% for root weight/plant in the two growing seasons, respectively. Root diameter in the second seasons recorded the highest value with Fe application (13.20 cm) followed by Zn application (12.83 cm) followed by control treatment (12.05 cm). The evident effect of iron on root parameters (length, diameter and weight) may be is related to the important role of iron in many physiological processes involved chlorophyll and protein synthesis (Lucena, 2000 and Fahad *et al*., 2014).

Data illustrated in Table 3 revealed that foliar application with Fe at rate 1g/l surpassed both Zn application and control treatment concerning Total Soluble Solids in root juice in the first season, while this trait not affected significantly by foliar application with micronutrients in the second season. Also, Fe treatment surpassed control treatment concerning sucrose percentage (%) but did not differ significantly from Zn treatment and that held true in the two growing seasons. Moreover, foliar application of micronutrients did not have significant effect on purity % in the two growing seasons.

Root yield/fed achieved the highest values with Fe treatment (20.35 t/fed. and 21.04 t/fed.), followed by Zn treatment (18.59 t/fed. and 19.28 t/fed.) in the first and second seasons, respectively. Foliar spray with Fe-EDTA surpassed foliar spray with Zn-EDTA by 9.46% and 9.13% concerning this trait in the two seasons, respectively. While, Fe treatment surpassed the control treatment (tap water) by 17.49% and 17.41%. These increases in root yield/fed. may be due to the increase in root length, root diameter and root weight/plant.

Both Fe and Zn treatments significantly surpassed control treatment concerning top yield/fed. in the two seasons. The differences between the two micronutrients treatments (Fe or Zn) did not reach the level of significance 5%. Foliar spray with Fe surpassed control treatment by 12.45% and 42.35%, while foliar spray with Zn surpassed control treatment by 7.75% and 30.56% in the two seasons, respectively. Zn treatment surpassed control treatment by 7.33% and 7.59% in the first and second seasons, respectively.

Table 3. Effect of foliar application of Fe and Zn on yield, yield component and quality of sugar beet during 2015/2016 and 2016/2017 seasons.

Foliar spray	Root length (cm)	Root diameter (cm)	Root weight (g/plant)	TSS %	Sucrose %	Purity %	Root yield (t/fed)	Top yield (t/fed)	Sugar yield (t/fed)
				2015/2016 season					
Control	17.33	11.67	1275.00	22.22	18.30	82.39	17.32	7.87	2.94
Fe	20.33	12.83	2193.30	22.61	18.66	84.01	20.35	8.85	3.50
Zn	18.83	12.30	1866.70	22.21	18.56	82.11	18.59	8.45	3.20
LSD at 5%	1.58	NS	128.60	0.36	0.33	NS	1.09	0.49	0.15
				2016/2017 season					
Control	18.18	12.05	1391.70	22.24	17.70	77.80	17.92	6.02	3.10
Fe	20.35	13.20	2260.00	22.40	18.06	78.82	21.04	8.57	3.71
Zn	19.48	12.83	1933.30	22.34	17.96	78.59	19.28	7.86	3.39
LSD at 5%	1.47	0.98	79.10	NS	0.29	NS	1.12	1.09	0.18

Sugar yield/fed recorded the superior values with Fe treatment (3.50 t/fed. and 3.71 t/fed.) in the first and second seasons, respectively. Foliar application of Fe-EDTA surpassed Zn-EDTA application by 9.37% and 9.44%, while Fe treatment surpassed control treatment by 19.04% and 19.67% in the two growing seasons. Zn treatment surpassed control treatment by 8.84% and 9.35% in the first and second seasons, respectively. These increases in sugar yield due to Fe treatment comparing with control treatment may be as results to the increase of both root yield and sucrose content which achieved by this trait and that was evident in the two seasons. These results are comparable to those mentioned by Nemeat-Alla and El-Geddawy (2001), Abd El-Gawad *et al*. (2004), Nemeat-Alla *et al*. (2009), Nemeat-Alla *et al*. (2014) and Rassam *et al*. (2015) who reported that foliar spray of mixture micronutrients significantly increased growth, yield and quality of sugar beet.

The effect of interactions between sowing dates and foliar application of micronutrients were not statistically significant on the all studied characters.

CONCLUSION

Results of this field study disclosed that application of Fe or Zn improved vegetative growth, which in turn improved, juice quality and productivity of sugar beet in salt affected soil conditions.

Each experiment was carried out in complete block design with three replicas each sowing date was allocated in separate experiment and then used combined analysis between the two expriments.

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تأثير مواعيد الزراعة والرش الورقي بالحديد والزنك علي إنتاجية بنجر السكر في التربة المتأثرة بالملوحة

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أقيمت تجارب حقلية بمنطقة سهل التينة المتأثرة بالملوحة جنوب مدينة بورسعيد خلال الموسمين 2015/2016-2016/2017 لدراسة تأثير ميعادي الزراعة (أول أغسطس وأول أكتوبر) والرش الورقي بالحديد والزنك علي إنتاجية بنجر السكر صنف حلاوة (متعدد الاجنة) ، في كل موسم تم دراسة ميعادي الزراعة في تجربتين منفصلتين بداخل كل تجربة تم الرش الورقي للحديد والزنك بعد 60 و 75 و 90 يوما من الزراعة. وقد اجريت التجارب باستخدام تصميم القطاعات كاملة العشوائية ذات الثلاث مكررات. أوضحت نتائج تحليل متوسط الموسمين تفوق ميعاد الزراعة الاول (اول اغسطس) على ميعاد الزراعة الثانى (اول اكتوبر) فى جميع الصفات تحت الدراسة، الرش الورقى بالحديد المخلبى (1 جرام /لتر) كان اكثر فاعلية من الرش بالزنك المخلبى (1.5 جرام/لتر) فى تحسين صفات الجذر (الطول ، القطر ، الوزن/نبات) ، وكذلك جودة العصير ، وزيادة محصول العرش والجذور والسكر/ فدان بالمقارنة بمعاملة الكنترول (بدون رش عناصر صغري). التفاعل بين مواعيد الزراعة والرش الورقى بالعناصر الصغرى لم يكن له تاثير معنوى على جميع الصفات المدروسة .