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RESPONSE OF SUGAR BEET YIALD AND QUALITY TO SOME MICRONUTRIENTS UNDER SANDY SOIL.

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ABSTRACT

Four 2yr-field experiments were carried out at Kalabsho- El-Dakahlia Governorate, in 2012/13 and 2013/14 winter growing seasons to study the effect both individual and combined applications of B, Zn and Mn on juice quality and the content of some macro-and micronutrients of sugar beet, var. Sultan.

The first experiment was devoted to B treatments (0 , 0.5 and 1kg fed^{-1}),the second experiment was devoted to Zn treatments (0 , 1.5 and 3 kg fed^{-1}) the third one to Mn levels (0, 1, 2 kg fed^{-1}) while the fourth experiment was assigned to the mixture of the these nutrients at three levels, i.e 0 B+Zn+Mn, 0.5kg B+1.5kg Zn+1kg Mn fed^{-1} and 1kg B+3kg Zn+2kg Mn fed^{-1} at the same levels mentioned befor. Each of the four experiment included 9 treatments which were the combination of 3 micro nutrient levels and three times of soil application, i.e. interaction after sowing, 50 (DAS) or 75 (DAS). Micronurients were applied only once as soil application. The experiments were laid out in complete randomized block design with four replications.

The results of the combined analysis of the two years could be summarized as follows:

Boron application at 0.5 kg fed^{-1} reduced TSS% at harvest, whereas Zn, Mn and the mixture showed no significant effect on TSS%. All micronutrients had no significant effect on sucrose% at harvest.

Manganese application at 2.0 kg fed^{-1} significantly raised purity% at harvest. Late application of all micronutrients mixture favorably affected purity% at harvest compared with early application.

The results showed that all micronutrients at all levels and at three application times had significant effect on roots and sucrose yields in sugar beet juice at harvest, also, B, Zn,Mn and their mixture at the highest levels significantly increased roots and sucrose yields.

The results indicated a significant increase in N% in leaves due to application of a mixture containing 0.5 kg B + 1.5 kg Zn + 1.0 kg Mn fed^{-1} compared with the check treatments and the highest level as well. Significant effect was observed for application time of Mn where application at 50 (DAS) from sowing or at sowing significantly surpassed the later application at 75 (DAS) in affecting N% in roots.

The only significant effect was for Zn when it was applied at the higher level. This effect was also recorded in K% in sugar beet leaves. The interaction between levels and dates of applying micronutrients mixture had significant effect on Zn content in sugar beet root.

Neither level of all micro nutrients nor application time had significant effect on B, Zn and Mn in sugar beet leaves and roots at harvest.

Keywords : sugar beet , juice quality , juice content , soil application , micronutrients , nitrogen and potassium , roots and sugar yields

INTRODUCTION

Sugar beet is becoming one of the important sugar crops. It grows well in the new reclaimed soils; maturity take short time compared to sugar cane and contains high sugar content. Improving quality parameters of sugar beet juice is the main demand for sugar companies to increase the extracted sugar as well as for the growers to increase their net income. Awad *et al.,*(2013a)

The proper application of micronutrients depends mostly on their effect on crops.

Application of micronutrients for nutrients mostly depends on their effect on crops. *EL-Taweel,*(*1999).* In recent years, sugar beet grown on sandy soils as newly reclaimed soils has shown a variety of visual symptoms that resemble nutrients deficiencies. Sugar beet nutrition had a great effect on beet productivity. For various crops, micronutrients fertilizers received great attention.

There is a great need to find out the proper technical recommendations for improving the productivity and quality of sugar beet under Egyptian conditions. Because the Egyptian soils suffer from a high pH values, the availability of P, K and micronutrients is reduced. *El-Geddawy et al.,* (2007 and 2008) showed that soaking sugar beet seeds with solutions of micronutrients 0.5 and/or 1 kg B fed^{-1}+ 4 kg Zn fed^{-1} before sowing significantly suppressed the dried method with respect to root diameter,weight/plant, root and sugar yield fed^{-1}.

Application of micronutrients mineral soluble salts unavailable forms. Many worker for micronutrients mentioned that**,** *Gezgin et al., (2000)* found that foliar application of B levels from 0, 500 and /or 750 g/boron fed-1 as (sodium borate 11% B). Increased significantly root and sugar yields via the increase in root sucrose*%. Osman et al., (2003 and 2004)* application of three levels of boron (0, 1 and 2 Kg fed^{-1}.) (as a borax, sodium borate 11% B) and 2 levels of Mn (0 and 1 Kg fed^{-1}) as a manganese sulfate 28% Mn) and the mixture of them 2 kg. B + 1 kg Mn fed^{-1}.

The results observed that, suppressed in root length, TSS%, sucrose%, root and sugar yields fed^{-1}. *Shafika and El-Masry ,(2006)* found that foliar spray with micronutrients, in mixtures of Zn, Mn and Fe increased significantly root growth, quality traits%, root and sugar yields fed^{-1}.

Zeinab and Samya, (2006) and Allam, (2008) used three concentrations from B (0, 0.02 and 0.04% boric acid) as foliar application on root quality and yields of sugar beet. The results, found that 0.02% boric acid attained the highest root growth, quality traits%, as well as root and sugar yields fed^{-1}.

Rosell and Ulrich (1964) reported that 9 ppm Zn application is the critical level of sugar beet plants. Zn application increased macro and micro elements in the mature blades and petiols such as Fe, Mn, nitrate and phosphate. They added that the critical level of Zn in sugar beet plants tissues was 8-10 ppm, where plants were sampled after 6 weeks from planting.

Last and Bean, (1990) found that leaf Mn concentration sampled in mid-July was greater than without $MnSO_4$ application and deficiency symptoms were least with $MnSO_4$ + adjuvant.

Rutskaya et al., (1981) studied the effect of applied B and Zn on the content of micronutrients in leaves and roots of sugar beet. The Zn content in the leaves was increased, whereas changes in their content in the roots were not significant. *Morsy and Taha, (1986)* claimed that the addition of B and/or Mn to sugar beet plants increased the concentration and uptake of N, P, K, B and Mn in sugar beet tops, roots and TSS. They also found that application of boric acid from 0.5-0.7 % three times and/or 0.1 % $MnSO_4$ three times attained the best results. *Saif, (1991)* reported that soil application of 0.5 kg B fed^{-1} and/or 4 kg Zn fed^{-1} gave the highest value of sucrose, TSS and purity%. *Tsolova and Peneva, (1992)* estimated the concentration of B, Zn and Mn in sugar beet tops and roots and the amounts removed per unit area in harvested tops and roots at different growth stages. They found that trace elements concentration increased in tops and decreased in roots. Zn concentration decreased in both parts, Mn concentration in tops increased to a peak, the largest amounts of B and Mn were 5.0 and 18.8 g ha^{-1} respectively and the greatest amount of Zn was 44.7 g ha^{-1}.

Soudi and El-Guibali, (2008) and Manal, Hussein, (2011) found that foliar application with (B + Zn + Mn + Fe) at the level 2 ml /l /400 L water fed^{-1} increased significantly root length, diameter, fresh weight/plant, as well as, sucrose%, purity%, root and sugar yields fed-1 in both seasons as compared with control treatment (without micronutrients) and 1 ml /l /400 L water fed^{-1}.

Awad et al.,(2013 a) It is concluded that foliar application (B+Zn+Mn) at the level of (3/4 L fed^{-1}.) with applied nitrogen fertilizer level at (140 kg fed^{-1}.) produced the highest mean values of the most traits for sugar beet under study.

Abd EL- Daiem, et al., (2015 a) concluded that foliar application (B+Zn+Mn) at the level of (1.5 L fed^{-1}.) with applied potassium fertilizer level at (48 kg K_2O fed^{-1}.) produced the highest mean values of the most traits for sugar beet under study.

This investigates aimed to study the effect of some micronutrients on yield and quality of sugar beet (*Beta vulgaris L*.).

MATERIALS AND METHODS

Four - field trials were carried out in Kalabsho-El-Dakahlia Governorate in two winter seasons (2012/2013 and 2013/2014) to study the effect of some micronutrients on juice quality and chemical composition of sugar beet *(Beta vulgaris L.)* plants. The experiments were carried out in a loamy sand soil. The chemical and mechanical analyses of the experimental soil are presented in Table (1). Each experiment included 9 treatments .i.e. 3 levels of the micronutrient at 3 dates in soil application, as follows:

Experiment 1: In this experiment 3 levels of boron were used (zero, 0.5 and 1 kg B fed^{-1}). Boron was applied as sodium borate (Borax) Na_2 $B_4O_7.10$ H_2O (11% B).

Experiment 2: In this experiment 3 levels of zinc which were used (zero, 1.5 and 3 kg Zn fed^{-1}). Zinc was applied as zinc sulfate Zn SO_4(22% Zn).

Experiment 3: In this experiment 3 levels of manganese were used (zero, 1 and 2 kg Mn fed^{-1}). Manganese was applied as manganese sulfate $MnSO_4$ (32% Mn).

Experiment 4: In this experiment 3 levels of the tested micronutrients mixtures which were B,Zn and Mn,(zero, 0.5 kg B + 1.5 kg Zn + 1kg Mn fed^{-1}). and (1 kg B + 3 kg Zn + 2kg Mn fed^{-1}).

Times application for all experimental treatments were at planting, after 50 and 75 day after sowing (DAS). All micronutrients either singly or mixed were applied once as soil application after complete mixing with appropriate amounts of fine sand, according to date of application.

The commercial sugar beet variety Sultan was used in the four trials. Planting was done on the 15^{th} of November in both growing seasons. Harvest was followed after 7 months in both seasons. Nitrogen fertilizer at 100 kg N fed^{-1}. in the form of ammonium nitrate (33.5% N) was applied in four equal doses, The first was applied after thinning and the others was applied at 2-weeks interval after the first application. Phosphours fertilizer at 30 kg P_2O_5 fed^{-1}. as calcium superphosphate (15 % P_2O_5) and potassium fertilizer at 48 kg K_2O fed^{-1}. as potassium sulphate (48 % K_2O) . Phosphoruis fertilizer was applied at seedbed preparation while potassium fertilizer were applied in split application in two equal doses, The first dose after thining and the second dose was applied after one month later.

The experiments were laid out in complete randomized block design with four replications. Plot area was (3x7m) = 21 m^2 . Each plot contained 6 ridges which were 7 m in length and 50 cm in width. The preceding crop was rice in corn seasons. All cultural practices for growing sugar beet were done as recommended for the region. At harvest planting, a sample of 5 plants was taken at random to determine the chemical composition and juice quality

I. juice quality:

1. Total soluble solids% (TSS %) which was determined using handl refractometer.
2. Sucrose% was determined according *to Le Docte, (1927).*
3. Purity % was calculated according to the following formula:

   Apparent purity % = Sucrose% / TSS % X 100.

II. Chemical composition:

The 5- plant samples taken at harvest were used for chemical analysis. Fresh samples of 100 g of leaves and roots were taken from each treatment and then oven dried at 70 ^{o}c and ground and kept for chemical determinations. Dry samples of 0.1 g each were wet digested using 5 ml concentrated sulfuric acid and perchloroic mixture acid as a catalyst. The digestion was diluted to 100 ml in volumetric flask using distilled water for the following analysis.

Table 1: Mechanical and chemical soil properties at the experimental site during the two growing seasons.

Soil analysis		2012/2013 season	2013/2014 season
A: Mechanical properties:			
Fine sand (%)		3.40	4.00
Coarse sand (%)		68.00	67.30
Silt (%)		18.00	18.30
Clay (%)		10.60	10.40
Texture		Loamy sand	Loamy sand
B: Chemical analysis			
Soil reaction pH (1:2.5suspension)		7.20	7.50
EC(dsm^{-1})		0.34	0.35
Available N (mg kg^{-1})		28.40	25.6
Available P (mg kg^{-1})		11.00	10.8
Available K (mg kg^{-1})		100.00	95.50
Mn (mg kg^{-1})		0.90	0.85
Zn (mg kg^{-1})		2.20	2.15
B (mg kg^{-1})		0.97	0.99
Soluble cations meq/100 g soil	Ca^{++}	0.44	0.43
	Mg^{++}	0.42	0.45
	Na^{+}	0.89	0.96
	K^{+}	0.04	0.05
Soluble anions meq/100 g soil	CO_3^{--}	0.00	0.00
	HCO_3^{-}	0.90	0.95
	Cl^{-}	0.71	0.82
	SO_4^{--}	0.i8	0.07

Nitrogen contents in leaves and roots were determined using micro kjeldahl apparatus according to Hesse ,(1971).Phosphorus contents in leaves and roots were determined in digested solution according to Olsen *et al.*, (1954) by using spectrophotometer. Potassium contents in leaves and roots were detrmined in the digested solution according to Brown and Lilliand (1964). Boron in mg 100 g^{-1} dry matter was estimated calorimetrically using Azomethine-H at 420 nm according to *John et al., (1975).* Zn and Mn in dry matter were determined as described in flame Method, Manual for Atomic Absorption, Model 22 Brooklyn AVE as given by the *(A.O.A.C., 1990).*Data statistically analyzed according to *Snedecor and Cochran, (1981).*

RESULTS AND DISCUSSION

1-Juice quality as affected by B, Zn and Mn application;

Results for the effects of B, Zn, Mn either alone or mixed at three levels and three different time of application on juice quality at harvest are shown in Table (2)These data indicate the following

1. Total soluble solids percentage (TSS %):-

Results in Table (2) showed that B single application at the higher level, i.e. 1 kg fed^{-1} significantly increased TSS% at harvest compared with the lower level (0.5 kg fed^{-1}).Also other micronutrients either applied alone or in combination did not significantly affect TSS% .Time application of all micronutrients had no marked effect on TSS% of sugar beet juice at harvest. Also, the effect of the interaction between nutrients level and application date showed no significant effects on TSS%. It could be concluded that B application at 1 kg fed^{-1} showed positive effects on TSS% in juice at harvest. Similar results for the positive effect of B on TSS% were also reported by *Awad,(2000), Awad et al.,(2013 a,b and c)* and *Abd EL-Daiem,et al .,(2015 a and b).*

2. Sucrose percentage:-

Results in Table (2) showed that all micronutrients at all levels applied and at three application times had no significant effect on sucrose% in sugar beet juice at harvest. The results showed that applying B, Zn, Mn and B + Zn + Mn at the lower level insignificantly increased sucrose%. Also, B, Zn, Mn and their mixture at the highest level insignificantly increased sucrose% at harvest. The interaction between microelement levels and application times had no significant effects on sucrose% in juice at harvest, for all micronutrients as well as for their mixture. However, a clear trend was observed where the highest values of sucrose% were recorded with all micronutrients when applied at the higher level, namely 1 kg B, 3 kg Zn, 2 kg Mn fed^{-1} and their mixture 1 kg B + 3 kg Zn + 2 kg Mn fed^{-1}) when these levels were applied 75 days from planting.

The general trend of the results indicates that the higher micronutrients level combined with the late application at 75 days had a positive effect, particularly when applied as a mixture for the three elements on sucrose% of sugar beet juice at harvest.

Table (2) Effect of levels and application time of boron, zinc, manganese and their mixtures on total soluble solids (TSS), sucrose , purity percentages, root yield and sugar yield Ton fed^{-1} of sugar beet at harvest. (combined analysis of the two growing seasons 2012/2013 and 2013/2014).

Experiments	Traits	Total soluble solids (TSS%) Application time				Sucrose % Application time				Purity % Application time				Roots yield Ton fed^{-1}	Sugar yield Ton fed^{-1}
	B,Zn,Mn and Mixture level	**At sowing**	**50 DAS**	**75 DAS**	**Mean**	**At sowing**	**50 DAS**	**75 DAS**	**Mean**	**At sowing**	**50 DAS**	**75 DAS**	**Mean**	**Mean**	**Mean**
	0	21.42	21.66	22.10	21.73	15.10	15.45	15.95	15.5	70.49	71.33	72.17	71.33	26.73	4.14
	Boron 0.5 kg B fed^{-1}	21.66	21.75	21.97	21.79	15.45	16.43	16.65	16.18	71.33	75.54	75.78	78.57	27.18	4.40
	1 kg B fed^{-1}	22.25	22.85	23.12	22.74	16.25	17.25	17.87	17.12	73.03	75.49	77.29	75.28	27.51	4.71
Exp 1	Mean	21.78	22.09	22.40	22.09	15.60	16.38	16.82	16.27	71.62	74.15	75.09	73.65	27.14	4.42
	L.S.D.at 0.05													0.12	
	Boron (B)				0.70				N.S				N.S		
	Application date (D)				N.S				N.S				N.S		
	B xD				N.S				N.S				N.S		
	0	21.75	22.15	22.45	22.12	15.24	15.65	16.00	15.63	70.07	70.65	71.27	70.66	25.79	4.03
	Zinc 1.5 kg Zn fed^{-1}	22.42	22.74	22.98	22.71	15.95	16.24	16.75	16.31	71.14	71.42	72.89	71.82	26.03	4.25
	3 kg Zn fed^{-1}	22.85	23.25	23.65	23.25	16.75	16.88	17.10	16.91	73.30	72.60	72.30	72.73	26.81	4.53
Exp 2	Mean	22.34	22.70	23.03	22.69	15.98	16.26	16.62	16.29	71.53	71.63	72.17	71.79	26.21	4.27
	L.S.D.at 0.05	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S		0.12	
	Zinc (Zn)				N.S				N.S				N.S		
	Application date (D)				N.S				N.S						
	Zn x D				N.S				N.S						
	L.S.D.at 0.05	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S		
	0	21.87	22.10	22.65	22.21	15.35	15.54	15.90	15.60	70.19	70.32	70.20	70.24	24.86	3.88
	Manganese 1 kg Mn fed^{-1}	22.65	22.95	23.60	23.07	16.15	16.55	16.85	16.52	71.30	72.11	71.40	71.61	24.93	4.12
	2 kg Mn fed^{-1}	22.98	23.45	23.70	23.38	16.53	17.26	17.77	17.19	71.93	73.60	74.98	73.52	25.26	4.34
Exp 3	Mean	22.50	22.83	23.32	22.88	16.01	16.45	16.84	16.43	71.15	72.05	72.21	71.81	25.02	4.11
	Manganese (Mn)				N.S				N.S				4.46		
	Application date (D)				N.S				N.S				N.S		
	Mn x D				N.S				N.S				N.S		
	L.S.D.at 0.05	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	4.46	0.29	
	0	22.12	22.65	23.25	22.67	15.75	16.12	16.56	16.14	71.20	71.17	71.22	71.19	24.98	4.03
	Mix. 0.5 + 1.5 + 1kg fed^{-1}	22.65	23.18	23.74	23.19	16.95	17.32	17.68	17.32	74.83	74.72	74.47	74.69	25.80	4.5
Exp 4	1 + 3 + 2 kg fed^{-1}	23.25	23.66	23.91	23.61	17.35	17.58	17.88	17.60	74.62	74.30	74.78	74.54	27.29	4.8
	Mean	22.67	23.16	23.63	23.15	16.68	17.01	17.37	17.02	73.58	73.44	73.51	73.52	26.02	4.4
	L.S.D.at 0.05	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	2.54	1.61	
	Mixture				N.S				N.S				N.S		
	Date				N.S				N.S				2.54		

The positive effects of the three micronutrients on sucrose% in sugar beet juice at harvest were also reported by *Morsy and Taha, (1986), Saif, (1991) ,Awad et al.,(2013 a,b and c)* and *Abd EL- Daiem,et al., (2015 a and b)* with B application. In addition the found effect of Zn on sucrose% was also reported by *Saif, (1991).*Concerning Mn effect on sucrose% *Morsy and Taha, (1986)* found that sucrose% in sugar beet juice significantly increased due to the application of Mn. Also, the positive effect of two or more of these micronutrients on sucrose% was also reported by many investigators (Awad et al., (2013 a,b and c**)** as well as Abd EL- Daiem,et al., (2015 a)).

3. Purity%:-

Results in Table (2) indicated that micronutrients application increased purity% of sugar beet juice at harvest. The increase in purity% due to micronutrients application reached the nonsignificant level with Mn where the highest Mn level insignificantly increased purity% compared with the check treatment and the lower level as well. Also, the results showed that applying the mixture 0.5 kg B + 1.5 kg Zn + 1 kg Mn fed^{-1}, increased purity% significant. Moreover, the higher level of micronutrients (1 kg B + 3 kg Zn + 2 kg Mn fed^{-1}) increased purity% compared with the check treatment. These considerable increases were only significant with Mn application.

It could be concluded that the application of B, Zn, Mn and their mixture favorabley, affected purity% particularly when these micronutrients were applied at the higher level alone or in a mixture. The greatest increases were recorded with mixture application.

The effect of application time of the mixed nutrients showed insignificant effect on purity%. The later application at 75 days insignificantly surpassed the earlier application at planting in effecting purity%. It is worth mentioning that with all single microelements, the later application increased purity% compared with earlier application, but the considerable differences in purity% were not significant.

4.Roots & Sugar Yields

Results in Table (2) showed that all micronutrients at all levels applied and at three application times had significant effect on root and sucrose yields in sugar beet juice at harvest. Also, B, Zn, Mn and their mixture at the highest levels significantly increased root and sucrose yields. On the other hand showed that the highest yields from roots and sugar yields productivity was with the treatment 1 kg B fed^{-1} in the first experiment while, the lowest yields at roots and sugar yields productivity was with control treatment in the third experiment.

A1- Nitrogen and potassium % in sugar beet leaves and roots:-

The results presented in Table (3) show the effect of single

and combined applications of B, Zn and Mn at two levels and at three application times on N, and K contents in leaves and roots of sugar beet at harvest combined analysis of the two growing seasons 2012/2013 and 2013/2014.

Table (3) Effect of levels and application time of boron, zinc, manganese and their mixtures on nitrogen (N) and potassium (K) percentages of sugar beet leaves and roots at harvest. (combined analysis of the two growing seasons,2012/2013 and 2013/2014).

Experiments	Traits	Leaf N% Application Time				Leaf K% Application Time				Root N% Application Time				Root K% Application Time			
	B,Zn,Mn and Mixture level	At sowing	50 DAS	75 DAS	Mean	At sowing	50 DAS	75 DAS	Mean	At sowing	50 DAS	75 DAS	Mean	At sowing	50 DAS	75 DAS	Mean
	0	3.50	3.30	3.10	3.30	4.20	4.00	4.20	4.10	1.90	1.80	1.80	1.80	2.00	1.80	2.10	2.00
Exp 1	Boron 0.5 kg B fed^{-1}	3.40	3.30	2.50	3.10	3.70	4.10	4.00	4.00	1.20	1.40	1.50	1.30	2.00	1.90	2.20	2.00
	1 kg B fed^{-1}	4.10	3.60	4.20	4.00	4.10	4.10	4.60	4.27	1.10	1.30	1.20	1.20	2.40	2.20	2.30	2.30
	Mean	3.60	3.40	3.30	3.40	4.00	4.10	4.30	4.13	1.40	1.50	1.50	1.50	2.10	2.10	2.20	2.10
	L.S.D.at 0.05	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S
	L.S.D.at 0.05 level																
	Boron (B)				N.S				N.S				N.S				N.S
	Application date (D)				N.S				N.S				N.S				N.S
	B xD				N.S				N.S				N.S				N.S
Exp 2	0	3.10	3.40	3.70	3.40	4.10	3.90	3.90	3.97	2.10	1.50	1.40	1.60	2.00	2.00	2.00	2.00
	Zinc 1.5 kg Zn fed^{-1}	3.60	4.00	3.70	3.80	3.70	3.70	3.90	3.77	1.30	1.30	1.00	1.20	1.70	1.90	1.90	1.90
	3.0 kg Zn fed^{-1}	3.20	3.60	3.70	3.50	4.10	4.10	4.40	4.20	1.20	1.20	1.30	1.20	2.30	2.10	2.40	2.30
	Mean	3.30	3.70	3.70	3.60	4.00	3.90	4.00	3.96	1.50	1.30	1.20	1.30	1.90	1.90	2.03	2.00
	L.S.D.at 0.05	N.S	N.S	N.S	N.S	N.S	N.S	N.S	4.28	N.S	N.S	N.S	N.S	N.S	N.S	N.S	0.43
	Zinc (Zn)				N.S				0.31				N.S				0.43
	Application date (D)				N.S				N.S				N.S				N.S
	Zn x D				N.S				N.S				N.S				N.S
Exp 3	0	3.50	3.80	3.40	3.50	4.00	3.90	4.30	4.07	1.50	1.30	1.10	1.30	1.90	1.60	1.80	1.80
	Manganese 1kg Mn fed^{-1}	4.70	4.50	4.10	4.40	3.80	4.10	4.00	3.97	1.30	1.30	2.10	1.20	1.80	1.90	1.90	1.90
	2 kg Mn fed^{-1}	3.20	3.30	3.40	3.30	4.20	4.20	4.10	4.17	1.20	1.60	1.10	1.30	2.10	2.20	2.20	2.20
	Mean	3.80	3.90	3.60	3.80	4.00	4.10	4.10	4.13	1.30	1.40	1.10	1.30	1.90	1.90	1.90	1.90
	L.S.D.at 0.05	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	0.24	N.S	N.S	N.S	N.S
	Manganese (Mn)				N.S				N.S				N.S				N.S
	Application date (D)				N.S				N.S				0.24				N.S
	Mn x D				N.S				N.S				N.S				N.S
Exp 4	0	3.60	3.60	3.50	3.50	3.80	3.90	4.0	3.70	160	1.50	1.60	1.50	2.00	2.20	1.80	2.00
	Mix.0.5+1.5 + 1 kg fed^{-1}	3.50	3.50	3.90	3.70	3.80	3.90	4.00	3.70	1.50	1.40	1.50	1.40	1.90	2.40	1.80	2.00
	1+3+2 kg fed^{-1}	3.40	3.50	3.30	3.40	4.10	4.40	4.60	4.20	0.90	1.60	1.50	1.40	2.30	2.20	2.60	2.30
	Mean	3.50	3.53	3.53	3.50	3.90	4.10	4.20	3.87	1.40	1.50	1.50	1.50	2.06	2.20	2.10	2.10
	L.S.D.at 0.05	N.S	N.S	N.S	0.23	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S
	Mixture				0.23				N.S				N.S				N.S
	date (D)				N.S				N.S				N.S				N.S
	Mix. x D				N.S				N.S				N.S				N.S

Nitrogen content in leaves:-

The results in Table (3) showed that N% in leaves was significantly affected by applying a mixture of the three micronutrients.The results indicated a significant increase in N% in leaves due to application of a mixture containing 0.5 kg B + 1.5 kg Zn + 1 kg Mn fed^{-1} compared with the highest. Also, other micronutrients applied alone showed no significant effect on N% in leaves when applied at two levels. Some slight differences were observed in N% due to applying micronutrients, but without any specific trend, and the differences were below the significant level.

Time of application of all nutrients did not significantly affected N% in leaves. Also, no significant interaction between levels and dates of micronutrients application on N% in leaves. It could be concluded that a mixture of the three microelements at the lower level induced an increase in N% in leaves. The effect of the interaction between levels and times of application did not significantly influence N% in leaves.

Results reported by Rosell and Ulrich, (1964) (applying Zn) and Morsy and Taha, (1986) and Abd EL- Daiem,et al., (2015 a) showed that N% in leaves increased due to application of micronutrients.

Potassium content in leaves:-

Results in Table (3) showed that K% in leaves increased significantly due to the application of the highest Zn level compared with the lower level. It was generally observed that with all micronutrients as well as their mixture a considerable increase in K% in leaves of sugar beet at harvest was observed when these nutrients were applied at the higher level.Time of application had no significant effect. However, slight increase was observed in K% in leaves due to the later application of the micronutrients at 75 days age.

In general, the highest K% was recorded with applying the highest micronutrients level at the latest application date.It could be concluded that micronutrients favorably affected K% in leaves. Results reported by *Awad et al.,(2013 a)* and *Abd EL- Daiem,et al., (2015 a)* showed that micronutrients such as B, Zn and Mn increased K% in sugar beet leaves.

Nitrogen content in roots:-

Results in Table (3) showed that all micronutrients applied singly or combined at both levels had no significant effect on N% in sugar beet roots at harvest. It is observed that no any increase in root N content supplied with B, Zn, Mn or their mixture. The significant effect found only was for application time for Mn, where application at 90 days from sowing or at sowing significantly surpassed the later application at 105 days age in affecting N% in roots. It could be concluded that N% in roots showed no significant response to micronutrients. Results reported by *Morsy and Taha, (1986), Awad et al.,(2013 a)* and *Abd EL- Daiem,et al., (2015 a)* applying B + Mn indicated a significant increase in roots N% due to applying microelements.

Potassium content in roots:-

Results in Table (3) showed that micronutrients application induced some increases in K% in sugar beet roots at harvest. In general, most increases in K% were clear but, mostly below the level of significance. The significant effect was found only for Zn when it was applied at the higher level. This effect was also recorded in K% in sugar beet leaves.

The general trend of the results indicated also that the application time did not significantly affect K% in roots. The level x application time interaction had no significant effect on K% in roots. However, the highest K% values were almost recorded with the highest level combined with the latest date. It could be concluded that a favorable effect was observed for micronutrients application on K% in sugar beet roots. The positive effect of micronutrients on K% in roots. The positive effect of micronutrients on K uptake by sugar beet plants was also reported by Morsy and Taha, (1986), and Abd EL- Daiem,*et al.,* (2015 a) .

A2. Boron, Zn and Mn (mgkg^{-1}) in sugar beet leaves:-

The results for the effects of the application of B, Zn, Mn and their mixture at two levels and three application times on B, Zn and Mn contents in sugar beet leaves at harvest are presented in Table (4) combined analysis of the two growing seasons 2012/2013 and 2013/2014.

Boron content in leaves-

The results in Table (4) showed that neither levels nor dates of application of the three micronutrients and their mixtures significantly affected B concentration in sugar beet leaves. It can be observed that very slight increases in B content in leaves are found particularly when B or B + Zn + Mn were applied. All differences in B content were very slight to reach the significant level.

The effect of application time on B content in leaves had no specific trend and all differences due to application date are negligible.

Similarly, the levels x application time effect on B concentration in leaves was not significant. From the present results it could be concluded that B application showed no marked effect on B concentration in leaves.

It was reported that the B concentration in sugar beet tops at harvest was 40 mg kg^{-1} and the symptoms of B deficiency did not appear when B concentration in the leaf was greater than 30 mg kg^{-1}, but symptoms were found when the concentration fell below 20 mg kg^{-1}.

Consequently, the experimental soil was fit to supply sugar beet plants with their B requirements. Results reported by *Morsy and Taha, (1986), Awad et al.,*(2013 a) and *Abd EL- Daiem,et al., (2015 a)* indicated that B application to sugar beet markedly increased B content in leaves.

Zinc content in leaves:-

Results in Table (4) showed that the three micronutrients did not significantly affect Zn content in sugar beet leaves at harvest. However, some considerable increases are observed in Zn content in leaves, particularly due to Zn applied alone or in the mixture. In addition, the results showed that Zn concentration in leaves of Zn treated plants. These considerable increases show the response of sugar beet plants to the applied Zn.

Table (4) Effect of levels and application time of boron, zinc, manganese and their mixtures on boron (B), zinc (Zn) and manganese (Mn) concentrations mg kg^{-1} of sugar beet leaves at harvest. (combined analysis of the two growing seasons 2012/2013 and 2013/2014)

Experiments	Traits	Leaf B mg kg^{-1} Application time				Leaf Zn mg kg^{-1} Application time				Leaf Mn mg kg^{-1} Application time			
	B,Zn,Mn and Mixture Level	At sowing	50 DAS	75 DAS	Mean	At sowing	50 DAS	75 DAS	Mean	At sowing	50 DAS	75 DAS	Mean
Exp 1	0	31.00	32.00	32.70	31.90	12.70	12.70	14.50	13.30	21.70	24.20	25.20	23.70
	Boron 0.5 kg B fed^{-1}	33.00	34.50	35.00	34.10	13.70	15.20	17.20	15.40	24.70	26.20	28.20	26.40
	1 kg B fed^{-1}	34.20	34.50	35.20	34.60	16.00	16.20	17.70	16.60	26.20	27.20	28.20	27.20
	Mean	32.70	33.60	34.30	33.50	14.10	14.70	16.50	15.10	24.20	25.90	27.20	25.80
	L.S.D.at 0.05	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S
	L.S.D.at 0.05 level												
	Boron (B)				N.S				N.S				N.S
	Application date (D)				N.S				N.S				N.S
	B xD				N.S				N.S				N.S
Exp 2	0	28.50	29.50	30.00	29.30	15.00	15.30	16.00	15.40	21.50	24.50	26.00	24.00
	Zinc 1.5 kg Zn fed^{-1}	30.80	31.00	30.50	30.80	23.00	23.00	23.50	23.20	24.80	24.30	26.80	25.30
	3.0 kg Zn fed^{-1}	30.80	31.00	32.30	31.30	28.00	31.80	33.50	31.10	29.30	30.80	31.80	30.60
	Mean	30.00	30.50	30.90	30.50	22.00	23.30	24.30	23.20	25.20	26.50	28.20	26.60
	L.S.D.at 0.05	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S
	Zinc (Zn)				N.S				N.S				N.S
	Application date (D)				N.S				N.S				N.S
	Zn x D				N.S				N.S				N.S
Exp 3	0	29.00	29.00	30.00	29.30	12.50	12.80	14.00	13.10	21.50	23.50	25.50	23.50
	Manganese 1kg Mn fed^{-1}	29.50	30.00	30.50	30.00	18.50	18.00	16.80	17.80	29.50	32.30	34.00	31.90
	2k g Mn fed^{-1}	31.80	31.00	31.50	31.40	19.80	16.50	20.00	18.80	33.00	34.80	35.50	34.40
	Mean	30.10	30.00	30.70	30.30	16.80	15.80	16.90	16.50	28.00	30.20	31.70	29.90
	L.S.D.at 0.05	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S
	Manganese (Mn)				N.S				N.S				N.S
	Application date (D)				N.S				N.S				N.S
	Mn x D				N.S				N.S				N.S
Exp 4	0	31.00	32.70	32.50	32.00	14.20	16.70	16.50	15.80	21.70	23.50	25.00	23.40
	Mix. 0.5 + 1.5+ 1 kg fed^{-1}	34.70	36.20	34.70	35.20	20.70	23.70	22.70	22.40	27.20	29.20	30.50	29.00
	1 + 3 + 2 kg fed^{-1}	34.50	35.20	35.00	34.90	27.70	28.70	33.50	30.10	33.00	34.50	35.50	34.30
	Mean	33.40	34.70	34.07	34.03	20.87	23.03	24.23	22.77	27.30	29.07	30.33	28.90
	L.S.D.at 0.05	N.S	N.S	N.S	N.S	N.S	N.S	N.S	2.46	N.S	N.S	N.S	N.S
	Mixture				N.S				N.S				N.S
	Date				N.S				N.S				N.S
	Mix. x D				N.S				2.46				N.S

Application time showed no significant effect on Zn content in leaves in spite of some slight increases observed at later application.

The interaction between levels and times of applying micronutrients mixture had significant effect on Zn content in sugar beet root. The results indicated that threw lower level of the mixtures was more effective when applied after 50 days, whereas the higher level of the mixture showed higher effect when applied after 75 days. The highest Zn content in sugar beet roots by applying 1 kg B + 3 kg Zn + 2 kg Mn fed^{-1} at 75 days from sowing.

The considerable effect of Zn application on Zn content did not reach the significant level probably due to the small number of replications devoted for the chemical analysis. Also, results reported by *Rosell and Ulrich, (1964)* and *Abd EL- Daiem,et al., (2015 a)* indicated that the critical level of Zn in sugar beet tissues was 9-10 ppm when plants were sampled after 6 weeks from sowing.

Consequently, the Zn level in the experimental site was quite satisfactory to supply the sugar beet plants with their needs of Zn since the leaves of check plants contained more than the critical content.

Manganese content in leaves:-

Results in Table (4) showed that neither micronutrients levels nor application times significantly affected Mn content in sugar beet leaves at harvest. Also, the interaction level x time had no significant effect on Mn content in leaves.

The results show some increases in Mn content due to Mn application either in single or mixed application. These results reported by Tsolova and Peneva, (1992) and Abd EL- Daiem,et al., (2015 a) showed that the greatest amount of Mn in sugar beet plants was 18.8 g ha^{-1}, (equivalent to 7.9 g fed^{-1}). The amount can be readily available in the experimental soil.

A3. Boron, Zn and Mn (mg kg^{-1}) in sugar beet roots:-

The results for the effects of the application of B, Zn, Mn and their mixtures at two levels and three application dates on B, Zn and Mn contents in sugar beet roots at harvest are presented in Table (5) combined analysis of the two growing seasons 2012/2013and 2013/2014.

Boron content in roots:-

Results in Table (5) showed that macronutrients levels, application time and their interaction had no significant effects on B content in sugar beet at harvest. It was observed that very slight increases were found in

B content particularly when B was applied alone or mixed with Zn and Mn. The results showed that roots of B treated plants. It could be concluded that B application slightly increased B content in sugar beet roots.

Time of application did not significantly affect B content. The differences among B concentration values due to application date showed no specific trend. Therefore, analysis of the check plants show clearly that the experimental soil contained adequate level of available B.

Result reported by Morsy and Taha, (1986), Alaa *et al.,* (2009), Awad et al.,(2013 a) and Abd EL-Daiem,*et al.,* (2015 a) indicated that B application to sugar beet markedly increased B content in roots.

Zinc content in roots:-

Results in Table (5) indicated that Zn applied or mixed with B and Mn at both application levels insignificantly increased Zn content in sugar beet roots at harvest. The results revealed that Zn content in roots of sugar beet treated plants. These marked increases were however, below the level of significance.

The application of Zn was associated a significant effect on Zn content in roots. Application of the lower Zn level (1.5 kg fed^{-1}) at 50 days age was more effective on Zn content, whereas the higher Zn level (3 kg fed^{-1}) was equally effective when applied after 50 or 105 days.

The interaction between Mn level and Mn application time significantly affected Zn content in roots. The highest Zn content was 15.3 mg kg^{-1} which was recorded with the higher Mn level applied either at 50 or 75 days. It could be concluded that Zn content in sugar beet roots was favorably affected by the application of Zn either alone or mixed with B and Mn. The present results is in general agreement with that obtained by Rustskaya *et al.,* (1981), Awad *et al.,*(2013 a) and Abd EL- Daiem,*et al.,* (2015 a).

Table (5) Effect of levels and application time of boron, zinc, manganese and their mixtures on boron (B), zinc (Zn) and manganese (Mn) concentrations (mg kg^{-1}) of sugar beet roots at harvest. (combined analysis of the two growing seasons 2012/2013 and 2013/2014).

Experiments	Traits	Root B mg kg^{-1} Application time				Root Zn mg kg^{-1} Application time				Root Mn mg kg^{-1} Application time			
	B,Zn,Mn and Mixture Level	At sowing	50 DAS	75 DAS	Mean	At sowing	50 DAS	75 DAS	Mean	At sowing	50 DAS	75 DAS	Mean
Exp 1	0	8.70	9.70	10.70	9.70	10.00	11.00	12.00	11.00	15.20	16.50	17.00	16.20
	Boron 0.5 kg B fed^{-1}	11.70	11.70	12.20	11.90	12.00	12.20	13.70	12.60	15.70	16.00	16.70	16.10
	1 kg B fed^{-1}	13.70	14.70	14.50	14.30	13.70	13.70	14.20	13.90	17.70	19.00	21.70	19.50
	Mean	11.40	12.00	12.50	12.00	11.90	12.30	13.30	12.50	16.20	17.10	18.50	17.30
	L.S.D.at 0.05 level	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S
	Boron (B)				N.S				N.S				N.S
	Application date (D)				N.S				N.S				N.S
	B xD				N.S				N.S				N.S
Exp 2	0	9.80	9.00	9.00	9.30	8.00	11.00	12.00	11.00	14.50	15.80	17.00	15.80
	Zinc 1.5 kg Zn fed^{-1}	10.50	10.30	11.50	10.80	13.50	17.00	15.50	15.30	15.80	16.00	17.30	16.30
	3.0 kg Zn fed^{-1}	11.30	12.00	13.30	12.20	16.30	18.80	18.80	17.90	17.30	17.50	20.30	18.30
	Mean	10.50	10.40	11.30	10.70	13.30	15.60	15.40	14.80	15.80	16.40	18.20	16.80
	L.S.D.at 0.05	N.S	N.S	N.S	N.S	N.S	N.S	N.S	1.19	N.S	N.S	N.S	N.S
	Zinc (Zn)				N.S				N.S				N.S
	Application date (D)				N.S				1.19				N.S
	Zn x D				N.S				N.S				N.S
Exp 3	0	9.50	9.00	8.80	9.10	9.80	10.80	11.80	10.80	22.00	22.50	22.50	22.30
	Manganese 1kg Mn fed^{-1}	10.50	10.50	10.30	10.40	12.50	13.80	12.50	12.90	22.00	23.00	25.00	23.30
	2k g Mn fed^{-1}	11.00	10.80	12.00	11.30	13.50	15.30	15.30	14.70	22.50	23.50	25.00	23.70
	Mean	10.30	10.10	10.30	10.30	11.90	13.30	13.20	12.80	22.20	23.00	24.20	23.10
	L.S.D.at 0.05	N.S	N.S	N.S	N.S	N.S	N.S	N.S	1.20	N.S	N.S	N.S	N.S
	Manganese (Mn)				N.S				N.S				N.S
	Application date (D)				N.S				N.S				N.S
	Mn x D				N.S				1.20				N.S
Exp 4	0	10.00	10.00	10.00	10.00	9.70	11.70	13.50	11.60	22.20	23.00	24.20	23.10
	Mix. 0.5 + 1.5+ 1 kg fed^{-1}	13.00	13.20	13.50	13.20	13.00	15.70	17.50	15.40	21.50	22.50	24.00	22.60
	1 + 3 + 2 kg fed^{-1}	14.50	13.50	14.70	14.20	17.70	19.50	19.70	19.00	23.00	23.50	25.00	23.80
	Mean	12.50	12.20	12.70	12.50	13.50	15.60	16.90	15.30	22.20	23.00	24.40	23.10
		N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S
	Mixture				N.S				N.S				N.S
	Date				N.S				N.S				N.S
	Mix. x D				N.S				N.S				N.S

Manganese content in roots:-

Results in Table (5) showed that all experimental factors and their interaction did not significantly affect Mn content in sugar beet roots at harvest. The results here followed the same pattern of response as shown with Mn content in leaves. Insignificant increases in Mn content in sugar beet roots followed the application of Mn either singly of mixed with B and Zn. Time of application of micronutrients had no significant effect on Mn content in roots.

Also, levels x times of micronutrients application did not significantly affect Mn content in roots. Generally, it was observed that slight increases in Mn content followed the later application of all nutrients and the increases in micronutrients level.

This general trend could be detected from the results in Table (5), where the highest values of Mn content in roots were recorded with the higher B, Zn, Mn and B + Zn + Mn level combined with the latest application at 75 days age.It could be concluded that micronutrients in general and Mn in particular insignificantly increased Mn content in sugar beet roots at harvest.

The results obtained by Alaa et al., (2009) and Awad et al.,(2013 a)as well as Abd EL- Daiem,et al., (2015 a**)** showed that Mn application increased Mn content in sugar beet tops and roots.

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إستجابة جودة محصول بنجر السكر لبعض المغذيات الصغري تحت ظروف الأراضي الرملية.

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****معهد بحوث المحاصيل السكرية - مركز البحوث الزراعية - الجيزة- مصر**

أجريت أربع تجارب حقلية بمنطقة قلابشو-محافظة الدقهلية خلال موسمى 2013/2012 و 2014/2013 لدراسة تأثير إضافة البورون و الزنك والمنجنيز ومخلوط منهماا على التركيب الكيماوى ونوعية الناتج النهائى لبنجر السكر صنف سلطان.

وقد تضمنت كل تجربة من التجارب الأربع تسعة معاملات عبارة عن التوافق بين ثلاثة مستويات من العنصر وثلاثة مواعيد للإضافة.

وقد كان التصميم المستخدم قطاعات كاملة العشوائية.

وكانت التجارب الأربعة كالتالى:-

1-التجربة الأولى إضافة البورون بمعدلات صفر و 0.5 و 1.00 كجم/للفدان وأضيف البورون على صورة (بوراكس)بورات صوديوم.

2-التجربة الثانية إضافة الزنك بمعدلات صفر و1.50 و 3.00 كجم/للفدان وأضيف الزنك على صورة كبريتات زنك.

3-التجربة الثالثة إضافة المنجنيز بمعدلات صفر و1 و2 كجم/للفدان وأضيف المنجنيز على صورة كبريتات منجنيز.

4- التجربة الرابعة إضافة مخلوط من العناصر الثلاثة السابقة بنفس المعدلات المذكورة مجتمعة.

وكانت مواعيد إضافة العناصر شاملة ثلاثة مواعيد هى:-

1- إضافة ارضية مرة واحدة عند الزراعة.

2- إضافة ارضية مرة واحدة بعد 50 يوم من الزراعة.

3- إضافة ارضية مرة واحدة بعد 75يوم من الزراعة.

ويمكن إيجاز أهم نتائج التحليل الإحصائى المتجمع للموسمين فى النقاط التالية:

أولا: تأثير إضافة المغذيات الصغرى على جودة العصير:-

أ - أدت إضافة البورون بمعدل 0.5 كجم/للفدان لنقص النسبة المئوية للمواد الصلبة الذائبة الكلية فى العصير بينما لم تؤدى إضافة الزنك والمنجنيز ومخلوط العناصر الى تأثير معنوى على هذه الصفة.

ب - لم تؤثر جميع معاملات العناصر الغذائية الصغرى على النسبة المئوية للسكروز فى العصير عند الحصاد.

ج - أدت إضافة المنجنيز بمعدل 2.0 كجم/للفدان لزيادة النسبة المئوية لنقاوة العصير عند الحصاد.

ثانيا: تاثير إضافة المغذيات الصغرى على التركيب الكيماوى:-

أ - أدت إضافة الزنك وخاصة بالمعدل الأعلى الى زيادة معنوية لمحتوى الأوراق من البوتاسيوم كما أدت إضافة مخلوط المغذيات الصغرى بالمعدل الأقل الى زيادة محتوى بنجر السكر من الأزوت عند الحصاد.

ب - لم تؤثر المغذيات الصغرى على محتوى كل من الأوراق وجذور بنجر السكر من البورون والمنجنيز والزنك تأثيرا معنويا.

ثالثا: تأثير إضافة المغذيات الصغرى على الإنتاجية:-

لوحظ أن كل المغذيات الصغرى البورون والزنك والمنجنيز وعند كل مستويات الإضافه ومع مواعيدالإضافه كان لها تأثيرا معنويا على إنتاجية الجذور وإنتاجية السكر.

ب- لوحظ أيضا أن المخلوط من هذه المغذيات وبزيادة مستويات الإضافه أدت إلى زياده معنويه فى الإنتاج لكل من محصول الجذور للبنجروبالتالى إنتاجية السكر.

توصى هذه الدراسة بالرش بمخلوط من العناصر الثلاثة السابقة بنفس المعدلات المذكورة مجتمعة وخصوصا فى هذة الأراضى حديثة الاستزراع.