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EVALUATION OF SOME MICRONUTRIENTS ROLE ON SUGAR BEET PRODUCTIVITY AND QUALITY

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ABSTRACT

Two field trials were carried out at El-Manyal Village, Talkha District, Dakahlia Governorate during 2012/2013 and 2013/2014 seasons to evaluate the role of three micronutrients "iron (Fe) at the rate of 0, 250 and 500 ppm, zinc (Zn) at the rate of 0, 100 and 200 ppm and boron (B)" at the rate of 0, 100 and 200 ppm on productivity and quality of sugar beet, cv. "Kawemira". A split-split plot design with four replicates was used in these experiments.The main results could be summarized as follows:

1- Raising iron (Fe) rates from 0.0 to 500 ppm (0.0 to 200 g/fad.), significantly increased all studied characters over both seasons, except for the percentages of root sucrose and root juice apparent purity in both seasons, where it significantly decreased root juice apparent purity in the first season, while it resulted in insignificant effects on the percentages of root sucrose in both seasons and the percentage of root juice apparent purity in the second season.
2- Raising zinc (Zn) concentrations from 0.0 to 200 ppm (0.0 to 40 and 80 g/fad.) resulted in gradual significant increases in all studied characters over the two seasons, except for root juice apparent purity %, which was significantly decreased in the first season, while it was insignificantly decreased in the second season.
3- Raising boron (B) concentrations from 0.0 to 100 and 200 ppm (0.0 to 40 and 80 g/fad), markedly increased all studied characters over both seasons, except root juice apparent purity %, which was insignificantly decreased in both seasons.
4- Root length (cm) and sugar yield (t/fad) were significantly affected by the interaction between the concentrations of both iron (Fe) and zinc (Zn) in the second season.

Generally, it could be concluded that spraying beet plants with iron (Fe) at rate of 200 g/fad. and 80 g/fad. of each one of zinc (Zn) and boron (B) is the suitable conclusion to maximize its productivity and quality under the environmental conditions of Dakahlia Governorate.

Keywords: Sugar beet, *Beta vulgaris* L., Micronutrients, Fe., Zn., B., yield, quality.

INTRODUCTION

In spite of cheapness of all micronutrients and its major roles in the field of crops production, our Egyptian farmers usually don`t interest in it. Some researchers studied the effect of micronutrients as Cooke and Scott (1993) who revealed that root fresh weight, sucrose % and root and top yields significantly increased by increasing boron levels. Karamvandi (1997) revealed that consumption of 20 kg/ha., borax can result in increases in root yield from 45.29 to 48.82 t/ha., sucrose concentration from 16.72 to 17.93% and yield of white sugar from 6.064 to 7.339 t/ha. Jaszczolt (1998) and Gobarah and Mekki (2005) found that application of boron fertilizer to sugar beet significantly increased root yield, yield components and increased recoverable sugar percent and sugar yield, while decreased Na. and K. in root juice. Since the impurities decreased, the juice purity % increased. El-

Geddawy *et al.* (2000) showed that the application of different rates of boron (zero, 0.5 or 1.0 kg. B/fad.) and zinc (zero, 1.0, 2.0, 3.0 or 4 kg. Zn/fad.) increased root yield, purity and the most consistent sucrose. Saif (2000) used four levels of boron (zero, 0.50, 1.00 and 1.50 kg. B/fad.) and found that applied doses of boron produced significant effects on root fresh weight, root yield in both seasons. She added that it increased sucrose and juice purity percentages over this of unfertilized treatment in the first season. Omran *et al.* (2002) showed that boron fertilizer treatments as boric acid (foliar spraying at 0.05 and 0.10 %) had significant effects on growth characters such as root and top dry weight, leaf area and total chlorophyll content. The highest sucrose, sugar yield, extractable sugar percentage, sugar coefficient and the highest purity were obtained from spraying boron fertilizer at the rate of 0.10 %. Kristek *et al.* (2003) and Vince (2008) found that foliar application of boron increased sugar beet yield and sugar content. Abd El-Gawad *et al.* (2004) stated that spraying sugar beet plants with boron at the rate of 0.5 kg/fad., decreased TSS %, whereas it had no significant effect on sucrose. Enan (2004) found that boron application at the rate of 0.5 kg/fad., increased root fresh weight/plant, while mixture application of (0.5 kg. B/fad. + 4.0 kg Zn/fad.) increased root fresh weight/plant, leaves fresh weight/plant and the percentages of sucrose, potassium and purity in root juice. Stevens and Mesbah (2004) found that application of zinc, boron, iron and manganese increased root yield of sugar beet by 14% compared with the case of non application of these micronutrients. It did not, however, significantly increase when using boron alone. Mostafa and Omran (2006) stated that foliar spray with boron significantly increased photosynthetic pigments (chlorophyll, a, b and carotenoids), N.% and B (ppm) content in beet roots, improved juice quality, while it significantly decreased Na and alpha amino-nitrogen. Allen *et al.* (2007) stated that boron increased the rate of transport of sugars which are produced by photosynthesis in mature plant leaves to growing regions. El-Hosary *et al.* (2007) stated that increasing boron dose negatively affected the value of total soluble solids percentage, but it significantly increased both root sucrose and purity percentages. El-Geddawy *et al.* (2007) cleared that using boron significantly increased root dimensions and sugar beet yields of root, top and sugar/fad., in both seasons. El-Sheref (2007) reported that root length, root diameter, root and top yields, gross sugar yield, white sugar yield and juice purity percentage were significantly increased by increasing boron rate from 0.5 kg. to 1.0 kg. H_3BO_3/fad. On the other hand, losses yield decreased by increasing boron rate. Osman *et al.* (2007) found that application of boron alone or combination with zinc produced higher TSS%, sucrose % in sugar beet roots compared with those fertilized or unfertilized with zinc alone. Yarnia *et al.* (2008) stated that balanced and efficient use of micronutrients such as manganese (Mn), boron (B), zinc (Zn) and iron (Fe) can improve agricultural production and quality. Hellal *et al.* (2009) stated that spraying sugar beet plants with boron at the rate of 50 ppm significantly improved the parameters of root yield, above ground growth, nutrient contents and balanced ratio of sugar. Ferweez *et al.* (2011) stated that increasing boron concentrations from zero to 0.05 and 0.10 % significantly

increased root length and diameter (cm), the percentages of gross sugar, recovery sugar as well as root, gross and recovery sugar yields/fad., in both seasons. On the other side, it decreased the percentages of Na, K and alpha amino-nitrogen in roots in both seasons. Abido (2012) sprayed beet plants with boron in the form of boric acid at the rates of control (without), 40, 80 and 120 ppm boron and found that increasing boron concentrations up to 80 ppm significantly increased root fresh weight, root length and diameter, the percentages of total soluble solids, sucrose, apparent purity and root and sugar yields/fad. in both seasons. While, boron application at 120 ppm came in the second rank with respect to these characters. Armin and Asgharipour (2012) in Iran, sprayed beet plants with 0.0, 4, 8 and $12^{0}/_{00}$ boron and found that spraying with concentrations of 8 and $12^{0}/_{00}$ significantly increased both root and sugar yields/fad. Abd El-Azez (2014) found that increasing the sprayed rates of boron significantly increased all growth characters, root yield/fad. and its components as well as top and sugar yields/fad. in both seasons. El-Sheref (2014) stated that boron application significantly increased root length and diameter, the percentages of gross and white sugar in roots as well as the yields of root, gross sugar and white sugar/fad. in both seasons. On the contrary, it decreased lost sugar yield (t/fad.) and the percentages of sugar loss, K, Na and alpha amino-nitrogen in both seasons.
So, this investigation was conducted to evaluate the roles of three micronutrients (Fe., Zn. and B.) on sugar beet productivity and quality.

MATERIALS AND METHODS

Two field trials were executed at El-Manyal village, Talkha District, Dakahlia Governorate during the two successive winter seasons of 2012/2013 and 2013/2014 to evaluate the roles of three micronutrients "iron (Fe), zinc (Zn) and boron (B)" on productivity and quality of sugar beet variety Kawemira. A split-split plot design with four replicates was used. The main plots were assigned to the three concentrations of iron (Fe) zero, 100 and 200 g/fad. (It is equivalent to zero, 250 and 500 ppm, respectively), that it were sprayed at 90 days after sowing (DAS). The sub-plots were devoted to the three concentrations of zinc (Zn) zero, 40 and 80 g/fad (It is equivalent to zero, 100 and 200 ppm, respectively), that it were sprayed at 105 days after sowing. While, the sub-sub plots were devoted to the three concentrations of boron (B) zero, 40 and 80 g/fad. (It is equivalent to zero, 100 and 200 ppm, respectively), that it were randomly sprayed at 120 days after sowing.

Each experimental basic unit included five ridges, each of 60 cm width and 3.5 m length, which comprising an area of 10.5 m^2 (1/400 fad). The previous crop was maize (*Zea mays* L.) in both seasons. Soil samples were taken at random from the experimental field area at a depth of 0.0-30 cm from soil surface and prepared for both mechanical (physical) and chemical analysis. The mechanical (physical) and chemical properties of the experimental soil are presented in Table 1.

Table 1: Mechanical and chemical soil properties at the experimental site during the two growing seasons of 2012/2013 (I) and 2013/2014 (II).

Soil analysis	I	II
A: Mechanical properties:		
Fine sand (%)	9.60	10.20
Coarse sand (%)	5.30	4.90
Silt (%)	32.10	30.80
Clay (%)	52.90	54.00
Texture	Clayey	Clayey
B: Chemical analysis		
Soil reaction pH	7.60	7.70
Available N (ppm)	48.40	49.30
Available P (ppm)	11.50	12.00
Exchangeable K (ppm)	140.00	130.00

The experimental field area was well prepared through three ploughings, leveling, compaction and then dividing into the experimental units. Both calcium superphosphate (15.5 % P_2O_5) and potassium sulphate (48.0% K_2O) at the rates of 31.0 and 24.0 kg/fad., respectively were added before the last ploughing. Sowing of dry sugar beet balls took place in the dry soil during the first week of September in both seasons. The experimental field area was immediately irrigated after sowing. Nitrogen in the form of urea (46.5% N) at the rate of 80 kg N/fad., was added in two equal doses at the first and second irrigations after thinning. Plants were kept free from weeds, which were manually controlled by hand hoeing for three times. All normal agricultural practices with the exception of the studied factors were conducted as usually done for growing sugar beet according to the recommendations of Ministry of Agriculture and Land Reclamation.

Studied characters:

A- Root attributes and quality parameters:

At harvest time (210 days after sowing), ten plants were randomly chosen from the three inner ridges of each sub-sub plot to estimate root yield attributes and quality parameters as follows:

1. Root fresh weight (g/plant).
2. Root length (cm).
3. Root diameter (cm).
4. Total soluble solids percentage (TSS %) in roots. It was measured in juice of fresh roots by using Hand Refractometer.
5. Sucrose percentage. It was determined Polarimetrically on a lead acetate extract of fresh macerated roots according to the method of Carruthers and OldField (1960).
6. Apparent purity percentage. It was determined as a ratio between sucrose % and TSS % of roots according to Carruthers and OldField (1960).

B- Root and sugar yields:

At harvest, all plants that produced from the three inner ridges of each sub-sub plot were collected and cleaned. Roots and tops were separated and weighed in kilograms, then converted to estimate:

1. Root yield (t/fad).
2. Sugar yield (t/fad). It was calculated by multiplying root yield by sucrose percentage.

All obtained data were statistically analyzed according to the technique of analysas of variance (AOV) for split-split plot design carried out as it was outlined by Gomez and Gomez (1984) by using means of “MSTAT-C” computer software package. Least Significant of Differences (LSD) method was used to test the differences between treatment means at 5% level of probability as described by Waller and Duncan (1969).

RESULTS AND DISCUSSION

1- Effect of iron (Fe) concentration:

Presented results in Table 2 clear that iron rates (concentrations) had significant effects on all studied characters in both seasons, except for the percentages of root sucrose in both seasons and root juice apparent purity in the second season. Raising iron concentrations from zero up to 500 ppm were associated with significant gradual increases in most of studied characters in both seasons, while root juice apparent purity in the first season was significantly decreased.

These positive results associated with the increase of iron concentrations might be due to the role of iron in; A) Increasing plant cells content of chlorophyll. B) Its share in formation of some enzymes such as peroxidase and catalase. C) Its share in the activity of some enzymes such as nitrate redoctase and nitrogenase. These results are in agreement with those stated by Yarnia *et al.* (2008).

2- Effect of zinc (Zn) concentration:

Listed results in Table 2 indicate that all studied characters were significantly affected by zinc concentrations (rates) in both seasons, except for root juice apparent purity in the second season. Increasing zinc concentration from zero to 200 ppm (from zero to 80 g/fad.) caused gradual increase in root fresh weight/plant, root dimensions (length and diameter), root and sugar yields/fad., the percentages of total soluble solids (TSS) and root sucrose in the two seasons. On the other side, it gradually decreased root juice apparent purity in the first season. The gradual increases in the previous mentioned characters might be due to the role of zinc through the following; A) Its share in starch formation. B) Its helping in the activity of starch synthetas. C) Its role in the tallness of plant stems. While, the gradual decrease in root juice purity in the first season because of the gradual increase in zinc concentration attributed to the fact that the increases in total soluble solids percentage were higher than the associated increases in sucrose percentage. These results are similar to those stated by Stevens and Mesbah (2004).

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3- Effect of boron (B) concentration:

The relevant results in Table 2 clear that all studied characters, except root juice apparent purity over both seasons were significantly affected by boron concentration (rate). There were positive relations between boron concentration and the changes in the mentioned studied characters in both seasons. These results may be due to the important biofunctions of boron inside beet plants as follows; A) Boron helps in translocation or transferring of sugar inside plants. B) It is very necessary in formation of plant cells. C) It plays a major role in formation of nuclic acids. and D) It has roles in formation and activity of hormones inside plants. Moreover, Mostafa and Omran (2006) and Allen *et al.* (2007) who stated that boron increased the rate of transport of sugars, which are produced by photosynthesis in mature plant leaves to actively growing regions. Similar results were stated by Cooke and Scott (1993), Karamvandi (1997), Gobarah and Mekki (2005), El-Geddawy et al. (2000), Saif (2000), Omran et al. (2002), El-Hosary et al. (2007), Abido (2012) and Armin and Asgharipour (2012).

4- Effect of the interaction:

Results in Table 2 show that all studied characters were not significantly affected by the interaction between or among the factors under study, except root length and sugar yield (t/fad) in the second season.

Results in Table 3 clear that both root length and sugar yield (t/fad) in the second season were significantly affected by the interaction between iron and zinc concentrations. The highest values of root length (31.90 cm) and sugar yield (6.819 t/fad.) were obtained from beet plants, which sprayed with 500 ppm Fe. and 200 ppm Zn.

Table 3: Root length (cm) and sugar yield (t/fad) as affected by the interaction between Fe. and Zn. concentrations during 2013/2014 (II) season.

Characters / Treatments	Root length (cm)			Sugar yield (t/fad)		
	Zn. concentrations					
	Without	100 ppm	200 ppm	Without	100 ppm	200 ppm
Fe. concentrations						
Without	27.46	27.63	27.96	5.637	5.808	5.962
250 ppm	28.43	29.13	29.53	6.081	6.334	6.466
500 ppm	29.73	30.03	31.90	6.548	6.620	6.819
F. test	*			*		
LSD at 5 %	0.65			0.345		

CONCLUSION

It could be concluded that spraying sugar beet plants with micronutrients (Fe, Zn and B) at the rates of 500, 200 and 200 ppm., respectively is the suitable recommendation to maximize its productivity and quality under the environmental conditions of Dakahlia Governorate.

REFERENCES

Abd El-Azez, Y.M (2014). Effect of yeast on sugar beet productivity under different levels of potassium and boron with wastes of sugar factories. Ph. D. Sc. Thesis, Fac. of Agric., Minia Univ.

Abd El-Gawad, A.M ; S.A.H. Allam ; L.M Saif and A.M.H. Osman (2004). Effect of some mincronutirents on yield and quality of sugar beet (*Beta vulgaris* L.). Juice quality and chemical compositions. Egypt. J. Agric. Res., 82(4): 1681-1701.

Abido W.A.E. (2012) Sugar beet productivity as affected by foliar spraying with methanol and boron. Int. J. of Agric. Sci., 4(7): 287-292.

Allen, V.B. ; J. David and E.D. Pilbeam (2007). Handbook of plant nutrition (Books in soils, plants and the environment). Boron by Umesh C. Gupta, pp: 241-278.

Armin, M and M Asgharipour (2012). Effect of time and concentration of boron foliar application on yield and quality of sugar beet. American-Eurasian J. Agric. & Environ. Sci., 12 (4): 444-448.

Carruthers, A. and J.F.T. OldField (1960). Methods for the assessment of beet quality. Int. Sugar J., 63: 72-74.

Cooke, D.A. and R.K. Scott (1993). The Sugar Beet Crop. Chapman and Hall London., pp:262-265.

El-Geddawy, I.H. ; A.A. El-Hosary ; A.M.M Saad and B.S. Ibrahim (2007). Effect of boron and molybdenum on growth and yield of some sugar beet varieties. Egypt. J. Agric., Res., 85(4): 1355-1366.

El-Geddawy, I.H. ; A.M Abd El-Hakim and Laila M Saif (2000). Multi variate analysis of yield and relative contribution of variables to its variation under some cultural practices in sugar beet. Egypt. J. Agric., Res., 78(1): 449-469.

El-Hosary, A.A. ; A.M.M Saad and I.H. El-Geddawy (2007). Effect of boron and molybdenum on chemical constituents and quality of some sugar beet varieties. Egypt. J. Agric. Res., 85(4): 1335-1353.

El-Sheref, Amira, E.E.M (2014). Effect of potassium and boon fertilization on yield and quality of sugar beet crop under different irrigation intervals in Northern Delta regions. Ph. D. Sc. Thesis, Fac. of Agric., Kafe El-Sheikh Univ.

El-Sheref, E.El. Amira (2007). Studies on yield and quality of sugar beet crop. M Sc. Thesis, Fac. of Agric., Kafe El-Sheikh Univ.

Enan, S.A.A.M (2004). Effect of transplanting and soil application of boron and zinc on yield and quality of sugar beet. Ph. D. Sc. Thesis, Fac. of Agric., Al-Azhar Univ. Cairo.

Ferweez, H. ; M.F. Ibrahim and A.M Elwan (2011-b). Improving yield and quality of sugar beet using boron at different levels of nitrogen fertilizer. Alexandra Sci. Exe. J., 32(1): 51-57.

Gobarah, Mirvat, E. and B.B. Mekki (2005). Influence of boron application on yield and juice quality of some sugar beet cultivars grown under saline soil conditions. J. App. Sci. Res., 1(5):373-379.

Gomez, K.N. and A.A. Gomez (1984). Statistical procedures for agricultural research. John Wiley and Sons, New York, 2nd Ed., 68 P.

Hellal, F.A. ; A.S. Taalab and A.M Safaa (2009). Influence of nitrogen and boron nutrition balance on sugar beet yield grown in calcareous soil. Ozean J. App. Sci., 2(1):1-10.

Jaszczolt E. (1998). Effect of two methods of fertilizing sugar beet with trace elements on the yields of roots and sugar. Gazeta-Cukrownicza, 106:232-234.

Karamvandi, A. (1997). Effects of optimum fertilizer consumption in increasing sugar beet production at region of Saveh and Karaj. M Sc. Thesis., Soil Sci. Dept., Tarbiat Modarres Univ.

Kristek, A. ; C.M Anlumovic ; A. Brkic and J. Kanisek (2003). Effect of foliar feed with boron and magnesium on sugar beet yield indicators. Listy. Cukrovarnicke A. Reparsk., 4:106-108.

Mostafa, Z.I. and S.E. Omran (2006). Effect of foliar spray with boron or magnesium in combination with nitrogen fertilization on sugar beet plants. Egypt. J. of Soil Sci., 64(2): 115-129.

Omran, S.E.H. ; A.H. El-Guibali and K.A. Aboshady (2002). Effect of zinc and boron application at different rates and methods on sugar beet plants. Annals of Agric. Sci. Moshtohor, 40(3): 1865-1875.

Osman, M.S. ; I.H. El-Geddawy ; M.G.A. Taha and S.A.A.M Enan (2007). Transplanting using paper box technique and micro-nutrition with relation to juice quality and chemical constituents sugar beet at different planting methods. Egypt. J. Agric. Res., 85(1): 211-229.

Saif, L.M (2000). Stepwise regression and path coefficient analysis for some sugar beet characters under levels of boron and nitrogen fertilization. Proc. 9th Conf. Agron. Minufiya Univ., 1-2 Sept. 2000. Pp:569-581.

Stevens, W.B. and A.O. Mesbah (2004). Zinc enhances sugar beet emergence and yield on a calcareous soil with marginal zinc availability. Crop Management, August, pp: 1-6.

Vince, L. (2008). Effect of boron fertilizer on sugar beet grown on fruit- field sand soil. Iowa State Univ., Muscatine Island Res., & Demons Farm ISRF09-20.

Waller, R. A. and D. B. Duncan (1969). A bays rule for symmetric multiple comparison problem Amer. Stat. Assoc. J. 1485-1503.

Yarnia, M ; M.B.K. Beam ; H.K. Rabat ; E.F.M Tabriz and D. Hassanpanah (2008). Effects of complete micronutrients and their application method on root yield and sugar content of sugar beet cv. Rassoul. J. Food Agric. and Environ., 6(3&4): 341-345.

تقييم دور بعض المغذيات الصغرى على إنتاجية وجودة بنجر السكر

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أقيمت تجربتان حقليتان بقرية المنيل – مركز طلخا – محافظة الدقهلية خلال موسمى الزراعة ٢٠١٢/٢٠١٣ و ٢٠١٣/٢٠١٤ م - لدراسة تأثير الرش بثلاث عناصر غذائية صغرى هى الحديد بمعدلات صفر ، ٢٥٠ ، ٥٠٠ جزء/المليون – والزنك بمعدلات صفر ، ١٠٠ ، ٢٠٠ جزء/المليون وكذلك البورون بمعدلات صفر ، ١٠٠ ، ٢٠٠ جزء/المليون على إنتاجية وجودة بنجر السكر (صنف كواميرا). نفذت التجارب فى تصميم القطع المنشقة مرتين فى أربع مكررات – حيث وزعت معدلات عنصر الحديد على القطع الرئيسية – كما وزعت معدلات عنصر الزنك على القطع الشقية الأولى – بينما وزعت معدلات عنصر البورون عشوائياً على القطع الشقية الثانية. ويمكن تلخيص أهم النتائج المتحصل عليها فيما يلى:

١- أدت زيادة معدلات عنصر الحديد من صفر إلى ٥٠٠ جزء/المليون إلى زيادة معنوية فى جميع الصفات المدروسة فى كلا الموسمين فيما عدا محتوى الجذور من السكروز والنسبة المئوية لنقاوة العصير حيث أدت نفس المعاملة إلى نقص معنوى فى النسبة المئوية لنقاوة العصير فى الموسم الأول. بينما لم يكن التأثير معنوياً فى الموسم الثانى- وكذلك لم يكن التأثير معنوياً أيضاً لمحتوى الجذور من السكروز فى الموسمين.

٢- أدت زيادة معدلات عنصر الزنك من صفر إلى ٢٠٠ جزء فى المليون إلى زيادة معنوية فى جميع الصفات تحت الدراسة خلال الموسمين فيما عدا النسبة المئوية لنقاوة العصير بالجذور خلال الموسمين- حيث سببت نقصاً معنوياً بها فى الموسم الأول. بينما لم يكن النقص معنوياً فى الموسم الثانى.

٣- أدت زيادة معدلات عنصر البورون من صفر إلى ٢٠٠ جزء فى المليون إلى زيادة معنوية فى جميع الصفات تحت الدراسة خلال الموسمين فيما عدا النسبة المئوية لنقاوة العصير بالجذور خلال الموسمين- فلم يكن التأثير معنوياً خلال الموسمين.

٤- أظهرت النتائج المتحصل عليها وجود تأثيراً معنوياً للتفاعل بين معدلات كل من عنصرى الحديد والزنك خلال الموسم الثانى فقط لكل من طول الجذر ومحصول السكر/فدان – حيث تم الحصول على أعلى القيم لكل من هاتين الصفتين عند رش نباتات بنجر السكر بعنصر الحديد بمعدل ٥٠٠ جزء/مليون مع الرش أيضاً بعنصر الزنك بمعدل ٢٠٠ جزء/المليون.

بصفة عامة توصى هذه الدراسة برش نباتات محصول بنجر السكر بكل من عناصر الحديد بمعدل ٥٠٠ جزء/المليون والزنك بمعدل ٢٠٠ جزء/المليون والبورون أيضاً بمعدل ٢٠٠ جزء/المليون للحصول على أعلى إنتاجية وجودة تحت الظروف البيئية بمحافظة الدقهلية.

Table 2: Root fresh weight, root length and diameter, root and sugar yields/fad and the percentages of total soluble solids (TSS), sucrose and juice purity as affected by micronutrients (Fe, Zn and B) concentration and their interactions during 2012/2013 (I) and 2013/2014 (II) seasons.

Characters / Treatments	Root fresh weight (g/plant)		Root length (cm)		Root diameter (cm)		TSS (%)		Sucrose (%)		Purity(%)		Root yield (t/fad.)		Sugar yield (t/fad.)	
	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II
A- Iron (Fe) concentration:																
Without	925.0	1032.7	27.35	27.68	10.94	10.92	22.20	22.43	17.74	17.86	79.92	79.67	31.974	32.457	5.678	5.802
250 ppm	994.4	1086.3	29.07	29.03	11.93	11.78	22.85	22.94	17.97	18.11	78.71	78.98	33.594	34.711	6.044	6.294
500 ppm	1067.2	1138.8	30.35	30.55	12.33	12.61	23.04	23.13	17.78	17.93	77.22	77.61	35.100	37.118	6.253	6.662
F. test	*	*	*	*	*	*	*	*	NS	NS	*	NS	*	*	*	*
LSD at 5 %	12.7	19.3	0.63	0.38	0.33	0.47	0.47	0.31	-	-	0.92	-	0.964	0.710	0.337	0.208
B- Zinc (Zn) concentration:																
Without	977.7	1063.6	28.46	28.54	11.57	11.47	22.28	22.47	17.65	17.73	79.26	79.00	32.930	34.284	5.823	6.088
100 ppm	994.4	1086.6	28.93	28.93	11.71	11.84	22.61	22.88	17.81	18.03	78.77	78.87	33.599	34.659	5.986	6.254
200 ppm	1014.4	1107.7	29.38	29.80	11.92	12.01	23.20	23.15	18.04	18.14	77.82	78.39	34.139	35.343	6.167	6.416
F. test	*	*	*	*	*	*	*	*	*	*	*	NS	*	*	*	*
LSD at 5 %	14.4	11.8	0.57	0.37	0.21	0.29	0.25	0.26	0.25	0.27	0.62	-	1.022	0.757	0.234	0.199
C- Boron (B) concentration:																
Without	967.2	1065.0	28.33	28.45	11.42	11.31	21.60	22.01	17.05	17.45	78.97	79.28	32.805	33.872	5.597	5.915
100 ppm	999.4	1089.1	29.01	29.15	11.76	11.83	22.82	22.96	17.92	18.01	78.54	78.50	33.622	34.772	6.029	6.264
200 ppm	1020.0	1103.8	29.44	29.66	12.02	12.18	23.66	23.52	18.53	18.45	78.34	78.48	34.240	35.643	6.349	6.579
F. test	*	*	*	*	*	*	*	*	*	*	NS	NS	*	*	*	*
LSD at 5 %	19.2	20.8	0.56	0.60	0.31	0.35	0.38	0.32	0.21	0.37	-	-	1.090	0.647	0.232	0.184
D- Interactions:																
A × B	NS	NS	NS	*	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	*
A × C	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
B × C	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
A × B × C	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS