EFFECT OF SOME MICRONUTRIENTS ON YIELD AND QUALITY OF SUGAR BEET (*BETA VULGARIS L.*)
II. JUICE QUALITY AND CHEMICAL COMPOSITIONS

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Abstract

Field experiments were carried out at Sakha Agricultural Research Station, Kafr El-Sheikh Governorate, in 1993/94 and 1994/95 seasons to study the effect of B, Zn, Mn and their mixtures on juice quality and chemical composition of sugar beet var. Ras Poly. Each of the four experiments included 9 treatments which were the combination of 3 micro nutrient levels and three dates of application zero, 0.5 and 1.0 kg B/fed; zero, 3 and 6 kg Zn/fed; zero, 20 and 40 g Mn/fed. Dates of application with all micronutrients were at sowing, 90 days and 105 days. Micro elements 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 study could be summarized as follows:

Boron application at 0.5 kg/fed 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.

Mn application at 40 g/fed significantly raised purity% at harvest. Late application of all micronutrients mixture favourably affected purity% at harvest compared with early application.

The results indicated a significant increase in N% in leaves due to application of a mixture containing 0.5 kg B + 3 kg Zn + 20 g Mn/fed compared with the check treatments and the highest level as well. Significant effect was observed for application date of 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. 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 date had significant effect on B, Zn and Mn in sugar beet leaves and roots at harvest.

INTRODUCTION

The limited available microelements resources in the arid and semi-arid regions represent the limitation of the agricultural dexelopment in such regions. The perfect application of the microelements resources is needed. The proper application of microelements depends mostly on their effect on crops.

Regarding the effect of boron fertilizer, Rutskaya *et al.* (1981) studied the effect of applied B on the content of micronutrients in leaves and roots of sugar beet. Morsy and Taha (1986) claimed that the addition of B 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 attained the best results. Saif (1991) reported that soil application of 0.5 kg B/fed gave the highest value of sucrose, TSS and purity%. Tsolova and Peneva (1992) estimated the concentration of B 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 trops and decreased in roots, the large amount of B was 5.0 g/ha.

Zinc fertilizer effects, 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. Rutskaya *et al.*(1981) studied the effect of applied 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. Saif (1991) reported that soil application of 4 kg Zn/fed gave the highest value of sucrose, TSS and purity%. Tsolova and Peneva (1992) estimated the concentration of Zn 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.

Manganese effects, Morsy and Taha (1986) claimed that the addition of 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 0.1 % $MnSO_4$ three times attained the best results. 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. Tsolova and Peneva (1992) estimated the concentration of 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 trops and decreased in roots. Mn concentration in tops increased to a peak, the large amount of Mn was 18.8 g/ha.

Mixture effects, 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 % $MnSO_4$ attained the best results. Saif (1991) reported that soil application of 0.5 kg B/fed and/or 4 kg Zn/fed 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 trops 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 respectively and the greatest amount of Zn was 44.7 g/ha. This investigate aimed to study the effect of some micronutrients on yield and quality of sugar beet (*Beta vulgaris L.*).

This investigate aimed to study the effect of some micronutrients on(1). yield and(2). quality of sugar beet (*Beta vulgaris L.*).

MATERIALS AND METHODS

Four field trials were carried out in Sakha Agricultural Research Station, Kafr El-Sheikh Governorate in 1993/1994 and 1994/1995 seasons. The field trials aimed to study the effect of some micronutrients on juice quality and chemical composition of sugar beet (*Beta vulgaris* L.). The experiments were carried out in a clay soil. The chemical and mechanical analysis of the experimental soil are presented in Table (1). Each experiment included 9 treatments which were the combination between 3 levels of the micro nutrient and 3 dates of soil application, as follows:

Experiment 1: This experiment included 3 levels of boron which were zero, 0.5 and 1 kg B/fed. Boron was applied as sodium borate 11% B.

Experiment 2: This experiment included 3 levels of zinc which were zero, 3 and 6 kg Zn/fed. Zinc was applied as zinc sulfate 22% Zn.

Experiment 3: This experiment included 3 levels of manganese which were zero, 20 and 40 g Mn/fed. Manganese was applied as manganese sulfate 33% Mn.

Experiment 4: This experiment included 3 levels of micro nutrient mixtures which were zero, 0.5 kg B + 3 kg Zn + 20 g Mn/fed. and 1 kg B + 6 kg Zn + 40 Mn/fed.

Dates of application for all experiments were at planting, after 90 and 105 days from planting. All micronutrients either singly or mixed were applied once as soil application after complete mixing with appropriate amounts of sand, according to date of application. The commercial sugar beet variety Ras-Poly was used in the four trials. Planting was done on the 15th of November in both growing seasons. Harvest was followed after 7 months in both seasons. Nitrogen fertilizer was applied at 70 kg N/fed., as ammonium nitrate 33.5% N, phosphours fertilizer at 30 kg P_2O_5/fed. as calcium superphosphate 15.5 % P_2O_5/fed and potassium fertilizer at 48 kg K_2O/fed. as potassium sulphate 48 % K_2O in both seasons. Phosphoruis fertilizer was applied at seedbed preparation whereas nitrogen and potassium fertilizers were applied in split application in two equal doses, the first dose after thining and the second dose was applied one month later. The experiments were laid out in complete randomized block design with four replications. Plot area was 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 both seasons. All cultural practices for growing sugar beet were done as recommended for the region.

At harvest, 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 percentage 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 grinded and kept for chemical determinations. Dry samples of 0.1 g each were wet digested using 5 ml concentrated sulfuric acid and perchloroic acid as a catalyst. The solution was diluted to 100 ml in volumetric flask using distilled water for the following analysis.

Table 1. Chemical and mechanical analysis of experimental soil for 1993/1994 and 1994/1995 seasons.

Season / Soil depth (cm)	1993/1994 0-15	1993/1994 15-30	1994/1995 0-15	1994/1995 15-30
Partial soil distribution				
Sand %	28.90	25.80	32.10	35.30
Silt %	40.30	41.90	39.90	38.90
Clay %	30.80	32.30	28.00	25.80
Available N ppm	40.00		37.15	
Chemical analysis in soil extraction				
a) Cations mg/L				
Ca	0.15	0.20	0.15	0.17
Na	0.13	0.31	0.35	0.49
K	0.12	0.04	0.10	0.21
b) Anions mg/L				
Cl	0.13	0.16	0.18	0.21
SO_4	0.09	0.10	0.13	0.22
CO_3	0.10	0.20	0.21	0.33
Available B	0.35 ppm		0.33 ppm	
Available Zn	0.55 ppm		0.57 ppm	
Available Mn	6.20 ppm		5.85 ppm	
Available Fe	10.00 ppm		9.45 ppm	

1. Nitrogen contents in leaves and roots were determined using micro kjeldahl apparatus according to Pergl (1945).
2. Potassium contents in leaves and roots were determined in the digested solution according to Brown and Lilliand (1964).
3. Boron in mg/100 g dry matter was estimated colorimitrically using Azomethine-H at 420 nm according to John *et al.* (1975).
4. Zn and Mn in mg/100 g dry matter were determined as described in flame Method, Manual for Atomic Absorption, Model 22 Brooklyn AVE at 213 nm as given by the (A.O.A.C., 1990).

Statistical analysis:

The data were exposed to the proper statistical analysis of variance of complete randomized block design according to Snedecor and Cochran (1967). For comparison among means, L.S.D. at 5% level of probability was used. Combined analysis of the two growing seasons was calculated.

RESULTS AND DISCUSSION

I. Juice quality at harvest

Juice quality at harvest as affected by B, Zn, Mn as single and combined application:

Results for the effects of B, Zn, Mn either alone or mixed at two levels and at different dates on juice quality at harvest combined combined analysis of the two growing seasons 1993/94 and 1994/95.

1. Total soluble solids percentage (TSS %)

Results in Table (2) showed that B single application at the higher level, i.e. 1 kg/fed significantly increased TSS% at harvest compared with the lower level (0.5 kg/fed). The results in Table (2) showed that B applied at 1 kg/fed increased TSS% by 0.3 and 0.8% compared with zero, and 0.5 kf/fed level, respectively.

All other elements either applied alone or in combination did not significantly affect TSS%.

Date of application of all micronutrients had no any 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 showed positive effects on TSS% in juice at harvest. Similar results for the positive effect of B on TSS% were also reported by Saif (1991).

2. Sucrose percentage

Results in Table (2) showed that all micronutrients at all levels applied and at three application dates 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% by 0.5, 0.5, 0.1 and 0.9% respectively, compared with the check treatment.

Also, B, Zn, Mn and their mixture at the highest level insignificantly increased sucrose% at harvest by 1.60, 1.50, 1.30 and 2.00% compared with the check treatment, respectively.

The interaction between microelement levels and application dates 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, 6 kg Zn, 40 g Mn and 1 kg B + 6 kg Zn + 40 g Mn/fed, when these levels were applied 105 days from planting. The highest sucrose% were 17.7, 17.3, 17.2 and 18.1%, recorded with the highest B, Zn, Mn and B + Zn + Mn, respectively when applied at 105 days from planting.

The general trend of the results indicates that the higher micronutrients level combined with the late application at 105 days had a positive effect, particularly when applied as a mixture for the three elements on sucrose% of sugar beet juice at harvest.

The positive effects of the three micronutrients on sucrose% in sugar beet juice at harvest were reported by Morsy and Taha (1986) and Saif (1991) with B application.

The positive 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 Morsy and Taha (1986) as well as Saif (1991).

3. Purity%

Results in Table (2) indicated that micronutrients increased purity% of sugar beet juice at harvest. The increase in purity% due to micronutrients application reached the significant level with Mn where the highest Mn level significantly increased purity% compared with the check treatment and the lower level as well.

The results showed that applying B, Zn, Mn and B + Zn + Mn at the lower levels (0.5 kg B, 3 kg Zn, 20 g Mn, 0.5 kg B + 3 kg Zn + 20 g Mn/fed, respectively) increased purity% by 4.2, 0.5, 1.2 and 4%, respectively.

Moreover, the higher level of micronutrients (1 kg B, 6 kg Zn, 40 g Mn and 1 kg B + 6 kg Zn + 40 g Mn/fed) increased purity% compared with the check treatment by 6.12, 5.40, 6.50 and 9%, respectively. These considerable increases were only significant with Mn application.

It could be concluded that the application of B, Zn, Mn anmd their mixture favourable affected purity% particularly when these elements were applied at the higher level. The greatest increases were recorded with mixture application.

The effect of application date of the mixed nutrients showed significant effect on purity%. The later application at 105 days significantly surpassed the earlier application at planting in effecting purity%.

Purity% were 67.5, 68.1 and 80.9%, when the micronutrients mixture was applied at sowing, 90 and 105 days, respectively.

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.

II. Chemical composition

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 dates on N, and K contents in leaves and roots of sugar beet at harvest combined analysis of the two growing seasons 1993/94 and 1994/95.

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 + 3 kg Zn + 20 g Mn/fed compared with the check treatment and the highest level as well.

All 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.

Date 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 dates of application did not significantly influence N% in leaves.

Results reported by Rosell and Ulrich (1964) (applying Zn) and Morsy and Taha (1986) (applying B and Mn) showed that N% in leave s 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.

Date of application had no significant effect. However, slight increase was observed in K% in leaves due to the later application of the micronutrients at 105 days age.

Level x date of micronutrients application did not significantly affect K% in leaves at harvest.

In general, the highest K% was recorded with applying the highest micronutrients level at the latest application date. That was clear with B, Zn and B + Zn + Mn application, where K% was 4.40, 4.42 and 4.40%, respectively.

It could be concluded that micronutrients favourably affected K% in leaves. Results reported by Morsy and Taha (1986) 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 only significant effect was for application date 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) (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 only significant effects was 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 date did not significantly affect K% in roots.

The level x application date interaction had no significant effect on K% in roots.

However, the highest K% values were almost recvorded with the highest level combined with the latest date. K% was 2.10, 2.40, 2.20 and 2.40% for the highest levels of B, Zn, Mn and their mixture, respectively when applied at 105 days age.

It could be concluded that a favourable effect was observed for micronutrients application on K% in sugar beet roots. The positive effect of microelements on K% in roots. The positive effect of microelements on K uptake by sugar beet plants was also reported by Morsy and Taha (1986) (applying B + Mn).

B, Zn and Mn (ppm) 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 dates on B, Zn and Mn contents in sugar beet leaves at harvest are presented in Table (4) combined analysis of the two growing seasons 1993/94 and 1994/95.

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

Similarly, the levels x application date 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 is clear from Table (4) that the check plants contained from 30 to 32.5 ppm B and the plants treated with B contained from 33.4 to 34.5 ppm.

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

Consequently, the experimental soil was fit to supply sugar beet plants with their B requirements.

Results reported by Morsy and Taha (1986) 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.

The results showed that Zn concentration in leaves of Zn treated plants ranged between 22.2 and 31.1 ppm as against 13.1-15.6 ppm in the leaves of the check plants. These considerable increases show the response of sugar beet plants to the applied Zn.

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

The interaction between levels and dates of applying micronutrients mixture had significant effect on Zn content in sugar beet root. The results indicated that thew lower level of the mixtures was more effective when applied after 90 days, whereas the higher level of the mixture showed higher effect when applied after 105 days. The highest Zn content in sugar beet roots was 33.3 ppm which was recorded by applying 1 kg B + 6 kg Zn + 40 g Mn/fed at 105 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) 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 dates significantly affected Mn content in sugar beet leaves at harvest.

Also, the interaction level x date 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. The Mn content in leaves ranged between 28.8 and 34.4 ppm compared with 23.2-23.5 for the plants of the check treatment.

These results reported by Tsolova and Peneva (1992) showed that the greatest amount of Mn in sugar beet plants was 18.8 g/ha, (equivalent to 7.9 g/fed). The amount can be readily available in the experimental soil.

B, Zn and Mn (ppm) 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 1993/94 and 1994/95.

Boron content in roots

Results in Table (5) showed that micronutroients levels, applicateion date 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 contained from 11.7 to 14.1 ppm B compared with mean values from 9.5 and 9.8 ppm for the check plants.

It could be concluded that B application slightly increased B content in sugar beet roots.

Date 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) 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 ranged between 15.2 and 18.8 ppm compared with 11 to 11.4 ppm for the cheeck plants. These marked increases were however, below the level of significance.

The application of Zn significantly affected Zn content in roots. Application of the lower Zn level (3 kg/fed) at 90 days age was more effective on Zn content, whereas the higher Zn level (6 kg/fed) was equally effective when applied after 90 or 105 days.

The interaction between Mn level and Mn application date significantly affected Zn content in roots. The highest Zn content was 15.3 ppm which was recorded with the higher Mn level applied either at 90 or 105 days.

It could be concluded that Zn content in sugar beet roots was favourably affected by the application of Zn either alone or mixed with B and Mn.

The prersent results is in genral agreement with that obtained by Rustskaya (1981).

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.

Roots of sugar beet plants treated with Mn contained 22.4-23.7 ppm Mn compared with a range of 22.3-22.9 ppm for the check plants.

Date of application of micronutrients had no significant effect on Mn content in roots.

Also, levels x dates 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 21.5, 20.3, 25 and 24.8 ppm, which were recorded with the higher B, Zn, Mn and B + Zn + Mn level combined with the latest application at 105 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 Morsy and Taha (1986) as well as Last and Bean (1990) showed that Mn application increased Mn content in sugar beet tops and roots.

Table 2. Effect of levels and application date of boron, zinc, manganese and their mixtures on total soluble solids (TSS), sucrose and purity percentages of sugar beet at harvest. (combined analysis of the two growing seasons 1993/1994 and 1994/1995).

Traits	Total soluble solids (TSS%) Application date (D)				Sucrose % Application date (D)				Purity % Application date (D)			
B,Zn,Mn and Mixture level	At sowing	90 Days	105 Days	Mean	At sowing	90 Days	105 Days	Mean	At sowing	90 Days	105 Days	Mean
0	24.00	24.00	24.00	24.00	14.90	15.50	16.30	15.60	61.90	64.70	68.30	64.90
Boron 0.5 kg B/fed	23.75	23.50	23.30	23.50	15.90	16.30	16.40	16.20	67.30	69.50	70.50	69.10
1 kg B/fed	24.25	24.50	24.00	24.30	16.80	17.20	17.70	17.20	69.40	70.10	73.60	71.02
Mean	24.00	24.00	23.80	23.90	15.90	16.30	16.80	16.30	66.20	68.10	70.80	68.40
0	23.50	23.50	23.80	23.60	15.00	15.00	16.00	15.30	63.80	63.70	67.50	64.90
Zinc 3 kg Zn/fed	24.00	24.25	24.30	24.20	15.40	16.00	15.90	15.80	64.30	66.00	65.80	65.40
6 kg Zn/fed	23.75	23.50	24.30	23.80	16.10	16.90	17.30	15.80	67.90	71.80	71.40	70.30
Mean	23.75	23.80	24.10	23.90	15.50	15.90	16.40	15.90	65.30	67.20	68.20	66.90
0.	24.25	24.30	23.30	23.90	14.90	15.10	15.90	15.30	61.50	59.80	68.70	63.30
Manganese 20 g Mn/fed	25.00	24.30	23.50	23.90	14.70	15.20	16.20	15.40	61.30	62.90	69.30	64.50
40 g Mn/fed	23.75	24.00	23.80	23.80	15.90	16.70	17.20	16.60	67.20	69.50	72.70	69.80
Mean	24.00	24.20	23.50	23.90	15.20	15.70	16.50	15.80	63.30	64.10	70.20	65.90
0	23.50	24.00	24.00	23.80	15.30	15.10	15.90	15.40	65.04	62.20	66.40	64.50
Mix. 0.5 + 3 + 0.2 kg/fed	23.75	23.50	24.00	23.80	15.70	16.30	16.80	16.30	66.30	69.30	69.90	68.50
1 + 6 + 0.4 kg/fed	23.75	23.50	23.80	23.70	17.08	17.10	18.10	17.40	71.20	72.90	67.30	73.50
Mean	23.67	23.67	23.90	23.80	16.02	16.10	16.90	16.40	67.50	68.10	80.90	68.80

L.S.D.at 0.05 level	TSS%	Sucrose %	Purity %
Boron (B)	0.61	N.S	N.S
Application date (D)	N.S	N.S	N.S
B xD	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
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
Mixture (Mix) of B, Zn and Mn	N.S	N.S	N.S
Application date (D)	N.S	N.S	2.46
Mix. x D	N.S	N.S	N.S

Table 3. Effect of levels and application date 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,1993/1994 and 1994/1995).

Traits	Leaves N% Application date (D)				Leaves K% Application date (D)				Roots N% Application date (D)				Roots K% Application date (D)			
B,Zn,Mn and Mixture level	At sowing	90 Days	105 Days	Mean	At sowing	90 Days	105 Days	Mean	At sowing	90 Days	105 Days	Mean	At sowing	90 Days	105 Days	Mean
0	3.30	3.10	2.90	3.10	4.00	3.80	4.00	3.90	1.70	1.60	1.60	1.60	1.80	1.60	1.90	1.80
Boron 0.5 kg B/fed	3.20	3.10	2.30	2.90	3.60	3.90	3.80	3.80	1.00	1.20	1.30	1.10	1.80	1.70	2.00	1.80
1 kg B/fed	3.90	3.40	4.00	3.80	3.90	3.90	4.40	4.10	0.90	1.10	1.00	1.00	2.20	2.00	2.10	2.10
Mean	3.40	3.20	3.10	3.20	3.80	3.90	4.10	3.90	1.20	1.30	1.30	1.30	1.90	1.80	2.00	1.90
0	2.90	3.20	3.50	3.20	3.90	3.70	3.70	3.70	1.90	1.30	1.20	1.40	1.80	1.80	1.80	1.80
Zinc 3 kg Zn/fed	3.40	3.80	3.50	3.60	3.50	3.50	3.70	3.50	1.30	1.30	1.00	1.20	1.70	1.90	1.90	1.90
6 kg Zn/fed	3.00	3.40	3.50	3.30	3.90	3.90	4.20	3.90	1.20	1.20	1.30	1.20	2.30	2.10	2.40	2.30
Mean	3.10	3.50	3.50	3.40	3.80	3.70	3.80	3.70	1.50	1.30	1.20	1.30	1.90	1.90	2.03	2.00
0	3.30	3.60	3.20	3.30	3.80	3.70	4.10	3.80	1.50	1.30	1.10	1.30	1.90	1.60	1.80	1.80
Manganese 20 g Mn/fed	4.50	4.30	3.90	4.20	3.60	3.90	3.80	3.80	1.30	1.30	2.10	1.20	1.80	1.90	1.90	1.90
40 g Mn/fed	3.00	3.10	3.20	3.10	4.00	4.00	3.90	3.90	1.20	1.60	1.10	1.30	2.10	2.20	2.20	2.20
Mean	3.60	3.70	3.40	3.60	3.80	3.90	3.90	3.90	1.30	1.40	1.10	1.30	1.90	1.90	1.90	1.90
0	3.40	3.40	3.30	3.30	3.60	3.70	3.80	3.70	1.40	1.30	1.40	1.30	1.80	2.00	1.60	1.80
Mix. 0.5 + 3 + 0.2 kg/fed	3.30	3.30	3.70	3.50	3.60	3.70	3.80	3.70	1.30	1.20	1.30	1.20	1.70	2.00	1.60	1.80
1 + 6 + 0.4 kg/fed	3.20	3.30	3.10	3.20	3.90	4.20	4.40	4.20	0.90	1.40	1.30	1.20	2.10	2.00	2.40	2.10
Mean	3.30	3.30	3.30	3.30	3.70	3.90	4.00	3.90	1.20	1.30	1.30	1.30	1.86	2.00	1.90	1.90
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
Zinc (Zn)				N.S				0.29				N.S				0.40
Application date (D)				N.S				N.S				N.S				N.S
Zn x D				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				0.20				N.S
Mn x D				N.S				N.S				N.S				N.S
Mixture (Mix) of B, Zn and Mn				0.21				N.S				N.S				N.S
Application date (D)				N.S				N.S				N.S				N.S
Mix. x D				N.S				N.S				N.S				N.S

Table 4. Effect of levels and application date of boron, zinc, manganese and their mixtures on boron (B), zinc (Zn) and manganese (Mn) concentrations ppm of sugar beet leaves at harvest. (combined analysis of the two growing seasons 1993/1994 and 1994/1995).

Traits	Leaves B ppm Application date (D)				Leaves Zn ppm Application date (D)				Leaves Mn ppm Application date (D)			
B,Zn,Mn and Mixture level	At sowing	90 Days	105 Days	Mean	At sowing	90 Days	105 Days	Mean	At sowing	90 Days	105 Days	Mean
0	30.80	31.80	32.50	31.70	12.50	12.50	14.30	13.10	21.50	24.00	25.00	23.50
Boron 0.5 kg B/fed	32.80	34.30	34.80	33.90	13.50	15.00	17.00	15.20	24.50	26.00	28.00	26.20
1 kg B/fed	34.00	34.30	35.00	34.40	15.80	16.00	17.50	16.40	26.00	27.00	28.00	27.00
Mean	32.50	33.40	34.10	33.30	13.90	14.50	16.30	14.90	24.00	25.70	27.00	25.60
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 3 kg Zn/fed	30.80	31.00	30.50	30.80	23.00	23.00	23.50	23.20	24.80	24.30	26.80	25.30
6 kg Zn/fed	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
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 20 g Mn/fed	29.50	30.00	30.50	30.00	18.50	18.00	16.80	17.80	29.50	32.30	34.00	31.90
40 g Mn/fed	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
0	30.80	32.50	32.30	31.80	14.00	16.50	16.30	15.60	21.50	23.30	24.80	23.20
Mix. 0.5 + 3 + 0.2 kg/fed	34.50	36.00	34.50	35.00	20.50	23.50	22.50	22.20	27.00	29.00	30.30	28.80
1 + 6 + 0.4 kg/fed	34.30	35.00	34.80	34.70	27.50	28.50	33.30	29.80	32.80	34.30	35.30	34.10
Mean	33.20	34.50	33.80	33.80	20.70	22.80	24.00	22.50	27.10	28.80	30.10	28.70

L.S.D.at 0.05 level	Leaves B	Leaves Zn	Leaves Mn
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
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
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
Mixture (Mix) of B, Zn and Mn	N.S	N.S	N.S
Application date (D)	N.S	N.S	N.S
Mix. x D	N.S	2.43	N.S

Table 5. Effect of levels and application date of boron, zinc, manganese and their mixtures on boron (B), zinc (Zn) and manganese (Mn) concentrations (ppm) of sugar beet roots at harvest. (combined analysis of the two growing seasons 1993/1994 and 1994/1995).

Traits	Roots B ppm Application date (D)				Roots Zn ppm Application date (D)				Roots Mn ppm Application date (D)			
B,Zn,Mn and Mixture level	At Sowing	90 Days	105 Days	Mean	At Sowing	90 Days	105 Days	Mean	At Sowing	90 Days	105 Days	Mean
0	8.50	9.50	10.50	9.50	9.80	10.80	11.80	10.80	15.00	16.30	16.80	16.00
Boron 0.5 kg B/fed	11.50	11.50	12.00	11.70	11.80	12.00	13.50	12.40	15.50	15.80	16.50	15.90
1 kg B/fed	13.50	14.50	14.30	14.10	13.50	13.50	14.00	13.70	17.50	18.80	21.50	19.30
Mean	11.20	11.80	12.30	11.80	11.70	12.10	13.10	12.30	16.00	16.90	18.30	17.10
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 3 kg Zn/fed	10.50	10.30	11.50	10.80	13.50	17.00	15.50	15.30	15.80	16.00	17.30	16.30
6 kg Zn/fed	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
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 20 g Mn/fed	10.50	10.50	10.30	10.40	12.50	13.80	12.50	12.90	22.00	23.00	25.00	23.30
40 g Mn/fed	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
0	9.80	9.80	9.80	9.80	9.50	11.50	13.30	11.40	22.00	22.80	24.00	22.90
Mix. 0.5 + 3 + 0.2 kg/fed	12.80	13.00	13.30	13.00	12.80	15.50	17.30	15.20	21.30	22.30	23.80	22.40
1 + 6 + 0.4 kg/fed	14.30	13.30	14.50	14.00	17.50	19.30	19.50	18.80	22.80	23.30	24.80	23.60
Mean	12.30	12.00	12.50	12.30	13.30	15.40	16.70	15.10	22.00	22.80	24.20	22.90

L.S.D.at 0.05 level	Roots B ppm	Roots Zn ppm	Roots Mn ppm
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
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
Manganese (Mn)	N.S	N.S	N.S
Application date (D)	N.S	N.S	N.S
Mn x D	N.S	1.17	N.S
Mixture (Mix) of B, Zn and Mn	N.S	N.S	N.S
Application date (D)	N.S	N.S	N.S
Mix. x D	N.S	N.S	N.S

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تأثير بعض العناصر الغذائية الصغرى على حاصل وجودة بنجر السكر
٢- صفات الجودة والتركيب الكيميائى

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٢ معهد بحوث المحاصيل السكرية - مركز البحوث الزراعية بالجيزة

أجريت أربع تجارب حقلية فى محطة بحوث سخا بمحافظة كفر الشيخ خلال موسمى ١٩٩٣/١٩٩٤ و ١٩٩٤/١٩٩٥ لدراسة تأثير إضافة البورون و الزنك والمنجنيز ومخلوط منها على التركيب الكيميائى ونوعية الناتج النهائى لبنجر السكر صنف راس بولى فى تسعة معاملات عبارة عن التوافق بين ثلاثة مستويات من العنصر وثلاثة مواعيد للاضافة. وقد كان التصميم المستخدم قطاعات كاملة العشوائية.

- وشملت التجربة الاولى اضافة البورون بمعدلات صفر و ٠,٥ و ١,٠٠ كجم/للفدان واضيف البورون على صورة بورات صوديوم.
- وشملت التجربة الثانية إضافة الزنك بمعدلات صفر و ٣,٠٠ و ٦,٠٠ كجم/للفدان واضيف الزنك على صورة كبريتات زنك.
- وشملت التجربة الثالثة إضافة المنجنيز بمعدلات صفر و ٢٠ و ٤٠ جم/للفدان واضيف المنجنيز على صورة كبريتات منجنيز.
- وشملت التجربة الرابعة إضافة مخلوط من العناصر الثلاثة السابقة بنفس المعدلات المذكورة مجتمعة. وتمت الإضافة أرضيا مره واحدة عند الزراعة أو بعد ٩٠ يوم من الزراعة أو بعد ١٠٥ يوم من الزراعة .

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

أولا: تأثير إضافة المغذيات الصغرى على جودة العصير:

- أدت إضافة البورون بمعدل ٠,٥ 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.
- لم تؤثر جميع معاملات العناصر الغذائية الصغرى على النسبة المئوية للسكروز فى العصير عند الحصاد.
- أدت إضافة المنجنيز بمعدل ٤٠ جم/للفدان لزيادة النسبة المئوية لنقاوة العصير عند الحصاد.

ثانيا: تأثير إضافة المغذيات الصغرى على التركيب الكيماوى:

- أدت إضافة الزنك وخاصة بالمعدل الأعلى إلى زيادة معنوية لمحتوى الأوراق من البوتاسيوم كما أدت إضافة مخلوط المغذيات الصغرى بالمعدل الأقل آلي زيادة محتوى بنجر السكر من الآزوتي عند الحصاد. بينما لم تؤثر المغذيات الصغرى على محتوى كل من الأوراق وجذور بنجر السكر من البورون والمنجنيز والزنك تأثيرا معنوياً.