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Effect of foliar application of microelements and potassium levels on growth, physiological and quality characters of sugar beet (*beta vulgaris* l.) under newly reclaimed soils

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ABSTRACT

Two field experiments were conducted during two successive seasons 2012/2013 and 2013/2014 at Nubaria area, Alexandria Governorate, in order to study the effect of foliar application of B, Fe, Zn and Mn at the concentrations of 1.0, 1.5 and 2.0 L /400 L water/fed and potassium fertilizer levels (24, 36 and 48 kg K_2O/fed.) on yield and physiological characters of sugar beet plant (*Beta vulgaris* L.) under newly reclaimed soils.

A split plot design with four replications was used. Results revealed that foliar application of B, Fe, Zn and Mn at the concentration of 1.5 l/fed recorded highest root diameter and root fresh weight/plant, as well as, sucrose%, root and sugar yields/fed., while, foliar application of B, Fe, Zn and Mn at the concentration of at 2 l/fed gave tallest root and percentage of root impurities (α- amino-N, Na and K). Fertilization of potassium at rate of 48 kg K_2O/fed gave highest values of root length, root diameter, the percentage of α-N, Na, K as well as root and sugar yields/fed in both seasons. On the contrary, a gradual reduction in sucrose% had been detected with the increase in potassium level over 36 kg K_2O/fed, while application of potassium at rate of 24 kg K_2O/fed recorded the lowest values in all characters in both seasons. The interaction between foliar spraying of B, Fe, Zn and Mn at the concentration of 1.5 l/fed and potassium fertilizer at rate of 48 kg K_2O /fed significantly affected root and sugar yields/fed and sucrose% in both seasons.

It could be summarized that, application of potassium at rate of 48 kg K_2O /fed and foliar spraying of B, Fe, Zn and Mn at the concentration of 1.5 l/fed significantly k,affected root diameter and root fresh weight, root and sugar yields/fed. as well as sucrose%

INTRODUCION

Sugar beet (*Beta vulgaris* L.) one of the most important genus of Chenopodiaceae family, its family includes approximately 1400 species (Watson and Dallwitz, 1992). Sugar beet became one of the important sugar crops; its roots are processed into white sugar, pulp and molasses for food, feed or industrial applications and are rarely used as a raw commodity. A typical sugar beet root consists of 75.9% water, 2.6% non-sugars, 18.0% sugar and 5.5% pulp. In the sugar fraction 83.1% is recovered as crystalline sucrose, 12.5% is recovered as molasses (Bichsel, 1987). Sugar beet plays a prominent role for sugar production, about 37.27% of locally sugar production, (CCSC, 2010), it grows well in the new reclaimed soils; maturity take short time compared to sugar cane and contains high sugar content. Many environmental and agronomic factors influenced sugar beet quantity and quality as fertilization and sowing methods. Improvement of sugar beet production can be achieved through application of potassium and sulphur fertilizer.

Sugar beet nutrition had a great effect on beet productivity. For various crops, micronutrients fertilizers received great attention. Osman (1997) and Abd El-Gawad *et al.*, (2004) found that Mn application at a level of 40 g/fed significantly raised purity%. Gezgin *et al.*, (2000) found that foliar application of B levels from 0, 500 and/or 750 g/boron as (sodium borate 11% B) increased significantly root and sugar yields via the increase in root sucrose %. Osman *et al.*, (2004) reported that foliar application of three levels of boron 0, 1 and 2 Kg/fed (as a borax, sodium borate 11% B) and 2 levels of Mn (0 and 1 Kg/fed.) as a manganese sulfate (28% Mn) and the mixture of them 2 kg. B +1 kg Mn/fed. The results revealed that, surpassed in root length, TSS%, sucrose%, root and sugar yields/fed. 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. El-Geddawy *et al.*, (2007 and 2008) showed that soaking sugar beet seeds with soulutions of micronutrients 0.5 and/or 1 kg B/fed + 4 kg Zn/fed before sowing significantly surpassed the dried method with respect to root diameter, weight/plant, root and sugar yield/fed. Soudi and El-Guibali (2008) and Manal, Hussein (2011) found that foliar application with (B + Zn + Mn + Fe) at the level 2 cm /l /400 l water/fed increased significantly root length, diameter, fresh weight/plant, as well as, sucrose%, root and sugar yields/fed. in studied seasons as compared with control treatment (without micronutrients) and 1 cm /l /400 l water/fed. Hellal *et al.*, (2009) concluded that in calcareous soil, high level of calcium carbonate are present. Boron should be applied to improve the yield and nutrient balance of sugar beet. El-Maghraby *et al*., (1998) and Khalil *et al*., (2001) found that sucrose, total soluble solids and purity of sugar beet juice increased with increasing K level. Further, it was found that quality and quantity of sugar in sugar beet roots, was enhanced by K fertilization (El-Harriri and Gobarh, 2001).

Potassium play an important role in regulating osmotic potential, increasing water uptake ability of sugar beet plants (Zengin *et al*., 2009). Potassium is essential for growth and is the main element used to regulate the water content of the plant (Rengel and Damon, 2008). EL–Shafai (2000) showed that increasing potassium application from zero up to 48 kg K_2O/fed significantly increased root yield. Ismail *et al*., (2002) found that potassium fertilizer significantly affected root fresh weight and root and sugar yields in two seasons, while sucrose % was significantly responded in the 1^{st} season only. Highest top yield was recorded with application of 24 kg K_2O /fed. Alaa *et al*., (2009) reported that root yield, sucrose%, white sugar% and sugar yield were significantly increased by adding 24 or 48 kg K_2O/fed compared with control, they added that potassium rate had no significant effect on K-content and α-amino nitrogen content. Nafei *et al* (2010) reported that k-fertilizer level at 36 kg K_2O/fed increased root length, root diameter, fresh weight /plant and root yield in both season as well as sugar yield in the 1^{st} season. Root and sugar yields of sugar beet significantly increased with potassium application at the rate of 114 kg/ha (Abdel-motagally *et al*., 2009). Mahdi and Mohammad (2012) reported that potassium application increased root yield, shoot yield, impure sugar percent, pure sugar percent and sugar yield. Salami and Saadat (2013) and Nabila *et al*., (2014) found that potassium significantly increased all the studied yield characters except shoot / root ratio and root diameter. In recent years, sugar beet grown on sandy soils as newly reclaimed soils has shown a variety of visual symptoms that resemble nutrients deficiencies.

Furthermore, the objectives of this investigation aimed to study the effect of foliar application of B, Fe, Zn and Mn at different concentrations and potassium fertilizer rates as well as their interaction on growth, physiological characters and quality of sugar beet, cv. Lola under newly reclaimed soils.

MATERIALS AND METHODS

Two field trials were conducted at Nubaria, Alexandria Governorate during 2012/2013 and 2013/2014 seasons to study the effect of three foliar spray of B, Fe, Zn and Mn at 1.0, 1. 5 and 2.0 L /400 L water/fed at 45 and 75 days from sowing date and three potassium fertilizer rates at 24, 36 and 48 kg K_2O/fed on growth, physiological characters and quality of sugar beet (*Beta vulgaris* L.). The foliar application of some micronutrients solution comprise of liquid chelated microelements, B, Fe, Zn and Mn, *i.e.* boron in the form of boric acid 9 % B, iron in the form of iron chelated (7.15% iron oxide), zinc in the form of zinc chelated (7% zinc) and Manganese in the form of manganese chelated (9.03% manganese oxide), which were sprayed at 45 and 75 days after sowing by using manual sprayer with 400 l/fed. The treatments were distributed in a split plot design with four replications, the foliar spray with microelements rates were allocated in the main plots, whereas, fertilizer with potassium rates distributed in the sub plots. The sub plot area was 19.60 m^2 including four ridges of 7 m in length and 70 cm apart and spacing between hills was 20 cm.

Seeds of sugar beet Lola variety were sown at 10^{th} and 20^{th} October and harvested after 7 months for the 1^{st} and 2^{nd} seasons, respectively. Nitrogen fertilizer at rate of 120 kg N/fed in the form of ammonium nitrate (33.5% N) was applied in four equal doses, the first was applied after thinning and the others were applied at 2-weeks interval after the first application. Phosphorus fertilizer at a rate of 30 kg/fed in the form of calcium super phosphate (15.5% P_2O_5) was added during land preparation. Potassium fertilizer at a rate of 24, 36 and 48 K_2O/fed in the form of potassium sulfate (48.5% K_2O) was applied in four equal doses with nitrogen fertilizer. The preceding crop was Maize at both seasons. Other agricultural practices for sugar beet field were carried out as recommended by Sugar Crops Research Institute.

Some physical and chemical analysis of the experimental site are conducted according to A.O.A.C. (2005) and the data shown in Table 1.

Table 1. Physical and chemical analysis of the experimental site.

Seasons	Partial size %	Soil Textural	Soil pH	E.C*. ds/m	$CaCO_3$ %	Organic matter%	Available contents %

	Clay	**Silt**	**Sand**	**%**	**1:2.5**				**N**	**P**		**K**
2012/2013	3.0	3.3	93.7	Sandy	7.7	1.6	10.6 %	0.75	4.4	3.21		132
2013/2014	3.6	4.7	91.7	Sandy	7.8	1.9	9.9 %	0.90	6.5	3.01		120
Seasons	Soluble cations (meq/l)				Soluble anions (meq/l)				Available contents (ppm)			
	Ca++	Mg++	Na+	K+	CO3-	HCO3-	Cl-	SO4-	B	Fe	Zn	Mn
2012/2013	2.00	3.02	3.24	0.25	2.50	1.10	3.02	2.17	0.31	4.2	2.6	3.8
2013/2014	2.05	3.00	3.14	0.35	2.60	1.09	3.00	2.10	0.35	4.1	3.5	2.4

***In the soil paste extract.**

At harvest time (210 days from sowing): A sample of 10 roots was randomly taken to determine the following characters:

Root growth traits:

*Root length (cm/plant). *Root diameter (cm/plant).

*Root fresh weight (g/plant). *Root yields (ton/fed.) were determined on the whole plot basis were harvested, topped and weighed to determine root yields/fed.

Physiological and quality characteristics:-

*Sucrose%: was polar-metrically determined on a lead acetate extract of fresh macerated root according to Le Docte (1927).

*Root impurities {α-amino nitrogen, sodium and potassium contents (meq/100g beet)} were estimated according to the procedure described by the Sugar Company using Auto Analyzer.

The analysis of variance was carried out according to Gomez and Gomez (1984) for all collected data. Treatment means were compared by Duncan's Multiple Range test according to Duncan (1955). All statistical analysis was performed using analysis of variance technique by means of "MSTATC" computer software package.

RESULTS AND DISCUSSION

Effect of foliar application of microelements concentrations on growth yield, physiological characters and quality of sugar beet.

Results presented in Tables 2, 3 and 4 indicated that foliar spray with B, Fe, Zn and Mn at the rate of 1.5 l/fed gave highest for root diameter and root fresh weight than foliar spraying at a rate of 1.0 or 2.0 l/fed. The same results were obtained for juice quality as sucrose% and purity% as well as root and sugar yields in both seasons. On the other hand, foliar application of B, Fe, Zn and Mn at rate of 2.0 l/fed gave highest root length and root impurities, *i.e.*, α-N, Na and K% than other micronutrients levels. This intensive competition was compensated by a sufficient increase in root fresh weight/plant, sucrose% as well as root and sugar yield. The stimulation effects of micronutrients on quality traits may be attributed to the increase in sucrose%. Boron is essential for the formation of new cells in meristems in addition to a vital role in sugar translation to roots. Manganese activates some of the enzyme reactions; it plays a role in regulating the levels of Auxin in plant tissues by activating the Auxin Oxidase system (Marschner, 1986). Furthermore, Mn acts as an activator for different enzymes, especially those of the interactions of Kerbs cycle and protein synthesis within the plant. The role of Fe as an electron carrier in photosynthetic phosphorylation and N-fixation, in addition to its role in building-up chlorophyll and the activity of metal of lavoprotein, which may be reflected on plant performance. The role of Zn in enhancement the vegetative growth, might be due to that Zn is known to be an essential constituent of three plants enzyme *i.e*. carboning anhydrase, alchohol dehydrogenase and superoxidase dismutase. In addition, Zn has a marked effect on the level of Auxin which appears to be required in the synthesis of intermediates in the metabolic pathway, through tryptophan to Auxin (Ohki, 1978) which in turn encourage the meristemic activity of the plant which resulted in more cell enlargement (Devlin and Witham, 1983). Sandman and Bogger (1983) stated that yield increment might be due to the favorable influence of Zn on plant enzyme activity and improving the photosynthetic and mobilization in plants. The pronounced effect of micronutrients is mainly due to their effect on growth hormones production which has a direct effect on plant growth, throughout their influence on the production of plant growth promoting substances and increase in various availability soil nutrients. These results are in agreement with those reported by El-Geddawy *et al*., (2007 and 2008); Soudi and El-Guibali (2008); Manal, Hussein (2011) and Awad *et al*. (2013 a).

Potassium fertilizer effects:

Results in Tables 2, 3 and 4 showed that potassium fertilizer levels led to significant differences in root length, diameter, fresh weight, sucrose% as well as, root and sugar yields/fed and α-N, Na and K% in both seasons. Fertilization of potassium at rate of 48 kg K_2O /fed gave the highest mean values for root length, diameter and fresh weight g/plant as well as root and sugar yields/fed, while, it gave the lowest percentages of sucrose. Similar results were obtained by Osman (2005) who found that froths criteria of sugar beet plants were significantly increased with increasing level of potassium fertilization up to 48 kg K_2O /fed. These results are in agreement with Abdel-motagally *et al*., (2009), Salami and Saadat (2013) and Nabila *et al*. (2014).These results are in harmony with those obtained by Ulgen *et al*. (2009) found that potassium positively affects sugar content because of its specific physiological effects during synthesis, transport and storage of sugars. Potassium enhances many enzyme actions aids in photosynthesis process and sugar formation and translocation. The role of potassium in making active enzymes cells division and growing, opening and closing of stomata and loading carbohydrates on phloem are the main cases of increase of root yield, by increasing on consume values of potassium (Taiz and Zeiger 2006). Furthermore, Karam *et al*., (2009) reported that Potassium also has another equally important role in the transfer of sugars produced in the leaves to the storage root. In its passage from leaf to storage root each molecule of sugar has to pass through in numerable cell membranes, and K^+ ions are an essential component of the 'molecular pump' within the cell membranes that facilitate this passage.

Table 2: Effect of foliar spraying of mixture of microelements rates and potassium levels on some roots growth traits during 2012/2013 and 2013/2014 seasons.

Traits	2012/2013 season			2013/2014		
Micoelements rates	**Root growth traits**			**Root growth traits**		
(l/fed.)	Root length	Root diameter	Root Fresh weight	Root length	Root diameter	Root Fresh weight
1.0	27.47 c	11.33 b	926.36 c	27.84 c	10.80 b	968.6 c
1.5	29.47 b	11.74 a	973.37 a	30.95 b	11.42 a	1004.3 b
2.0	31.82 a	11.88 a	942.66 b	31.83 a	11.44 a	1074.4 a
F- test	**	*	**	**	**	**
K levels:						
24	27.11 c	10.43 c	826.83 c	27.01 c	10.26 c	874.9 c
36	30.09 b	11.44 b	968.98 b	30.31 b	11.36 b	1028.0 b
48	31.56 a	13.08 a	1046.58 a	33.31 a	12.04 a	1144.50 a
F- test	**	*	**	**	**	**
F- test interaction	**	Ns	**	**	**	**

RL= Root length (cm), RD = Root diameter (cm), RFW = Root fresh weight (g/plant), *, ** and Ns indicate p <0.05, <0.01 and not significant, respectively. Means of each treatment followed by the same letter are not significantly different at 5% level, according to Duncan's multiple range tests.

Potassium fertilization at rate of 24 kg K_2O /fed gave the lowest mean values for α-N, Na, K% and sucrose% in the two seasons as compared with other levels of potassium. This was compensated by a sufficient increase in root fresh weight/plant, sucrose% as well as root and sugar yield. Such effect may be due to that potassium fertilizer enhanced the uptake of other minerals which finally reflected in better growth of root and quality, also, due to the especial role of high potassium level that stimulate vegetative growth and hence more essential elements absorbed which increased its level in beet roots at harvest (Moustafa, Shafika *et al.*, 2005). These results are in agreement with those obtained by Alaa *et al*. (2009) and Awad *et al*. (2013 b).

Table3: Effect of foliar spraying of mixture of microelements rates and potassium levels on yield of sugar and roots yields and sucrose% during 2012/2013 and 2013/2014 seasons.

Traits	2012/2013 season			2013/2014		
Micoelements rates	**Yields (ton/fed.)**		**Sucrose%**	**Yields (ton/fed.)**		**Sucrose%**
(l/fed.)	**Root yields**	**Sugar yields**		**Root yields**	**Sugar yields**	
1.0	25.73 c	4.31 c	16.60 c	25.96 c	4.43 c	16.89 b
1.5	27.74 a	4.75 a	16.99 a	28.66 a	4.98 a	17.30 a
2.0	26.02 b	4.40 b	16.73 b	26.49 b	4.52 b	16.86 b
F- test	**	**	**	**	**	**
K levels:						
24	24.07 c	3.79 c	15.69 c	24.35 c	3.85 c	15.88 c
36	26.69 b	4.53 b	16. 9 b	27.20 b	4.74 b	17.23 b
48	28.74 a	5.13 a	17.73 a	29.56 a	5.34 a	17.94 a
F- test	**	**	**	**	**	**
F- test interaction	**	*	**	**	*	**

***, ** and Ns indicate p <0.05, <0.01 and not significant, respectively. Means of each treatment followed by the same letter are not significantly different at 5% level, according to Duncan's multiple range tests.**

Table 4: Effect of foliar spraying of mixture of microelements rates and potassium levels on Root impurities % during 2012/2013 and 2013/2014 seasons.

Traits	2012/2013 season			2013/2014		
Microelements rates	Root impurities %			Root impurities %		
(l/fed.)	α-N	Na	K	α-N	Na	K
1.0	1.43 b	1.62 b	3.21 b	1.31 b	1.71 b	3.07 b
1.5	1.32 c	1.57 b	3.06 c	1.25 c	1.49 c	2.95 c
2.0	1.57 a	2.06	3.43 a	1.44 a	2.05 a	3.22 a
F- test	**	*	**	**	**	**
Potassium levels:						
24	1.14 c	1.63 c	2.82 c	1.12 c	1.64 c	2.71 c
36	1.48 b	1.76 b	3.36 b	1.34 b	1.75 b	3.18 b
48	1.70 a	1.86 a	3.51 a	1.53 a	1.88 a	3.34 a
F- test	**	*	**	**	**	**
F- test interaction	**	Ns	**	**	**	**

Root impurities % (g/100 g DW), i.e. (α-N=α-amino nitrogen, Na= sodium, K= potassium). *, ** and Ns indicate p <0.05, <0.01 and not significant, respectively. Means of each treatment followed by the same letter are not significantly different at 5% level, according to Duncan's multiple range tests.

Effect of interactions:

Results in Tables 5 mentioned that the interaction between foliar spraying of B, Fe, Zn and Mn at different concentrations and potassium fertilizer levels affected significantly root and sugar yields/fed and sugar%, the high mean values of these characters were obtained when fertilized at rate of 48 kg K_2O /fed and foliar spraying of B, Fe, Zn and Mn at rate of 1.5 l/fed in both seasons. On the other hand foliar spraying of B, Fe, Zn and Mn at rate of 1.0 l/fed and 24 kg K_2O /fed gave the lowest root and sugar yields/fed and sugar% in both seasons. The beneficial effects of the studied micronutrients and potassium are more related to their active role for building new meristemic cells, enhanced cell elongation and increased the ability rate of leaves for photosynthetic process. The beneficial effect of the interaction between these micronutrients may be attributed to each one by increasing plant growth or maintaining favorable balance between them. The positive effect of micronutrients as individually or mixture on sugar beet plants was also reported by Soudi and El-Guibali (2008), Alaa *et al*. (2009), Manal, Hussein (2011) and Awad *et al*. (2013 a).

Table 5: Effect of the interaction between foliar spraying of mixture of microelements rates and potassium levels on roots & sugar yield and Sugar% during 2012/2013 and 2013/2014 seasons.

Interaction		Seasons					
		2012/2013			2013/2014		
Microelements rates (l/fed.)	Potassium levels	Roots yield	Sugar yield	Sugar %	Roots yield	Sugar yield	Sugar %
1.0	24	23.17 f	3.66 f	15.52 h	23.60 h	3.77 h	15.79 g
	36	23.02 c	4.33 d	16.67 e	26.13 e	4.48 f	17.01 d
	48	27.99 b	4.92 c	17.61 b	28.14 c	5.05 d	17.88 b
1.5	24	25.23 d	3.97 e	15.87 f	25.47 f	4.07 g	25.47 f
	36	27.95 b	4.86 c	17.24 c	28.76 b	5.14 c	17.78 c
	48	30.07 a	5.41 a	17.87 a	31.75 a	5.73 a	18.05 a
2	24	23.8 e	3.75 f	15.86 g	23.98 g	3.73 h	15.79 g
	36	26.1 c	4.4 d	16.79 d	26.71 d	4.59 e	16.88 e
	48	28.16 b	5.05 b	17.7 b	28.79 b	5.23 b	17.9 b

CONCLUSION

It is concluded that foliar application of B, Fe, Zn and Mn at rate of 1.5 l/fed and fertilized with potassium at rate of 48 kg K_2O/fed produced highest sugar beet yield and yield component.

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تأثير الرش بتركيزات العناصر الصغرى والتسميد البوتاسى على النمو والصفات الفسيولوجية والجودة لبنجر السكر فى الأراضي حديثة الاستصلاح

خالـــــــد عبدالـــــــدايم عبـــــــدالعال* ، شـــــــيماء عبـــــــدالعظيم بـــــــدوىو شهرزاد محمد مرشدى نعينع*****
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أجريت تجربتان حقليتان خلال موسمي ٢٠١٣/٢٠١٢ و ٢٠١٤/٢٠١٣ بمنطقة النوبارية بمحافظة الإسكندرية وذلك بهدف دراسة تأثير ثلاثة مستويات من محلول مخلوط العناصر الغذائية الصغرى (بورون – حديد – زنك – منجنيز) بمعدلات ١.٠ و ١.٥ و٢.٠ لتر/٤٠٠ لتر ماء/فدان بعد ٤٥ و٧٥ يوم من الزراعة وثلاثة معدلات من التسميد البوتاسى وهى ٢٤و ٣٦ و٤٨ كجم.بو$_2$ا/فدان على النمو والخصائص الفسيولوجية وصفات الجودة لنبات بنجر السكر صنف لولا عديد الأجنة.

تم استخدام تصميم القطع المنشقة مرة واحدة في أربع مكررات حيث وضعت معدلات الرش بالعناصر الغذائية الصغرى في القطع الرئيسية ووضعت معدلات التسميد البوتاسى في القطع الشقية ويمكن تلخيص النتائج كما يلى:

١- أوضحت النتائج أن الرش بمعدل ١.٥ لتر/فدان للعناصر الغذائية الصغرى المستخدمة إلى زيادة قطر ووزن الجذر والنسبة المئوية للسكروز ومحصول الجذور والسكر طن/فدان. بينما انخفضت النسبة المئوية للشوائب (ألفا أمينونيتروجين والصوديوم والبوتاسيوم) وعلى العكس زاد طول الجذر والنسبة المئوية للشوائب بزيادة مستوى الرش إلى ٢.٠ لتر/فدان.

٢- أشارت النتائج إلى أن زيادة التسميد البوتاسى من ٢٤ إلى ٤٨ كجم.بو$_2$ا/فدان أدى إلى زيادة طول وقطر ووزن الجذر الطازج والنسبة المئوية للشوائب (ألفا أمينونيتروجين والصوديوم والبوتاسيوم) ومحصول الجذور والسكر للفدان، وعلى العكس لوحظ انخفاض فى النسبة المئوية للسكروز والنقاوة بزيادة مستوى التسميد البوتاسى مقارنة بالمستوى الأقل أى ٢٤ كجم.بو$_2$ا /فدان.

٣- أظهرت النتائج أن للتفاعل بين الرش بمحلول العناصر الغذائية الصغرى بمعدل ١.٥ لتر/فدان وإضافة التسميد البوتاسى بمعدل ٤٨ بو$_2$ا /فدان تأثير معنوي على صفات النسبة المئوية للسكروز ومحصولي الجذور والسكر/فدان.

توصى هذه الدراسة بالرش بمخلوط العناصر الغذائية الصغرى (بورون، حديد، زنك، منجنيز) بمعدل ١.٥ لتر/فدان مع إضافة التسميد البوتاسى بمعدل ٤٨ بو$_2$ا /فدان للحصول على أعلى إنتاجية لمحصولي الجذر والسكر تحت ظروف منطقة الدراسة وهى الأراضى حديثة الاستصلاح بمحافظة الأسكندرية.