Effect of Nitrogen, Potassium and Manganese Fertilization on Growth and Yield of Sugar Beet

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ABSTRACT

The goal of this work was to walk a wide step on that road arrives to the optimum demand of nitrogen, potassium and manganese for sugar beet. This work was done in Abis area for two seasons (2005-2006 and 2006-2007). Nitrogen fertilization showed a significant effect on the growth of sugar beet plant where increased the yield of the whole plant, root, shoot and sugar, also increased the percentage of soluble salts solids, sugar and amino N in tuber tissues, especially with the highest rate of N application (150 mg N/ kg soil) where increased the sugar yield as the main product 41.4 and 39.7% for the first and second seasons, respectively. The rate of 100 mg K/ kg soil was the best rate of potassium addition with most of studied parameters especially the sugar production where increased it by 16.8 and 19.8% for the first and second seasons, respectively . The addition rate of Manganese (0.2 mg Mn/kg soil) was the best rate where, promoted the root weight and consequently the sugar yield where increased it by 31.5 and 33.4% for the first and second seasons, respectively.

INTRODUCTION

In recent years, there has been rapid development in sugar beet cultivation in the new reclaimed soils (calcareous soils) to minimize the gap between the production and consumption of sugar. Most of researches were conducted in that new reclaimed soil. The soil of Nile Delta (Alluvial soil) needs more research to get the optimum demand of the macro and micro nutrients.

Sugar beet contains 4 to 7 g N per kg of fresh beet produced (Carter et al., 1974 and Halvorson et al., 1978). Compared with other crops such as corn (Zea mays L.), deep-rooted sugar beet scavenges the soil profile for residual N and recovers considerably more soil N and relies less on fertilizer N (Hills et al., 1983). Also, because of the negative effects of high soil N level on sucrose concentration and recovery, optimum soil N levels for sucrose production are usually lower than for beet yield (Adams et al., 1983; Anderson and Peterson, 1988).

In Montana, the greatest sucrose yield was obtained with 112 kg N fertilizer ha^{-1} and NO_3 accumulated in the soil when more than 168 kg N ha^{-1} was applied (Halvorson and Hartman, 1975). Sucrose yields in Montana were near maximum when spring soil NO_3 plus added N was about 200 to

225 kg ha^{-1} (Halvorson et al., 1978). In Texas, sucrose yield did not respond to fertilizer N when NO_3 in the top 1.2 m of the soil profile was 180 kg ha^{-1} at planting (Winter, 1990). In Nebraska, when 35 to 45 kg NO_3 ha^{-1} was available in the top 1.8 m of the soil at planting, 160 to 220 kg N fertilizer ha^{-1} was needed to optimize sucrose yield (Anderson and Peterson, 1988). In Wyoming, when soil NO_3 at 0.3 m was about 9 mg kg^{-1}, sucrose yield was at maximum with 170 kg N fertilizer ha^{-1} (Lauer, 1995). Carter et al. (1974) in southern Idaho found that sucrose yield was maximum when NO_3 plus mineralized N at the top 0.4 m of the soil was about 250 to 300 kg ha^{-1}.

The effect of potassium fertilization on the sugar beet yield was studied carefully through those studies conducted to get the optimum combination of NPK. The studies of K as independent factors showed the necessary application of K to sugar beet. Orlovius (1986) showed that application of mineral K fertilizer; 450 Kg K_2O / ha increased the sugar beet yield by 5% regardless of residue supply.

Cumakov (1996) found that K had a positive effect on sugar beet and sugar yields. Brandenburg (1931) showed that manganese deficiency causes small angular chlorotic spots on the sugar beet leaves and the leaves grow upright and roll in wards. Draycott and Parley (1973) found that manganese sulphate in aqueous solution sprayed on sugar beet leaves can greatly increase their manganese concentration and within a few days-decrease the severity of deficiency symptoms.

MATERIALS AND METHODS

The experiment was carried out in Abis area in the same spot for two seasons (2005-2006 and 2006-2007). Soil of the experimental area was well prepared and divided into 3 replicates with split-split plot design. Each replicate contained 48 plots (plot area = 10.5 m^2) as 4 main plots fertilized with 4 levels of N as ammonium nitrate (75, 100, 125 and 150 mg N/ kg soil), 4 sub-plots fertilized with 4 levels of K as potassium sulphate (50, 75, 100 and 125 mg K/kg soil) and 3 sub-sub-plots were fertilized with 3 levels of foliar applied Manganese (0, 0.1 and 0.2 mg Mn/kg soil). Sub-sub plot size was 1 m^2. During soil preparation 100 mg P/kg soil (superphosphate) were added to the experiment soil. Monogerm sugar beet (Beta vulgaris *L.*) (Plino. Var) seeds were cultivated and all agricultural practices were applied as usual during growing seasons.

The soil was chemically analyzed for pH, EC, soluble cations and anions in the soil paste (Table 1) according to standard methods edited by Black (1965) and Mulvaney (1996) for the two seasons.

Table 1. Some chemical properties of the used soil.

Season	EC	pH	Cations (meq/L)				Anions (meq/L)				mg/kg soil
	dS m^{-1}		Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	HCO_3^-	CO_3^{2-}	Cl^-	SO_4^{2-}	N
1st	2.7	8.0	7.5	6.9	10.2	1.2	1.5	0.0	24.6	1.6	11.0
2nd	2.9	8.1	8.0	6.9	12.0	1.1	1.4	0.1	25.5	1.5	11.3

The yield was harvested at 186 days age and the whole plants, roots and shoots were weighed for the first and second seasons (Tables 2 and 3). The tuber yield of each treatment was analyzed for sucrose according to the method described by Le Docte, 1927, and amino N contents according to the method described by Brown and Lilliand (1964). The data of sugar yield of all treatments were calculated and the data of plant growth (whole plant, shoots, roots and sugar yield as ton/faddan) and the quality parameters (dry root, dry shoot, T.S.S., sucrose, Amino N as a percentage) were computed and statistically analyzed for testing the significance of the tested factors and the possible interaction between them.

RESULTS AND DISCUSSION

Effect of nitrogen fertilization

The obtained data (Tables 2 and 3) showed a significant positive effect of applied nitrogen rate on the studied parameters (growth and quality parameters).The data of the second and third levels (N2 and N3) of applied N for all studied parameters were, more or less, closed to each other and cleared a significant enhancement in the yield of whole plant, root, shoot and sugar in ton/faddan and in the percentage of dry root, dry shoot, total soluble salts, sucrose and amino acids. The highest level of N application 150 mg N/kg soil was the best in its positive effect on the studied parameter especially on the quality parameter, where the whole plant was raised 31 and 31.9% comparing with the lowest level of N addition for the first and second seasons, respectively. The rising extents were 26.4 and 22.8% for roots, 43.5 and 58.2% for shoots, 41.4 and 39.7% for sugar, 26.5 and 26.5% for dry root, 31.3 and 31.3% for dry shoot, 26.1 and 26.2% for total soluble salts, 18.4 and 13.2% for sucrose and finally 134.7 and 133.5% for amino N for the first and second seasons, respectively. The data mentioned demonstrated the strong effect of applied N at 150 mg N/kg soil on the sugar yield due to the combination between the two positive effects of the root yield and sucrose percentage at the same time. Also, amino N percentage were much hugged besides the dry root and dry shoot which makes the leaves and roots after sugar extracting are more useful in animal nutrition. The results obtained here, did not agree with that obtained by Halvorson et al., 1978; Winter, 1990; Carter et al. 1974 and Anderson and Peterson, 1988, where they announced that sugar yield did not response to more addition of mineral N when spring soil N plus added N was about 200 to 225 kg ha^{-1}, 180 kg ha^{-1}, 250 to 300 kg ha^{-1} and 160 to 220 kg N fertilizer ha^{-1}, respectively. As known, the Egyptian soil -in general- is poor in soil N which means more need to mineral N to be applied to reach the maximum sugar yield.

Effect of potassium

The obtained data (Tables 2 and 3) showed that potassium as an essential plant nutrient affected significantly on all plant items studied in both seasons. The data of both seasons were closed to each other as shown in Figures 2a and 2b. The third level of K added to soil (100 mg K/kg soil) increased significantly the whole plant weight 14.2 and 11.7% for the first and second seasons, respectively. The beet tubers weight also, enhanced dramatically with the third K level where increased it 15.4 and 16.5% for the first and second seasons, respectively. Shoots did not show significant effect with the second and third levels of K, where the highest level showed significant negative effect for both seasons. While the dry mater percent of root and shoot in both seasons were enhanced with application levels up to 100 mg K/kg soil. The higher level of 125 mg K/kg soil continued in rising this percent for dry root only and went to make it less than the lowest addition level. The results of sugar production and sucrose percentage in both seasons showed that, there was significant effect of potassium fertilization rate. The sugar yields were promoted 16.8 and 19.8% for the first and second seasons, respectively with the second rate of K added. The second level of added K increased significantly the sucrose concentration as percentage. More added K pushed the sucrose concentration down where, the highest level converted the effect from positive to negative. More added K caused more soluble salts and amino N percent up to the highest level of added K (125 mg K/kg soil).

Effect of manganese

The data of Manganese effect (Tables 2 and 3) cleared the significant positive effect on the whole plant, root and sugar yield. Dry matter percent of root, total soluble salts and amino N were also affected positively with more addition of manganese up to 0.2 mg/kg soil. Sucrose concentration did not affected by manganese addition. In spite of the positive significant promotion of whole plant, the leaves yield were affected negatively, which means that the added manganese not only supported the growth of beet root but also inhibited the leaves growth (Figure 3a). Generally, manganese foliar application up to 0.2 mg/kg soil was enough to keep the plant healthy and promoted the sugar yield where increased it by 31.5 and 33.4 % for the first and second seasons, respectively.

Table 2. Effect of nitrogen, potassium and manganese fertilization rate on the weight of plant, root, shoot and sugar yield and the percentage of dry root, dry shoot, total soluble salts, sucrose and amino nitrogen (first season).

Treat.	Plant	Root	Shoot	Sugar	Dry root	Dry shoot	T.S.S	Sucrose	Amino N
	Ton/ faddan				%				
N1	23.76 d	17.18 d	6.58 c	3.09 d	28.23 d	10.08 d	26.17 d	17.48 c	1.24 d
N2	28.01 c	19.15 c	8.87 b	3.37 c	31.73 c	10.74 c	27.29 c	17.58 b	1.99 c
N3	28.95 b	20.36 b	8.59 b	3.63 b	33.29 b	11.43 b	27.5 b	17.86 b	2.65 b
N4	31.15 a	21.72 a	9.44 a	4.37 a	35.72 a	13.24 a	33.00 a	20.07 a	2.91 a
K1	26.21 d	17.84 c	8.37 b	3.27 c	30.60 d	11.30ab	26.88 d	18.23 b	1.69 b
K2	28.30 b	20.02 b	8.28 b	3.82 a	32.14 c	11.49 a	28.67 c	18.98 a	2.35 a
K3	29.94 a	20.58 a	9.35 a	3.78 a	32.70 b	11.59 a	28.75 b	18.34 b	2.37 a
K4	27.43 c	20.49 a	6.95 c	3.58 b	33.53 a	11.10 b	29.67 a	17.44 c	2.38 a
Mn1	25.97 c	16.58 c	9.39 a	3.02 c	29.18 c	11.58 a	27.06 c	18.20 a	2.02 c
Mn2	28.39 b	20.99 b	7.40 c	3.85 b	33.48 b	11.06 b	28.35 b	18.26 a	2.26 b
Mn3	29.57 a	21.62 a	7.95 b	3.97 a	34.07 a	11.47 a	29.88 a	18.31 a	2.31 a

Table 3. Effect of nitrogen, potassium and manganese fertilization rate on the weight of plant, root, shoot and sugar yield and the percentage of dry root, dry shoot, total soluble salts, sucrose and amino nitrogen (second season).

Treat.	Plant	Root	Shoot	Sugar	Dry root	Dry shoot	T.S.S	Sucrose	Amino N
	------------- Ton/ faddan -------------				------------------------ % ------------------------				
N1	22.98 d	17.47 d	5.52 c	3.07 d	28.23 d	10.23 d	25.77 c	17.63 d	1.28 d
N2	26.96 c	18.92 c	8.04 b	3.34 c	32.05 c	10.91 c	26.88 b	17.77 c	2.03 c
N3	28.05 b	20.11 b	7.94 b	3.74 b	33.62 b	11.60 b	27.09 b	18.02 b	2.63 b
N4	30.19 a	21.46 a	8.73 a	4.29 a	36.07 a	13.43 a	32.51 a	20.21 a	2.97 a
K1	25.32 d	17.61 c	7.71 a	3.18 c	30.91 d	11.47ab	26.47 c	18.54 b	1.74 b
K2	27.51 b	19.77 b	7.74 a	3.80 a	32.46 c	11.66ab	28.24 b	19.16 a	2.34 a
K3	28.70 a	20.33 a	8.37 a	3.86 a	33.03 b	11.77 a	28.32 b	18.43 b	2.40 a
K4	26.64 c	20.23 a	6.41 b	3.60 b	33.86 a	11.27 b	29.22 a	17.59 c	2.43 a
Mn1	24.71 c	16.37 c	8.34 a	2.99 c	29.74 c	11.75 a	26.66 c	18.25 a	1.92 c
Mn2	27.57 b	20.74 b	6.83 c	3.86 b	33.81 b	11.23 b	28.10 b	18.38 a	2.26 b
Mn3	28.85 a	21.35 a	7.50 b	3.99 a	34.41 a	11.65 a	29.43 a	18.44 a	2.49 a

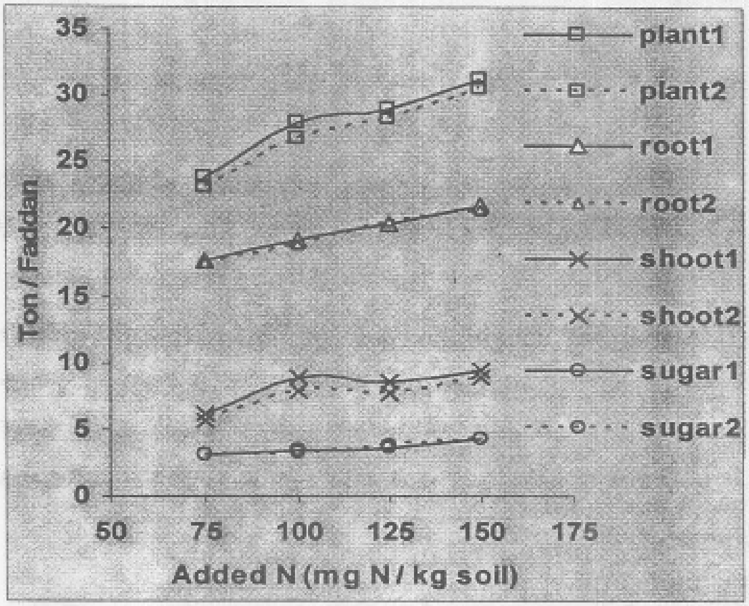

Fig.1a: Relationship between N fertilization rates and the yield of plant, root, shoot and sugar of sugar beet.

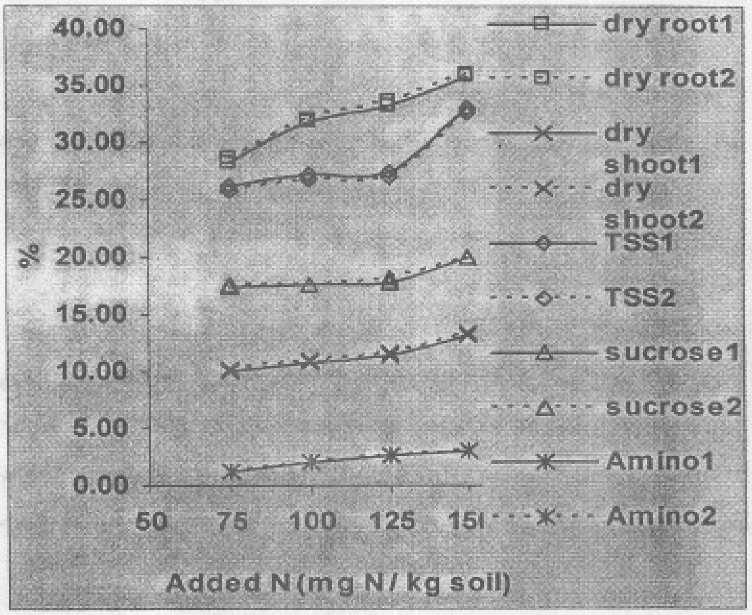

Fig. 1b: Relationship between N fertilization rates and the percentage of the dry root, dry shoot, T.S.S., sucrose and amino nitrogen.

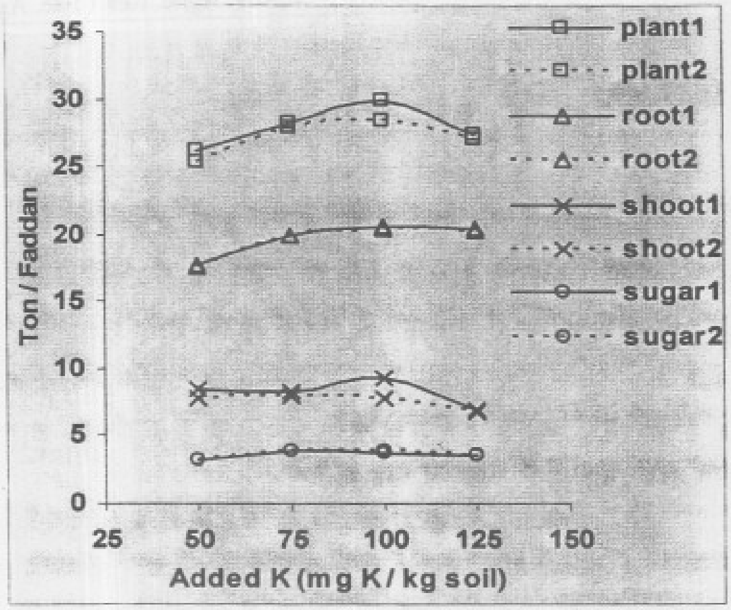

Fig.2a: Relationship between K fertilization rates and the yield of plant, root, shoot and sugar of sugar beet.

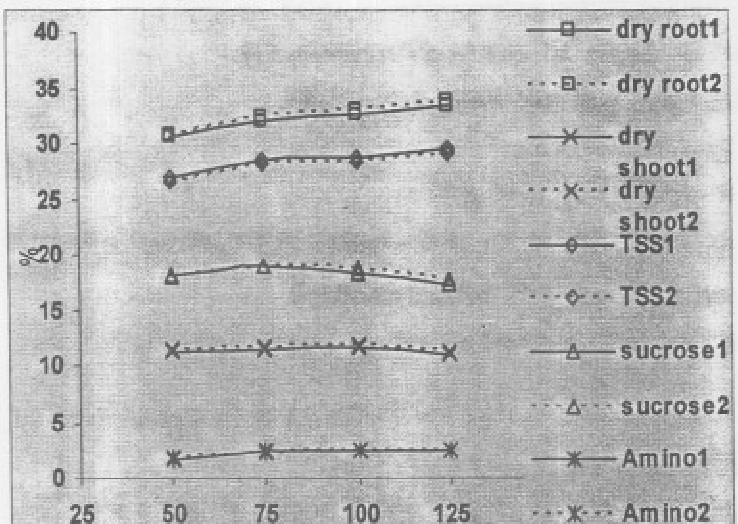

Fig. 2b: Relationship between K fertilization rates and the percentage of the dry root, dry shoot, T.S.S., sucrose and amino nitrogen.

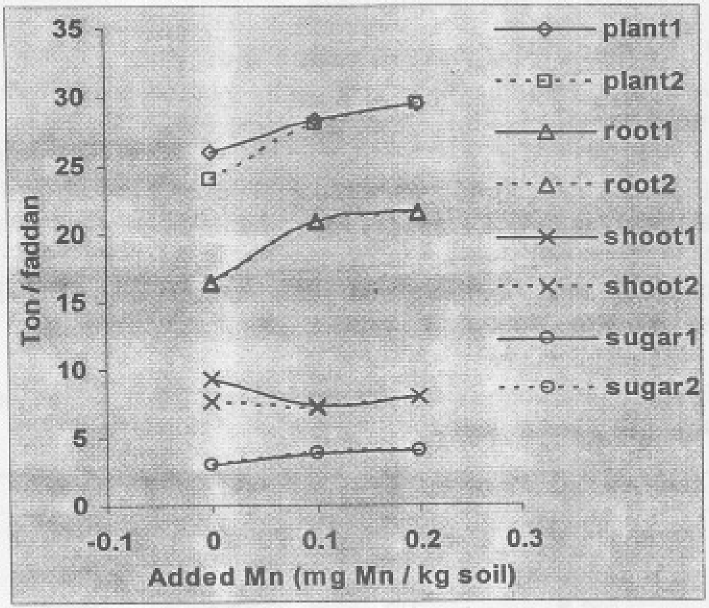

Fig.3a: Relationship between Mn fertilization rates and the yield of plant, root, shoot and sugar of sugar beet.

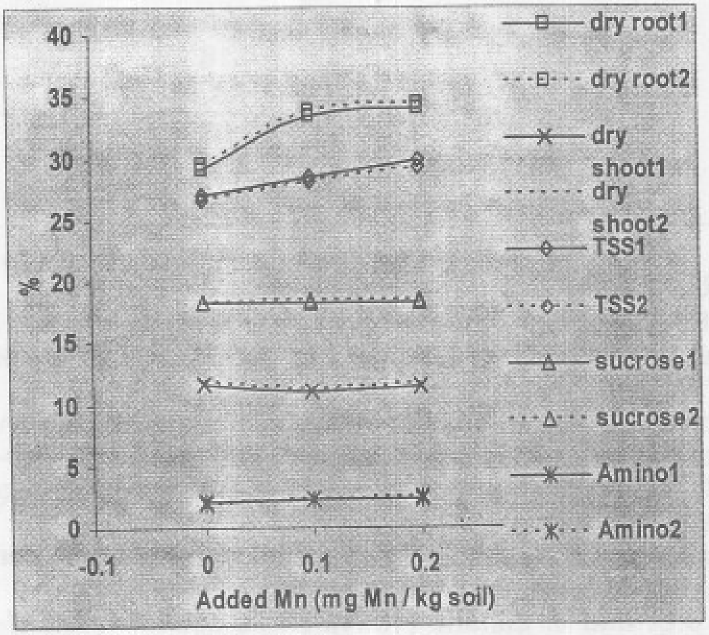

Fig. 3b: Relationship between Mn fertilization rates and the percentage of the dry root, dry shoot, T.S.S., sucrose and amino nitrogen.

Effect of interaction between studied factories

Sugar yield was affected significantly by the interaction between the studied nutrients (N, K, Mn). Data represent the interactions N*K, N*Mn, and K*Mn are listed in Table 4. The interaction between the highest level of added N (150 mg/kg soil) and the second level of added K (75 mg/kg soil) resulted a sugar yield 4.62 ton/faddan. The interaction between N and Mn resulted 4.94 ton sugar /faddan with the highest levels of both. The highest level of added Mn and the third level of added K resulted the 4.30 ton sugar / faddan as the best interaction effect.

Table 4: Effect of Interaction between studied factors on sugar yield mean (ton/faddan).

	N1	N2	N3	N4	LSD
K1	2.6	3.03	3.4	3.68	0.576
K2	3.11	3.58	3.91	4.62	
K3	3.4	3.6	3.93	4.52	
K4	3.18	3.16	3.75	4.33	
Mn0	2.77	2.91	3.01	3.26	0.699
Mn1	3.19	3.52	4.06	4.66	
Mn2	3.26	3.6	4.18	4.94	
	K1	K2	K3	K4	
Mn0	2.75	3.13	3.05	3.03	0.699
Mn1	3.25	4.02	4.3	3.87	
Mn2	3.54	4.27	4.24	3.92	

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الملخص العربى

تأثير التسميد بالنتروجين و البوتاسيوم و المنجنيز على نمو ومحصول بنجر السكر

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استهدفت الدراسة تحقيق خطوه واسعة على طريق الوصول لمعرفة أفضل الإحتياجات لبنجر السكر من النتروجين و البوتاسيوم و المنجنيز وقد أجريت الدراسة فى منطقة أبيس لموسمين (٢٠٠٥-٢٠٠٦ و ٢٠٠٦-٢٠٠٧). وقد أوضحت النتائج الآتى:

- أظهر التسميد بالنتروجين تأثيراً معنوياً على نمو بنجر السكر حيث أدى إلى زيادة الوزن المحصولى للمجموع الخضرى والمجموع الجذرى وبالتالى النبات الكلى وايضا محصول السكر , كما أدى إلى زيادة تركيز الأملاح الكلية الذائبة وتركيز السكروز و الأحماض الأمينية فى أنسجة الدرنات وكان أفضل معدل إضافة للنتروجين عند ١٥٠ مجم نيتروجين / كجم أرض والذى أزاد من محصول السكر كمنتج رئيسى بنسبة ٤١,٤ و ٣٩,٧ % مع موسمى الزراعة الأول و الثانى على الترتيب .
- بالنسبة للبوتاسيوم فكان أفضل معدل إضافة هو ١٠٠ مجم بوتاسيوم / كجم أرض وخاصة بالنسبة لإنتاج السكر والذى أزاد من محصول السكر كمنتج رئيسى بنسبة ١٦,٨ و ١٩,٨ % مع موسمى الزراعة الأول و الثانى على الترتيب .
- أما بالنسبة لعنصر المنجنيز فكانت إضافته بمعدل ٠,٢ مجم منجنيز/ كجم أرض هى الأفضل وحققت أعلى وزن محصولى للدرنات وبالتالى إنتاج السكر وحققت زيادة فى إنتاج السكر بنسبة ٣١,٥ و ٣٣,٤% مع موسمى الزراعة الأول و الثانى على الترتيب.