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MACRO-ELEMENTS REQUREMENTS OF SUGAR BEET

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ABSTRACT

Two field experiments were carried out during the two growing seasons 2005/2006 and 2006/2007 at the Experimental Farm of Sakha Agricultural Research Station North Nile Delta region, Agricultural Research Center, Egypt. The effect of three levels from N, P and K and their interaction on yield and quality of sugar beet. The most important finding could be summarized as follows:

a- Nitrogen and phosphorus levels significantly affected on top, root and sugar yields/fad as well as root characters (root length and diameter as well as root weight/plant) in both seasons. increasing both nitrogen and phosphorus levels significantly increased all mentioned characters in the two seasons of study. On the other hand, potassium level failed to excert any significant effect on these traits, except root length in the two seasons.

b- The obtained data reveal that increasing nitrogen level significantly decreased T.S.S% and sucrose %, but had no significant effect on purity % in both seasons. phosphorus and potassium fertilizer in significantly affected all quality characters in the two seasons.

c- The interaction between or among the studied factors had no significant effect on all traits under study.

It was concluded that the application of 120 kg N, 60 kg P_2O_5 and 48 kg K_2O/fad. Could be recommended as optimum NPK fertilization treatments for higher yields and quality of sugar beet.

INTRODUCTION

Sugar beet (*Beta vulgaris* L.) is the vital crop to man as a sucrose of high energy pure food and as an important source of feed for livestock. Together with sugar can, it provides all sugar consumed annually allover the world. In Egypt, sugar beet growing area had been increased during the last years and the production of sugar from the sugar beet plants have taken place.

The main objectives of the present investigation was to study the effect of NPK fertilizers on growth attributes, yield and quality of sugar beet under Kafr El-Sheikh conditions (North Nile Delta region).

Nitrogen, phosphorus and potassium fertilizers are considered the most important fertilizers for different crops as well as sugar beet. Sugar beet nutrition has been subjected the greatest amount of study and yet is receiving much attention. Nitrogen fertilization is the agronomic variable to obtain maximum sugar beet important growth and yield as well as improve its quality. Badawi *et al.* (1995), El-Hennawy *et al.* (1998), El-Hawary (1999) as well as Hassanin and Elayan (2000) found that increasing nitrogen rate increased root length and diameter as well as root and sugar yields (t/fad.). They also, added that average yields of tops, roots and sugar content were increased by increasing the rates of nitrogen applied. Obeed (1988), Mahmoud *et al.* (1990) and Nemeat Alla (1991) reported that increasing of applied nitrogen decreased juice purity while sugar content was not affected.

Phosphorus fertilization seems to be critical for the growth in the field. El-Kassaby *et al.* (1991), El-Hawary (1994), Hassanin and Elayan (2000) reported that yield of roots, tops and sugar were increased by increasing applied phosphorus, while sucrose percentage was not affected. However, Hassanin and Elayan (2000) found that quality traits were not significantly affected by phosphours rates.

Adding K results a significant increase in the concentration of N and K in both roots and leaves. Phosphorus increased up to 30 units of K2O and then began to decrease as the added K increased. Concentration of micronutrients (fe, Cu, Mn and Zn) increased in both roots and leaves as the K added increased. At the same time there was great response to T.S.S., Sucrose and purity % with the increased in K added up Bishr, *et al.* (1973); El-Kassaby, *et al.* (1991); Hegazy, *et al.* (1992) and Amer *et al.* (2004).

Potassium fertilizer showed significant effects on root length, root diameter, root fresh weight, sucrose %, purity %, root/top ratio, top yield and sugar yield (Osman, 2005 a and b)

MATERIALS AND METHODS

The present investigation was carried out at the Experimental Farm of Sakha Agricultural Research Station, Agricultural Research Center, during 2005/2006 and 2006/2007 seasons. The preceding crop was maize in both seasons. Chemical analysis of soil experimental site were presented in Table1.

The two experiments were laid out in split-split plot design with three replications which was used as follow :

a- Three levels of nitrogen (60, 90 and 120 kgN/fad) were applied in the form of urea (46% N) and arranged in main plots.

b- Three levels of phosphours (45, 60 and 75 kg P_2O_5/fad) were applied in the form of calcium superphosphate (15% P_2O_5) and allocated in sub-plots.

c- Three levels of potassium (24, 48, 72 kg K_2O_2/fad) were applied in the form of potassium sulphate (48% K_2O) and arranged in sub-sub plots.

Table 1. Chemical analysis of the soil experimental site (0-30 cm depth) at farm of Sakha research Station, Kafr El-sheikh in 2005/2006 and 2006/2007 seasons.

Seasons	PH 1 : 2.5	EC m mhas cm.	Organic matter %	Available			Anions q/L.			
				N ppm	P ppm	K ppm	HCo_3^-	el^-	So_4^{--}	Co_3^{--}
2005/2006	8.3	3.38	1.79	15.48	6.51	278.50	6.3	6.1	0.33	0.0
2006/2007	8.4	3.35	1.76	15.60	6.47	280.65	6.6	6.4	0.21	0.0

Phosphorus was applied at planting, while nitrogen and potassium fertilizers were applied twice. The first application was after thinning and included half of the nitrogen quantity and all the potassium quantity. The second application tock place one month later and included the other half of the nitrogen quantity.

Each plot contained four rows, 7 m-long and 50 cm. apart with an area 14 m. The "Pleno" cultivar was obtained from the Delta company for sugar in Kafr El-Sheikh Governorate. Sowing dates were October 20^{th}, 29^{th} in the first and second seasons, respectively. Seeds was sown in hills 20 cm apart at rate of 4 : 5 seeds/hill. The plants were thinned to one plant per hill after 40 days from planting. Other cultural practices were conducted for each plot in a similar manner whenever possible.

After about 195 days form sowing date, the plants were ready to harvest. The two middle rows in each plot were harvested to prevent border effect and the yields of roots, tops and sugar were recorded. A random sample of ten roots from each plot was taken to measuring at random root dimensions yield characters (root length as well as diameter and root weight) and sugar content. Sucrose percentage in the roots was determined polarmeterically according to method of Le Docte (1927). The juice purity percentage was determined according to the method of Silin and Silina (1977). Total soluble solids (T.S.S.) were determined with a hand refractometer. Sugar yield per faddan was calculated according to the following equation:

Sugar yield (t/fad) = Root yield (t/fad) × sucrose %

The analysis of variance was carried out according to Snedecor and Cochran (1967). Treatment means were compared by Duncan's multiple range test (Duncan, 1955).

RESULTS AND DISCUSSION

The effect of nitrogen, phosphorus and potassium levels and their interactions on root length, root diameter and root weight of sugar beet plants at harvest during 2005/2006 and 2006/2007 seasons are presented in Table (2).

A. Root dimension

A.1. Root length

Data in Table 2 cleared that nitrogen fertilizer levels had a significant effect on length of root (cm.) at harvest in the two seasons. The longest roots were obtained from 90 kg N/fad. Also, root length was significantly affected by phosphorus in the first season only. Application of 60 kg P_2O_5/fad gave the longest roots. Moreover, increasing potassium levels from 24 to 48 K_2O/fad. Significantly increased the root length in both seasons. Similar results were recorded by Badawi *et al.* (1995), El- Hennawy *et al.* (1998) as well as Hasanin and Elayan (2000).

A.2. Root diameter :

Table 2 further illustrates that there was significant effect for nitrogen and phosphorus treatments and not by potassium in both seasons. The highest root diameter was recorded at 90 kg N/fad. Similarly, application of 60 and 75 kg P_2O_5/fad. Produced highest root diameters in both seasons, respectively. Increasing potassium levels from 24 to 72 K_2O/fad. Had not significant effect on root diameter in both seasons. El-Moursy *et al.* (1998) found that application of nitrogen, phosphorus and potassium markedly increased root diameter.

Table 2. Root length, root diameter and root weight kg/plant of sugar beet as affected by nitrogen rate, phosphorus rate and potassium rate in 2003/2004 and 2004/2005 seasons.

Treatment	Root length (cm.)		Root diameter (cm.)		Root weight kg /plant	
	2005/2006	2006/2007	2005/2006	2006/2007	2005/2006	2006/2007
Nitrogen rate (N) :						
60kg N/fad.	26.0 b	23.3 b	11.2 b	10.2 b	0.92 c	0.88 c
90kg N/fad.	26.5 b	24.6 a	12.6 b	10.7 a	1.10 b	0.95 b
120kg N/fad.	27.1 a	24.8 a	12.5 a	10.9 a	1.20 a	1.01 a
F-test	*	*	*	*	**	*
Phosphorus rate (P) :						
45Kg P_2O_5/fad.	25.4 c	24.1	11.3 b	10.0 b	0.98 b	0.85 c
60 Kg P_2O_5/fad.	26.7 b	23.9	12.7 a	10.3 b	1.11 b	0.92 b
75 Kg P_2O_5/fad.	27.5 a	24.6	12.2 a	11.4 a	1.21 a	1.07 a
F-test	**	NS	*	*	**	**
Potassium rate (K) :						
24 Kg K_2O/fad.	25.5 b	22.4 v	12.2	10.4	1.07	0.91
48 Kg K_2O /fad.	27.1 a	26.0 a	11.9	10.6	1.06	0.94
72 Kg K_2O /fad.	27.0 a	24.2 b	12.0	10.2	1.04	0.99
F-test	*	**	NS	NS	NS	NS
Interaction :						
N × P	NS	NS	NS	NS	NS	NS
N × K	NS	NS	NS	NS	NS	NS
P × K	NS	NS	NS	NS	NS	NS
N × P × K	NS	NS	NS	NS	NS	NS

*, ** and NS indicate P<0.05 and not significant, respectively.
Means of each factor designated by the same letter are not significantly different at 5% level using Duncan's multiple range test.

A.3. Root weight kg/plant :

Weight of root per plant was significantly affected by nitrogen and phosphorus treatments and affected by potassium levels in both seasons, Table 2. The heaviest roots were obtained from 90 kg N/fad. In both seasons. Such increase in weight of root may be due mainly to increased root length and diameter accompanied by nitrogen fertilization. These findings agree with those of Nemeat Alla (1991) and Hassanin and Elayan (2000). Application of 75 kg P_2O_5/fad. Gave the heaviest roots in both seasons. Potassium fertilization not affected on root weight in both seasons.

B. Top, root and sugar yields

B.1. Top yield (t./fad.)

It is evident from Table 3 that yield of tops/fad. was significantly affected by nitrogen and phosphorus fertilizer and not by potassium in both seasons. The highest yield of tops in tons/fad. was obtained at the highest level of nitrogen (120 kg N/fad). The increase in top yield with increasing nitrogen fertilization level reflected its effect on leaf number and probably on leaf weight and area. These results confirmed with those of Nemeat Alla (1991), El-Morusy *et al.* (1998) and Osman (2005).

Yield of tops/fad. was increased significantly with increasing phosphorus application up to 75 and 60 kg P_2O_5/fad. in two seasons, respectively. Top yield had no significant increase with increasing potassium levels in both seasons. These results were supported by the findings of El-

Hawary (1994), Badawi *et al.* (1995) and El-Morusy *et al.* (1998) who reported that P_2O_5 fertilization increased top yield.

B.2. Root yield (t./fad.)

Data, presented in Table (3) show the effect of nitrogen, phosphorus and potassium fertilization and their interactions on yield of roots in tones/fad. in both seasons. Root yield/fad. was significantly affected by nitrogen and phosphorus in the two seasons. While potassium had no effect.

The average root yield of sugar beet was increased from about 28.0 to 30.09 tons/fad. in the first season and from about 22.73 to 27.20 tons/fad. in the second season when the application of nitrogen was increased from 60 to 120 kg N/fad. The increase in root yield by increasing nitrogen application might be attributed to increased efficiency of nitrogen fertilization in building and translocation of metabolites from leaves which, developing roots. These findings agreed with those of Badawi *et al.* (!995), El-Hennawy *et al.* (1998), Hassanin and Elayan (2000) and Osman (2005).

The highest root yield/fad. was obtained by 75 and 60 kg P_2O_5/fad. in the two seasons, respectively. On the other hand, root yield/fad. not affected by increas·g potassium level from 24 to 48 or 72 kg K_2O/fad. in both seasons. The results were obtained by El-Hawary (1994), Badawi *et al.* (1995) and El-Morusy *et al.* (1998).

Table 3. Top, root and sugar yields of sugar beet as affected by nitrogen, phosphorus and potassium rates in 2005/2006 and 2006/2007 seasons.

Treatment	Top yield (t/fad.)		Root yield (t/fad.)		Sugar yield (t/fad.)	
	2005/2006	2006/2007	2005/2006	2006/2007	2005/2006	2006/2007
Nitrogen rate (N) :						
60 kg N/fad.	11.59 c	10.44 b	28.00 c	22.73 c	4.16 c	3.30 c
90 kg N/fad.	12.70 b	11.24 a	29.20 b	25.40 b	4.42 b	3.73 b
120 kg N/fad.	13.24 a	11.60 a	30.09 a	27.20 a	4.71 a	4.28 a
F-test	**	**	**	**	**	**
Phosphorus rate (P) :						
45 Kg P_2O_5/fad.	12.08 b	10.53 b	26.72 c	24.51 b	4.08 b	3.67 b
60 Kg P_2O_5/fad.	12.47 b	11.15 b	29.79 b	25.34 a	4.59 a	3.83 a
75 Kg P_2O_5/fad.	12.98 a	11.59 a	30.78 a	25.49 a	4.63 a	3.80 a
F-test	*	*	*	*	**	*
Potassium rate (K) :						
24 Kg K_2O/fad.	12.31	10.98	28.90	25.31	4.33	3.74
48 Kg K_2O /fad.	12.59	11.01	29.10	24.92	4.51	3.78
72 Kg K_2O /fad.	12.63	11.28	29.30	25.11	4.44	3.79
F-test	NS	NS	NS	NS	NS	NS
Interaction :						
N × P	NS	NS	NS	NS	NS	NS
N × K	NS	NS	NS	NS	NS	NS
P × K	NS	NS	NS	*	NS	NS
N × P × K	NS	NS	NS	NS	NS	NS

*, ** and NS indicate P<0.05 and not significant, respectively.
Means of each factor designated by the same letter are not significantly different at 5% level using Duncan's multiple range test.

B.3. Sugar yield (t. fad.).

Results in Table 3, illustrated that sugar yield/fad. was highly significantly affected by nitrogen fertilization in both seasons. Average sugar yield/fad. was increased from about 4.2 to 4.8 t/fad (in 2005/2006) and from about 3.3 to 4.3 t) fad. (in 2006/2007) as the nitrogen levels were increased from 60 to 120 kg N/fad. Such effect reflects the responses of root yield and sugar percentage to nitrogen fertilization levels by Hassanin and Elayan (2000) and Osman (2005).

In both seasons, sugar yield/fad. was significantly affected by phosphorus application. The highest yield of sugar resulted from 60 and 75 kg P_2O_5/fad. which were not significantly different from each other in both seasons. El-Hawary (1994), Badawi *et al.* (1995) and El-Morusy *et al.* (1998) found that increasing phosphorus level increased sugar yield.

Potassium application gave no significant effect on yield of sugar in both seasons. Results of Bishr *et al.* 1973) and Hassanein (1979) agreed with the present results. However, different results were obtained by Hegazy *et al.* (1992), who revealed that K-fertilization, in general tended to decrease slightly of sugar yield.

C. Quality characters :

The effects of different levels of nitrogen, phosphours and potassium fertilizers and their interactions on quality characters in 2005/2006 and 2006/2007 seasons are given in Table (4).

C.1. Total soluble solids (T.S.S.) :

The analyses of variance revealed that total soluble solids of sugar beet were significantly affected by nitrogen treatments but not by phosphorus and potassium fertilization in 2005/2006 and 2006/2007 seasons, Table 4. Total soluble soluble solids ranged from 20.0 to 21.0% in 2005/2006 and from 19.3 to 20.3 in 2006/2007 when the nitrogen application was increased up to 120 kg N/fad. Neither phosphorus nor potassium fertilization had significant effects on (T.S.S.) in both season.

C.2. Sucrose percentage

In both seasons, sucrose percentage was highly significantly influenced by nitrogen fertilizer level. The highest level of nitrogen application (120 kg N/fad.) produced the highest sugar content in 2005/2006 and 2006/2007 seasons, Table 4. Similar results were obtained by Ahmed (2003) who found that sucrose percentage was increased with high nitrogen rate.

Data also indicated that phosphorus and potassium had no significant effect on sucrose percentage in both seasons. These results are in good agreement with those obtained by El-Hawary (1994), Badawi *et al.* (1995) and El-Morusy *et al.* (1998), who reported that phosphours and potassium fertilizers did not affected on sucrose percentage.

C.3. Juice purity percentage :

From data presented in Table (4), it could be seen that nitrogen application did not exhibit significant differences in juice purity % in both seasons. This result is similar to that of Obead (1988) and Nemeat Alla (1991).Both phosphours and potassium had no significant effect on juice purity percentage in both seasons. These findings agreed with those obtained by Hassanein (1979) and El-Morusy *et al.* (1998).

Table 4. Total soluble solids (T.S.S.), sucrose percentage and purity percentage of sugar beet as affected by nitrogen, phosphorus and potassium rates in 2005/2006 and 2006/2007 seasons.

Treatment	T.S.S. %		Sucrose %		Purity %	
	2005/2006	2006/2007	2005/2006	2006/2007	2005/2006	2006/2007
Nitrogen rate (N) :						
60 kg N/fad.	20.0 b	19.3 b	15.20 c	14.54 b	75.53	74.56
90 kg N/fad.	20.2 b	19.7 b	15.45 b	14.68 b	75.79	75.38
120 kg N/fad.	21.0 as	20.3 a	15.67 a	15.75 a	75.65	77.59
F-test	**	*	**	*	NS	NS
Phosphorus rate (P) :						
45 Kg P_2O_5/fad.	20.5	19.7	15.28	14.97	74.54	75.96
60 Kg P_2O_5/fad.	20.4	19.9	15.54	15.10	76.29	75.88
75 Kg P_2O_5/fad.	20.3	19.7	15.49	14.89	76.16	75.70
F-test	NS	NS	NS	NS	NS	NS
Potassium rate (K) :						
24 Kg K_2O/fad.	20.4	19.5	15.25	14.78	74.83	75.72
48 Kg K_2O /fad.	20.3	20.0	15.56	15.18	76.65	75.90
72 Kg K_2O /fad.	20.5	19.8	15.50	15.01	75.50	75.92
F-test	NS	NS	NS	NS	NS	NS
Interaction :						
N × P	NS	NS	NS	NS	NS	NS
N × K	NS	NS	NS	NS	NS	NS
P × K	NS	NS	NS	NS	NS	NS
N × P × K	NS	NS	NS	NS	NS	NS

*, ** and NS indicate P<0.05 and not significant, respectively.
Means of each factor designated by the same letter are not significantly different at 5% level using Duncan's multiple range test.

Effect of the interaction :

The differences in sugar beet yield as well as root and quality characters due to the interaction between or among NPK fertilizer levels was not significant in both seasons. This indicates that the response of sugar beet to the three fertilization elements (NPK) was independently

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احتياجات بنجر السكر من العناصر الكبرى

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أجرى البحث بالمزرعة البحثية لمحطة البحوث الزراعية بسخا – مركز البحوث الزراعية خلال موسمى ٢٠٠٥/٢٠٠٦ و ٢٠٠٦/٢٠٠٧ لدراسة الاحتياجات السمادية لمحصول بنجر السكر من النتروجين والفوسفور والبوتاسيوم وأثرة ذلك على محصول الجذور والعرش والسكر وطـول الجذر وقطرة ومحتوى السكر ونسبة المواد الصلبة الذائبة ودرجة النقاوة. وقد اسـتخدم تصـميم القطع المنشقة مرتين فى كلا الموسمين حيث وضعت معدلات السماد الأزوتى الثلاثة (٦٠- ٩٠ – ١٢٠كجم/ف) فى القطع الرئيسية ووضعت معدلات السماد الفوسـفاتى الثلاثـة (٤٥ – ٦٠ – ٧٥ كجم فو٢ أ٥/ف) فى القطع الشقية الأولى ومعدلات السماد البوتاسى الثلاثة (٢٤ – ٤٨ – ٧٢كجـم بو٢ أ/ف) فى القطع الشقية الثانية.

وقد أوضحت النتائج ما يلى :

١- أثرت كل من مستويات الأزوت والفسفور معنويا على محصول العرش والجذور والسـكر للفدان. وكذلك على كل صفات الجذور المدروسة (طول وقطر الجذر ووزن الجذر لكـل نبات) بكلا موسمى الدراسة وفقد أدت زيادة معدلات الأزوت والفسفور الى زيادة معنويـة فى كل الصفات السابق ذكرها بكلا الموسمين. ومن ناحية أخرى لم يكـن للبوتاسـيوم أى تأثير معنوى على كل الصفات السابقة فيما عدا صفة طول الجذر بكلا الموسمين.

٢- اظهرت النتائج المتحصل عليها أن زيادة معدلات الأزوت أدت الى نقص معنوى فى كـل من النسبة المئوية للمواد الصلبة الذائبة الكلية ومحتوى السكروز بالجذور، بينما لم يكن لها تأثير معنوى على النسبة المئوية للنقاوة فى كلا الموسمين. فى نفس الوقت لم يؤثر كلا من معدلات التسميد الفسفورى والبوتاسى على كل صفات الجودة المدروسة بكلا الموسمين.

٣- لم يكن للتفاعل بين عوامل الدراسة أى تأثير معنوى على أى من الصفات المدروسـة.

ومن هذه النتائج وتحت ظروف الدراسة التى تمت بمحافظة كفرالشيخ يتضـح أن أنسـب معدلات للتسميد هى ١٢٠ كجم نيتروجين، ٦٠ كجم فوسفور، ٤٨ كجم بوتاسـيوم للفـدان حيـث أعطت أعلى محصول من الجذور والأوراق والسكر وجودة أفضل.