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YIELD AND QUALITY OF SUGAR BEET AS AFFECTED BY DIFFERENT NITROGEN AND SULPHUR RATES UNDER CLAYEY SOILS

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ABSTRACT

Two field experiments were conducted at the Experimental Farm of Sakha Agricultural Research Station, ARC, Egypt during 2001/2002 and 2002/2003 growing seasons. The experiments were conducted to study the response of sugar beet to three nitrogen fertilizer rates, (60, 80 and 100 kg N/fed.) and four sulpher rates (0, 100, 200 and 300 kg S/fed.).

The results indicated that root length and diameter, dry matter accumulation at harvest time (g/plant), root/ top ratio, root and top yields/fed. Were gradually increased with increasing nitrogen rate from 60 kg N/fed., whereas TSS% was decreased. Sugar yield/fed., sugar percentage and juice purity percentage were not affected by nitrogen rate in both seasons. Sulphur rates resulted significant differences in length and diameter of sugar beet roots, dry matter accumulation (g/plant), root/top ratio as well as root and top yields/fed. in favour of plants received 300 kg S/fed. Compared to control plants. No significant differences were detected in sugar yield/fed., TSS%, sugar percentage and juice purity percentage due to sulphur fertilizer application in both seasons.

It can be concluded that application of 80 kg N/fed. And 200 kg S/fed. Could be recommended for optimum sugar beet yield under the conditions of this investigation.

INTRODUCTION

Recently, sugar beet crop has an important position in Egypt crop rotation as winter crop not only in the fertile soils, but also in poor, saline, alkaline and calcareous soils. Whereas, it could be economically grown in the newly reclaimed soils such as present in large area in Kafr El-Sheikh Governorate at the Northern parts of Egypt, as one of the most tolerant crops to salinity and wide range of climates.

Improvement of sugar beet production can be achieved through optimizing the cultural practices such as fertilization (good management program concerning nitrogen fertilizer rate and other macronutrients such as P. and K.). The need for sulphur has never been recognized in Egyption agriculture as a soil amendment and nutritional element. Only recently, started to deal with the use of sulphur for agricultural purposes.

Nitrogen is considered the most important nutrient for different crops as well as sugar beet. The sugar beet response to nitrogen fertilizer has been studied by many scientists. They reported that sugar beet produce maximum sucrose only if N is available in the proper soil, where N-fertilization is the most important agronomic variable to obtain maximum sugar beet growth and yield as well as improve its quality El-Essawy (1996), Nemeat-Alla (1997), Basha (1999), El-Zayat (2000), Hassanin and Elayan (2000), Hassanein and

El-Shebiny (2000), Nemeat-Alla (2001), Abo El-Wafa (2002), Nameat-Allta *et al.* (2002) and Badr (2004).

As the Egyption soils suffer from a high pH values, where the availability of P. and a number of micronutrients is reduced, the use of S fertilizer might help in decreasing this alkalinity during S biological oxidation. In this respect, Hassan and Olsen (1966) reported that applied S to corn increased the availability of plant nutrient from soils such as P, K, Mg, Fe, Mn and Zn. Also, the addition of S to alkali soil gave further increase in yields and nitrogen content was increased in cotton plants, which fertilized with urea, ammonium sulphate or ammonium nitrate (Nasseem and Nasrallah, 1981). Regarding the use of sulphur for sugar beet, El-Kammah and Ali (1996) and Hashem *et al.* (1997) reported that yields of sugar beet, sucrose content and TSS% were significantly increased with increasing levels of applied S. On the other hand, Ouda (2002) found that applied of S fertilizer at rate of 6, 8 and 10 kg S/fed. for sugar beet in newly cultivated sandy soil decreased significantly the most studied characters and concluded that addition of 100 kg N/fed. along with 6 kg S/fed. produced the highest sugar yield.

This investigation aimed to study the response of sugar beet to nitrogen fertilizer rate in relation to sulphur fertilizer.

MATERIAL AND METHODS

Two field experiments were conducted at the Experimental Farm of Sakha Agic. Res. Station during two successive seasons, i.e. 2001/2002 and 2002/2003. The preceding crop was rice in the two seasons. The soil of experimental fields was clay in texture. Physical and chemical analysis of experimental soils were presented in Table (1).

Table (1): Physical and chemical analysis of experimental soils (0-30 cm depth) in 2001/2002 and 2002/2003 seasons.

Soil characters	Seasons	
	2001/2002	2002/2003
PH 1:2.5	8.3	8.4
EC mmhos/cm	3.38	3.41
Organic matter %	1.75	1.60
Clay	53.60	53.41
Silt	25.71	25.74
Sand	20.69	20.85
Texture class	Clayey	Clayey
Available :		
N.(ppm)	15.25	16.14
P (ppm)	6.20	6.00
K (ppm)	280.10	288.35
Anions meq/L:		
HOC^{-}_{3}	6.2	6.5
Cl^{-}	5.6	6.1
So^{-}_{4}	0.16	0.22
Co^{-}_{3}	0.0	0.0

Super phosphate was added in the form of calcium super phosphate (15.5% P_2O_5) at the rate of 30 kg P_2O_5/fed., while potassium was applied in the form of potassium sulphate (48% k_2O) at the rate at 24 kg K_2O/fed. during soil preparation.

A split plot design with four replications was used in both seasons. The main plots were assigned to the three nitrogen rates, i.e. 60, 80 and 100 kg N/fed. Nitrogen fertilizer was applied in the form of urea (46% N) in two equal doses: the first at 4-leaves stage and the second at 8-leaves stage. The sub-plots were allocated to the four sulphur levels, i.e. 0, 100, 200 and 300 kg sulphur/fed. in one dose before planting. Sulphur fertilizer was band applied approximately 10 cm below hills.

Each sub-plot included six ridges each 60 cm apart and 7 m. long. Sowing took place on 15th October 2001 and 22nd October 2002. Seed of multigerm cultivar "Rasspoly" was sown in hill 20 cm apart at rate of 4-5 seeds per hill. Fourty days after sowing thinning to one plant/hill was done. Other cultural practices for growing sugar beet were conducted as recommended. At maturity (200 days from sowing), the four middele ridges of each plot were harvested to determine top and root yields. Sample of ten guarded plants were taken at random to estimate root dimensions (length and diameter). Each sample was separated into leaves and roots and dried to constant weight at 105°C to calculate root/top ratio. Total soluble solids (TSS%) was determined using hand Refractometer. Sucrose percentage was determined by Sucrometer according to Le Docte (1927). Juice purity percentage was calculated according to the method of Silin and Silina (1977). Sugar yield per feddan was calculated according to the following equation :

$$\text{Sugar yield (t/fed)} = \text{Root yield (t/fed)} \times \text{Sucrose \%}$$

The analysis of variance was carried out according to Gomez and Gomez (1984). Treatment means were compared by Duncan's multiple range test (Duncan, 1955). All statistical analysis were performed using analysis of variance technique by means of "IRRSTAT" computer Software Package.

RESULTS AND DISCUSSIONS

Growth characters :

A-1- Root dimensions :

Data in Table (2) show that nitrogen fertilizer rate had a significant effect on root dimensions (length and diameter) at harvest time in both seasons. Increasing nitrogen level from 60 to 100 kg N/fed significantly increased root dimensions. The highest values of root length and diameter were recorded at the highest nitrogen level (100 kg N/fed) without significant differences with 80 kg N/fed. in most cases. The increase in root length and diameter with increasing nitrogen rate may be attributed to the effect of nitrogen in increasing division and elongation of root cells led to increasing root dimension. These results are in agreement with those of El-Essawy (1996), Nemeat-Alla (1997), El-Zayat (2000), Nemeat-Alla (2001) and Badr (2004).

Root dimensions were significantly affected by sulphur rate in both seasons (Table 2). Application of 300 and 200 kg S/fed, being insignificant, exceeded the control treatment in root length and diameter in both seasons. These results are in accordance with those reported by Hussein (2001).

The interaction between nitrogen rate and sulphur application had no significant effect on root length and diameter in both seasons (Table 2).

Table (2): Root length an root diameter as affected by the nitrogen rate and sulphur fertilizer in 2001/2002 and 2002/2003 seasons.

Factor	Root length (cm)		Root diameter (cm)	
	Seasons			
	2001/2002	2002/2003	2001/2002	2002/2003
N rate (kg N/fed):				
60	31.9 7 b	32.4 1 b	14.1 3 b	14.8 1 b
80	32.5 6 ab	32.9 7 b	15.2 2 a	15.6 7 a
100	33.1 6 a	34.1 3 a	15.7 2 a	16.1 9 a
F-Test	*	*	*	*
S rate (kg S/fed):				
Contr ol	30.8 8 b	31.2 6 b	12.6 3 c	13.3 7 c
100	31.9 2 ab	33.2 6 a	15.4 6 b	15.4 2 b
200	32.9 7 a	33.7 4 a	15.8 3 a	16.1 3 a
300	33.7 9 a	34.4 0 a	16.1 7 a	16.7 4 a
F-Test	*	**	**	**
Interaction	NS	NS	NS	NS

***, ** and NS indicate $P < 0.05$, $P < 0.01$ and not significant, respectively. Means of each factor followed by common letter are not significantly different at 5% level using Dancan's multiple range test.**

A-2 Dry matter accumulation :

Nitrogen rate had a significant effect on dry matter accumulation (g/plant) in the both seasons (Table 3). Application of 100 kg N/fed produced the highest dry matter accumulation in the two seasons, while application of 60 kg N/fed. Produced the lowest dry matter accumulation per plant. Similar results were obtained by El-Essawy (1996), Nemeat-Alla (1997), El-Zayat (2000) and Badr (2004).

Sulphur application significantly affected dry matter accumulation (g/plant) in both seasons (Table 3). The highest sulphur level (300 kg S/fed) produced the highest dry matter accumulation/plant in the two seasons. Each increment of applied sulphur resulted in a significant increase in dry matter accumulation/plant. El-Kammah and Ali (1986) came to the same result.

Table (3): Dry matter accumulation and root/top ratio as affected by the nitrogen rate and sulphur fertilizer in 2001/2002 and 2002/2003 seasons.

Factor	Dry weight (g/plant)		Root/top ratio	
	Seasons			
	2001/2002	2002/2003	2001/2002	2002/2003
N rate (kg N/fed):				
60	178.15 c	175.57 b	4.89 c	4.65 c
80	182.58 b	176.24 b	5.17 b	4.97 b
100	197.40 a	180.59 a	5.61 a	5.51 a
F-Test	**	*	**	*
S rate (kg S/fed):				
Control	182.00 d	170.74 d	5.02 b	4.88 b
100	184.63 c	175.87 c	5.26 ab	5.01 ab
200	186.87 b	179.93 b	5.31 a	5.11 ab
300	190.67 a	183.29 a	5.32 a	5.18 a
F-Test	**	*	*	*
Interaction	**	NS	NS	NS

*, ** and NS indicate $P < 0.05$, $P < 0.01$ and not significant, respectively. Means of each factor followed by common letter are not significantly different at 5% level using Dancan's multiple range test.

The interaction between nitrogen rate and sulphur level had a significant effect on dry matter accumulation/plant in the first season only (Table 4). Application of 100 kg N/fed. with 300 kg S/fed. resulted in the highest dry matter accumulation (203.57 g/plant) at harvest.

Table (4): Dray matter accumulation (g/plant) at harvest by the interaction between nitrogen rate and sulphur fertilizer in 2001/2002 season.

S. rate (kg/fed)	N. rate (kg/fed)		
	60	80	100
Control	176.35 i	178.48 h	191.16 d
100	176.70i	181.15 g	196.05 c
200	178.49 h	183.31 f	198.81 b
300	181.06 g	187.37 e	203.57 a

A-3- Root/top ratio :

Data in Table (3) show that root/top ratio was significantly effected by nitrogen rate in both seasons. Root/top ratio was gradually increased by increasing nitrogen rate. Application of 100 kg N/fed produced the highest root/top ratio in the two seasons. Hassanin and Elayan (2000), Nemeat-Alla *et al.* (2002) showed that root/top ratio was increased with increasing N-fertilizer when soil N is limited.

Increasing sulphur level from 0 to 300 kg S/fed significantly increased root/top ratio (Table 3). Adding 300 kg S/fed produced the highest root/top ratio without, compared with control. Similar results were obtained by Hussein (2001).

The interaction between nitrogen level and sulphur rate had insignificant effect on root/top ratio in both seasons (Table 3).

B- Root, top and sugar yields :

B-1- Root yield (t/fed):

Increasing nitrogen level from 60 to 100 kg N/fed significantly increased root yield/fed at harvest in both seasons (Table 5). Root yield was increased from 28.45 and 29.87 to 31.50 and 31.74 t/fed as N-level increased from 60 to 100 kg N/fed in the first and second season, respectively. The increase in root yield caused by nitrogen application may be attributed to the favorable effect of nitrogen in building up the photosynthetic area of beet plants and consequently accumulation of more dry matter in roots. Increasing N-level from 80 to 100 kg N/fed gave simelar root yield/fed in the two seasons. Similar results were obtained by Nemeat-Alla (1997), El-Zayat (2000), Hassanein and El-Shebiny (2000), Nemeat-Alla *et al.* (2002) and Badr (2004).

Table (5): Root, top and sugar yields (t/fed) as affected by nitrogen rate and sulphur fertilizer in 2001/2002 and 2002/2003 seasons.

Factor	Root yield (t/fed)		Top yield (t/fed)		S-yield (t/fed)	
	Season					
	200/2002	2002/2003	200/2002	2002/2003	200/2002	2002/2003
N rate (kg N/fed):						
60	28.45 b	29.87 b	7.44 b	7.81 b	4.80	4.96
80	27.77 ab	30.76 ab	8.13 ab	8.67 ab	4.96	5.05
100	31.50 a	31.74 a	8.89 a	9.13 a	5.12	5.17
F-Test	*	*	*	*	NS	NS
Sulpher (kg S/fed):						
Control	29.32	29.62 b	7.31 b	7.73 d	4.74	4.92
100	29.77	30.42 b	7.83 b	8.26 c	4.88	5.02
200	29.98	31.33 a	8.59 a	8.78 b	4.99	5.11
300	30.57	31.80 a	8.89 a	9.38 a	5.22	5.18
F-test	NS	**	*	**	NS	NS
Interaction	NS	NS	NS	NS	NS	NS

*, ** and NS indicate $P < 0.05$, $P < 0.01$ and not significant, respectively. Means of each factor followed by common letter are not significantly different at 5% level using Dancan's multiple range test.

Non of the interaction between N-level and sulphur rate had a significant effect on root yield at harvest in both seasons (Table 5).

B-2- Top yield (t/fed) :

As shown in Table (5), the top yield of sugar beet plants at harvest significantly increased with increasing nitrogen rate. The highest top yield was obtained from applying 100 kg N/fed without significant difference with 80 kg N/fed in the two seasons. Similar results were obtained by El-Essawy (1996), Basha (1999), Nemeat-Alla (2001) and Badr (2004).

Yield of tops/fed at harvest was significantly affected by sulphur fertilizer in both seasons (Table 5). The highest yield of tops was obtained from 300 kg S/fed in both seasons. No significant difference between 200 and 300 kg S/fed was recognized in this trait in the first season. The increase in top yield with increasing sulphur fertilization in the two seasons may be due to increasing the availability of different nutrient elements Hassan and Olsen (1966) and El-Kammah and Ali (1996).

The interaction effect between N-rate and S-fertilizer on top yield/fed at harvest was not significant in both seasons.

B-3- Sugar yield (t/fed) :

Neither nitrogen nor sulphur fertilizer and their interaction significantly affected sugar yield in both seasons (Table 5). Similar results were obtained by Nemeat-Alla (2001).

El-Kammah and Ali (1996) and Hashem *et al.* (1997) reported that increasing levels of applied S significantly increased sugar yield.

The interaction between N-level and S-rate insignificantly effect sugar yield/fed in the two seasons.

C- Quality parameters :

C-1- Total soluble solids percentage (TSS %) :

From Table (6) it is clear that TSS% was significantly affected by nitrogen rate in the two seasons. TSS % was gradually decreased by increasing nitrogen level. Excessive nitrogen reduced TSS % by partitioning of more photosynthetic to tops than to the roots of sugar beet plants. El-Essawy (1996), Hassanin and Elayan (2000), Nemeat-Alla (2001) and Badr (2004) came to similar results and the same conclusion.

No significant differences were detected in TSS% due to sulphur fertilizer application as well as due to the interaction between N-level and S-rate in both seasons (Table 6).

C-2- Sugar and Juice purity percentage :

Analysis of variance showed insignificant differences among N-level and S-rate on sugar and juice purity percentages in both seasons (Table 6). The decrease in sucrose and juice purity percentage related to the increase in rates of nitrogen my be due to the role of nitrogen non sucrose substance such as proteins amino acids and other substance which led to decreasing juice purity percentage.

Also, the interaction between the two factors under study had insignificant effect on sugar and juice purity percentage in the two seasons (Table 6).

It can be concluded that application of 80 kg N/fed. And 200 kg S/fed. Could be recommended for optimum sugar beet yield under the conditions of this investigation.

Table (6): Total soluble solids (TSS), sugar percentage and juice purity as affected by the nitrogen level and sulphur rate in 2001/2002 and 2002/2003 seasons.

Factor	TSS %		Sugar percentage		Juice purity %	
	Season					
	200/2002	2002/2003	200/2002	2002/2003	200/2002	2002/2003
N rate (kg N/fed):						
60	20.69 a	20.84 a	16.66	16.64	80.34	81.69
80	20.16 b	20.38 b	16.20	16.40	80.47	80.54
100	20.02 c	19.88 c	16.19	16.27	80.55	79.82
F-Test	*	**	NS	NS	NS	NS
Sulpher (kg S/fed):						
Control	20.43	20.79	15.98	16.63	79.77	81.28
100	20.33	20.33	18.24	16.51	79.64	80.95
200	20.33	20.24	16.08	16.30	79.00	80.54
300	20.06	20.10	17.11	16.30	83.41	79.96
F-test	NS	NS	NS	NS	NS	NS
Interaction	NS	NS	NS	NS	NS	NS

***, ** and NS indicate $P < 0.05$, $P < 0.01$ and not significant, respectively. Means of each factor followed by common letter are not significantly different at 5% level using Dancan's multiple range test.**

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تأثير معدلات النيتروجين والكبريت على محصول بنجر السكر وجودته تحت ظروف الأراضى الطينية الثقيلة

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أجريت تجربتان حقليتان بالمزرعة البحثية لمحطة البحوث الزراعية بسخا – مركز البحوث الزراعية – مصر خلال موسمى الزراعة ٢٠٠١/٢٠٠٢، ٢٠٠٢/٢٠٠٣ . تم تنفيذ التجارب لدراسة استجابة بنجر السكر لثلاث مستويات من التسميد الأزوتى وهى ٦٠، ٨٠، ١٠٠كجم أزوت/فدان وعلاقتها بأربعة مستويات من الكبريت وهى صفر، ١٠٠، ٢٠٠، ٣٠٠كجم كبريت/فدان. استخدم فى تنفيذ تلك التجارب تصميم القطع المنشقة فى أربع مكررات.

ويمكن تلخيص أهم النتائج المتحصل عليها فيما يلى :

دلت النتائج أن كل من طول الجذر وقطرة، وزن المادة الجافة المتجمعة للنبات وقت الحصاد، نسبة الجذر/العرش، محصول كل من الجذر والعرش للفدان قد زادت زيادة تدريجية، بينما نقصت نسبة المواد الصلبة الذائبة الكلية بزيادة معدلات الازوت حتى ١٠٠كجم أزوت/فدان فى كلا موسمى الدراسة. كما أوضح تحليل التباين أنه كان هناك إختلافات غير معنوية بين مستويات التسميد الأزوتى على كل من محصول السكر للفدان ومحتوى السكر وكذلك نسبة نقاوة العصير فى كلا الموسمين.

أدت إضافة ٣٠٠كجم كبريت للفدان الى الحصول على أعلى القيم من كل من طول وقطر جذور بنجر السكر والمادة الجافة المتجمعة للنبات ونسبة الجذر/العرش وكذلك محصول الجذور والعرش طن/فدان بدون إختلافات معنوية مع معدل ٢٠٠كجم كبريت/الفدان فى معظم الحالات فى كلا الموسمين. ولم تكن هناك إختلافات معنوية فى محصول السكر طن/فدان ونسبة المواد الصلبة الذائبة الكلية ومحتوى السكر وكذلك نسبة نقاوة العصير نتيجة الى إضافة الكبريت فى كلا الموسمين.

ويمكن أن نستخلص من نتائج هذه الدراسة أنه بإضافة ٨٠كجم أزوت/فدان وكذلك إضافة ٢٠٠ كجم كبريت/فدان يمكن الحصول على أقصى محصول من بنجر السكر.