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Response of Sugar Beet (*Beta vulgaris* L.) to Potassium and Sulphur Supply in Clayed Soil at North Delta, Egypt

N.M.M. Awad, H.S. Gharib*# and Sahar M.I. Moustafa
*Sugar Crops Res. Inst., Agric. Res. Center, Giza and *Agronomy Dept., Fac. Agric., Kafrelshiekh University, Kafrelshiekh, Egypt.*

THE SUGAR beet (*Beta vulgaris* L.) cultivar “Farida” was grown on a clayed soil at Agricultural Research Station, Agricultural Research Center, Egypt, during 2011/2012 and 2012/2013 years. The aim of this study is to study growth, yield and quality response of sugar beet cultivar "Farida" to three potassium rates (12, 24 and 48 kg K_2O/feddan) (feddan (fed)= 0.42 hectare) and three sulphur rates (0, 125 and 250 kg S/fed) in clayed soil at North Delta, Egypt.

Application of potassium fertilizer at the rate of 48 kg K_2O/fed resulted in a substantially increase in leaf area index (LAI) and dry matter accumulation (g/plant), root length (cm), root diameter (cm), root weight (g), root yield (ton/fed), top yield (ton/fed), total sugar (%), concentration of K, alkalinity coefficient, extraction of white sugar (%), losses sugar (%) and white sugar yield (ton/fed) compared with the rate of 12 kg K_2O/fed in the two seasons. The inverse was true in juice purity (%) in the first season. The rate of 24kg K_2O/fed was statistically at par with the rate of 48 kg K_2O/fed in all the mentioned traits in both seasons. Potassium fertilizer rate had no significant effect on root/top ratio, concentration of Na and α-amino nitrogen (meq/100g) in both seasons and the percentage of juice purity (%) in the second season. Increasing sulphur rate from 0-250 kg S/fed significantly increased dry weight (g), LAI , root dimensions (length and diameter) (cm), root weight (g), top yield (ton/fed), root yield (ton/fed), gross sugar (%), white sugar (%), juice purity (%) and sugar yield (ton/fed) in both seasons. Application of sulphur fertilizer improved juice purity by decreasing impurities (K, Na and α-amino-N) in roots and, loss sugar (%) in the two seasons. Sugar beets received 250 kg S/fed produced the highest root and sugar yield (ton/fed). The interaction between potassium and sulphur rates had a significant effect on root and white sugar yields/fed. The maximum root and white sugar yields were achieved from beets received 24 or 48 kg K_2O along with 250 kg S / fed in both seasons. It can be concluded that application of 24 kg K_2O plus 250 kg S /fed was the recommended treatment for optimum root and extractable white sugar yield per unit area at Kafrelshiekh Governorate, Egypt.

Keywords: Sugar beet, (*Beta vulgaris* L.), Potassium, Sulphur, Rates, Yield and quality.

#**Corresponding author:** H.S. Gharib , Tel. : +201225005818 , E-mail address: hanysony@yahoo.com

Sugar beet (*Beta vulgaris* L.) is a major winter crop in Kafrelshiekh Governorate, Egypt, because of its tolerance to salinity and drought, where its productivity makes it a good cash crop. Sugar beet is composed primarily of carbon (C), hydrogen (H) and oxygen (O), but other elements are necessary as components of structural tissues or as participants in biochemical reactions (Draycott, 2003). Those are known with essential elements. He added that those elements needed in large quantities (macronutrients) by sugar beet are N, P, S, K, Ca and Mg. Those needed in small amounts (micronutrients) are B, Cu, Fe, Mn, Mo and Zn. Sugar beet is classified as a plant of high potassium requiring crop (Johanson *et al.*, 1971). Potassium has a special role in most plants in the opening and closing of stomata) (Mengel & Kirkby 1987). It is also very mobile in plant tissues and is found throughout theki plant. It is important for photosynthesis, and transport of sugar produced in the leaves relies on potassium for movement to the storage root. At harvest, plants given potassium (and sodium) have a significantly greater sugar percentage than those given none. Abdel-Mawly & Zanouny (2004) found that total soluble solids, refineable sugar, purity percentages of root juice, total root yield and top yield of sugar beet plants increased as K fertilizer increased. Mehrandish *et al.* (2012) found that potassium application increased root yield, shoot yield, impure sugar percent, pure sugar percent and sugar yield. Maximum and minimum root yield, impure sugar percent, pure sugar percent and sugar yield were observed in 100 kg K_2O ha^{-1} and control treatments, respectively. They added that application of 100 kg K_2O ha^{-1} improved quantitative and qualitative characteristics of sugar beet under full and deficit irrigation. The beneficial effect of K fertilization on growth, yield and quality of sugar beet was showed by some previous studies **(**Sobh *et al*., 1992; El-Ramady, 1997; El-Shafai, 2000; Ouda, 2002; Amer *et al.*, 2004; Ferweez & Abo El-Wafa, 2004; Draycott, 2006; Hermans *et al.*, 2006; Moustafa & El-Masry, 2006; Ismail & Allam, 2007; Seadh *et al.*, 2007; Abdel-Motagally & Attia, 2009; Abo-Shady *et al*., 2010 and Nafei *et al.*, 2010).

Sulphur is one of the major nutrients and is required to synthesize key amino acids, which in turn are needed to produce functional and structural proteins (Willenbrink, 1967). About 90% of the reduced S is bound through the amino acids methionine and cysteine. Sulphur is also needed as a functional group of coenzymes, so that S deficiency results in a change of protein synthesis. The Egyptian soil is thought to be deficient in availability of certain plant nutrients as a result of many reasons such as intensive cropping, low percentage of soil organic matter and alkaline conditions of soil. The use of sulphur might help in decreasing soil alkalinity through sulphur biological oxidation by soil microorganisms to sulphuric acid, which in turn lowers soil pH and increase the availability of nutrients notably phosphorus and several of micronutrients **(**El-Kammah & Ali, 1996). Sulphur deficiency may affect the amount of assimilates and thereby the sugar storage in the root of sugar beet by the drastic decrease of the chlorophyll content of the leaves (Hocking, 1995 and Kastori *et al*., 2000). Additionally, sulphur deficiency can be serious not only through an effect on yield, but also by altering the N/S ratio (Hocking, 1995 and Sexton, 1996). If a higher proportion of assimilated nitrogen is stored in free amino acids or amides, the technical quality of sugar beet is decreased. These N compounds, summed up as alpha-amino N, are important impurities in sugar beet, adversely affecting sugar extractability (Burba, 1996). Thomas *et al.* (2003) conducted field experiments at high- and low-S status sites in two seasons to investigate the effect of sulphur application on the growth and metabolism of sugar beet. They found that application of sulphur (25 kg ha^{-1}) resulted in a 25% increase in root yield together with significant increases in root and shoot dry matter accumulation at the low-S site only in one season. Beet quality was also increased through a reduction in a-amino N concentration. They added that application of sulphur to high-S status sites had no effect on the growth or metabolism of sugar beet. El-Kammah & Ali (1996), Hashem *et al*. (1997) and Nemeat Alla (2005) found beneficial effect of sulphure on growth, yield and quality of sugar beet. Zengin *et al.* (2009) found that fertilizer treatments containing potassium (K), magnesium (Mg) and sulphur (S) increased root yield of sugar beet by 42% and 39% in the Kuzucu and Alakova locations, respectively. Fertilizer treatments improved the sugar content of the root while the amino-N levels were not consistently affected.

This study was proposed to evaluate response of sugar beet to potassium and sulphur supply at North Delta, Egypt.

Materials and Methods

Two field experiments were conducted on a clay soil at Sakha Agricultural Research Station, Agricultural Research Center, Egypt, during 2011/2012 and 2012/2013, to study the effect of three potassium and three sulphur rates on growth, yield and quality of sugar beet (*Beta vulgaris* L.) cultivar "Farida". The preceding crop was cotton in both seasons. The three potassium rates were 12, 24 and 48 kg K_2O/fed (feddan (fed) = 0.42 hectare) in the form of potassium sulphate (48 % K_2O). The three sulphur rates were used as 0, 125 and 250 kg S/fed in the form of sulphur fertilizer mixing with sulphur oxidizing bacteria. Representative soil samples were taken from each site at the depth of 0-30 cm from the soil surface. Samples were air-dried then ground to pass through a two mm sieve and well mixed. The procedure of soil analysis followed the methods of Black *et al.* (1965). Results of chemical analysis in both seasons are shown in Table 1.

TABLE 1. Chemical analysis results of the experimental site's soil (0-30 cm) in 2011/12 and 2012/13.

Season	pH* (1:2.5)	EC** (ds/m)	OM (%)	Available (ppm)				Anions (meq/l)		
				N	P	K	S	HCO^{-3}	Cl^-	SO^{-4}
2011/12	8.10	2.97	1.65	17.18	6.60	243	7.41	4.97	5.84	0.21
2012/13	8.22	2.66	1.53	18.45	6.91	265	7.12	5.33	5.31	0.23

*pH determined in soil suspension 1:2.5
** EC determined in soil paste extract.

The experimental field was fertilized with 31 kg P_2O_5/fed in the form of superphosphate fertilizer (15.5 % P_2O_5) during soil preparation. A split plot design with four replications was used. The main plots were assigned to three potassium rates and the sub-plots to three sulphur rates. The plot size was 21.6m^2 (3.6 × 6 m). Each plot included six ridges 60 cm apart and 6 m long. Sowing was done on 15th October 2011 and 20th October 2012. Seeds of multigerm sugar beet cultivar "Farida" were sown in hills 20 cm apart on one side of the ridge at the rate of 3-4 seeds per hill. Then, main plots were fertilized by banding sulphur fertilizer mixing with sulphur oxidizing bacteria below hills (≈ 10 cm) with the mentioned rates and irrigated immediately. Light irrigation was given after 8 days from the sowing to ensure of high emergence. Thirty five days after the sowing, all the plants were thinned as to be one per hill. Potassium fertilizer with the mentioned rates was applied after thinning in one dose. Also, the nitrogen fertilizer in the form of urea (46 % N) with the recommended rate (90 kg N/fed) was applied as split into two equal doses, half one before the second irrigation after thinning and the other one after 15 days later before the third irrigation. Other cultural practices were done as recommended.

In each plot, 2 ridges were devoted for plant growth sampling and 4 ridges for determining root and top yields at harvest. Five guarded plants were randomly taken from each plot at 175 days after sowing (DAS) to determine leaf area (cm^2) and dry weight of root and top per plant (g). The different plant fractions were oven dried to a constant weight at 70 ^oC. For leaf area measurements, the disk method was used. Leaf area index (LAI) were calculated according to this formula (Watson, 1952):

LAI= leaf area per plant/ unit ground area occupied by one plant

At harvest (210 DAS), the central area of 18.9 m^2 of the devoted ridges for yield determination were harvested to obtained root and top yields (ton/fed). Ten guarded plants were taken at random and were screened for root and top yields / plant (g), root diameter (cm) and root length (cm).

Sugar and other chemical content in roots were determined in Delta Company of Sugar by means of an automatic sugar polarimeter according to Le Docte as described by Mc Ginnus (1971). Corrected sugar content (white sugar) of sugar beet was calculated by linking the non-sugars K, Na and α-amino-N (expressed as milliequivalents/100g of beet) as described by Harvey & Dutton (1993) as follows:

$$Z_B = \text{Pol} – [0.343(K+Na) +0.094\ N_{BI}+0.29].$$

where:

Z_B = Corrected sugar content (% beet)

N_{BI}= α-amino-N determined by the "blue number" method.

Juice purity percentage (QZ) was calculated as following in the Delta Company:

$$QZ= \frac{Z_B}{Pol}$$

The obtained data were subjected to analysis of variance according to Gomez & Gomez (1984). Treatment means were compared by Duncan's Multiple Range Test (Duncan, 1955). All statistical analysis was performed using analysis of variance technique by means of "MSTAT-C" computer statistical software.

Results and Discussion

Growth

Means of LAI, dry matter accumulation (g/plant) and root/top ratio of sugar beet as affected by potassium and sulphur rates in 2011/2012 and 2012/2013 are presented in Table 2.

TABLE 2. Leaf area index, dry matter accumulation and root/top ratio of sugar beet as affected by potassium and sulphur rates in 2011/12 and 2012/13.

Factor	Leaf area index (LAI)		Dry weight (g/plant) (DW)		Root/top ratio	
	2011/12	2012/13	2011/12	2012/13	2011/12	2012/13
K rate (kg K_2O/fed):	**	*	*	*	NS	NS
12	4.68 b	4.03 b	255 b	242 b	3.66	3.56
24	4.91 ab	4.10 ab	277 ab	262 ab	3.68	3.58
48	5.01 a	4.13 a	283 a	263 a	3.65	3.59
S rate (kg S/fed):	**	*	**	**	*	*
0	4.41 c	4.03 b	238 c	227 c	3.58 b	3.38 b
125	4.87 b	4.11 a	268 b	252 b	3.6 b	3.49 b
250	5.32 a	4.13 a	309 a	288 a	3.82 a	3.85 a
Interaction	NS	NS	NS	*	NS	NS

*,**and NS indicate P< 0.05, P< 0.01 and not significant, respectively. Means of each factor designated by the same latter are not significantly different at 5% level using Duncan's MRT.

Effect of potassium rate

Application of potassium fertilizer at the rate of 48 kg K_2O/fed resulted in a substantially increase in LAI and dry matter accumulation (g/plant) at 175 DAS compared with the rate of 12 kg K_2O/fed. No significant differences in LAI and dry matter accumulation were detected between the rate of 24 kg K_2O/fed and the two mentioned rates in both years. Application of K at the proper rate might be enhanced the enzymatic activities, probably caused higher mobilization of nutrients in soil and plant and translocation of photosynthetic in the plant system, which ultimately resulted in higher dry matter accumulation. When plants suffer from K deficiency, translocation of photo assimilated from leaves into actively growing parts of plants is severely reduced leading to reduce growth and development (Hermans *et al*., 2006). Potassium rate had no significant effect on root/top ratio in both seasons. These results are in agreement with those of Ismail & Allam (2007), Fathy *et al.* (2009) and Nafei *et al*. (2010).

Effect of sulphur rate

LAI, dry matter accumulation (g/plant) and root/top ratio were significantly increased by increasing sulphur rate in both seasons (Table 2). Beet plants received 250 kg S/fed were significantly superior to those without sulphur fertilizer in dry matter accumulation (g/plant), LAI and root/top ratio at 175 DAS in both seasons. These results might be principally due to that sulphur element may be oxidized by soil microorganisms to sulphuric acid which in turn lowers soil pH and increase the availability of certain plant nutrients notably phosphorus and several of micronutrients, *i.e.* iron, manganese, zinc and thus increasing plant uptake of these nutrients which led to increasing photosynthetic area of beet plants and consequently accumulation of more dry matter per plant (El-Kammah & Ali , 1996). The favorable effect of sulphur fertilizer on plant growth has been shown previously by Thomas *et al.*(2003), who found that application of sulphur (25 kg ha^{-1}) resulted in a significant increases in root and shoot dry matter accumulation at the low-S status site only.

Effect of interaction

The interaction between potassium and sulphur rates had a significant effect on dry weight per plant at 175 DAS in the second season, only. Data in Table 3 show that a significant increase in dry weight (g/plant) was accompanied each increment of applied sulphur at any potassium rate. At the same rate of sulphur fertilizer, beets received 48 or 24 kg K_2O/fed being insignificant, surpassed those received 12 kg K_2O/fed in dry weight/plant. Beets received 48 or 24 kg K_2O along with 250 kg S/fed accumulated the greatest dry matter, while those received 12 kg K_2O without sulphur fertilizer accumulated the lowest one. On the other hand, the effect of interaction was not significant on LAI and root/top ratio in the two seasons.

TABLE 3. Dry matter accumulation (g/plant) of sugar beet at 175 days after sowing as affected by the interaction between potassium rate and sulphur rates in 2011/12 and 2012/13.

Potassium rate (kg S/fed)	Sulphur rate (kg S/fed)		
	0	125	250
0	210 e	234 d	236 d
125	238 d	258 c	261 c
250	279 b	293 a	292 a

Means designated by the same latter are not significantly different at 5% level using Duncan's MRT.

Root and top yields and their components

Means of root length (cm), root diameter (cm), root weight (g), root yield (ton) and top yield (ton) as influenced by potassium and sulphur rates in 2011/2012 and 2012/2013 seasons are presented in Table 4.

TABLE 4. Root yield, top yield and root dimensions of sugar beet as affected by potassium (K) and sulphur (S) rates in 2011/12 and 2012/13.

Factor	Root length (cm)	Root diameter (cm)	Root weight (g)	Top yield (ton/fed)	Root yield (ton/fed)
2011/12 season					
K rate (kg K_2O/fed):	*	*	**	*	**
12	31.30 b	13.64 b	1055 b	7.67 b	27.22 b
24	32.21 ab	14.33 ab	1127 ab	8.42 a	28.75 ab
48	33.51 a	14.91 a	1159 a	8.55 a	28.87 a
S rate (kg S/fed):	**	**	**	*	**
0	30.41 b	13.62 b	973 c	7.9 c	26.59 b
125	32.33 ab	14.26 b	1116 b	8.18 ab	28.12 b
250	34.28 a	15.01 a	1252 a	8.57 a	30.13 a
Interaction	NS	NS	**	*	**
2012/13 season					
K rate (kg K_2O/fed):	*	**	**	*	*
12	32.19 b	13.82 b	1007 b	7.61 b	26.19 b
24	33.21 ab	14.52 b	1084 ab	7.83 ab	27.04 ab
48	34.18 a	15.51 a	1117 a	7.98 a	27.31 a
S rate (kg S/fed):	*	*	**	*	**
0	31.25 b	14.04 b	948 c	7.56 b	24.59 b
125	33.3 ab	14.65 ab	1061 b	7.76 b	26.14 b
250	35.03 a	15.17 a	1199 a	8.1 a	29.81 a
Interaction	NS	NS	*	NS	**

*, ** and NS indicate $P< 0.05$, $P< 0.01$ and not significant, respectively.
Means of each factor designated by the same latter are not significantly different at 5% level using Duncan's MRT.

Effect of potassium rate

There was a significant difference among potassium rates in root yield, top yield and its attributes in the two seasons. Beets received 48 kg K_2O/fed produced longer, thicker and heavier roots as well as greater root and top yields than those received 12 kg K_2O/fed in the two seasons. Data revealed that no significant difference between beets received potassium fertilizer at rates of 48 or 24 kg K_2O/fed in root yield (ton) and its attributes in both seasons. Results show that potassium fertilizer enhanced deep rooting. Such increase in root yield obtained from application of potassium fertilizer with rates of 48 or 24 kg K_2O/fed can be attributed to improve beet growth, in terms of greater dry weight, longer and thicker roots and heavier root weight. Also, application of potassium fertilizer with proper rate increased top yield through increasing dry matter accumulation and leaf area. These results are in accordance with those reported by Abdel-Mawly & Zanouny (2004), Amer *et al*. (2004), Moustafa & El-Masry (2006), Ismail & Allam (2007), Fathy *et al. (*2009), Zengin *et al.* (2009), Abo-Shady *et al.* (2010), Nafei *et al*. (2010) and Mehrandish *et al.* (2012).

Effect of sulphur rate

Application of sulphur fertilizer exerted a significant effect on root yield, root length, root weight and top yield in favor of 250 kg S/fed compared with control treatment in the two seasons. Thus, the highest sulphur rate increased root yield through increasing LAI, dry matter accumulation, root dimensions (length and diameter) and root weight. The positive effect of sulphur fertilizer on root yield is supported by studies of Thomas *et al.* (2003), Nemeat Alla (2005) and Zengin *et al.* (2009).

Effect of interaction

Root weight and root yield per fed were significantly affected by the interaction between potassium and sulphur rates in both seasons. Data in Table 5 show that increasing sulphur rate from 0 to 250 kg S/fed at any potassium rate increased root weight and root yield per fed in the two seasons. Beets received 48 or 24 kg K_2O along with 250 kg S /fed outyielded those received 12 K_2O alone in both season. In this connection, Zengin *et al.* (2009) indicated that a fertilizer treatment including 81 kg K_2O ha^{-1}, 27 kg Mg ha^{-1}, and 46 kg S ha^{-1} may be recommendable in fertilization of sugar beets, together with regular nitrogen and phosphorus applications, under similar conditions, in order to achieve a balanced mineral nutrition and sustain better root yields.

TABLE 5. Root weight and root yield of sugar beet as affected by the interaction between potassium and sulphur rates in 2011/12 and 2012/13.

Potassium rate (kg K_2O/fed)	Sulphur rate (kg S/fed)	Root weight (g)		Root yield (ton/fed)	
		2011/12	2012/13	2011/12	2012/13
12	0	931 e	879 d	25.70 f	23.30 d
	125	1061 c	991 cd	27.53 de	25.70 c
	250	1173 b	1152 ab	28.42 bc	27.57 b
24	0	948 de	974 cd	26.83 ef	25.00 c
	125	1125 bc	1069 bc	28.23 cde	26.13 bc
	250	1308 a	1209 a	31.20 a	29.18 a
48	0	1040 cd	992 cd	27.23 de	25.47 c
	125	1162 b	1123 ab	28.60 cd	26.60 bc
	250	1274 a	1237 a	30.77 ab	29.87 a

Means of each column designated by the same latter are not significantly different at 5% level using Duncan's MRT.

Sugar yield and root quality

The soluble non-sugars, potassium, sodium and α-amino nitrogen in the roots are regarded as impurities because they interfere with sugar extraction. Means of these impurities, alkalinity coefficient, gross sugar (%), extractable white sugar (%), loss sugar (%), juice purity (%) and white sugar yield per fed (ton) as affected by potassium and sulphur rates in 2011/12 and 2012/13 are presented in Table 6.

TABLE 6. Sugar yield and root quality of sugar beet as affected by potassium (K) and sulphur (S) rates in 2011/12 and 2012/13.

Factor	Gross sugar (%)	K	Na	(K+Na)	α-N	K+Na/ α-N	White sugar	Juice purity	Loss sugar	Sugar yield (ton/fed)
		(meq/100g)					(%)			
2012/13 season										
kg K_2O/fed:	*	**	NS	*	NS	*	*	*	**	*
12	18.05b	5.54b	1.46	7.00b	1.97	3.56b	15.17b	84.04a	2.88b	4.136b
24	18.40a	6.04a	1.44	7.47a	1.94	3.85a	15.36a	83.47ab	3.04ab	4.428a
48	18.53a	6.4a	1.41	7.82a	1.92	4.07a	15.37a	82.95b	3.15a	4.447a
kg S/fed:	**	*	*	**	*	NS	*	**	*	**
0	17.72b	6.31a	1.58a	7.89a	2.13a	3.71	14.52b	81.97b	3.2a	3.861c
125	18.40a	5.88b	1.43b	7.31b	1.89b	3.86	15.43a	83.84a	2.98b	4.339b
250	18.86a	5.79b	1.3c	7.09b	1.82b	3.91	15.96a	84.66a	2.89b	4.812a
Interaction	**	NS	NS	*	NS	NS	NS	NS	NS	*
2012/13 season										
kg K_2O/fed:	*	*	NS	*	NS	*	*	NS	*	*
12	18.19b	5.35b	1.38	6.73b	1.94	3.48b	15.40b	84.67	2.78b	3.944b
24	18.42ab	5.82a	1.35	7.17a	1.91	3.76a	15.49ab	84.07	2.93a	4.157ab
48	18.56a	5.96a	1.32	7.28a	1.89	3.86a	15.60a	84.00	2.96a	4.27a
kg S/fed:	*	*	*	*	**	*	**	**	*	**
0	17.66b	5.95a	1.46a	7.41a	2.1a	3.53b	14.63b	82.85b	3.03a	3.599c
125	18.58a	5.71ab	1.33b	7.04b	1.85b	3.81a	15.70a	84.51a	2.88b	4.104b
250	18.93a	5.47b	1.26b	6.73b	1.79b	3.76a	16.17a	85.39a	2.77b	4.668a
Interaction	**	NS	NS	NS	NS	NS	NS	NS	NS	**

*, ** and NS indicate P< 0.05, P< 0.01 and not significant, respectively.
Means of each factor designated by the same latter are not significantly different at 5% level using Duncan's MRT.

Effect of potassium rate

Potassium fertilizer rate had no significant effect on concentration of Na and α-amino nitrogen in both seasons and the percentage of juice purity in the second season. However, total sugar (%), concentration of K and (K+Na), alkalinity coefficient (K+Na/α-amino nitrogen), extraction of white sugar (%), losses sugar (%) and white sugar yield (ton) were significantly increased by increasing potassium rate in both seasons. Although, application of potassium fertilizer at the rate of 24 and 48 kg K_2O/fed increased the concentration of gross sugar in roots, it decreased juice purity % in the first season. This might be due to increasing concentration of K in juice roots, which causes troubles during juice purification and crystallization and in turn decreased purity. Beet plants received 48 kg K_2O/fed produced the highest white sugar yield, while those received 12 kg K_2O/fed produced the lowest one in the two seasons. Beets at the rate of 48 kg K_2O were statistically at par with at the rate of 24 kg K_2O/fed in white sugar yield in both seasons. Such increase in white sugar yield at 24 and 48 kg K_2O/fed may be due to the considerable increase in root yield and white sugar extraction percentage. The favorable effect of potassium fertilizer which improved yields and chemical constituents may be due to the vital role of potassium in building up metabolites and activating starch synthetase enzymes and carbohydrates accumulation which transferred from leaves to developing roots consequently enhanced root and chemical constituents (Nitoses &, Evans 1969). Role of potassium in photosynthesis and activity of enzymes related to sucrose synthesis and also it's participation in loading the sucrose to phloem are from the most important reasons of increase in sugar's rate and increasing in potassium consumption (Draycott, 2006). Mehrandish *et al.* (2012) reported that potassium increased percent of recoverable sugar and reduced of non-sugar material specially nitrogen and sodium. These results are in accordance with those reported by Amer *et al*. **(**2004), Ismail & Allam (2007), Zengin *et al.* (2009), Nafei *et al*. (2010) and Mehrandish *et al.*(2012).

Effect of sulphur rate

There was a substantial difference in sugar yield and all traits of juice root quality among sulphur fertilizer rates in both seasons. The concentration of soluble non-sugars (K, Na, K+Na and α-amino nitrogen) in the roots and loss sugar (%) were significantly decreased by increasing sulphur rate. Thus, total sugar (%), alkalinity coefficient, extraction of white sugar (%) and juice purity (%) were increased as sulphur rate increased in both seasons. Data show that increasing sulphur fertilizer rate increased juice purity (%) through increased gross sugar (%) and decreased the concentration of soluble non-sugars and in turn increased extraction of white sugar (%). White sugar yield was gradually increased by each increment of applied sulphur fertilizer in both seasons. The maximum white sugar yield was obtained from beets received 250 kg S/fed. This may be due to increase root yield and extraction of white sugar (%). In this connection, Thomas *et al.* (2003) reported that application of sulphur (25 kg ha^{-1}) increased beet quality through a reduction in a-amino N concentration. These results are in accordance with those reported by Nemeat Alla (2005) and Zengin *et al.* (2009).

Effect of interaction

The interaction between potassium and sulphur rates had a significant effect on Gross sugar % and sugar yield in both seasons and the concentration of (K+Na) in the first season, only. Data in Table 7 show that increasing sulphur rate from 0 to 250 kg S/fed at any potassium rate increased gross sugar (%) and sugar yield per fed and decreased the concentration of (K+Na). However, increasing potassium rate from 12 to 24 kg K_2O/fed at the same sulphur rate significantly increased the concentration of (K+Na). There was no significant difference between rates of 24 and 48 kg K_2O/fed in this respect at the same sulphur rate. Beets received 24 or 48 kg K_2O along with 250 kg S/fed outyielded those received 12 K_2O alone or along with 125 kg S /fed in both seasons. These results are in accordance with those reported by Zengin *et al.* (2009), who indicated that Kalimagnesia fertilizer containing K, Mg and S was effective in improving the sugar content of the root, while the amino-N levels were not consistently affected by the fertilizer treatments.

TABLE 7. Sugar yield and some root quality of sugar beet as affected by the interaction between potassium and sulphur rates in 2011/12 and 2012/13 .

K rate (kg k_2O/fed)	S rate (kg S/fed)	Gross sugar (%)		(K+Na) (meq/100 g)	Sugar yield (ton/fed)	
		2011/12	2012/13	2011/12	2011/12	2012/13
12	0	17.51 f	17.34 d	7.41 cd	3.72 e	3.364 g
	125	18.13 de	18.37 b	6.80 e	4.22 c	4.011def
	250	18.51 cd	18.85 a	6.79 e	4.467 b	4.459 bc
24	0	17.81 ef	17.79 c	7.99 ab	3.912 d	3.674 fg
	125	18.45 cd	18.55 b	7.43 cd	4.357 bc	4.087 de
	250	18.94 ab	18.92 a	7.00 de	5.017 a	4.709 ab
48	0	17.83 ef	17.85 c	8.26 a	3.951 d	3.759 ef
	125	18.63 bc	18.81 a	7.70 bc	4.44 b	4.216 cd
	250	19.12 a	19.03 a	7.49 bcd	4.952 a	4.836 a

Means of each column designated by the same latter are not significantly different at 5% level using Duncan's MRT.

It can be concluded from this study that 24 K_2O along with 250 kg S/fed was the recommended treatment for optimum root and extractable white sugar yield per unit area at Kafrelshiekh Governorate.

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إستجابة بنجر السكر لإستخدام سمادى البوتاسيوم والكبريت فى الأراضى الطينيه بمنطقة شمال الدلتا

نبيل مرسى محمد عوض ، هاني صبحي غريب[*] و سحر مأمون إبراهيم مصطفى
معهد بحوث المحاصيل السكرية – مركز البحوث الزراعية – الجيزة و[*]قسم المحاصيل – كلية الزراعه – جامعه كفر الشيخ – كفر الشيخ – مصر .

تم زراعة بنجر السكر صنف "فريدا" فى تربة طينيه بالمزرعة البحثية بمحطة البحوث الزراعية بسخا- محافظة كفر الشيخ- مصر ، لدراسة إستجابة نمو محصول وجودة بنجر السكر لثلاث مستويات من السماد البوتاسى (١٢، ٢٤، ٤٨ كجم بو٢ أ/ فدان) وثلاثة مستويات من السماد الكبريتى (صفر ، ١٢٥، ٢٥٠ كجم كبريت/فدان) فى الأراضى الطينية بمنطقة شمال الدلتا. استخدم فى تنفيذ التجارب تصميم القطاعات المنشقة ذو الأربع مكررات حيث وضعت الثلاث معدلات من السماد البوتاسى فى القطع الرئيسية ، بينما وضعت الثلاث معدلات من السماد الكبريتى فى القطع الشقية. وكانت أهم النتائج كما يلى:

أدى إستخدام السماد البوتاسى بمعدل ٤٨ كجم بو٢ أ/ فدان إلى زيادة معنوية فى الوزن الجاف للنبات، دليل مساحة الأوراق ، طول وسمك الجذر ، محصول الجذور، محصول العرش. ، طول الجذر، نسبة السكر الكلى ، محتوى البوتاسيوم ، ومعامل القلوية ، نسبة السكر المفقود ونسبة السكر الأبيض المستخلص ، محصول السكر الأبيض بالمقارنة بإضافته بمعدل ١٢ كجم بو٢ أ/ فدان. وكان العكس صحيحا فى نسبة نقاوة العصير فى الموسم الأول. ولم يختلف معدلى البوتاسيوم ٢٤ ، ٤٨ كجم بو٢ أ/ فدان معنويا فى التأثير على جميع الصفات السابقة. ولم تتأثر معنويا نسبة الجذر/العرش ، وتركيز الصوديم والنيتروجين الأمينى بمستويات السماد البوتاسى فى الموسمين.

أدت زيادة معدل السماد الكبريتى من صفر إلى ٢٥٠ كجم كبريت/فدان إلى زيادة الوزن الجاف للنبات ، دليل مساحة الأوراق ، نسبة الجذر إلى العرش ، طول وسمك ووزن الجذر، محاصيل الجذور والعرش والسكر الأبيض للفدان، محتوى السكر الكلى، نسبة السكر الأبيض المستخلص ، نقاوة العصير فى كلا الموسمين. وقد أدى إستخدام الكبريت إلى تحسين جودة عصير الجذور بتقليل تركيز المواد الغير سكرية الذائبة (البوتاسيوم والصوديوم والنيتروجين الأمينى) التى تعيق إستخلاص السكر الأبيض وبناء على ذلك تؤدى إلى زيادة نسبة السكر المستخلص وتقليل نسبة السكر المفقود. وقد أدى إستخدام الكبريت بمعدل ٢٥٠ كجم للفدان إلى الحصول على أعلى محصولى جذور وسكر. وقد يرجع هذا إلى أن إضافة الكبريت للتربة يؤدى إلى تقليل pH التربة مما يؤدى إلى تيسر الفوسفور

وبعض العناصر الصغرى التى يمتصها النبات وتؤثر على العمليات الحيوية وزيادة نمو النبات مما ينعكس على الإنتاجية.

أثر التفاعل بين معدلات البوتاسيوم والكبريت معنويا على محصولى الجذور والسكر الأبيض للفدان. وقد تحقق أعلى محصولى جذور وسكر أبيض من نباتات بنجر السكر المسمدة بالسماد البوتاسى بعدل ٢٤ أو ٤٨ كجم بو$_٢$ أ/ فدان وسماد كبريتى بمعدل ٢٥٠ كجم للفدان فى الموسمين.

ومن نتائج هذه الدراسه يمكن التوصيه بتسميد بنجر السكر فى الأراضى الطينية بشمال الدلتا بمحافظة كفر الشيخ بالسماد البوتاسى بمعدل ٢٤ كجم بو$_٢$ أ/ فدان بالإضافة للسماد الكبريتى بمعدل ٢٥٠ كجم للفدان للحصول على أعلى أنتاجيه.