ORIGINAL RESEARCH

Research on Crop Ecophysiology
Vol. 10/2, Issue 1 (2015), Pages: 33- 40

Effects of Potassium Sulfate Fertilizer Application on Sugarcane (Cultivar CP 48-103) Qualitative-Quantitative Yield

BEHNAM HAJJARI[1], EBRAHIM PANAHPOUR[2*], ALI GHOLAMI[2]
1- Department of Soil Science, Khouzestan Science and Research Branch, Islamic Azad University, Ahvaz, Iran
2 , 3- Department of Soil Science, Collage of Agriculture, Ahvaz Branch, Islamic Azad University, Ahvaz, Iran

*Corresponding author E-mail: e.panahpour@gmail.com

Received: 7 July 2014 Accepted: 20 November 2014

ABSTRACT
This study was carried out in farm of Dehkhoda institute (2013-2014). The study was done as randomized complete blocks design with five potassium sulfate amounts (0, 50, 100, 150 and 200 kg/ha) and four replications. According to results, potassium affected the number of stalk numbers, yield, and the amount of obtainable sugar ($p<0.01$) and purity ($P<0.05$). The highest stalk numbers (186351), yield (111.62 ton/ha), obtainable sugar (10.86 %), and purity (89.9%) were obtained in 200 kg/ha potassium. Results showed that the amount of potassium in the mentioned region is not sufficient and adding potassium as potassium sulfate will increase the qualitative-quantitative yield of sugarcane.

Keywords*:* Potassium, Sugarcane, Stalks length yield, Stalk numbers, Obtained sugar, Purity.

INTRODUCTION

Sugarcane (*saccharum sp*) is the main crop of tropical and subtropical regions of the world which is used mainly to produce sugar and ethanol (Lalitha and Premachandran, 2007).

Potassium plays an important role in plant physiological activities including the activation of enzymes and plant protein synthesis, photosynthesis and osmotic adjustment. In plants with potassium deficiency, soluble nitrogen compounds and sugars will be accumulated and also starch will be reduced (Marschner, 1995). Sugarcane like any other sugar plant has high potassium requirement, so that producing 100 tons of straws removes 160 kg/ha potassium (K_2O) and the recommended amount of potassium fertilizer to offset this will be 150 -200 kg (K_2O) per ha (Funconeir, 1994).

Potassium acts as a catalyzer in plant metabolism. It also condensates the cell sap (Malakooti and Homaei, 2004). Presence of potassium makes sucrose production from simple sugars possible. This element contributes in production and neutralization of organic acids and increases product quality by balancing sugar and acids. Potassium is an important part of enzymes and improves water use efficiency. This element strengthens cell walls and tissues and increases efficiency of nitrogen fertilizer (Mansouri, 2011).

Cell enlargement includes the formation of a large central vacuole that occupies 80 - 90 percent of cell volume. This occurs by potassium accumulation in cells which is necessary both for pH stability of cytoplasm and for increasing the osmotic potential within the vacuole (Hartong *et al.,* 1981).

Most of potassium is absorbed in canopy completion period or tillering. The highest sugarcane yield and height were obtained from 600 kg/ha potassium, whereas the highest sugar amount and stalk numbers were belonged to 300 kg/ha. The amount of sugar was equal in 300 and 600 kg/ha treatments (Carpella *et al.*, 1989). Sugarcane absorbs 710 g/ha of potassium daily in cultivation time and during maximum growth and 950 g/ha in first harvest stage (Malavotla, 1994). Accumulation of soluble sugars and nitrogen compounds and reducing the starch amount will occur in plants with potassium deficiency. Also, transfer of sugar will be reduced (Marschner, 1995). The yield of 91.25 tons per hectare was obtained by simultaneous application of phosphorus and potassium in cultivation time (Faghirhossein *et al.*, 2010). Adding 225 kg of K_2O per hectare increased corn yield up to 20.9% (Yoiing, 2003). Marschner (1995) reported that potassium plays important role as an effective element in sugar production and starch reduction. In a study by Jafarnejadi (2013) the highest sugarcane yield (147.5 ton/ha) was obtained from 200 kg/ha potassium chloride (1/4 at cultivation time and the rest in three times along with nitrogen fertilizer). Also, the highest sugar, syrup and purity percentages (12.9, 32.1, and 89.7%, respectively) were obtained by this treatment. In a study about the effects of topdressing and spraying potassium on yield components of safflower, the highest yield (2458.7 kg/ha) was obtained from potassium chloride topdressing and the highest oil percentage was obtained from potassium sulfate spraying (49.88 kg/ha) (Amirkhalili, 2011). This study was conducted to evaluate the effect of different amount of potassium sulfate on yield and related traits of sugarcane.

MATERIALS AND METHODS

In order to investigate the effects of potassium sulfate fertilizer on qualitative-quantitative yield of sugarcane (cultivar CP 48-103) this study was carried out in *DC 04-11* farm of Dehkhoda institute (2013-2014). The study was done as randomized complete blocks design with five potassium sulfate amounts (0, 50, 100, 150 and 200 kg/ha: k_0-k_4, respectively) and four replications. The region has annual precipitation of 250-300 mm and average temperature of 23-31C°. The climate is warm and dry and soil is loamy silt. Each experimental plot had seven rows with a length of 250m. Fertilizer was poured in furrows at August 19, 2013 and cultivation was done at August 23, 2013. Two lines of each side of the plot were considered as margins and samples were taken from middle lines. Obtained data were analyzed using SPSS program and graphs were drawn using Excel.

Results of physicochemical analysis of the soil are presented in Table 1. Soil had loamy silt texture and average salinity. The amount of salinity was increased from 1.41 ds/m in depth to 2.4 ds/m in surface due to evapotranspiration. Acidity of soil (pH) was neutral to alkaline and this trend was increased by soil depth. The amount of soluble sulfate was high (11.68 mg/l) in soil surface due to high evapotranspiration but it was decreased by depth. This trend was in agreement with pH amount.

Table 1. Soil analysis results of three depths

Sampling depth	EC (dS/m)	pH	+Ca2 (meq/l)	Mg^{2+} (meq/l)	Na^+ (meq/l)	CEC ($cmol^+$/kg)	Soluble potassium (meq / l)	SO_4^{2-} (meq/l)	Cl^- (meq/l)	NO_3^- (meq/l)	SAR $(cmol^+/kg)^{1/2}$	Exchangeable sodium ($cmol^+$/kg)	Organic matters (%)	Absorbable potassium ($mg.kg^{-1}$)	Texture
0-33	2.4	7.34	10	11	15.65	16.74	0.16	11.68	12.5	5.6	5.43	2.66	0.8	97	Silty Loam
33-66	1.65	7.42	5.83	7.5	18.4	16.43	0.11	3.8	8.3	5.6	5.39	2.23	0.71	92	
66-100	1.41	7.51	2.5	6	18.9	16.43	0.07	2.49	7.8	0	7.15	2.16	0.68	90	

RESULTS AND DISCUSSION

Variance analysis of some qualitative-quantitative properties of sugarcane is presented in Table 2. According to results, potassium affected all traits significantly at 1% probability level except purity which was affected at 5% level.

Table 2. Variance analysis of some qualitative-quantitative properties of sugarcane

Source of variation	df	Mean Squares					
		Stalk diameter	Stalk length	Yield	Stalk numbers	Purity	Sugar yiled
Replication	3	0.680	15.97	10.3	6945927	1.86	0.221
Potassium	4	0.355**	432.97**	434.55**	889952663**	3.82*	0.919**
Error	12	0.0173	8.89	8.38	7433013	0.96	0.028
CV (%)		5.99	1.7	2.92	1.6	1.1	1.64

Stalk Diameter

Stalk diameter of sugarcane was increased by higher application of potassium sulfate. In control treatment, stalk diameter was 1.77 cm whereas it was 2.52 cm in K_4 and K_3 treatments did not show significant difference (Figure 1). This is probably because of increase in nitrogen absorption by potassium application which has increased dry matter and therefore, increased stalk diameter. Also, in a study by El-Tilib *et al.* (2004) which 144 kg/ha of K_2O was used, stalk diameter was increased significantly. This is in agreement with findings of Hazrati and Tahmasbi (2012). Potassium preparation is followed by cell enlargement due to potassium accumulation and also lignifying of vessel systalk (Kholdbarin and Eslamzadeh. 2011).

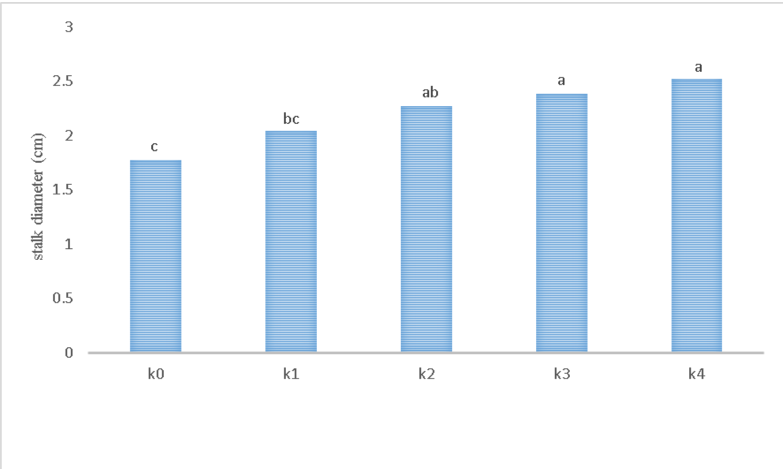

Figure 1. Mean comparison of stalk diameter based on LSD 5%

Stalk Length

Potassium sulfate affected stalk length significantly so that the length was increased from 162.63 cm in control treatment to 184.78 cm and 188.51 cm in K_3 and K_4 treatments, respectively. Although the difference between these treatments was not significant, but potassium increment increased the stalk length (Figure 2). It seems that potassium in cultivation time increases the stomatal diffusion resistance significantly which results in decreased transpiration, increased leaf water potential and thus increases the size of the cell, followed by sugarcane stalk elongation (Valdron, 1964).

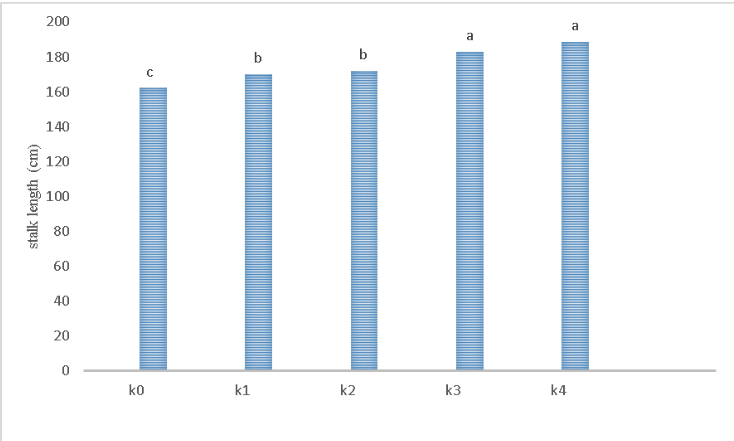

Figure 2. Mean comparison of stalk length based on LSD 5%

Stalk Yield

Stalk yield was affected by potassium sulfate and was increased from K_0 to K_4, so that the yield of control was 85.05 ton/ha whereas K_1 to K_4 treatments had 93.85, 97.69, 106.25, and 111.62 ton/ha yields, respectively.The difference between K_2 and K_3 treatments was significant (Figure 3). Increase in stalk yield was the result of increase in stalk number per unit area. Also, stalk elongation caused an increase in biomass. The reason was increase of water content of plant which has led to increase in size and numbers of cells which resulted in yield increment.

In Rilner Alves Flores *et al.* (2014) study, using 162 kg of potassium in second ratoon produced 132.9 ton/ha sugarcane stalk. Potassium helps stalk elongation by strengthening gibberellic acid. Also, it prepares necessary dissolved material in vacuoles for cell enlargement in companion with other organic acids anions (Kholdbarin and Eslamzadeh. 2001).

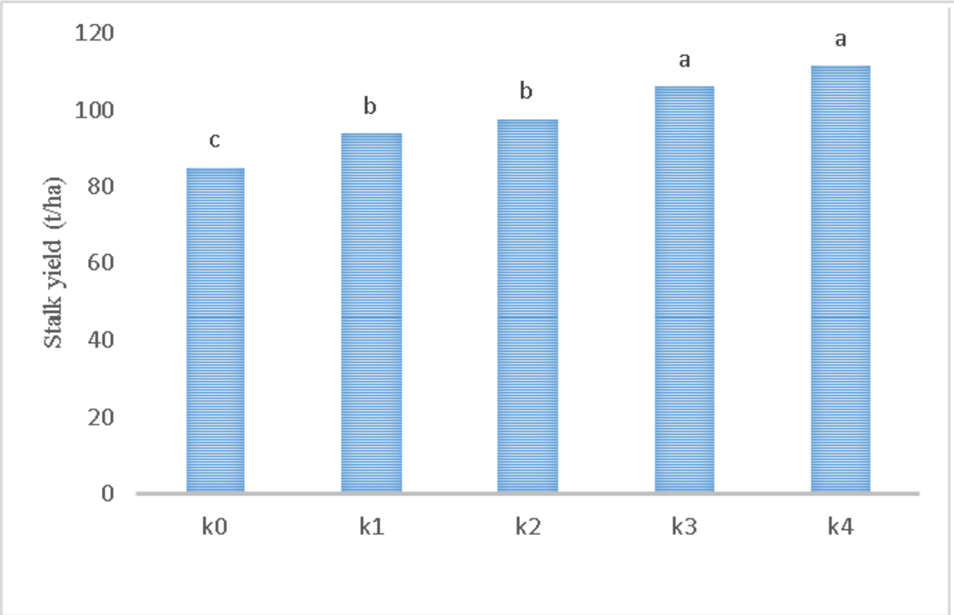

Figure 3. Mean comparison of stalk yield based on LSD 5%

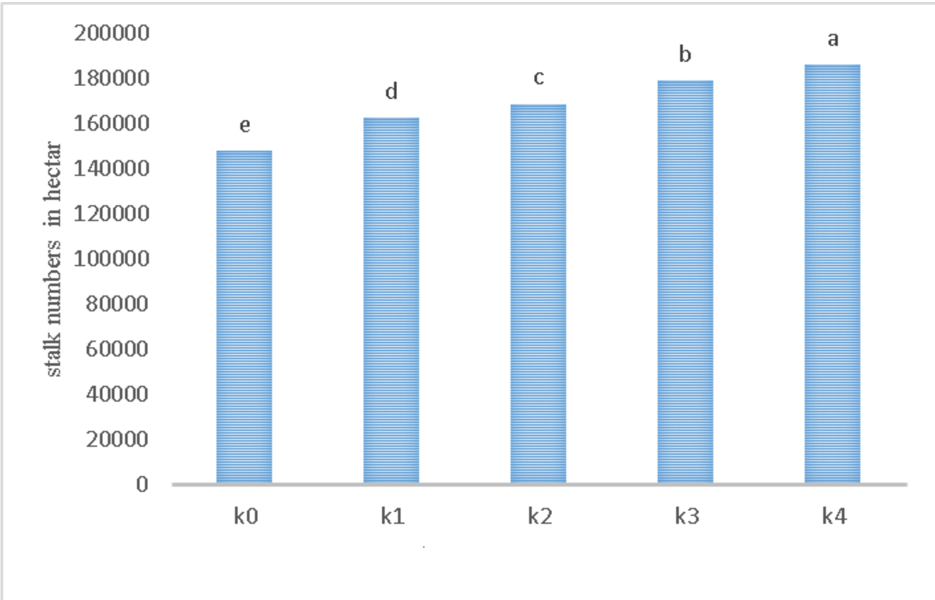

Figure 4. Mean comparison of stalk numbers based on LSD 5 %

Stalk Numbers

Potassium affected the number of stalk number significantly ($p<0.01$) so that K_4 and K_3 treatments with 186351 and 179475 had the highest and K_0 with 147994 had the least stalk number per hectare (Figure 4).

Purity of the Syrup

Potassium fertilizer affected syrup purity significantly ($p<0.05$), and using 200 kg/ha treatment had the highest purity (89.89%) whereas control showed the least (87.63%) (Figure 5). The probable reason for this is the increase in sugar percentage by potassium application (Fotouhi, 2003). Potassium makes sucrose from simple sugars and low amounts of it lead to sucrose reduction (Asfia, 1997). Therefore, potassium application (as an effective element on syrup purity) has an important role in sugar yield increment.

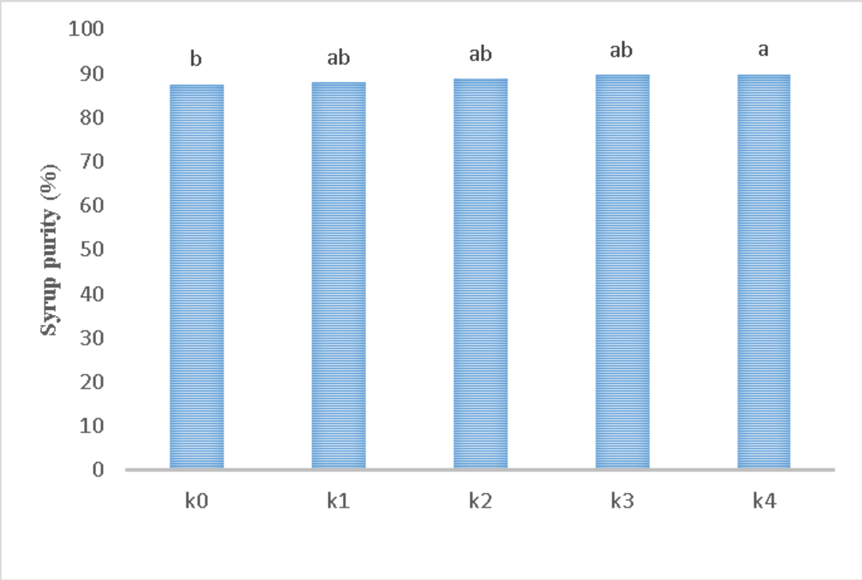

Figure 5. Mean comparison of syrup purity based on LSD 5%

Sugar Yield

The effect of potassium on obtainable sugar was significant ($p<0.01$) (Figure 6). Mean comparisons showed that 150 and 200 kg/ha treatments had the highest sugar productions (10.86 and 10.65, respectively) which were not statistically different but were different from control mean (Figure 6).

According to the literature, potassium deficit increases simple sugars and amino acids in stalk and reduces net efficiency of extraction. Also, because of potassium effects on decreasing nitrogen of leaves (unusable nitrogen) and converting reducing sugars to sucrose, net efficiency of sugar is increased.

According to the obtained results, potassium application was really effective in sugar formation and increasing the percentage of sugar in proportion to control. It has been shown that in plants with potassium deficit accumulation of soluble sugars, reduction in amount of starch and accumulation of nitrogen compounds will be occurred. Also, potassium deficiency reduces the transfer of sugar in the plant (Marschner, 1995).

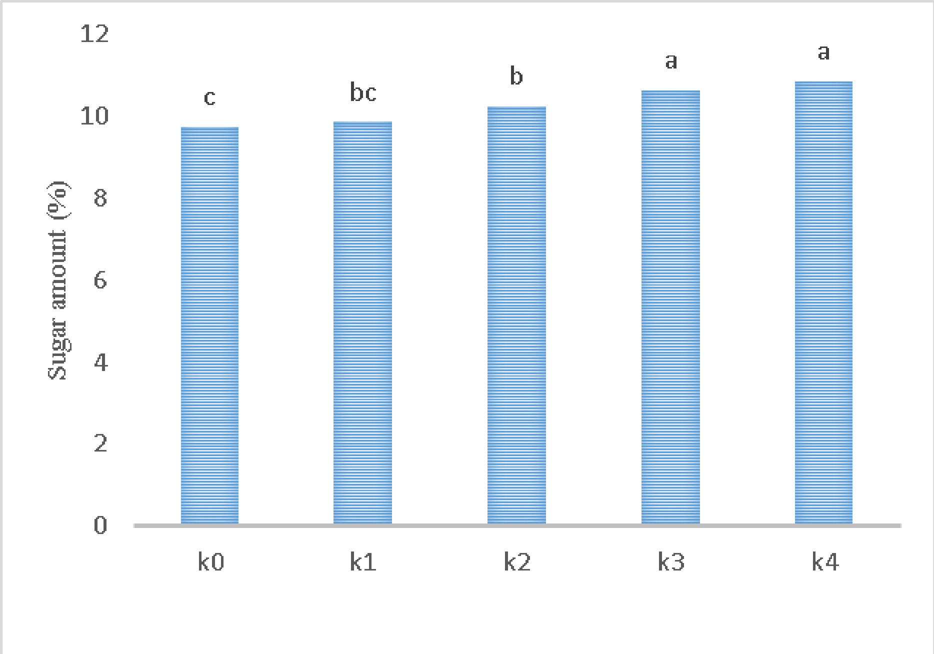

Figure 6 . Mean comparison of sugar yield based on Lsd 5%

CONCLUSION

Based on the results obtained, soil of the studied region was poor in potassium content. Potassium increased stalk yield and stalk number due to positive effect on gibberellic acid activity. Also, it caused cell enlargement and increase in stalk diameter by accumulation in cells and lignifying vessels systalk. These results are in agreement with reports of Hazrati and Tahmasbi (2012), Kholdbarin and Eslamzadeh (2001) and Jafarnejadi (2013). Potassium sulfate application increased obtained sugar percentage. Another considerable result was non-significant effect of fertilizer in lower levels on syrup purity whereas 200 kg/ha treatment increased the purity. These are in agreement with reports of Asfia (1997), Fotouhi (2003), and Jafarnejadi (2013).

Considering the potassium situation and its fast depletion from the soil, lower amounts of fertilizer don’t have effects on yield increment because in such conditions, a significant portion of the fertilizer will be stabilized in the soil and are not usable for plant. Also, by increasing the potassium concentration, the amount of stabilization will be increased (Savaghebi, 2003). On the whole, using potassium fertilizers from various sources and in various stages of plant growth is recommended for saving soil stability and increase in sugarcane yield.

REFERENCES

Asfia Gh A. 1997. Potassium element and sugarcane (translation). Sugarcane and global news articles. Sugarcane Industries Development Corporation. East and Southern Africa.

Amirkhalili N. 2011. Assessment the effect of topdressing and potassium fertilizer spraying on yield components of autumn sunfflower. MSc Thesis. Islamic Azad University, Damghan branch. 95, pages.

El-Tilib MA, Elnasikh MH, and Elamin EA. 2004. Phosphorus and potassium fertilization effects on growth attributes and yield of two sugarcane varieties grown on three soil series. Journal of Plant Nutrition, 27(4): 663-699

Faqir Hussain, MAS, Muhammad AA., Naeem FA, Arshad AC. 2010. Impact of balanced fertilization along with phosphorus and patassium application on yield and quality of sugarcane. International Journal of Agriculture an Applied Sciences, 2(2):95-100.

Fotouhi F M, Shahin M. 2003. Sugarcane nutrition. Islamic Azad University of Dezful.

Funconeir R. 1994. Sugarcane. Macillan Education. London, pp. 12-33.

Hazratiyadkori S, Tahmasebi Sarvestani. 2012. Effect of different nitrogen fertilizer levels and benzyl adenin (BA) on growth and ramet production of Aloe vera L. Iranian Journal of Medicinal and Aromatic Plants. Iran, Vol 28, No 2(56):210-223.

Hartung W, Heilmann B. and Gimmler H. 1981. Do chloroplasts play a role in abscisic acid synthesis? Plant Sci. Lett. 22, 235-242.

Hunsigi G. 1993. Production of sugar cane. Verlag Berlin Heidelberg Printed in Germany.

Jafarnejadi A R. 2013. The response of yield of sugarcane *(Saccharum officinarum L.)* to different sources of potassium fertilizers. Journal of Crop Physiology. Islamic Azad University, Ahwaz, 5(19): 71-61.

Kholdbarin B, Eslamzadeh T. 2001. Mineral nutrition of higher plants. (Translation). Shiraz University Press.

Karupplah N, Vadlamudi B, and Kaaufman PB. 1989. Purification and characterization of soluble (cytosolic) and bound (cell wall) isoforms of invertases in barley elongation stem tissue. Plant Phisiology, 91: 993-998.

Lalitha R. and Premachandran MN. 2007. Meiotic abnormalities in intergeneric hybrids between Saccharum spontaneum and *Erianthus arundinaceus* (Gramineae). Cytologia, 72(3): 337-343.

Malavolta E. 1994. Nutrient and fertilizer management in sugarcane. International Potassium Institute, No.14. Switzerland.

Marschner H. 1995. Mineral nutrition of higher plants. 2th end, New York: Academic press, p 890.

Rilner Alves Flores, Renato De Mello Prado, Hilario Junior De Almeida, Marcio Alexander Panceli, Jonas Pereira De Souza Junior and Anelisa De Aquino Vidal Lacerda Soares. 2014. Potassium Nutrition in Ratoon Sugarcane under a Conservation Cropping System. Cienc Suelo (Argantina), 32(1): 53-62.

Seyyed Manouri F. 2011. Sugarcane climate in Haft Tappeh. Tehran University. MSc Thesis.

Yuying Li. 2003. Corn Response to Potassium on Black Soil in Heilongjiang, Better Crops International, 17(2): 3-5.