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Impact of Sulphur Fertilizer on Sugarcane Performance Under Heavy Clay Soils "Vertisols", Sudan

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Abstract

The effect of sulphur in the form of ammonium sulphate on the performance of sugarcane under heavy clay soils of Sudan was conducted at the research farm of Kenana Sugar Company during two consecutive seasons (2012/13- 2013/14). The experiment was laid out in a randomized complete block design (RCBD) with four replications and gross plots of 4 rows x 10m length x 1.50m width with a 5m length inspection road between each block to evaluate the effect of sulphur on sugarcane yield and quality. Applications of fertilizers were at the rate of 69 and 23kg/feddan for Nitrogen and phosphorus respectively (nitrogen in the form of urea & ammonium sulphate and phosphorus in the form of tri-super phosphate (TSP) (standard practice) and Sulphur at the rate of 0.00, 12.00, 24.00, 36.00 and 48.00 kg Sulphur/feddan in the form of ammonium sulphate. The results revealed that Sulphur (S) had a positive impact on sugar and cane yield/feddan Compared to (control) and the negative impact on plant density, also insignificant on sugar yield/feddan and its application had a significant effect on the Fiber% cane, but there were insignificant differences among means of Pol% cane, Brix% cane, ERSc (estimated recovery of sucrose), purity% and moisture %cane, also Insignificant differences were obtained among the means of the internodes number and plant height of all tested treatments.

Keywords: Sugarcane, Sulphur, Yield, quality, fertilizer

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Introduction

Sugarcane belongs to the grass family (Poaceae), an economically important grain plant family that includes maize, wheat, rice, sorghum and many forage crops (Jannoo *et al.*, 2007). It is one of the most important field crops in the tropics. Indeed, according to FAO (2001) (Kwong and Ramasawmy-Chellen, 2006), perennial, tropical or subtropical grass widely grown in a zone around the world within 30º of Equator (Ming *et al.*, 2006). It is usually vegetatively propagated from auxiliary buds on the stem (or stalk) cuttings. The first, "plant" crop is generally harvested from 12 to 24 Months after planting; thereafter, "ratoon" crops may be harvested at shorter to equal time periods. Ratoon crops may be grown in several cycles. The large, mature stalks contain juice of 9 to 18% sucrose. The juice is extracted by crushing the stalks with high-pressure rollers in a mill. Sucrose is crystallized from the juice after water is removed by boiling to produce a brown-colored raw sugar. White sugar is produced by re-crystallization from raw sugar in a refinery (Ming *et al.*, 2006). The main sugarcane growing countries include: India, Brazil, Cuba, Australia and Mexico (Ali, 1986).

The general sugarcane fertilizers recommendations have been transformed in to a set of a site/soil- specific that recommendations are promoted with an integrated or (whole-of system) approach to nutrient management (AW, PW *et al.,* 2005). A mineral element is considered to be essential to plant growth and development and involved in plant metabolic function and the plant can not complete its life cycle correctly without this element. Usually, the plant exhibits a visual symptom indicating deficiency in a specific nutrient, which normally can be corrected or prevented by supplying that nutrient. Visual nutrient deficiency symptoms can be caused by many other plant stress factors, therefore; caution should be exercised when diagnosing deficiency symptoms (Havlin *et al.*, 2005; Tisdale *et al.*, 1985).

Sulphur is one of the 16 elements essential to crop production, and it is essential for maximum crop yield and quality, often ranked behind only nitrogen, phosphorus and potassium in importance (Jeschke and Diedrick, 2010). Sulphur is becoming more of a limiting nutrient in crop production than in the past.

The reasons for this increasing need include: higher crop yields which require more sulphur, increased use of high analysis fertilizers containing little or no sulphur; reduced amounts of atmospheric sulphur fallout in rainfall; and reduced soil sulphur reserves from organic matter losses due to mineralization and erosion (AW, PW *et al.,* 2005; Ceccotti, 1996). Sulphur plays an important role in the plant's metabolism, and required for amino acids, proteins and photosynthesis. Sulphur deficiencies are often confused with Nitrogen deficiencies. Symptoms of Sulphur deficiency appear as: Stunted plant growth, General yellowing of leaves. In less severe S deficiency situations, visual symptoms may not be apparent, but both yield and quality of crops will be affected (Ceccotti, 1996). Sulphur concentrations in crop plants should range between 0.2 and 0.5 percent. The sulphur status of crops is best diagnosed by plant analysis, The concentration of S in plant tissue is commonly used as an aid in diagnosis of deficiency, and the establishment of critical concentration values is an essential prerequisite for the interpretation of leaf analysis (Randall *et al.*, 1997; Shrift, 1961).

Sugarcane exhibits luxury consumption and removes a considerable quantity of S from the soil. A hundred ton crop of cane contains about 47.6 kg SO_4 (Ali, 1986; Humbert, 1968).

Re-evaluation of the fertilization program was required to cope with the influx of new high yielding cultivars and the improved management level which includes well land preparation, proper irrigation, good weed control and other agronomic practices. This study aims at determining the sulphur level best suited for high cane and sugar production under the current husbandry standard.

Materials and Methods

The soil is brown heavy clay and classified as true vertisols, the upper 60 cm of the soil profile is cracking clay with 40 – 60% clay content; the dominant clay mineral is montmorillonite. Bulk density 1.60 -1.70gm cm^{-3}, 90% of the upper horizon has electric conductivity (EC) less than 2 mmhos/cm., the organic carbon ranges between 0.30 – 0.40%, the available phosphorus (P) ranges between 0.03 – 11.50 ppm, available Potassium (K) 170 –350 ppm, cation exchangeable capacity (CEC) 58–61, the exchangeable sodium percent (ESP) is less than 15, and the soil pH ranges between 7.0 – 8.50 (Ali, 1986).

The experiment was conducted in season 2012/13- 2013/14 to study the effect of different levels of sulphur in the form of ammonium sulphate on sugarcane yield and quality. The levels of sulphur were 0.00, 12.00, 24.00, 36.00 and 48.00 kg S/feddan add at the planting date time, the test cultivar is TUC75-3 which occupies about 15% of the commercial sugarcane fields at Kenana Scheme. The treatments were laid out in a randomized complete block design (RCBD) replicated four times. The plot area was 4 rows ×10m ×1.50m $(60m)^2$. The planting and harvesting date were in Feb. 2012 to March. 2013 (first season) and Jan. 2013 to Feb. 2014, respectively. The irrigation interval was within the recommended range of 10-12 days. The land preparation was: uprooting of previous crop stools, deep plowing, harrowing, leveling, and furrowing at a distance of 1.50m. Similar to the standard practice, Nitrogen was applied one dose 69.00 kg N/feddan in the form of urea completed by ammonium sulfate as indicated dose at the planting date time. Phosphorus applied at the planting date also at the rate of 23.00 kg P/feddan in the form of tri-super phosphate (TSP). Soil samples, to determine its major characters, were taken before planting and after harvesting dates.

Growth and yield components: height, thickness and number of millable cane stalks per unit area were measured at monthly interval for 4 months in 5 plants tagged in each plot.

Leaf tissue samples composed of the leaves number 3, 4, 5 and 6 of 5 stalks from each plot were collected at 6 month age of the cane. The blades were separated for N determination and the sheaths for P, K and S determinations. The cane was harvested and the yield determined at age of 13 Months for the plant crop cycle. Ten stalk samples were collected and the cane quality analyses were done following the ICUMSA system for determination of pol%, Brix% and fiber%. Yield and yield component data parameters were statistically analyzed using MSTAT-C computer package.

Results and Discussion

Cane and Sugar Yields

The field yield in terms of tons cane per feddan (TCF) and tons sugar per feddan (TSF) were shown in table 1. Generally, higher cane yields were recorded under rates of 36, 48, 12, 24 and 0.0 kg S/feddan respectively, and sugar yields were recorded under rates of 36, 48, 24, 12 and 0.0 kg S/ fed respectively, while lower cane and sugar yields were recorded under rate 0.0 kg S/feddan (control).

Table 1: Effect of sulphur levels on sugarcane, cane yield/feddan (TCF), Sugar yield/feddan (TSF) and plant population

S levels kg/fed	Yield/ TCF	Yield/TSF	Population/ 1000/ fed
0.00	54.79	7.97	40.18
12.00	59.75	8.38	43.54
24.00	57.19	8.56	37.21
36.00	63.84	9.44	39.97
48.00	62.00	9.19	40.32
Mean	59.52	8.71	40.24
C. V%	6.66	9.22	13.75
SE±	1.98	0.40	2.77
Sig.	*	Ns	Ns

Analysis of variance showed significant differences among treatment means on cane yield, and no significant differences among treatments on sugar yield. But it all cane and sugar yield the sulphur levels gave the best productivity than the control.

Plant Density

The plant population ranged from about 37.21 to 43.50 thousand stalks/feddan. Plant population count for different sulphur levels are shown in table 1. The analysis of variance showed that there were no significant differences among treatments.

Hence the plant population did not respond significantly to sulphur application. But it was slightly increased with dose 12 and 48 kg S/feddan respectively above control and then decreased under no sulphur (control).

These effects in an increase and decrease didn't reach a significant level. Treatment 12 and 48 kg S/feddan were caused slight increase, but it was statistically insignificant.

Plant Height (cm)

Plant height is a main parameter of growth and yield. Although an internodes properties (length, thickness and shape) are varietal characters, yet the rate of elongation and length of the internodes and hence plant height provide information about the general condition of the crop vigour. In table 2 application of sulphur did not affect plant height in any particular trend. But in general, the application of sulphur on sugarcane Variety TUC75-3 is slightly affected in dose 24 kg S/feddan which was the best, because it was given the highest among all treatments. The analysis of variance also showed that the effect of applied sulphur on stalk height was not significant for all sulphur rates.

Stalk Diameter (cm)

Analysis of variance showed significant differences among treatment means. It was known from these data that the stalk diameter was affected by sulphur application. Stalk diameter measurements were shown in table 2.

Table 2: Effect of Sulphur levels on sugarcane, plant height (cm), internodes no. and stem thickness (cm)

S levels kg/fed	Plant height	Internodes No.	Thickness (cm)
0.00	272.25	22.00	2.57
12.00	257.75	21.45	2.81
24.00	279.25	23.60	2.75
36.00	261.80	21.45	2.85
48.00	268.10	22.70	2.87
Mean	267.83	22.24	2.77
C. V%	9.04	9.15	3.90
SE±	12.10	1.02	0.05
Sig.	Ns	Ns	*

Cane Quality

The cane quality parameters include Brix% cane, Pol% cane, Fiber% cane, ERSc (estimated recoverable sugar), Purity% and Moisture%. The results of the first two parameters (Brix% cane and Pol% cane) were shown in table 3. Analysis of variance of these parameters showed no significant differences among treatments, while no significant differences also among other cane quality parameters included ERSc, Purity and Moisture. Analysis of variance of Fiber% cane in table 3 showed a significant difference between treatments. There is a significant difference between treatment 36 kg S/feddan and all other treatments, significant differences between treatment 24 kg S/feddan and treatment 0.00 kg S/ feddan (control). There is no significant difference between treatment 12, 48 kg S/feddan and treatment 0.00 (control). According to these results, the treatment 0.00 kg S/feddan (Control) was the best as it gave a higher fiber contents and that mean the sulphur was not positive effect on sugarcane, because the treatment no sulphur (control) was the best among each treatment.

Table 3: Effect of Sulphur levels on Sugarcane quality, Brix% cane, Pol% cane and Fiber% cane

S levels kg/fed	Brix% cane	Pol% cane	Fiber% cane
0.00	17.06	16.08	16.30
12.00	17.23	15.82	15.67
24.00	18.09	16.72	16.02
36.00	18.09	16.59	15.00
48.00	17.85	16.56	15.21
Mean	17.66	16.36	15.63
C. V%	6.17	5.20	4.16
SE±	0.55	0.43	0.33
Sig.	Ns	Ns	*

Table 4: Effect of Sulphur Levels on Sugarcane ERSc, purity and moisture% cane

S levels kg/fed	ERSc	Purity	Moisture%
0.00	14.48	94.52	66.70
12.00	14.00	91.86	67.10
24.00	14.92	92.93	65.95
36.00	14.76	91.86	66.95
48.00	14.80	88.94	66.95
Mean	14.59	92.02	66.73
C. V%	5.24	4.06	1.69
SE±	0.38	1.87	0.56
Sig.	Ns	Ns	Ns

Conclusions

In conclusion the study revealed that:

Sulphur was found had a positive impact on cane and sugar yield/feddan, as compared to control.

Recommendations

According to the results of this study, we recommend for the plant cane cycle (cultivar TUC75-3) 36 kg S/feddan equivalent to 150 kg ammonium Sulphate/feddan broadcast planting date at Kenana Sugar Company estate.

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