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Availability of Some Essential Minerals in Halfa and Alguneid Sugarcane Growing Soils (Sudan)

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Abstract

Sugarcane plays a vital role in the industrial growth of Sudan as an important economic crop. This work was aiming to measure the availability of Na, K, Ca, Mg, P and N as macro-nutrients in Halfa and Alguneid sugarcane schemes. Soil samples were collected from different parts of each sugarcane growing field. Minerals concentrations were determined by atomic absorption spectroscopy. Notable differences in nutrients content were indicated between Halfa and Alguneid soils. Halfa scheme soils showed minerals content means as Mg (16.76 meq/L), Na (9.89meq/L), and Ca (0.91 meq/L). Algunied soils showed significantly low means of Na (0.367 meq/L), Mg (0.32 meq/L) and Ca (0.058 meq/L). The mean of Algunied soil N (0.067%) was almost similar to that of Halfa N (0.051%), which may reflect the insufficient nitrogen supply for optimum sugarcane growth. Phosphorus showed low mean values in the two fields as (0.00015%) in Halfa and (0.0013%) in Alguneid soils indicating a severe deficiency that can negatively influence root development and yield potential. Halfa soils may need gypsum applications whereas Algunied field may require fertilization management including P and N.

Keywords: Sugercane, Nutrients, Long term use, Compaction, Deficiency.

1. INTRODUCTION

Sugarcane is one of the world's most important vital cash crops, significantly contributing to the industrial and economic sectors; its productivity is highly dependent on soil fertility and balanced supply of essential nutrient. The availability of essential nutrients in agricultural soils can increase plant's vulnerability to diseases and pests. Navnit Kumar *et al.,* (2023) reported that, plant disease may reduce sugarcane yield by (20%). Sugarcane needs potassium in large quantities (Ghaffar *et al.,* 2013, hatt *et al.,* 2021b). Bhatt *et al.,* (2021a) estimated the suitable availability of K for sugarcane growing soils as (0.25-0.51 me/100 g). Exchangeable K has high positive relation with clay content which seems to be the most important factor in determining sugarcane yield (Finck, 1961). Nitrogen is essential for the synthesis of proteins and it is mostly applied in the reduced form (NH_3, NH_4^+) or oxidized form (NO_x). Excess nitrate may increase salt stress whereas, excess nitrogen leads to fast growing of plants that are very susceptible to insects and disease damage (Navnit Kumar *et al.,* 2023). To avoid P and K decrease in soils, the two nutrients should be applied to maintain favorable levels. The nutrients Ca, Mg, S, Cl, Mn, Si, and Ni play diverse roles in optimizing plant health and resistance against diseases (Tesfaye Wakgari *et al.,* 2018). In Ethiopia, the declining of sugarcane yield and productivity was suggested to be due the effects of soil compaction in addition to the effects of pests and diseases (Yagus Wijayanto *et al.,* 2022). Soil compaction results in the loss of soil organic matter (Hamza and Anderson, 2005). The long-term sugarcane cultivation under low soil organic matter condition changes the physicochemical properties of soil (Barzegar *et al.,* 2000). These studies collectively underscore the importance of maintaining balanced levels of N, P, K, Ca and Mg in sugarcane soils to optimize growth enhance yield and improve both biotic and biotic stresses. The recommended range for these is summarized in table 1.

Table 1: The recommended levels of K, Ca, Mg and P in sugarcane soils (Rodrigues *et al.*, 2013)

Level	P	K	Ca	Mg
Very High	>80	>6		
High	41-80	3.1-6.0	>7	>8
Medium	16-40	1.6-3.0	4-7	5-8
Low	7-15	0.8-1.5	0-3	0-4
Very Low	0-6	0-0.7		

2. METHODOLOGY

The study was conducted at two sugar factories in Sudan: Halfa and Alguneid, both of which possess distinct environmental and soil characteristics suitable for comparative evaluation.

A total of ten composite soil samples were collected at 50 cm depth from different parts of each scheme. Sample numbers were reduced by accurate preparation of mixed composite samples. Content of the nutrients, Na^{+}, Ca^{2+}, Mg^{2+}, N, and P were determined in each composite soil sample using the appropriate standard procedures and analytical grade chemicals.

3. RESULTS AND DISCUSSION

Macro-nutrients content

Halfa scheme

Halfa samples showed relatively high sodium levels content with a mean value as (9.89meq/L), which may negatively affect soil structure, porosity and nutrients uptake. Calcium values were generally low with a mean of (0.91 meq/L). Therefore, Ca levels may need to be improved. As shown by (table 2, fig 1) magnesium levels were significantly different ranging between (0.664 meq/L) and (40.830 meq/L) with a mean value as (16.76meq/L). Such variations may reflect some differences in geological background of the sampling sites. Potassium was measured in only one composite sample from Halfa scheme. It showed adequate concentration of K for sugarcane cultivation as (75.08mg/l). According to E. C. A. Oliveira *et al.* (2010), sugarcane K demand is predominantly over Ca, N, Mg and P. Montero-Arellano *et al.,* (2022), reported K (25.60±6.73) mg/l.

Table 2: Minerals content of Halfa field

Mineral Sample	Na meq/l	Ca meq/l	Mg meq/l	N%	P%
1	1.027	0.033	0.664	0.048	0.00009
2	26.110	2.626	40.830	0.076	0.00018
3	2.544	0.057	4.602	0.028	0.00018
mean	9.89	0.91	16.76	0.051	0.00015

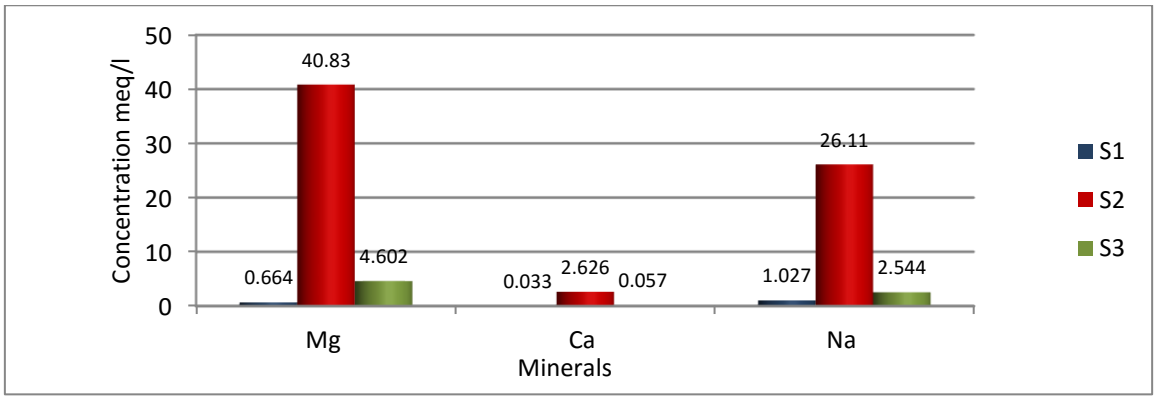

Fig. 1: Minerals means in Halfa Scheme

Algunied scheme

Algunied soils showed very low sodium content with a mean of (0.367meq/L), which, is good for water infiltration. Calcium mean was (0.058meq/L) which is very low compared with that of magnesium (0.32meq/L). The low levels of Ca may reduce nutrient exchange capacity and negatively affect the Mg/K balance in the soil-plant system and hinder Ca uptake. Mg domination over calcium is often associated with weaker soil structure and reduction of nutrients availability for plant (table 3. fig 2). Calcium is extremely important in normal cell growth and it`s concentration should usually be twice of Mg. Dhan Pal and Yihenew G.Selassie (2018) showed Na as (8.5 to 20.2meq/l), Mg (0.2 to 2.6meq/l) Ca (4.7 to 12.6meq/l), and K (0.1 to 0.2meq/l). Soil structure improvement and water availability may need addition of gypsum, plant residues and organic matter (Costa, M. S. *et al.* 2021).

Table 3: Minerals content of Algunied field:

Mineral Samples	Na meq/l	Ca meq/l	Mg meq/l	N%	P%
Southern	0.481	0.055	0.277	0.053	0.0004
Middle	0.437	0.040	0.379	0.076	0.0005
Northern	0.183	0.079	0.304	0.073	0.0004
mean	0.367	0.058	0.32	0.067	0.0013

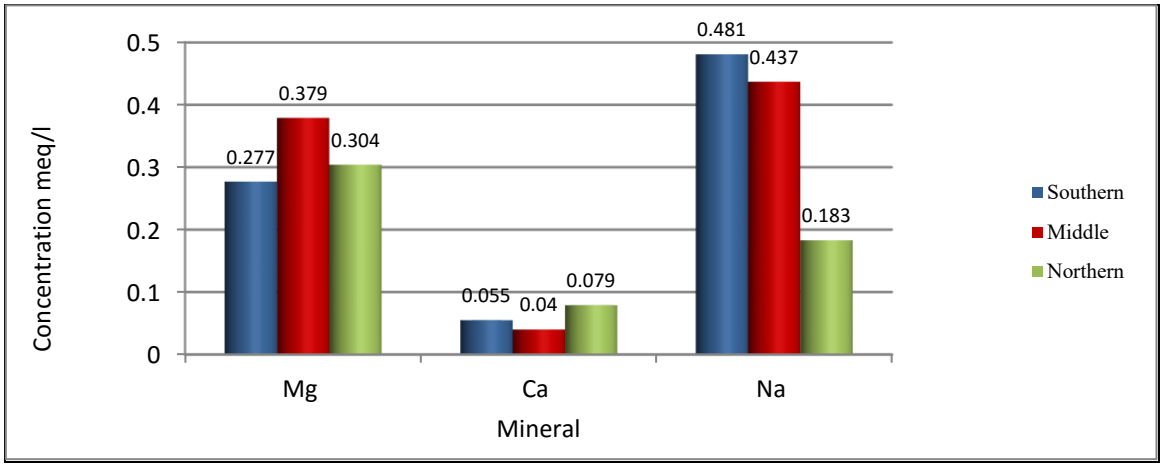

Fig. 2: Minerals means in Algunied Scheme

Nitrogen and phosphorous

Nitrogen (N) was slightly higher in Algunied soils (0.053-0.076%) compared to Halfa (0.028-0.048%) (table.2). Total nitrogen was reported by Wakgari *et al.,* (2020) as (< 0.12%) and by Montero-Arellano *et al.,* (2022) as (0.78±0.02mg/l). Halfa samples showed nitrogen mean of (0.051%), which is relatively low than that of Algunied samples (0.067%). The two schemes therefore suffer a lack of soil nitrogen for sugarcane growth. T. Wakgari *et al;* (2018) reported that, total nitrogen, and available P may significantly be affected by land use.

Significantly low phosphorus mean value was shown by Halfa soils as (0.00015%) and Algunied soils as (0.0013%) which may indicates severe phosphorus deficiency in the two schemes. This may need a use of phosphorus fertilizers to restore soil fertility and support healthy sugarcane growth. Such deficiencies can directly affect root development and overall plant productivity. Montero-Arellano *et al.,* (2022), reported P as (5.20±0.31mg/L). Wakgari *et al.,* (2020) recorded P range of (2.51 to 8.63 mg/kg) and considered such range is not adequate for sugarcane cultivation. In most soils, maximum availability of P would be expected in the slightly acid to neutral pH range. In acid soils, with Fe, Al, and Mn to form insoluble products, makes P less available. In alkaline soils, P reacts with Ca and reduces P availability. Therefore, soil pH is important to maximize availability of P and plant health. Available nitrogen of the samples investigated by Forth, (1990) ranged from (119 to 385 kg/ha), which, indicates that the soil samples were suffer from nitrogen deficiency (Forth 1990).

CONCLUSION AND RECOMMENDATIONS

- Significant variations in physical and chemical properties were observed between Halfa and ALguneid Soils.
- Alguneid soils showed favorable physical and chemical properties which, may suit sugarcane cultivation.
- Phosphorus fertilizers may need to be applied to the two sites. Organic matter amendments are highly required to increase nitrogen levels.
- Soil characteristic in Halfa Scheme may need to be improved by adding nitrogen and Phosphorus fertilizers in addition to management of salinity and sodium hazards.
- The two Schemes may need further research to confirm the effects of long-term use on soil properties and sugarcane productivity.

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