Effect of different NaCl Concentrations on Accumulation of Some Chemical Elements in Leaves and Roots of Sugar Beet (Beta vulgaris L.) Seedling

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ABSTRACT

An experiment was conducted in pots at the demonstration farm of College of Agriculture, University of Bahri, Sudan during 2016-2017 to study the effect of different NaCl concentration on accumulation of Sodium (Na+), Calcium (Ca++) .Potassium (K+), and Phosphorus (P) in leaves and roots of sugar beet seedling. The experiment was arranged in randomized complete block design (RCBD) with three replications and four treatments of different concentration of sodium chloride in soil. The treatments were 4 dS/m, 8 dS/m , 12 dS/m , and 16 dS/m referred to as S1, S2, S3, and S4 respectively. Results showed that when NaCl concentration increased in soil, Na^+ accumulation significantly increased in sugar beet seedling leaves and roots. Ca^{++} accumulation in leaves significantly increased and not significantly in roots of sugar beet seedling when NaCl concentration was increased. Higher concentration of Nacl decreased significantly K^+ accumulation in leaves and roots of sugar beet seedling. Increasing concentration of Nacl increased accumulation of P in sugar beet seedling leaves and root.

Keywords: *Sugar beet, seedling, Na Cl ,accumulation, Na^+, Ca^{++} ,K+,P.*

Introduction

Currently, more than 800 million hectares of land throughout the world are salt affected, accounting for more than 6 % of the word's total land area (Munns and Tester, 2008). The varietal differences in salinity tolerance that exist among crop plants can be utilized through screening programs by exploiting appropriate traits for salinity tolerance (Kingsbury *et. al*., 1984).

Sugar beet (*Beta vulgaris L.)* is one of the most important commercial crops that supplies approximately 35 % of the world's sugar (Liu *et. al*., 2008). Sugar beet widely cultivated in the arid and semi-arid regions. (Omar, *et. al*., 1998; Flowers *et. al*., 2000; Rozema and Flowers, 2008). Therefore, it is necessary to evaluate salinity tolerance of local commercial sugar beet cultivars in the seedling stage.

Sugar beet is very sensitive to salinity during the seedlings stage (Jamil *et. al*., 2006). It has been observed that salinity inhibits seed germination and growth of young seedlings in sugar beet, and this inhibitory influence is a specific result of ionic toxicity and not principally due to osmotic stress (Ghoulam *et. al*, 2002).

The deleterious effects of soil salinity on plants growth are associated with excessive accumulation of Na^+ and Cl^- as most saline soils are dominated by these ions (Flowers *et. al*., 1977), and K^+ deficiency caused by competition with the high external Na^+ concentration (Flowers and Yeo, 1988).

It is well documented that a greater degree of salinity tolerance in plants is associated with a more efficient system for selective uptake of K^+ and/or Ca^{++}over Na^+ (Wang, *et. al*., 2009; Wu and Wang, 2012). It is suggested that K^+ and Ca^{++} play key roles in several physiological processes, such as stabilization of membranes and control of enzyme activity, Na^+ does not function as a macro-nutrient, and thus the substitution of K^+ by Na^+ and the decrease in Ca^{++}concentration may cause ion imbalances (Tuna, *et. al*., 2007). Na^+/K^+ and Na^+/ Ca^{++} ratios are useful indicators of the degree of plant resistance to salinity (Juan, *et. al*., 2005). Therefore, control of Na^+ accumulation, and low Na^+/K^+ and Na^+/Ca^{2+} ratios may enhance salinity tolerance in plants. In leaf, Na^+ concentration remained unchanged when the external concentrations of NaCl were below 100 mmol, while significantly increased by41-fold when plants were exposed to 200 mmol. By contrast, K^+ concentration in root displayed the decreasing trend with the increase of NaCl concentrations (Wu, *et. al*., 2015). Dadkhah and Grrifiths (2006) found that at lowest salinity a significantly higher Na+ content in the leaves. Concentrations of Na^+ and Cl^- in leaves were increased with increasing NaCl (Yan, *et. al*., 2014). With increasing external concentrations of NaCl in sugar beet, Na^+ concentrations in both shoot and root significantly increased .In contrast, K^+ concentrations in both shoot and root gradually decreased (Guo-Qiang *et. al*., 2013). As salt concentrations increased, degree of growth arrest became obvious; in addition, under salt stress, the highest concentrations of Na^+ and Cl^- were detected in the tissue of petioles and old leaves (Wang, *et. al*., 2017). Shoot Ca^{++} concentration of sugar beet was significantly increased by salinity. It is also observed that different concentrations of NaCl clearly reduced root Ca^{++} (Guo-Qiang, *et. al*., 2013). There was no significant difference between two sugar beet cultivars in concentrations of Na^+ and Cl^- in the leaves at different concentrations of NaCl (Yan, *et. al*., 2014). N and K contents in the tissue of leave, petiole and root decreased rapidly with the increase of NaCl concentrations whereas P content showed an increasing pattern in these tissues (Wang, *et. al*., 2017). With the increase of NaCl concentration, Na^+ concentrations both in root and stem showed the increasing trend, whereas to a lesser degree in root than in stem (Wu, *et. al*., 2015). Neither lower (5 and 10 mmol) nor higher (100 and 200 mmol) salinity significantly affected K^+ concentration both in stem and leaf, while moderate levels (25 and 50 mmol) significantly enhanced K^+ accumulation (Wu, *et. al*.,2015) . Munns and Tester (2008) reviewed that plants have a Na^+ exclusion mechanism that maintains a low level of Na^+ in the leaves during salt stress; thus, the major osmoticum in leaves was K^+. Plants have developed diverse strategies to resist salt stress, such as restricting Na^+ uptake, activating Na^+ exclusion or cellular compartmentalization of excessive Na^+ into the vacuole (Hasegawa, *et. al*., 2000); (Yang, *et.al*.,2012).

K^+ uptake by plants is severely affected by the presence of Na^+ in the nutrient medium. Due to its similar physicochemical properties, Na^+ competes with K^+ in plant uptake (Abdul Wakeel, 2013). An increase in the concentration of K^+ in salt-affected soils may support enhanced K^+ uptake and reduce Na^+ (Abdul Wakeel, 2013). NaCl applications decreased calcium contents in the leaf and root tissues of sugar beet (Bülent, 2017).

MATERIALS AND METHODS

An experiment was conducted in pots at the demonstration farm of College of Agriculture, University of Bahri, Khartoum, Sudan (latitude 15°- 44 N; longitude 32°- 39 E, and altitudes 398 m above sea level) during December 2016 to February 2017 to investigate the effect of different sodium chloride (NaCl) concentration in soil on accumulation of Sodium (Na+), Calcium (Ca++) .Potassium (K+), and Phosphorus (P) in leaves and roots of sugar beet seedling (*Beta vulgaris L.)* .The experimental design was randomized complete block design (RCBD) with three replications ; each four pots represented one plot. Four levels of sodium chloride concentration in the silt soil namely 4 dS/m, 8 dS/m, 12 dS/m, and 16 dS/m referred to as S1, S2, S3, and S4 respectively were used. The procedure of NaCl to be applied to soil for different salinity levels were calculated as reported by (Richter and Vander, 1975). The formula used to calculate the amount of salt to be added is:

$$G(\text{salt to be added per 100g}) = \frac{0.064 dSm-1 \times water\ saturation}{100}$$

Based on the above formula the calculated amount of salt (NaCl) to correspond the different salinity levels were as follow: 8.65 g NaCl/7kg silt soil for 4dS/m; 17.3g

NaCl/7 kg silt soil for 8dS/m; 25.95 g NaCl/7 kg silt soil for12dS/m; and 34.60g NaCl/7 kg silt soil for 16 dS/m. The NaCl was dissolved in 200ml of distilled water; added to soil and mixed with it very well. Ten seeds of Lenard variety which provided by Agricultural Research Station – Wad Madani, Sudan were sown in each pot on 14/12/2016 and irrigated twice a week with distilled water. Five plants were taken randomly on 14/2/2017 from each pot to determine the concentration (mg/l) of Na^+, Ca^{2+}, K^+ , and P in leaves and roots of the seedling. Data analyzed statistically using Statistic 8.

Results and Discussion

Table (1): Effect of different concentrations of NaCl on Na^+, Ca^{2+}, K^+, and P leaves content (mg/l)

Treatments	Na^+ mg./l	C^{++} mg/l	K^+mg/l	P mg/l
S1	2.27^{cd}	0.69^{b}	2.47^{a}	0.64^{a}
S2	2.67^{b}	0.69^{b}	2.43^{a}	0.67^{a}
S3	2.70^{b}	0.70^{b}	2.17^{b}	0.71^{a}

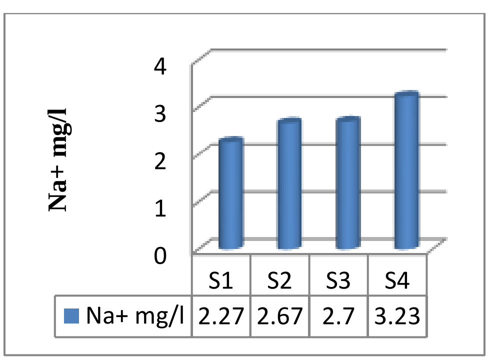
S4	3.23[a]	0.76[a]	1.90[c]	0.74[a]
SE (±)	**0.40**	**0.04**	**0.18**	**0.16**
CV (%)	**18.09**	**7.09**	**9.78**	**33.77**

Means followed by the same letter(s) within a column are not significantly different at the 5% level according to Duncan's Multiple Ranges Test (DMRT). **S1**= 4ds/m, **S2**=8ds/m, **S3**=12ds/m and **S4** =16ds/m soil salinity concentrations. **Na** $^{+}$ = sodium leaves content, **Ca** $^{++}$ = calcium leaves content, **K** $^{+}$= potassium leaves content, and
P= phosphorus leaves content mg/l.

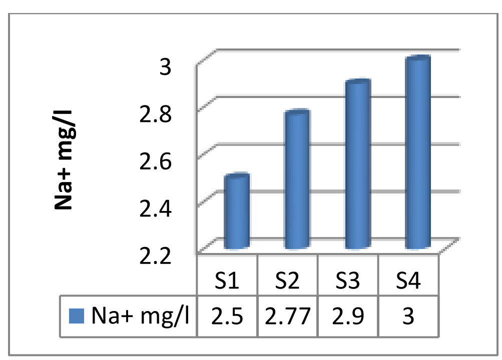
Table (2): Effect of different concentrations of NaCl on Na^{+}, Ca^{++}, K^{+}, and P roots content (mg/l).

Treatments	**Na^{+} mg/l**	**Ca^{++}mg/l**	**K^{+}mg/l**	**P mg/l**
S1	2.50[b]	0.70[a]	1.67[a]	0.51[a]
S2	2.77[a]	0.62[a]	1.47[b]	0.53[a]
S3	2.90[a]	0.61[a]	1.37[b]	0.57[a]
S4	3.00[a]	0.60[a]	1.27[c]	0.60[a]
SE (±)	**0.25**	**0.12**	**0.19**	**0.13**
CV (%)	**10.89**	**25.87**	**15.89**	**32.39**

Means followed by the same letter(s) within a column are not significantly different at the 5% level according to Duncan's Multiple Ranges Test (DMRT). **S1**= 4ds/m, **S2**=8ds/m, **S3**=12ds/m and **S4** =16ds/m soil salinity concentrations. . **Na** $^{+}$ = sodium roots content, **Ca** $^{++}$ = calcium roots content, **K** $^{+}$= potassium roots content, and
P= phosphorus roots content mg/l.

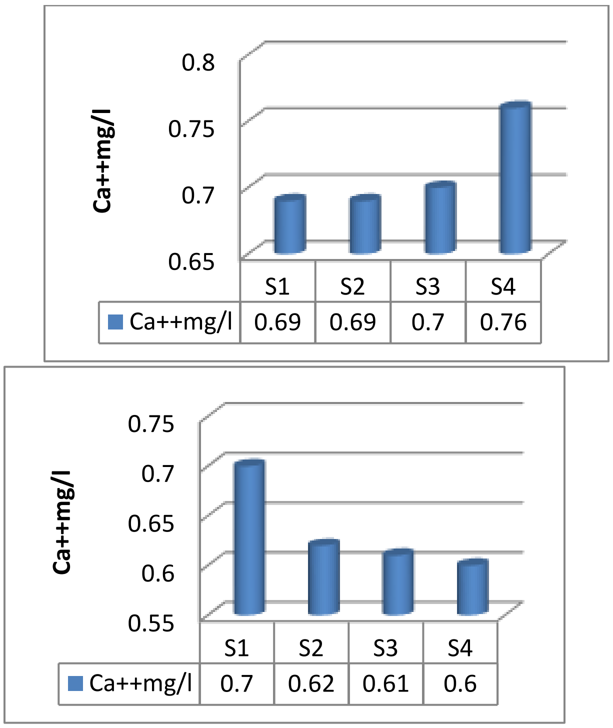


(A)



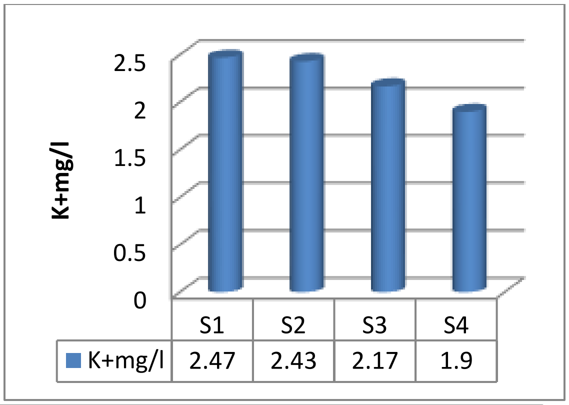
(B)

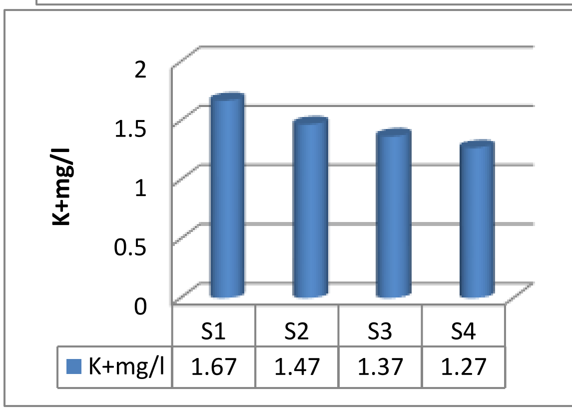
Fig. (1): Effect of different concentrations of NaCl on Na^{+} leaves (A) and roots (B) content (mg/l).



(A) **(B)**

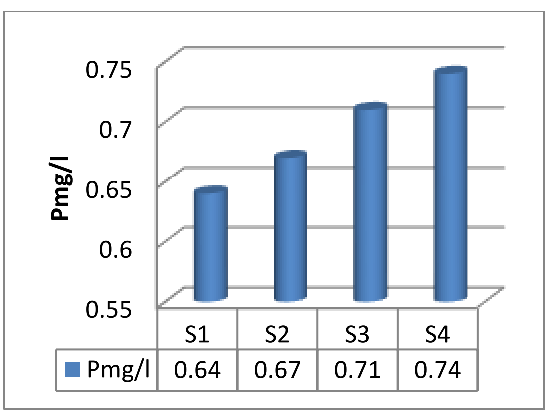
Fig. (2): Effect of different concentrations of NaCl on Ca^{2+} leaves (A) and roots (B) content (mg/l).

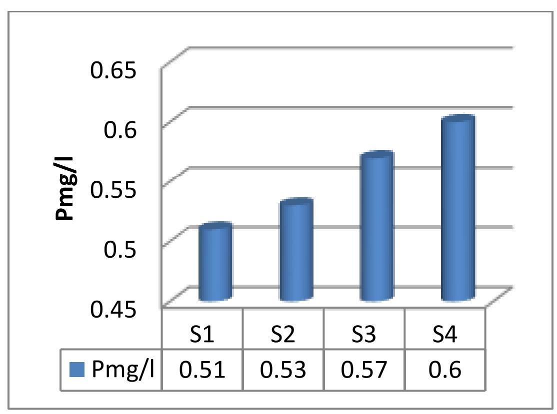




(A) **(B)**

Fig. (3): Effect of different concentrations of NaCl on K^+ leaves (A) and roots (B) content (mg/l).





(A) **(B)**

Fig. (4): Effect of different concentrations of NaCl on P leaves (A) and roots (B) content (mg/l).

Results showed that higher concentration of NaCl increased significantly Na^+ accumulation in sugar beet seedling leaves (Table 1). The highest Na+ concentration on leaves was observed in S4 treatment whereas the lowest one was found in S1 treatment (Fig. 1A). Same finding was recorded by Dadkhah and Grrifiths (2006), who found that higher salinity concentration significantly, increase Na^+ content in the leaves. Yan, *et. al*., (2014) also found that concentrations of Na^+ in leaves were increased with increasing NaCl. Wang, *et. al*., (2017) stated that under salt stress, the highest concentrations of Na^+ were detected in the tissue of petioles and old leaves. Na^+ accumulation in the roots of sugar beet seedling was increased significantly when soil concentration of NaCl increased (Table 2). The lowest accumulation of Na^+ in sugar beet seedling root was given by S1 treatment (fig.1B). This result was in conformity with that of (Guo-Qiang *et. al*., 2013), who stated that increasing external concentrations of NaCl in sugar beet, Na^+ concentrations in both shoot and root significantly increased; and (Wu *et. al*., 2015), who reported that with the increase of NaCl concentration, Na^+ concentrations in both root and stem showed increasing trend. The increase of Na^+ in leaves and root of sugar beet seedling when salt concentration in soil increased may due to non efficient mechanism of exclusion of the seedling.

Results showed that different treatment of Nacl concentration had significant increasing effects on Ca^{++} accumulation in leaves of sugar beet seedling (Table 1). The highest accumulation was observed in S4 treatment whereas the lowest was in S1 treatment (Fig. 2A). Guo-Qiang *et. al*., (2013), observed same result; they stated that concentration of Ca^{++} in sugar beet shoot was significantly increased by salinity.

Data in table 2 showed decreasing trends in Ca^{++} accumulation in sugar beet seedling root as affected by different concentration of Nacl. The lowest accumulation was observed in treatment S4 whereas the highest was in treatment S1 (Fig.2B). The increase of Ca^{++} in leaves and root of sugar beet seedling may due to association of salinity tolerance in plants with a more efficient system for selective uptake of Ca^{++}over Na^+.

Results revealed that application of different treatments of Nacl concentration significantly decreased K^+ accumulation in leaves of sugar beet seedling (Table1). The highest accumulation was observed in treatment S1whereas the lowest was in treatment S4 (Fig. 3A). Data in (Table 1) showed that different treatments of Nacl concentration decreased significantly K+ accumulation in sugar beet seedling root. The highest accumulation was observed in treatment S1whereas the lowest was in treatment S4 (Fig. 3B).This result was supported by (Guo-Qiang *et.al*.,2013) they stated that with increasing external concentrations of NaCl in sugar beet , K^+ concentrations in both shoot and root gradually decreased; and (Wang *et .al*., 2017) who mentioned that N and K contents in the tissue of leave, petiole and root decreased rapidly with the increase of NaCl concentrations. This may caused by competition with high external Na^+ concentration and similar physicochemical properties where Na^+ competes with K^+ in plant uptake.

According to results increasing of NaCl concentration had no significant effect on accumulation of P in sugar beet seedling leaves (Table 1). The lowest P accumulation in leaves was given by S1 treatment (Fig.4A) . Table (2) showed that application of different treatments of NaCl concentration increased P concentration in sugar beet seedling root. The highest concentration was found in treatment S4 and the highest was in treatmentS1 (Fig.4B).Wang *et .al*.,(2017) found same result, they observe that with the increases of NaCl concentrations P contents in the tissue of leave, petiole and root showed an increasing pattern in these tissues. The excessive accumulation of Phosphorous in sugar beet seedling leaves and roots may attribute to salt concentration induction.

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