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Effect of different NaCl concentrations on seed germination and early seedling growth of sugar beet (*Beta vulgaris* L)

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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 seasons to study the effect of different NaCl concentration in soil on seed germination and seedling growth of sugar beet. The experiment was arranged in randomized complete block design (RCBD) with three replications and four treatments of sodium chloride concentrations in soil; they were 4 dS/m, 8 dS/m, 12 dS/m, and 16 dS/m referred to as S1, S2, S3, and S4 respectively. The results showed that the applications of four levels of NaCl concentration on silt soil revealed significant increased between the treatments that effect sugar beet seed germination, leaves number of seedling, leaf area index and root length, also the results appeared no significant effect on leaves dry weight, root dry weight and root diameter of seedling. The study concluded that Sugar beet is a salt-tolerant crop, but it's sensitive to salinity during germination and seedling growth. In the present study, the best level of sodium chloride, which gives highest growth, was 4dS/m, where the lowest growth parameters were found in 16dS/m.

Keywords: Sugar beet, NaCl, seed germination, seedling growth

Introduction

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. Ironically, persistent irrigation can result in salinized land (Omar, *et. al*., 1998; Flowers, *et. al*., 2000; Rozema and Flowers, 2008). This salinization of soils will inevitably reduce the yield of sugar beet (Ibrahim, *et. al*., 2012). Moreover, genetic variability exists for salinity tolerance in different sugar beet cultivars (Ghoulam, *et. al*., 2002). The ability of plants to tolerate excess salts in the rhizosphere is of considerable importance in arid and semi-arid regions where salinization of soil usually prevails. Therefore, it is necessary to evaluate salinity tolerance of local commercial sugar beet cultivars in the seedling stage. Salinity is one of the major environmental factors that severely limit growth and yield of crop plants because most of the crop plants are sensitive to salinity caused by high concentrations of salts in the soil (Rozema and Flowers, 2008; Kronzucker and Britto, 2011). The deleterious consequences of high salt concentrations in the external solution of plant cells are hyperosmotic shock and ionic imbalance (Begum, *et al*., 2013) [4]. Although sugar beet is thought as a natrophilic species (Wakeel, *et. al*., 2011), it is very sensitive to salinity during the seedlings stage (Jamil, *et. al*., 2006) [15]. It observed that, in all of genotypes there was a decrease in germination percentage due to salinity stress increment (Mostafavi, 2012) [17]. 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 and Fares, 2001; Panahi, *et. al*., 2013). Increased salt concentration caused a decrease in germination. Strong reduction was observed mainly at the higher level of salt concentration compared to control (Jamil, *et. al*., 2006) [15]. Although, salt stress affects all growth stages of a plant, seed germination and seedling growth stages are known to be more sensitive for most plant species (Begum *et al*., 2013) [4]. Increasing salinity levels decreased root length of sugar beet seedling (Mostafavi, 2012) [17]. It was found that seed germination and root length were significantly affected by salinity levels (Zadeh and Asgharzad, 2007).

Low concentration of NaCl (50 mm) enhanced fresh and dry weights of shoot and root (Wu, *et. al.*, 2013)

Material and methods

Pots experiment was conducted to investigate the effect of different sodium chloride (NaCl) concentration in soil on seed germination percentage and seedling growth of sugar beet (*Beta vulgaris* L.). The experiment was carried out during December 2016 to February 2017 in the open space of College of Agriculture Farm - University of Bahri - Khartoum North Elkadarow - Sudan. Latitude 15 - 16 N; longitude 31- 34 E, and altitudes 398 m above sea level. The experimental design was randomized complete block design (RCBD) with three replications and each four pots represented one plot. Four levels of sodium chloride concentration in the soil namely 4, 8, 12, 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) as follow: 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/7kg silt soil for 8dS/m; 25.95 g NaCl/7kg silt soil for12dS/m; and 34.60g NaCl/7kg 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 pour water. Seedlings were thinned to five plants in each pot ten days after planting. Harvesting was done on 14/2/2017. Data collection for germination was done by counting germinated seeds daily for ten days whereas seedling growth parameters were done at harvest by taking five plants randomly from each plot to determine the following parameters: number of leaves, leaf area index, leaves dry weight (g), roots dry weight (g), root diameter (mm), root length (cm) and leaf area index.

Results

Table 1: Effect of NaCl levels on mean seed germination and vegetative growth of sugar beet seedling.

T/P	GR	N.L	L.A.I	L.D.W	R.D.W	R.D	R.L
S1	95.85 a	7.27 a	0.6527 a	4.6168 a	3.8759 a	8.97 a	16.50 a
S2	93.30 a	7.20 ab	0.8533 a	3.4057 a	2.4005 a	7.23 a	16.90 a
S3	88.30 b	7.27 a	0.2483 b	4.4507 a	3.1107 a	8.67 a	16.50 a
S4	91.67 ab	7.13 b	0.5690 a	3.4190 a	2.9298 a	8.27 a	13.87 b
SE(+)	3.25	0.14	0.616	1.211	1.476	1.74	0.400
C.V(%)	0.54	6.74	4.03	2.55	2.52	1.22	4.76

Means followed by the same letter(s) within a column are not significantly different at the 5% level according to LSD = 0.05.

GR= Germination. NO.L= Number of leaves. L.A.I= Leaf area index. L.D.W= Leaf dry weight. R.D.W= Root dry weight. R.D= Root diameter. R.L= Root length.

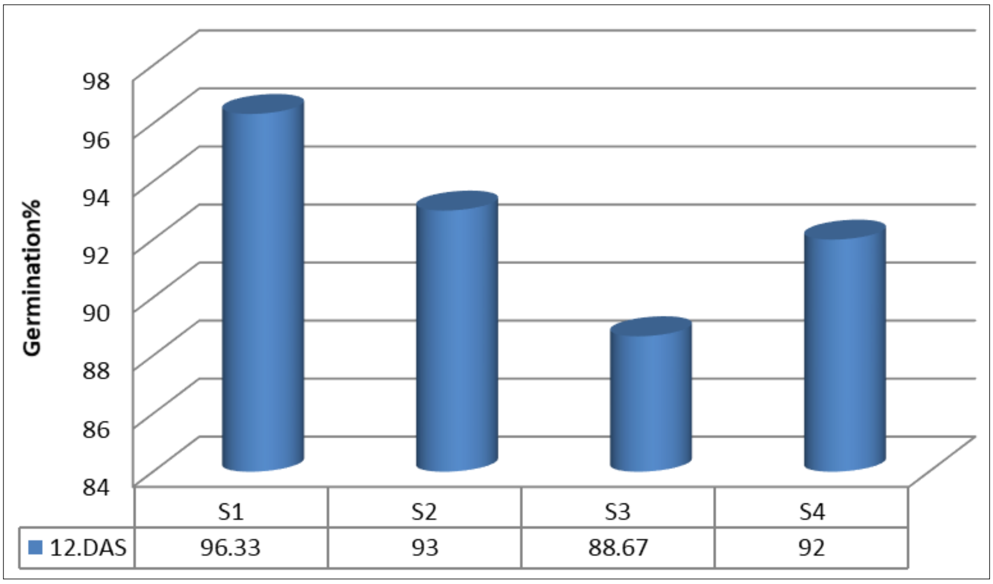

Fig 1: Effect of different concentration of NaCl on mean seed germination percentage of sugar beet.

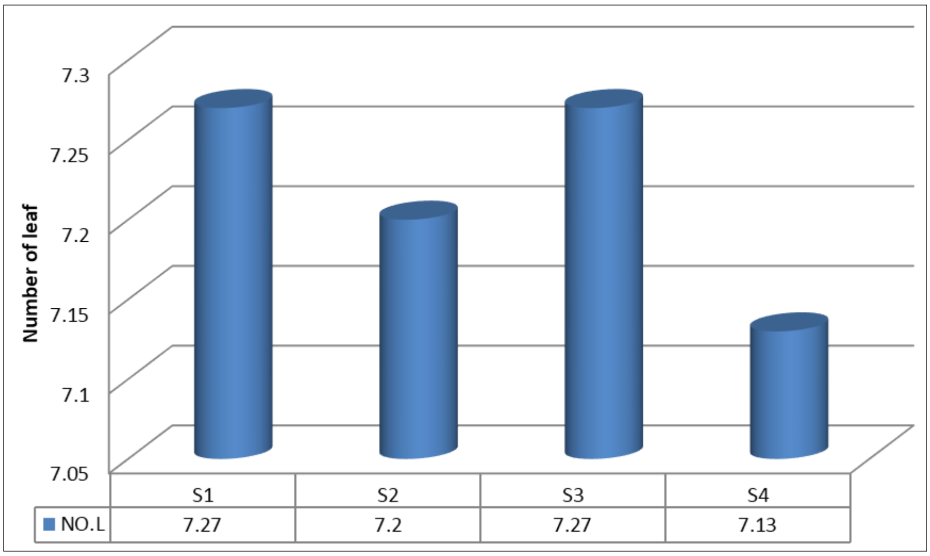

Fig 2: Effect of different concentration of NaCl on mean number of sugar beet seedling leaves

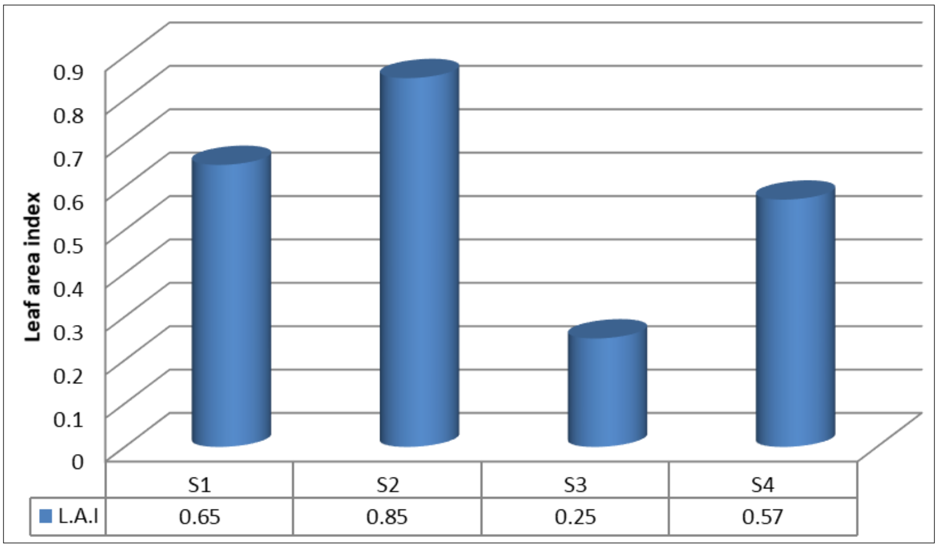

Fig 3: Effect of different concentration of NaCl on mean leaf area index of sugar beet seedling

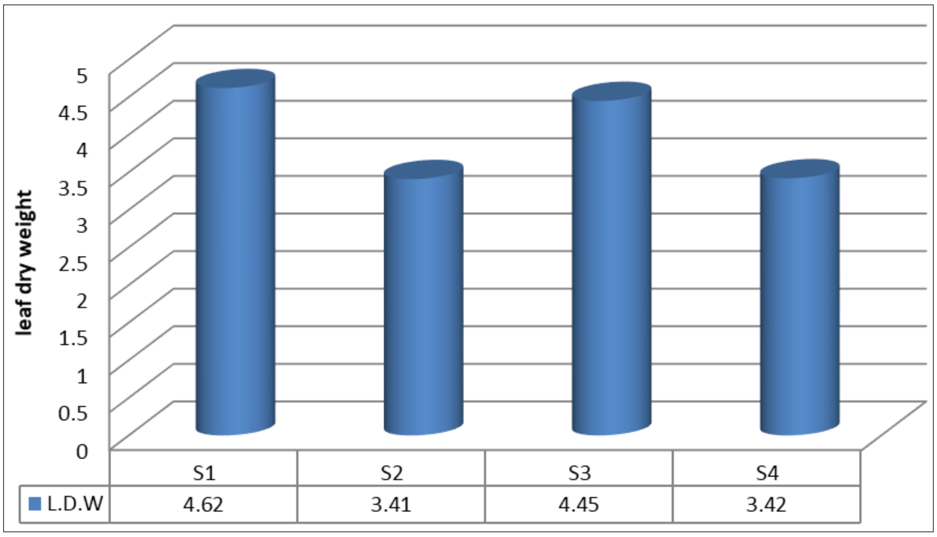

Fig 4: Effect of different concentration of NaCl on mean leaves dry weight (g) of sugar beet seedling

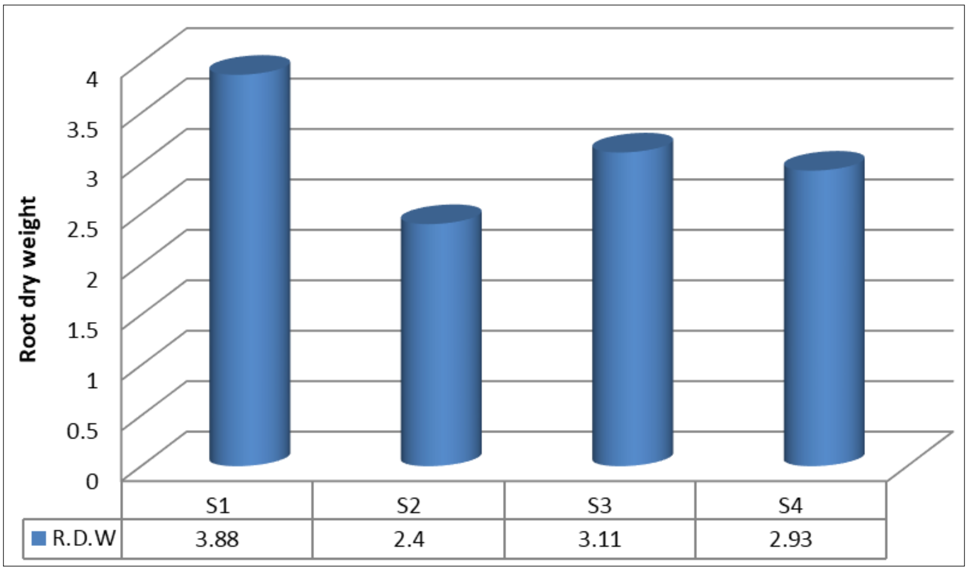

Fig 5: Effect of different concentration of NaCl on mean root dry weight (g) of sugar beet seedling.

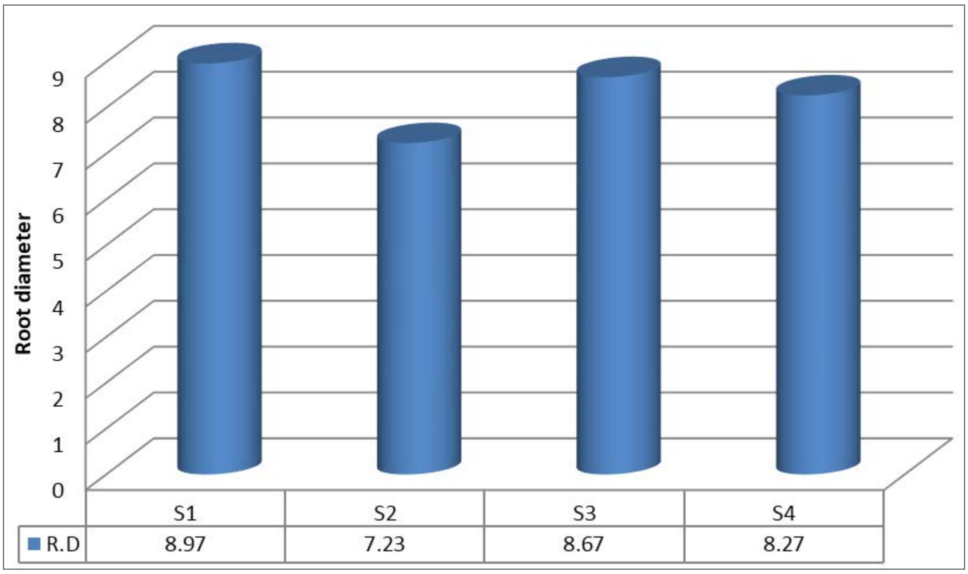

Fig 6: Effect of different concentration of NaCl on mean root diameter (mm) of sugar beet seedling

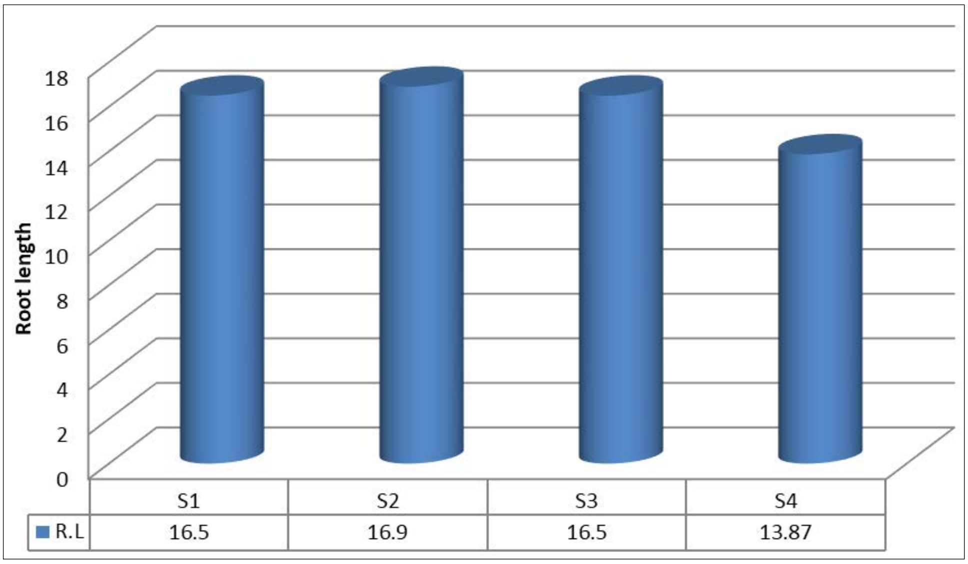

Fig 7: Effect of different concentration of NaCl on mean root length (cm) of sugar beet seedling.

Discussion

There were significant differences between Sodium Chloride concentration levels application on sugar beet germination%. The Increased in sodium chloride levels decreased the germination % of seeds. S1 and S2 treatments had the significant increased in germination percentage (95.8%) and (93.3%) respectively compared to S3 germination% (88.3%) after 12 days after sowing Table (1) Fig. (3). Salinity stress can affect seed germination through osmotic effects (Doorenbaos, and Kassam, 1979) [8]. Under saline conditions, germination ability of seeds differ from one crop to another and even a significant variation is observed. This result were with the finding of (Ghoulam and Fares, 2001; Panahi, *et. al.*, 2013) where they observed that increasing salinity concentration inhibits seed germination of sugar beet. Both seed germination and seedling root length were enhanced by low salinity level (Ali, *et. al.*, 2007) [3].

Numbers of sugar beet seedling leaves showed significant differences between the S1 and S3 treatments compared to S4 due to increase in NaCl concentration levels table (1). Increased NaCl concentration decreased the number of leaves of sugar beet seedling. Treatment S1 recorded the highest number of leaves (7.27) while S4 treatment recorded the lowest number of leaves (7.13) Fig. (2). Seedlings are a major factor limiting satisfactory stand establishment. Salt stress affects many physiological aspects of plant growth. Shoot growth was reduced by salinity due to inhibitory effect of salt on cell division and enlargement in growing point (Maghsoudi and Maghsoudi 2008). Similar results were obtained by (Dadkhah and Griffiths, 2006) [6], who reported that number of leaves were significantly decreased by increasing salinity.

Application of NaCl concentration levels on soil to sugar beet revealed significant increased on leaf area index between the treatments table (1). S1 and S2 recorded the highest leaf area index (0.6527) and (0.8533) respectively; whereas S3, and S4 recorded the lowest leaf area index (0.2483) and (0.5690) respectively Fig. (3). Dadkhah and Griffiths, (2006) [6] obtained similar result they reported that leaf area index was significantly decreased by increasing salinity.

No significant differences between the leaves dry weight (g) due to different NaCl concentration levels application was observed table (1). The increased of NaCl levels in soil decreased the leaves dry weight of sugar beet seedling. The highest leaves dry weight per plant was obtained by S1 treatment (4.617g), whereas the lowest dry weight was recorded in S2, and S4 (3.405g), and (3.419g) respectively fig. (4). this result due to number of leaves per plant and leaf area index. The result showed that there were no significant differences between NaCl concentration levels on root dry weight (g) table (1). Increased NaCl levels decreased root dry weight (g). The highest root dry weight was recorded in S1 (3.88g) and the lowest was recorded in S2, and S4 (2.4g) and (2.9g) respectively fig. (5). Sugar beet is one of the most salt tolerant crops. But it is reported to be less tolerant of salinity during germination, emergence, and in the seedling stage (Duan, *et. al.*, 2004) [9]. Dadkhah and Griffiths, (2006) [6] obtained similar results they reported that dry weight of leaves and roots were significantly decreased by increasing salinity.

Table (1) revealed that there were no significant differences between different NaCl concentration levels on root diameter (mm). The increased of sodium chloride concentration in soil decreased the root diameter per plant. S1 treatment recorded the highest root diameter (8.97mm) while S4 treatment was recorded the lowest root diameter (8.27mm) fig. (6). this result was confirmed by (Dadkhah and Griffiths, 2006) [6] who reported that diameter of roots was significantly decreased by increasing salinity. Otherwise there were significant differences among NaCl levels on root length (cm) between S1, S2, and S3 with S4 table (1). Increased of NaCl concentration decreased the root length of sugar beet seedling. The longest root length was obtained by S1 application (16.5cm) whereas the shortest root length was obtained by S4 application (13.9 cm) fig. (7). Saline soils decrease water absorbance and, consequently, cell development; therefore, effects of salt stress on root length are higher than on hypocotyls length (Jamil *et. al.*, 2006) [15]. These results agree with that obtained by Dadkhah and Griffiths (2006) [6] who reported that length of roots were significantly decreased by increasing salinity.

Conclusion

Sugar beet is a salt-tolerant crop, but it's sensitive to salinity during germination and seedling growth.

In the present study, the best level of sodium chloride, which gives highest growth, was 4dS/m, where the lowest growth parameters were found in 16dS/m.

Recommendation

Although the sodium chloride was not significantly, affected germination and growth of sugar beet seedling, but it could be recommended that the amount of NaCl should not exceed 4dS/m and 8dS/m, because they gave high growth, while 12dS/m and 16dS/m showed some reduction of growth.

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