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Effect of Salt Stress on Germination, Growth and Yield of Maize (*Zea mays* L. CV. Ghota-1)

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This research was conducted during the growing season 2010 at Talbeiseh region, located 10 km north of Homs city, 487m above sea level, average annual rainfall of about 400 mm. Maize (*Zea mays* L. CV. Ghota-1) variety approved local synthetic Ghota -1 was irrigated with saline water according to the following concentrations of sodium chloride salt (NaCl) Irrigation water used without the addition of salts (control), Irrigation water with 2g/L sodium chloride, Irrigation water with 4g/L sodium chloride Irrigation water with a further 6g/L sodium chloride, Irrigation water with 8g/L sodium chloride. This study to investigate the response of maize variety to different levels of salinity in irrigation water, and determine its ability to grow and develop in conditions of irrigation with saline, in addition to estimate productivity and quality of forage under salt stress conditions. Three grains of maize was planted in plastic pots measuring (40 × 40) cm. Plants were thinned to one plant after germination. Randomize complete block design was set with three replications, data were analyzed using statistical analysis software (Genstat-7) and means are compared by the least significant difference test LSD at a significance level of 5%. The results showed a clear effect of saline irrigation water on plants as it is when using irrigation water of high salt concentration, i.e. (6 mg/L and 8mg/L) the all plants death, these treatments gradually until age 45 days from sowing, due to the impact of salinity on the tissues of these plants. The results showed also a clear effect of saline irrigation water on the morphological and productivity features of the plants under study. Control remains superior for the percentage and speed of germination, plant height, green fodder yield, the percentage and yield of dry matter, the percentage of organic matter and the percentage of raw protein at 2 g/L and 4g/L treatments, indicating the reduction of all of that traits by increasing of water salt concentration. However these two concentrations have surpassed control for raw ash percentage. Consequently, maize variety Ghota-1 could tolerate water salinity stress up to 4g/L of sodium chloride, while all morphological and productivity characteristics were affected.

Key words: Maize, Ghota-1, Salt stress, Growth, Germination, Yield.

Salinity represents a kind of threat to the areas receive annual rainfall less than 300 mm (Levitt, 1980). Accordingly, the increasing of soil salinity is considered as one of the most important problems that limiting the crop growth and the expansion in agricultural production in irrigated, arid and semi arid regions (Asch *et al.*, 2000). Recent studies of desertification in the Arab World indicated that about 2% of the Arab lands are deteriorating as a result of salinity increasing and 13% of West Asia salty lands, while in Syria, the lands that affected by salinity is about 2.7% of the total irrigated agricultural lands (Pasternak, 1987). Also, it can be noted that the improper of agriculture care considered as one of the most important causes of increasing land salinity in the irrigated areas.

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The decreasing in freshwater resources, increasing of agriculture land that irrigated by saline water, increasing of population together with increasing in food demands all are the main problems of the current era. In order to ensure that the salty agricultural areas are not out of the agricultural plan, we can study the response of several types and varieties of different crops that locally are adapted to the salinity conditions.

Type of crop plays an important role in the extent of soil salinity tolerance where it differences according to the type of crop, stage of growth, as well as varieties of the same crop (Karmsker *et al.,* 2008, Ahmade *et al.,* 2009, Maqsood, 2009).

According to that, it can be worked on developing or introducing a genetic model which are salinity-tolerant to be grown in highly saline lands and thus reducing the high costs of lands farming and raise the efficiency of its use.

The aim of this study was to estimating the extent of maize tolerant to various ratios of water salinity (Ghota -1).

The maize crop considered as one of the important crops cultivated in the Syria, this importance appears in using of it as a feed crop by using its dry corn or as green forage by whole plant with inflorescence feminine or in the form of hay or silage. Where the maize plant is very suitable crop for silage industry, as it is easy to digest by the animals, have a great nutritional value and rich with carotenes (Mittler, 2002).

Highly saline water used for irrigation in several countries around the world. FAO (1989), (Chen et al., 2008) reported 20 countries in the world used water, with salinity ranges between 2.25 and 20 dS/m, for irrigation of crops planted in various soil types and atmospheric conditions.

Kovda (1973) showed that the ratio of saline water used in irrigation in four countries to the sum of irrigation water. In USA it is found that 10% of the irrigation water has salinity ranges from 2.25 - 5.00 dS/m, and more than half of this irrigation water has salinity of 4 dS/m and higher.

In the occupied Palestine, 4% of the irrigation water has salinity ranges from 2.25 to 6 ds/m, while this percentage increases in India to 40% (Schubert *et al*., 2009)

This saline water can be used for irrigation of salt-tolerant crops. Also, the saline lands can be planted by these crops to get benefits. There are many halophytes that adapted to natural salinity conditions are growing in saline areas. These halophytes contain 2600 species. Saline species represent less than 5% of the Arabian region flora that containing 150 species of saline plants where it can be used as animal fodders (Dellaaquila and Spada 1993). It possible to develop new varieties of crops and examine the extent of tolerant to salinity conditions in different environments. (Bernstein et al., 1993), studied the mechanism of salt stress effect in sorghum and its patterns, with respect to shape, physiological and biochemical characteristics. He concluded that the increasing in sodium chloride (NaCl) in the growing media leads to positive or negative changes in the studied morphological, physiological and biochemical characteristics, where reducing in germination percentage, roots lengths, and plants trunk, of the examined maize species takes place. The species also showed variation in their ability to give highly grains yields. The examined species showed clear variations in their response to salt stress during growing stages of the plant. He considered that the grainy yield is one of the most criterions in determining the response of sorghum to salt stress.

Soil salinity also, affecting the morphological features of the plants. Osman *et al.,* (1988) studied the effect of salinity on the dry matter yield of maize and sunflower. They found that, the salinity causes a significantly shortages in maize leaf area (during 3 – 9 weeks), sunflower leaf area (during 0 – 9 weeks), and leaf weight during fruit growth (6 – 9 weeks). Abdel Gawad *et al.,* (1990) concluded that the increasing of salinity percent in irrigation water leads to shortness in the plant height, leaf numbers, dry weight of the leaf, and dry weight of the plant trunk of maize. Also, Molazem (2006) found that high salt concentration affecting the crop productions.

(Sumer *et al*., 2008), found that the increasing of salinity percent resulted in decreasing of maize crop and the length of the plant.

The effect of several saline concentrations ranges from 0 to 12 mmohs on the dry weight of some varieties of maize and found that some types were more tolerant for salinity increase and give dry weight higher than other types (Singh *et al.,* 2008).

Akram *et al*., (2010), studied the effect of

different sodium chloride concentrations as 0 (control), 40, 80, 120 mil mole in different maize fields in Pakistan. They distinguished a clearly variations in some characteristics as plant length and weight of the fresh and dry plant according to the concentration level.

Clearly, salinity also affects the plant germination and the growth speed. Radic *et al.,* (2007) used varieties of salinity concentration (0 – 0.22 mol) to study their effect on some genotypes of maize. They found a tolerant for salinity till a limit and a decrease in germination and seedling growth occurred when 0.2 mol salinity concentration used. The genotypes showed different tolerance degrees against salinity increases.

In Egypt, a study carried out by Mouhana *et al.,* (2010) a comparison between several genotypes of Syrian and Egyptian Maize In terms of the salt tolerance of stress during germination and seedling phases. Three rates of saline concentration are tested (2ds/m, 4ds/m and 6ds/m) in addition to treating of the control. They found a moral influence in some treatments as germination speed, plant height in ages 15, 29 and 35 days, number of plant leaf at 22 days age and the plant area covered by leaf at ages 15, 29 and 36 days. It also noticed the plant death in higher salinity (6dS/m).

Study Objectives

1) Study the effect of saline stress on maize according to some morphological and physiological features.
2) Determine the tolerance extent of maize of type (Ghouta-1) to different levels of water salinity, in order to evaluate the possibility of cultivating in saline water resources environments.
3) Estimating the productivity and quality of feed resulting in salt stress conditions.

MATERIALS AND METHODS

Test Site

The experience planted in the area near Talbeiseh ,10 km to the north of Homs city, 487m above sea level, located within the first stable zone where the average annual rainfall of about 400 mm.

Experimental material

Experimental material included maize (Ghouta-1), planted on 29/5/2010 in plastic pots, (40 cm x 40 cm dimension), where three beans planted in one pot, while one was left after gemination stage and placed in the normal field conditions.

Treatments

Sodium chlorid salt was used to determine the level of salinity according to the following irrigation water treatments:

1. Standard irrigation water with no added salts (control).
2. Irrigation water with 2g/L sodium chloride.
3. Irrigation water with 4g/L sodium chloride.
4. Irrigation water with 6g/L sodium chloride.
5. Irrigation water with 8g/L sodium chloride.

The irrigation every 4 to 6 days with the same amount and at the same time for all pots.

Hoeing and weed control, the grown weeds in the pot removed by hands frequently.

Sampling

The plant were cut during the milk maturity stage then weighted to determine the green weight after that it is dried at 60^{o}C to determine the dry weight and then grinded for the required chemical experiments.

Chemical analyses of both agricultural soil and irrigation water were carried out before planting to determine the salinity percentage of each. The chemical analyses carried out in the chemical laboratories, college of agriculture, Bath University. The soil was moderately clayey. Table (2) illustrates the results of the chemicals analyses of the pots soils and the irrigation water.

Experiment Designing

Planting was carried out using complete random sectors method with three times repeat, for each treatment a five pots have been planted. Accordingly, the number of pots = 3*5*5 = 75 pots.

Statistical analysis

The data were analyzed using the statistical program (GENSTAT-7) depending on the least significant difference value (LSD) to show the treatment effect in the studied characters at 5% significance level.

Studied Characters

1. Germination percentage, naturally grown grains were counted according to (ISTA, 1985) after complete germination and then germination percentage was determined.
2. Germination speed, determined by using activity index according to the following

equation (Maguire, 1962):

$$VI = S\ (N X / DX)$$

Where VI: is germination speed. NX: is the number of grains grown tell the day X DX: is the days passed from the beginning of the germination experiment until the day X.

3. Plant height/cm: the plant height from soil surface to the base of inflorescence note were measured for each treatment, then determine the average for each frequent.
4. Plant production of green fodder (g/plant): by weighting the fresh plant, that being cut, of each treatment and determining the average.
5. Dry-matter percent (%): determined by placing a known weight of the fresh sample in electricity oven at 105°C till dryness according the equation:

$$\text{The completely dry -mater \%} = \frac{\text{Weight of dry sample}}{\text{Weight of fresh sample}} \times 100$$

6. Plant production of dry-matter (g/plant): determined by the following equation:
Dry-mater production = the production of one plant of green fodder (g/plant) x dry-matter percent
7. The ash percent: determined by burning the known weight sample of the primary dry-matter in ashtray at 757°C for 12hrs and applying the following equation

$$\text{Ash percent in the primary dry-matter} = \frac{\text{Ash weight}}{\text{Weight of primary dry-matter}} \times 100$$

The ash percent in the dry matter calculated by the following equation

$$\text{Ash percent in the dry-matter} = \frac{\text{Ash percent in the primary dry-matter}}{\text{dry-matter percent}} \times 100$$

8. Organic matter percent: determined by weight difference

$$OM\% = 100 - Ash\%$$

9. Percentage of raw protein: determined for the primary dry sample according to Kjeldahl method and applying the following equation:

$$\text{Raw protein in the dry-matter} = \frac{\text{Raw protein percent in the primary dry-matter}}{\text{Dry-matter percent}} \times 100$$

RESULTS AND DISCUSSION

Ratio and Speed of Germination

Fig. (1), showed a significantly effect of sodium chloride salt in the ratio of germination as it reached the highest effect in 93.33% then decreased with salt concentration increased in the irrigation water till reaches lowest value at the two treatments 6g/L and 8 g/L (48.89%), (51.11%) respectively. The speed of germination is significantly affected by sodium chloride salt concentration as it becomes lower with the increasing of the salt in the irrigation water reaches higher value at 5.64 and lower value during the treatments 6g/L and 8g/L (2.62), (2.50) respectively (Fig. 1).

According to the above shown results, it is clear that the salt have a negatively effect on the ratio and speed of germination which is coincide with the previous results as (Radic *et al.,* 2007) as they found a clear tolerance to salinity increases until a specific limit, they also found that there was a distinct shortage in speed of germination and seedling growth by using 0.20 mol or more in an experiment carried out on several genotypes of maize. (Mouhana *et al.,* 2010) experimentally compared between several genotypes of Syrian and Egyptian maize in terms of tolerance to salt

Table 2. Results of the chemicals analyses of the soils and the irrigation water

Analysis	Result	Description
Soil		
Organic Matter	1.96%	Moderately
Phosphorus	19 ppm	Good
Potasium	321 ppm	Good
pH	8	Weak base
EC	251 µS/cm	Not salty
Irrigation water		
pH	7.12	Weak base
EC	273 µS/cm	Fresh water

stress in both germination and seedling stages, they found that the high salt concentrations affect most of the plant characteristics including the ratio and speed of germination.

The reason of that as mentioned by (Kent, and Lauchli, 1985), is due to that the presence of salts in the seed germination media causes a decrease in water potential, lowering water motion and delayed seeds swelling before germination, which reduces the amount of water absorbed by the seed, this adversely affects the metabolic processes through increased the accumulation of phenolic compounds, causing a low germination percentage and a fall in the water potential gradient between the seed and the absorption media so the rate of water absorption by seeds decreases.

Plant Height (cm)

The statistical analyses showed a significantly effect of sodium chloride concentration in irrigation water on the plant height character, the plant height was at maximum value in the control (86.33 cm) and minimum value in the 4g/L treatment (68 cm), there was no significantly difference between the control and treatment of 2 g/L, as well as between 2 g/L and between the treatment of 4 g/L (Figure 3). Which is coincide with the studies showed that the increasing of irrigation water salinity, negatively affect the plant morphological features.

Abdel Gawad *et al.,* (1990) pointed out that the increase of salinity in irrigation water has led to a decrease in plant height, number of leaves

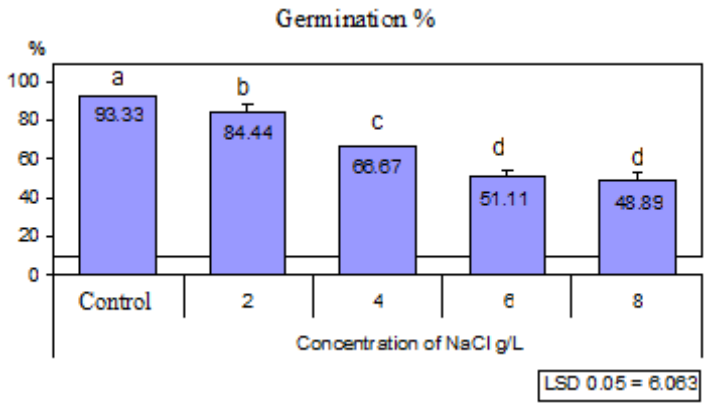

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Fig. 1. The effect of sodium chloride concentration on the germination ratio

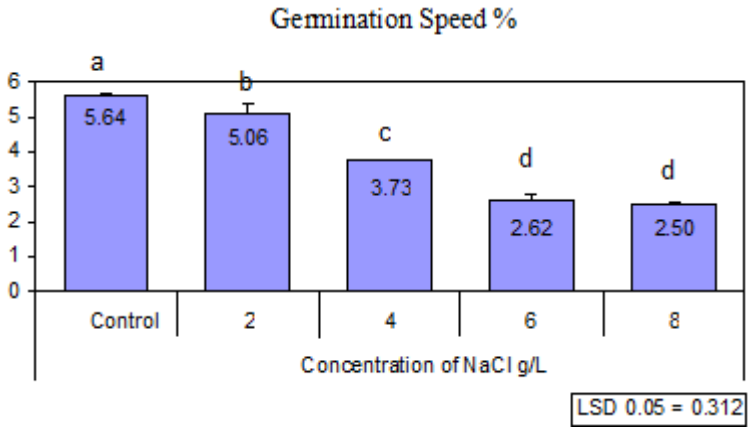

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Fig. 2. The effect of sodium chloride concentration on the germination speed

and dry weight of the leaves as well as the dry weight of the stem of maize. Also, Abdul Hamid (2008) found that the increase in salinity led to shortage of maize crop as well as the length of the plant. This has also approved by (Mouhana *et al.*, 2010).

Green Fodder Productivity (g/plant)

The results of the statistical analysis showed the existence of a significant effect of the sodium chloride salt concentration on the production of green fodder, where the highest value of production wa at the control (283.67 g) which was higher than that of the treatment of 2g/L (224.67g), which also was higher than the treatment of 4g/L (147.67g) (Fig. 4). From the results we can note that the production of green fodder declined with increasing salt concentration in the irrigation water as salts affected the growth of plants and thus led to a lack of productivity which confirmed by many references. Osman *et al.*, (1988) studied the effect of salinity on the growth and production of dry matter in the maize and sunflower crops. They concluded that salinity caused a significant decrease in the leaves weight during fruiting growth, (6-9 weeks). Molazem (2006) also, concluded that high salts concentrations affect crop productivity. Abdul Hamid (2008) found that an increase in salinity led to a lack of the maize crop, as well as the plant length. Mohammad Akran *et al.*, (2010) studied the effect of different

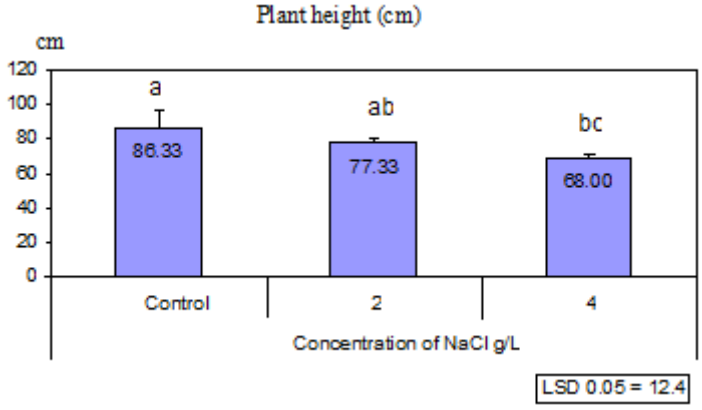

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Fig. 3. The effect of sodium chloride concentration on the plant height

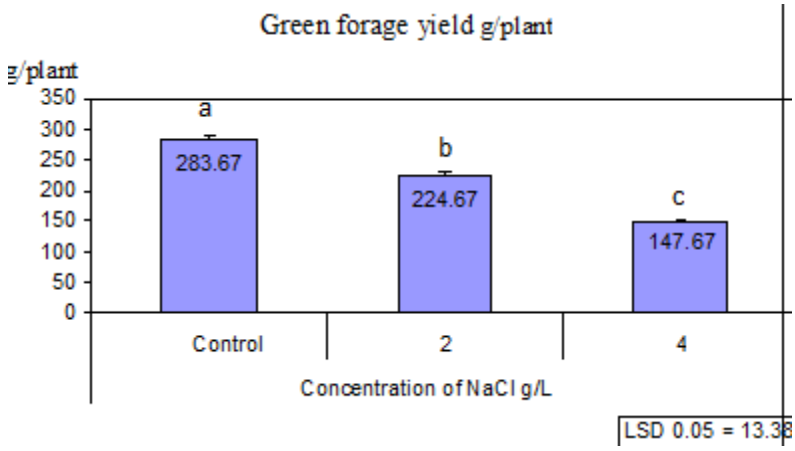

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Fig. 4. The effect of sodium chloride concentration on green fodder productivity (g/plant)

concentrations of sodium chloride, as zero (the control) 40, 80 and 120 m.mol on different hybrids of maize, they found that there are a clear variations in many features such as plant height and weight of the fresh and dry plant at different levels of salinity. This coincide with the results of Yuncai *et al.*, (2007), as they proved that dry and salt stress and salt cause loss in wet weight of maize.

Dry-matter percentage and dry-matter production (g/plant)

Figure (5) shows the existence of significant differences among the studied treatments in terms of vulnerability to sodium chloride salt concentration, the treatment of the control (26.86%) was higher than all other treatments. The treatment of 2g/L (22.83%) was higher than 4g/L (19.44%) treatment. As well as for the production of dry matter where the treatment of the control (76.24 g) was higher than the 2g/L (51.34g) and 4g/L (28.7g) treatments. The treatment of 2g/L was higher than the treatment of 4g/L (Fig. 6).

This is due to the increased of sodium chloride salt concentration in the irrigation water causes a clearly decline in both the percentage and the productivity of dry matter by impacting the plant growth in general. Many studies indicated that increase salts in irrigation water adversely affect the productivity of the dry matter. Abdel Gawad *et al.*, (1990) indicated that the increase of salinity in irrigation water has led to a decrease in plant height, number of leaves and dry

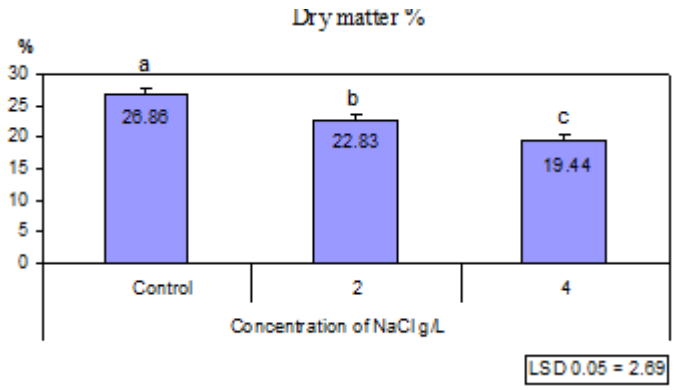

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Fig. 5. The effect of sodium chloride concentration on dry-matter percentage

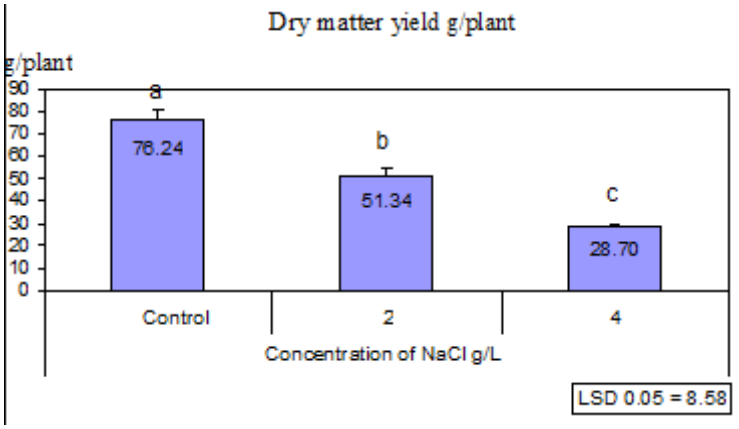

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Fig. 6. The effect of sodium chloride concentration on dry-matter productivity (g/plant)

leaves weight as well as the dry weight of the maize stem.

Molazem (2006) found that high concentrations of salts affect crop productivity. By examining the effect of different concentrations of salinity ranges from zero to 12 mmohs on the dry weight of some maize varieties it was founded that some varieties were more tolerant to salinity and gave dry weight more than some other varsities of lower tolerant (Singh *et al.,* 2008).

The present study results are coincide with the study of Mohamed Akran et al. (2010) as they studied the effect of sodium chloride concentrations ranges from zero (control), 40, 80, and 120 mmoh some different maize hybrids. They found a significantly different in most features as plant length, weight of fresh and dry plant according to the level of salinity.

Raw Ash Content (%)

The statistical analysis of the results shows a significant effect of the sodium chloride salt concentration on the ash content in the dry matter. The ash percent increases with increasing salt concentration in irrigation water. From figure (7), the 4g/L (21.75%) treatment have higher effect than other two treatments. The 2g/L (11.41%) treatment have higher effect than the control treatment (6.98%).

The increase in the ash percentage is due to the increase of the sodium chloride salt concentration in the irrigation water, and this explains that irrigation with salt water leads to salt

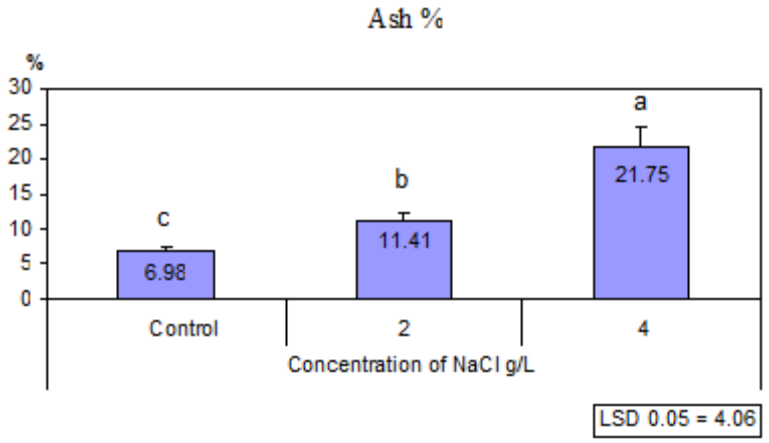

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Fig. 7. The effect of sodium chloride concentration on ash percentage in dry-matter (%)

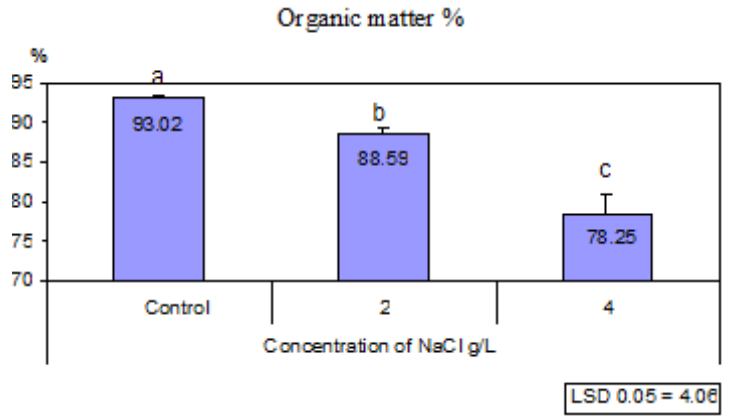

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Fig. 8. The effect of sodium chloride concentration on organic matter percentage in the dry matter (%)

accumulation in the plant tissues, especially the leaves. This is in line with what Sankari (1986) said, that salts tolerant of a plant is due to its ability to highly concentrate in the leaves before damaging them.

Organic Matter Percentage in the Dry Matter (%)

Figure (8) illustrates that increasing the sodium chloride salt concentration in irrigation water led to a decline in the proportion of organic matter where the treatment of the control (93.02%) outperformed both the remaining treatments, and also the treatment of 2g/L (88.59%) outperformed the treatment of 4g/L (78.25%). Of course, this lack of organic matter is mainly due to the effect of salts in the plant growth and productivity in general, leading to a decrease in the organic matter percentage in the dry matter.

Raw Protein Percentage (%)

The statistical analysis results showed a significant effect of the sodium chloride salt concentration on the protein precentage, which decreased with increasing of salt concentration in the irrigation water. As shown in Fig. (9), the treatment of the control (9.92%) outperformed the remaining two treatments, and also the treatment of 2g/L (8.97%) outperformed the 4g/L (7.42%) treatment.

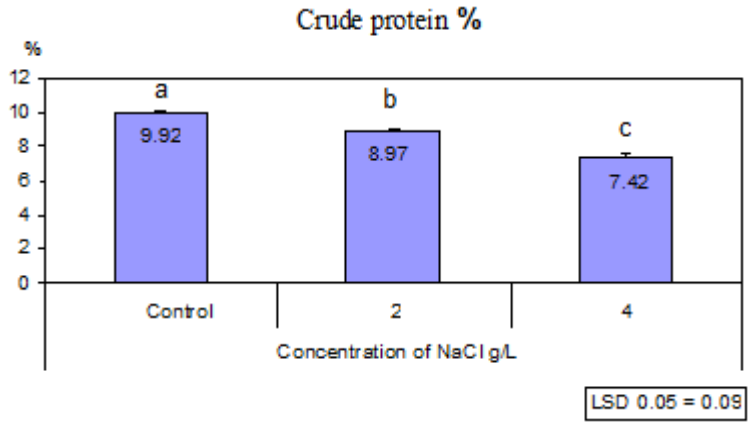

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Fig. 9. The effect of sodium chloride concentration on the raw protein percentage in dry-matter (%)

CONCLUSIONS

1) The control treatment (control) outperformed the two treatments 2g/L and 4g/L in, both the percentage and speed of germination, production of green fodder, percentage and productivity of dry matter, the percentage of organic matter and raw protein. Also, the treatment of 2g/L is outperformed 4g/L treatment in all these qualities. Meaning that, these features decreased with increasing the salt concentration in the irrigation water.
2) The control treatment (control) outperformed the 4g/L treatment in plant height feature while the different was not significantly between the control treatment and 2g/L treatment and between both 2g/L and 4g/L treatments.
3) The 2g/L and 4g/L treatments outperformed the control treatment; also, 4g/L outperformed the 2g/L treatment in raw ash percentage.

As shown from the results, the maize variety (GHOTA-1) can tolerate a salt concentration in irrigation water until (2g/L and 4g/L) but all morphological features and production characteristics will be affected. So the above mentioned variety can be planted in the areas have irrigation water salinity ranges from 2 to 4 g/L.

Continuous studies should be made on some other maize verities under the effect of salt concentration in irrigation water.

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