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GROUND ADDITION EFFECT OF SODIUM CHLORIDE SALT ON GROWTH OF *ZEA MAYS* L.

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Abstract

The experiment was carried out in a private field in the province of Diyala / Al-Muqdadiya district / Abi Saida area, 60 km north-east of the city of Baquba (center of the governorate) during the spring season of 2019. The plant was grown in a soil with a sandy clay texture in order to understand the ground addition effect of sodium chloride salt in some morphological characteristics of *Zea mays* L. Moreover, the experiment included the cultivation of yellow maize (5018 class) in pots, with four levels of sodium chloride addition (0, 50, 100, 150 and 200 mmol) including control treatment of a factorial experiment with five treatments and four replicates and equal to 20 experimental units conducted according to Compete Randomized Design (C.R.D). The results showed that the treatments) control, 50 and 100 mmol/L) was superior in the average plant height, stem diameter, leaf area and chlorophyll guide in the leaf, where the highest average were 154.25, 168.00, 152.50 cm, 1.47, 1.65 and 1.39 cm and 3. 76, 4.03 and 3.06 dsm^2/plant and 22.02, 20.79 and 19.55 SPAD, respectively, compared with the treatments of 150 and 200 mmol/L. These concentrations gave the lowest average reached 139.62, 139.75 cm, 1.25, 1.27 cm, 2.69, 2.59 dsm^2/plant and 17.58, 15.60 SPAD, respectively. The control treatment 0 and treatment of 150 mmol/L was superior in the average number of leaves and gave the highest average of 13.50 and 13.00 leaf/plant, compared to the treatments of 100, 50 and 200 mmol/L, which gave the lowest average of 12.00, 12.62 and 12.75 leaf/plant, respectively.

***Key words**:* Ground addition, Sodium chloride salt, *Zea mays* L.

Introduction

The plant's response to environments with high salt content is one of the most important agricultural parameters that researchers are interested in agricultural production. Moreover, salinity is one of the main factors that is limiting the production of agricultural crops, where the high salt concentrations has a negative effect on agricultural expansion, especially in dry and semi-dry areas (Ola *et al*., 2012). Soil salinity occurs because of the accumulation of salts, such as sodium salts (sodium chloride, sodium carbonate and sodium sulfate) and it's undoubtedly effect on the soil properties and water movement. The increasing of sodium concentration ions (Na^+) in the soil solution increases the cation exchange capacity of sodium and if the sodium adsorption rate on mud granules reaches 15% or more, this causes a change in the soil physical and chemical properties, therefore the structure of the soil system become imbalance (Ashraf, 2002). Furthermore, the salinity increasing in soil or irrigation water leads to an increase of osmotic pressure, which reduces the readiness of free water in the root area and this condition, is similar to drought stress, which leads to reduced salinity the growth due to decreased water stress in the leaves (Mass, 1986). (Yoko and Hassagawa, 2002) pointed out that the harmful effect of salts on the plant comes from the plant's inability to absorb the necessary water for vital activities and to create a state of chemical drought and nutrient imbalance. Nutrient imbalance results from the competition of Na^+ and Cl^- with nutrients such as K^+, Ca^{+2}, No3 (Yuncai and Schmidhaher, 2005), where the soil service and yield, irrigation water quality, weather conditions and cultivar of crop can all affect salinity bearing capacity. Yellow maize ranks the third in terms of the nutritional importance of world grain crops after wheat and rice (Younis, 1993). Its cultivation varies according to temperature changes and water availability, as it can be planted in different thermal environments, therefore it's considered as a tropical and subtropical crops, which makes it widespread in many parts of the world. Yellow maize is a C4 plant group (Younis *et al.*, 1987) and it is considered a main

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food source for a large number of the world's population and its planting for the purpose of obtaining food-rich, dietly and industrial grains. This crop planting for its high nutritional value for both humans and animals that contains of carbohydrates, proteins, oil, crude fiber and mineral materials. As well as, it contains vitamins such as vitamin A, Thiamine (B1) and Cobalamine (B12) and enter as a raw material in many food industries such as starch, oil and others, as well as being essential in the manufacture of concentrated feed for poultry (Shuillet and Jabouri, 1986). Halophilic plants are characterized by their ability to regulate the flow of water to them during the exposure salt stress compared with non-halophilic plants (glycophytes). The increasing of exposure to salinity also often leads to a decrease in transpiration (Prado, 2000), where transpiration percentage affects the transfer of ions from root cortex cells to the root xylem and then to the stem xylem (Trotel *et al*., 1996). Moreover, salinity causes many synthetic changes in the plant leaves such as the thickness of the cortex plates, the number and size of stomata and the thickness of the cuticle (Azmi, 1990, Alam). Furthermore, the plants, exposure to environmental stress conditions such as thermal and water stress and the plants attempt to overcome these stresses by increasing some special compounds such as proline. Finally, This study aims to investigate the effect of salt stress on the lack of relative water content of the plant cell and the consequent decrease in the average growth of yellow maize.

Materials and Methods

The experiment was carried out in a private field in the province of Diyala / Al-Muqdadiya district / Abi Saida area, 60 km north-east of the city of Baquba. The cultivation was carried out during the spring season of 2019 in sandy clay soil texture, in order to understand the ground addition effect of sodium chloride salt in some morphological characteristics of *Zea mays* L. Additionally, the experiment included the cultivation of yellow maize (5018 class) in pots, with the addition of four levels of sodium chloride 0, 50, 100, 150 and 200 mmol, as well as, comparison additions to the soil. Thus, it became a factorial experiment with five treatments and four replicates, equal to 20 experimental units conducted according to Compete Randomized Design (C.R.D). Plastic pots were uniformly fertilized for all experimental units simultaneously with urea 46% N of 140 kg/ha as a source of nitrogen and triple super phosphate 21% P 120 kg/ha as the source of phosphorus. All phosphorus amounts were added with one third of nitrogen amount and mixed with the soil before planting, while the remaining two batches of nitrogen fertilizer were added after 45 and 70 days of planting (Younis, 1993). Yellow maize seeds (5018 class) were planted and the germination was on 9/5/2019, where the seeds planted in plastic pots with a capacity of 10kg and a diameter of 30cm from the top, and 30cm depth in hills of 5cm depth by ten seeds in each pot with light irrigation after planting. Finally, the plants were defoliated in two stages, the first one after 20 days of planting, by leaving four plants. Sesamia Cretica was controlled using 10% of diazinon granulated pesticide by feeding at a center of plant after 20 days of planting as a preventive control, while the second control was after 10 days of the first control (Younis, 2012).

Preparation of salt solution NaCl

Sodium chloride was prepared by dissolving 58.44g of sodium chloride in a liter of distilled water to obtain a concentration of 1mol of sodium chloride salt. Then a concentrations of 50, 100, 150 and 200 mmol/L of sodium chloride salt were prepared by the dilution of concentrated solution 1mol and added once a week during the vegetative growth stage.

Studied traits

Plant height (cm): The plant length was measured by a graduated tape, from the soil surface to the top of the plant (Kirby and Atkins, 1968, Kambal, Webester, 1965 and House, 1985).

Stem diameter (cm): Stem circumference was measured from the center of the first internodes above the soil surface by a graduated tape made of fabric and the computational relationship between the circumference and diameter was adopted to extract the diameter of the stem circumference (cm) = diameter × constant ratio 3.14 (Quinby, 1963).

Number of leaves (leaf/plant): The leaves were calculated for each plant from the first green leaf close to the soil surface to the top of the plant, likewise measure the leaves that die at the base of the stem or are buried due to field operations (Kambal and Webester, 1966).

Leaf area (ds^2/plant): when flowering is complete, the leaf area calculated according to the equation (the square leaf length / the ear leaf × 0.75) if the number of leaves is more than 13. While leaf area equal to (the square leaf length / the ear leaf × 0.65) if the number of leaves is less than 13 (Sahoki, 1990).

Chlorophyll guide (SPAD) in the leaf: the chlorophyll in the leaves was calculated after 80 days of cultivation using the manual digital scale SPAD-502 meter device in the field directly (Felix *et al*., 2000).

Statistical analysis: Completely Randomized Design (C.R.D) was used with four replicates, where each one containing 4 plants. Finally, the results were analyzed at a probability level ($P \leq 0.05$) and a 95% confidence level, and the least significant difference (LSD) test was used to compare the averages of different treatments.

Results and Discussion

Plant Height (cm): The results showed that the treatments) control, 50 and 100 mmol/L) was exceeded in the average plant height, by giving the highest average of (154.50, 168.00, 152.50 cm) with an increase of (10.55, 20.32 and 9.22%) and respectively. Compared to the treatments of 150 and 200 mmol/L that given the lowest average of 139.26 and 139.75 cm with a decrease of 17.10 and 3.72%, respectively as shown in fig. 1. The decrease in plant height was due to the role of increasing the salinity of irrigation water in increases the salinity of soil. Subsequently, the salinity of soil has negatively affected the plant growth through the osmotic and toxic effect and the effect on the nutrient balance of the nutrients, which was consistent with (Al-amari, 2015, Gandahi *et al*., 2009) findings. They noted that the irrigation with high salinity water for yellow maize irrigation caused a decrease in plant height. Moreover, the decrease in plant length by the increases salts in irrigation water was due to the increase in the ions concentration and its direct negative effects, such as, inhibiting enzyme activity in seedling cells, this causes proteins deposition and inhibits the active sites of these enzymes. These results were consistent with (Soliman *et al*., 1994) findings that the watering with salty water causes a decrease in soluble protein percentage in the leaves and this is reflected on plant growth and on all vegetative characteristics of diameter and leaf area due to decrease the expansion, division and differentiation rates of leaf cells (Allen *et al.,* 1998). Furthermore, the decrease in plant height may be due to the effect of sodium chloride salt on germination of the yellow maize seeds, as (Fadil *et al*., 2014) observed. The Exposure of sesbania seeds to NaCl salt solutions has led to reduced germination capacity after 14 days of immersion in saline solution. Finally, it was observed from the results that whenever increase the salt concentration, the germination percentage of sesbania decreased at concentrations (100, 150 and 200 mmol/L), where the germination percentage was 85%, 40% and 4%, respectively, compared to the untreated seeds where their germination percentage was 100%. The decrease in plant height may be due to the indirect effect of salinity as it increases the osmotic stress of the solution at high salinity levels, this caused a shortage or inability to absorb water and nutrients, leading to decreased plant height (Condon *et al*., 1993).

Stem Diameter (cm): The results showed that the treatments (control, 50 and 100 mmol/L) exceeded in the average stem diameter, by giving the highest average of (1.47, 1.65 and 1.39) cm with an increase of (15.74, 32.00, 11.20%), respectively, compared to the treatments of 150 and 200 mmol/L. Which it gave the lowest average of 1.25 and 1.27cm with a decrease percentage of 24.24 and 20.00%, respectively. The increase in stem diameter in concentrations 50 and 100 mmol/L and control may be attributed to the increase in plant height in these concentrations, while the decrease in stem diameter in concentrations 150 and 200 mmol/L was due to a decrease in plant height by increasing the concentration of sodium chloride salt as shown in fig. 1. Otherwise, it may be due to the role of increasing the salinity of irrigation water in increasing the soil salinity and then the soil salinity has negatively affected the plant growth through the osmotic and toxic effect. As well as, the effect on the nutritional balance of nutrients and this was consistent with (Al-amari, 2015, Gandahi *et al*., 2009) findings, as mentioned previously. The decrease in length with the increase salts in irrigation water was due to the increase in the ions concentration, which is directly negative effects such as inhibition of enzymatic activity in seedling cells that leads to the proteins deposition and inhibits the active sites of these enzymes and this negatively affects the stem diameter.

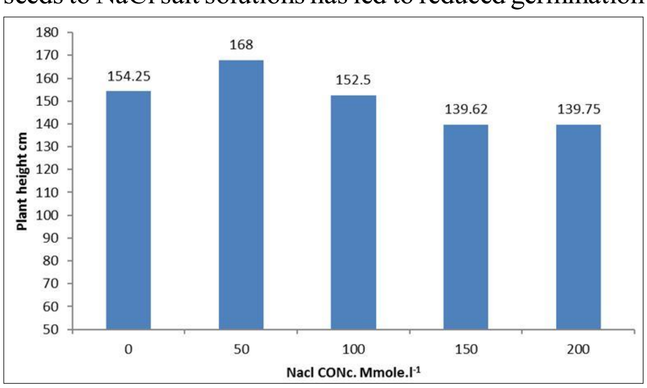

Fig. 1: Effect of sodium chloride salt concentrations NaCl mmol/L on plant height (cm) of *Zea mays* L.

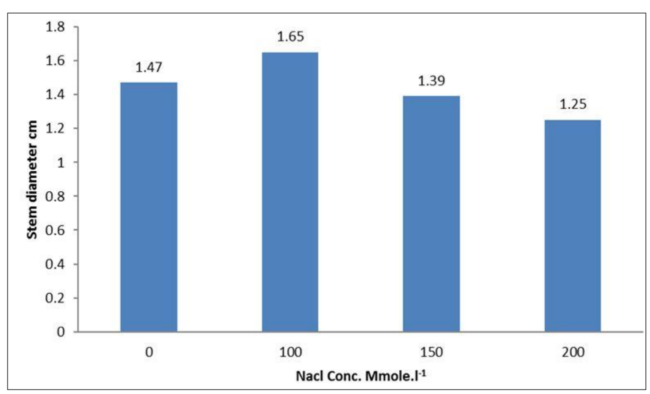

Fig. 2: Effect of sodium chloride salt concentrations NaCl mmol/L on stem diameter (cm) of *Zea mays* L.

The result was consistent with (Soliman *et al*., 1994) findings, where the watering with salty water causes a decrease in soluble protein percentage in the leaves, which is reflected on plant growth and on all vegetative characteristics of diameter and leaf area due to decrease the expansion, division and differentiation rates of leaf cells (Allen *et al*., 1998). Salt stress leads to water stress within the cell, leading to an imbalance between the antioxidant content of plant tissues such as Carotenoids, Tacopherol, vitamin E, C and glutathione and between free radicals such as Roes that resulting from oxidation processes under stress conditions. Furthermore, these materials protect photosynthesis system membranes under stress conditions. These results were consistent with all researchers (Prado *et al*., 2000) on *Chenopodium quinoa* L. plant and (Ola *et al*., 2012) on *Leptochloa fusca* L. plant, where they pointed out that the salts indirectly affect growth, where the amount of photosynthesis products and the hormones production speed that act as a conductor of information are decreasing, leading to inhibition the growth and decrease stem diameter.

Number of leaves (leaf/plant): The results showed that control treatment and treatment of 150 mmol/L exceeded in the average number of leaves, were given the highest average reached 13.50 and 13.00 leaf/plant with an increase of 012.5 and 8.33%, compared to the treatments 100, 50 and 200 mmol/L. These concentrations gave less average that reached to (12.00, 12.62 and 12.75 leaf/plant), with a decrease of 11.11-, 6.51- and 5.55%, respectively as shown in fig. 3. The increase in the number of leaves may be attributed to the increase in plant height and diameter, while the decrease in the number of leaves may be due to the low plant height and its diameter for the same salt concentrations as shown in fig. 1, 2. Several studies have shown the effect of salt stress on germination, where the soil salinity degree is an important factor in the germination timing of saline and non-saline plant seeds. (Ungar, 1996) indicated that the germination of Puccinella nuttalliana seeds was delayed for one day at the concentration of 0.5% Sodium Chloride Salt, while its germination was delayed by 8 days when placed in a 2% solution of the same salt. A study conducted by (Mansour, 1996) showed that salinity stress has led to a decrease in germination rate and elongation of radicle and plumule in two wheat cultivars, one sensitive and the other resistant. Contrary to these results, it was found that the seeds of saline plants can survive for a long time under high salt stress conditions, as the seeds of Messerchmida argenta endure immersion in seawater for 20-30 days without losing their vitality (Lesko and Walker, 1969). The absorption of NaCl by saline plants is related to their ability to use Na^+ and Cl^- in the outer media to regulate osmotic pressure within cells to avoid toxicity because of the accumulation of these two elements. The ability of saline plants to control the absorption of chlorine and sodium elements even with high salt concentrations in the outer media corresponds to the growth of these plants and this growth determines the speed of the plant's ability to store these mentioned ions. Moreover, the plant growth also determines the physiological mechanism of salt accumulation in the plant, because during plant was exposed to the salt stress, carbon and nitrogen are flowing to the plant, resulting in metabolic products used by the plant, even temporarily, such as polyols, cyclitols, ammonium compounds, amino acids, sugar (Mobraky, 2001).

(Abd-El-Ghaffer *et al*., 1998), showed that the exposure of wheat to salt stress of (6.3 and 9%) of sodium chloride salt has led to reduce the total soluble proteins. Conversely, (Singh and Vijayakumar, 1974) showed that salinity increased protein content and decrease fat in wheat grains. As (Ola *et al*., 2012) also showed that the treatment of *Leptochloa fusca* L. Plant with 0.01mol of sodium chloride salt resulted in plant adaptation to inhibit the effect of salt stress, this is reflected on the vegetative growth of plant height and number of leaves.

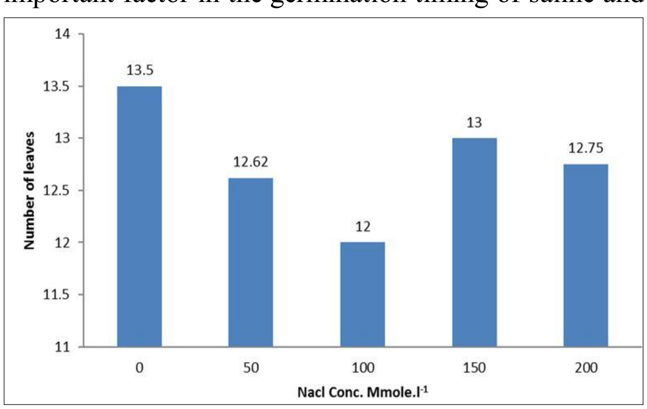

Fig. 3: Effect of sodium chloride salt concentrations NaCl mmol/L on number of leaves (leaf/plant) of *Zea mays* L.

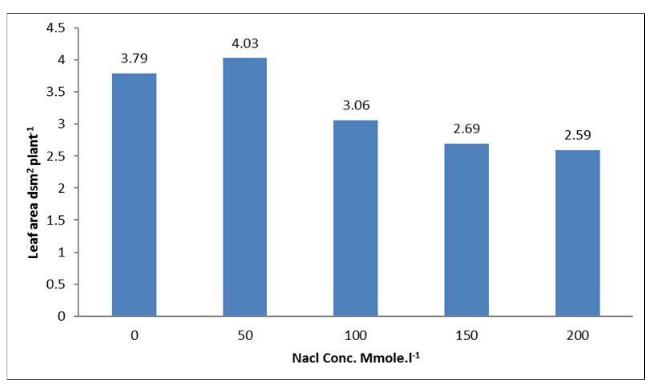

Fig. 4: Effect of sodium chloride salt concentrations NaCl mmol/L on leaf area (dsm^2/plant) of *Zea mays* L.

Leaf area (dsm^2/plant): The results showed the superiority of treatments (control, 50 and 100 mmol/L) in the average leaf area, by giving the highest average reached (3.76, 4.03 and 3.06 dsm^2/plant), with increase of (46.87, 55.59 and 18.14%) compared to the treatments of 150 and 200 mmol/L. These concentrations gave the lowest average reached 2.69 and 2.59 dsm^2/plant, with a decrease of (-33.25 and -35.73%), respectively as shown in fig. 4. The increase in leaf area may be attributed to the increase in plant height, diameter and number of leaves, while the decrease in leaf area may be due to low plant height, diameter and number of leaves for the same salt concentrations as shown in fig. 1, 2, 3. (Aboud and Abdul, 2017) pointed out that the effect of salt stress on the leaf area decreased from 2703.16 cm^2 to 2541.35, 2349.20 and 1966.11cm^2 respectively. This was due to the role of increased salinity of negative irrigation water in plant growth through the osmotic and toxic effect on the nutritional balance of nutrients (Boudjabi *et al*., 2015, Dhooki *et al*., 2013).

The decrease in the leaf area may be due to the difference in the osmotic pressure, as the water moves from one point with a low concentration of salt to another point with the highest concentration. Otherwise for water from a point with a higher concentration of water, to another point with a lower concentration, as the presence of salt will dilute water), this was called the osmotic pressure of the system and as the concentration of dissolved substances in a system increases, are increasing the osmotic pressure. Whereas increasing osmotic pressure restricts the freedom of water to move, as water molecules become constrained by salt molecules and increasing the osmotic pressure of a system has negatively affected its water effort and thus affects the plant leaf area (Abu Jadallah, 2010). (Arnom, 1949) pointed out that the addition of 150 mmol of sodium chloride to the nutrient solution for hydroponic has led to a steep decline in the leaf area of sunflower, particularly in the first four weeks and the leaves were more sensitive than stems and roots due to increase salt stress. (Broadbent, 1985) observed that the plant response to salt stress through the decline in the vegetative growth was rapid and begins as soon as the concentration of salts around the root increases to the extent that exceeds the salinity threshold and in most plants was 40 mmol. Finally, sodium chloride and this decrease in growth is largely due to the osmotic effect to the salts outside the roots.

Chlorophyll guide (SPAD): The results showed the superiority of treatments (control, 50 and 100 mmol/L) in the average chlorophyll guide in leaf, by giving the highest average reached to (22.02, 20.79 and 19.55) SPAD, with an increase of 41.15, 33.26 and 25.32% compared to the treatments of 150 and 200 mmol/L. These concentrations were given the lowest average reached 17.58 and 15.60 SPAD, with a decrease of -20.16 and -29.15%, respectively as shown in fig. 5.

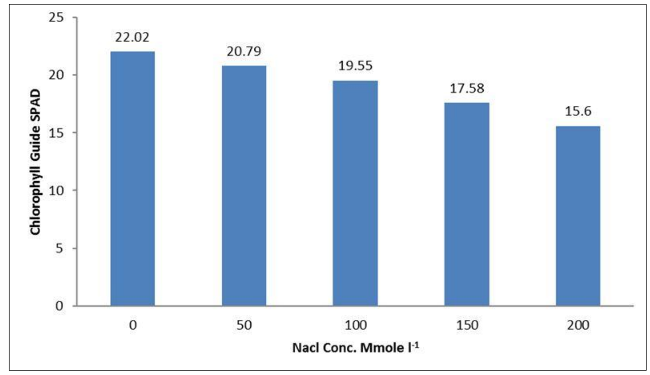

Fig. 5: Effect of sodium chloride salt concentrations NaCl mmol/L on chlorophyll guide (SPAD)of *Zea mays* L.

The increase in leaf chlorophyll may be attributed to the increase in plant height, diameter, number of leaves and leaf area, while the decrease in the leaf area may be due to the low plant height, stem diameter, less number of leaves and leaf area for the same salt concentrations as shown in fig. 1,2,3,4 (Abboud and Abdel, 2017), pointed out that there was a significant decrease in the chlorophyll concentration in the leaves with increasing the salinity levels, where the averages of leaf content values of chlorophyll were 44.61, 37.92, 31.93 and 29.59 SPAD for the levels of irrigation water with electrical conductivity of 1.8, 3, 4.5 and 6 dsm/m, respectively. This may be due to increased osmotic pressure and toxic effect of salinity that inhibited growth, elongation, extension cells, that negatively affected leaf content of chlorophyll (Abboud, 1998). These results are consistent with (Gandahi, 2010, Al-wativi, 2013) that indicated to a decrease in the chlorophyll dye concentration in the plant when exposed to salt stress.

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