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# The interaction effect of leaching requirements, salinity of irrigation water, levels of added sulfur and type of organic matter on soil salinity cultivated with maize plants (*Zea mays* L.)

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## Abstract

An experiment was carried out using pots in the plastic house of the Agricultural Research Station / College of Agriculture / University of Basrah / Karma Ali site during the year 2022, to study the effect of adding mineral sulfur, organic matter, leaching requirements, and salinity of irrigation water on soil salinity planted with maize plants. By using two types of organic residuses (cow and alfalfa residuses) and with three levels of added mineral sulfur (0%, 0.8% and 1.6%) and three levels of leaching requirements (15, 25 and 35%) in excess of the field capacity and two levels of irrigation water salinity ( 4 and 8 $dSm^{-1}$), where organic residues and mineral sulfur were added mixed with the surface layer of the study soil and incubated for 60 days before planting yellow corn (*Zea mays* L.) while maintaining soil moisture at field capacity. After the process of incubating the soil with mineral sulfur and organic matter in pots, yellow corn seeds were sown with crop service operations such as fertilization and irrigation operations carried out according to the above treatments. After 60 days of planting, the plants were mowed to estimate soil salinity. And the end of the experiment. The results of the study showed that the addition of organic residuses led to a decrease in the electrical conductivity of the soil at the end of the experiment from 6.11 $dSm^{-1}$ to 3.05 and 3.17 $dSm^{-1}$ for the alfalfa and cows respectively, and the decrease was more clear "in the alfalfa residuses , and the level of leaching requirements exceeded 35% in reducing the electrical conductivity of the soil compared to the other two levels, to reach 3.16 $dSm^{-1}$, and the salinity of irrigation water 4 $dSm^{-1}$ excelled in reducing the electrical conductivity of the studied soil to become 3.01 $dSm^{-1}$, while the value of the electrical conductivity of the soil increased with the increase in the percentage of addition of mineral sulfur to reach 2.58, 4.35, and 3.94 $dSm^{-1}$ for the levels of 0, 0.8, and 1.6%, respectively.

**Key words: organic residues, leaching requirements, mineral sulfur, salinity of irrigation water.**

# I. INTRODUCTION

Sulfur is one of the compounds used by many researchers as soil conditioners, as its final effect on the soil is to reduce the pH, increase the solubility of nutrients and make it more available for the plant, as many researchers found an increase in growth and production of a number of crops when adding sulfur to the soil (Mona *et al*., 2011). Sulfur is fond in large places in the world and being incidentally present in the oil industry, so adding sulfur has become a common method for a number of researchers as a means of soil management and reclamation, and with this is still a small part of this product used until now if compared to the quantity produced from it, and sulfur can also be used as a reformer for many properties of fertile soil and increase the readiness of many nutrients that are available in the soil as insoluble compounds (Shaker and Rahi, 2002).

Sulfur is used in agricultural development, especially in calcareous soils, where it constitutes a large percentage of the Iraqis soils which is characterized by containing a high percentage of calcium carbonate, which clearly affects some of the soil properties responsible for plant growth, whether it is physical such as soil-water relations and the appearance of the surface crust problem, or it was chemical such as the high pH or fertility such as reducing the availability of nutrients for the plant, and thus Soil containing more than 8% of calcium carbonate affects the soil properties shown above and thus reduces plant growth and productivity (Hassan *et al*., 2012). Therefore, sulfur contributes to the reclamation of alkaline soils through its acidic properties, which increase the availables of the elements, increase water conductivity and porosity, and improve drainage and thus improve soil structure. The addition of leaching requirements and net leaching water movement is required to remove salts to prevent them from concentrating in the root zone to the appropriate level to bear plants to ensure that it does not affect their growth and productivity. The leaching salts from soil and the improvement of its physical and chemical properties depends on several factors, including those related to the irrigation method, salinity, the amount of water added during the irrigation process, the time period between irrigations, as well as soil properties and other factors (Kamel and Bakry, 2009). The addition of organic residues is one of the effective strategies to reducing the damage of irrigation water salinity and increasing plant tolerance, as it improves the distribution of soil pores, which in turn increases the ability to hold water and aeration, and improves root secretions such as organic acids that regulate the pH of the soil and reduce the harmful effect of salts in the soil solution (El-Dardiry, 2007), as well as organic residues have a role in the sodium ion leaching and reducing the ratio of exchange sodium and electrical conductivity (Walker and Bernal, 2008), as well as working on the nutritional balance in the soil that is disturbed by the presence of an increase of certain ions at the expense of essential nutrients and improving ventilation conditions and the movement of oxygen for soil organisms increases the biological activity and the availability of nutrients. (Abbawi and AL-Zubaidi., 2022). Hao *et al*. (2008) indicated that the addition of organic residues to the soil has a role in improving the soil's physical properties related to permeability, porosity, air and water movement in the soil. Also, the organic materials added to the soil from different sources play an important role for the soil, as these materials directly affect the improvement of soil structure and increase the stability of the aggregates. It also leads to an increase in the ability of the soil to available water and preserve the surface of the soil from erosion and erosion by forming aggregates through the adhesion of soil particles to each other, as it acts as a binder, and thus the difficulty of its disintegration and drift, whether by water or wind (Tarchitzky and Chen.,2002). Therefore, this study aimed to demonstrate the effect of adding mineral sulfur, organic matter, leaching requirements, and salinity of irrigation water on the physical properties of soil cultivated with maize plants.

## II. MATERIALS AND WORKING METHODS

The experiment was conducted in a plastic house in the Agricultural research station / University of Basrah / Karma Ali (southern Iraq) during the year 2022 on a surface soil sample (0-30 cm) brought from the same site in order to study the interference effect of leaching requirements, irrigation water salinity and added sulfur levels. and the type of organic matter on soil salinity cultivated with maize plants. The soil was air-dried and then sieved through a 4 mm sieve. Its physical and chemical properties shown in Table (1) were estimated according to the approved standard methods. The soil texture was estimated according to what was reported in Black (1965) and the ions of calcium, magnesium, sodium, potassium, chloride, carbonates,bicarbonates and sulfates in a soil extract: water (1:1) according to what was reported in Richards (1954), and the rest of the attributes were estimated according to what was mentioned in . Page *et al.* (1982).

**Table (1) Some primary physical and chemical properties of the studied soil.**

| **Parameters** | **Depth ( 0-30 cm)** | **Unit** |
|---|---|---|
| PH | 8.12 | ------- |
| ECe. | 6.11 | dS $m^{-1}$ |
| CEC | 13.88 | Cmol $^{+}$ $gm^{-1}$ |
| available N | 4.22 | mg $kg^{-1}$ |
| available P | 11.01 | |
| available K | 114.88 | |
| Total N | 0.41 | gm $kg^{-1}$ |
| Organic Carbon | 2.32 | |
| Organic meatal | 3.80 | |
| Ca | 9.5 | mmol $l^{-1}$ |
| $Mg^{++}$ | 7.77 | |
| $Na^{+}$ | 36.1 | |
| $K^{+}$ | 1.62 | |
| $HCO_3^{-}$ | 5.42 | |
| $CO_3^{--}$ | 0.00 | |
| $Cl^{-}$ | 34.41 | |
| $SO_4^{--}$ | 13.30 | |
| Partical Density | 2.64 | Mg $gm^{-3}$ |
| Bulk Density | 1.31 | |
| Porosity | 35 | % |
| Sand | 110 | gm $kg^{-1}$ |

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| | | |
|---|---|---|
| Silt | 434 | |
| Clay | 456 | |
| texture | Silty Cly | |

Sufficient amounts of alfalfa plant were collected from one of the fields of the agricultural research station, washed, dried and sieved through a sieve of 1 mm. As for the cow residuses, it was collected from animal fields near to the study area in sufficient quantities. Foreign materials were removed from it, mixed well and sieved through a sieve of 1 mm. The organic residue was mixed with the dry soil of each pot (5 kg of soil) at a rate of 2% (weight: weight).

The study was carried out by four factors:

1- The type of organic residuses, including (cows and alfalfa).

2- The percentage of added mineral sulfur (0%, 0.8% and 1.6%).

3- Irrigation water salinity (4 and 8 dS $m^{-1}$).

4- Leaching requirements (15, 25 and 35%) in excess of the field capacity.

Organic residues and mineral sulfur were mixed with the soil of the study and incubated for 60 days before planting the yellow corn plant while maintaining the soil moisture at the field capacity and with three replications. After the process of incubating the soil with mineral sulfur and organic matter in pots, seeds of yellow corn (*Zea mays* L.) Baghdad 3 variety were planted, and after germination and the emergence of seedlings, a thinning process was carried out to obtain one plant in each pot Crop service operations were carried out by fertilization operations according to Al-Abedi, 2011, as the compound fertilizer NPK (12:11:18) was added at an amount of 66.4 kg K $h^{-1}$, and the compound fertilizer (18:46:0) was added to replace the element phosphorus with an amount of 86 kg P $h^{-1}$, which was added in one addition before Agriculture. Nitrogen fertilizer was added in the form of urea fertilizer 46% N to compensate for the nitrogen element, at an amount of 320 kg N $h^{-1}$, in two additions, the first after 10 days of planting and the second after 30 days of planting, and after 60 days of planting, the plants were harvested to estimate soil salinity. The irrigation process is according to the previous treatments. The amount of water required for rinsing was determined based on the wet moisture of the soil before each irrigation and according to the following equation:

$$\mathbf{d = (w_{f.c.} - w_{i.w.}) * Pb * D * A} \quad \ldots\ldots\ldots\ldots\ldots\ldots (\text{Kovda,1973})$$

**which :**

d = The amount of water needed for irrigation (cm3)

$w_{f.c.}$ =Weight moisture percentage before subsequent watering (%)

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$w_{i.w}$. Weight moisture percentage at the previous watering (%)

Pb = bulk density of soil ( Mg $gm^{-3}$)

D = soil depth (cm)

A = area of the pot (cm2)

Then the result of the equation was multiplied by the percentage of leaching requirements and according to the above transactions, which were added to the total amount of water, as the amount of water added to each anvil was 2.39, 2.54 and 2.75 liters for leaching requirements of 15, 25 and 35%, respectively. The electrical conductivity of soil solution in a soil: water extract (1:1) was estimated after 30 and 60 days of maize plant growth. The experiment was analyzed statistically according to the design of the factorial experiments with four factors and three replications 3 * 2 * 3 * 2 * 3 (leaching requirements * irrigation water quality * percentage of added mineral sulfur * type of organic matter * repeats) using the sectors design, and the data were analyzed statistically using the SPSS program and variance analysis ananalysis of variance and the F-test using the rate of least significant difference (R.L.S.D) to compare the averages of the studied treatments (Al-Rawi and Khalaf Allah, 2000).

## III. RESULT& DISCUSSION

Figure 1 shows the presence of a high significant effect of organic residues on the electrical conductivity values of the soil solution. The lowest value of the electrical conductivity of the alfalfa treatment, which amounted to 8.74 $dSm^{-1}$ and 3.05 $dSm^{-1}$ after the middle and end of the experiment respectively, compared to the treatment of cow residues (10.07 and 3.17 $dSm^{-1}$) After the middle and the end of the experiment sequentially, noting the increase in the electrical conductivity values of the soil filter the middle of the experiment, and the reason may be due to the effect of adding mineral sulfur. This result agrees with the findings of (Lakhdar *et al*., 2010) and (Mahdy, 2011), who indicated that the addition of organic residues to saline soils improved the salt leaching conditions due to the reduction of the bulk density of the soil, the increase in porosity, and the improvement of construction.These residues have different effects in leaching the NaCl salt, reducing the exchange sodium ratio (ESP), electrical conductivity, and increasing the water moving in soil. Abd AL-Hseen *et al*.(2020) found a decrease in the salinity of the original soil to more than 50% when using organic residues, and the reason was attributed to the effectiveness of soil microbes that contribute to improving the soil's physical and chemical properties ,He also indicated that the ability of organic residues to reduce soil salinity depends on the type of these residues, and attributed the reason to the ability of the organic source to collect particles and improve leaching conditions and what the organic source can add of salts that may reduce of its efficiency in reducing soil salinity, in addition to that the use of leaching requirements during the period of implementation of the experiment increased the chance of leaching of salts below the surface layer, especially when the texture is medium for the soil of the field and with the presence of an water drainage system in the study place. The reason for the superiority of alfalfa residues over cow residues in reducing the electrolytic conductivity of the soil may be due to the

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ability of alfalfa residues to reduce nitrogen transformations in the soil and the decrease in the amount of ammonium liberated and nitrates formed, which indicates an improvement in soil properties (Riam *et al*., 2021).

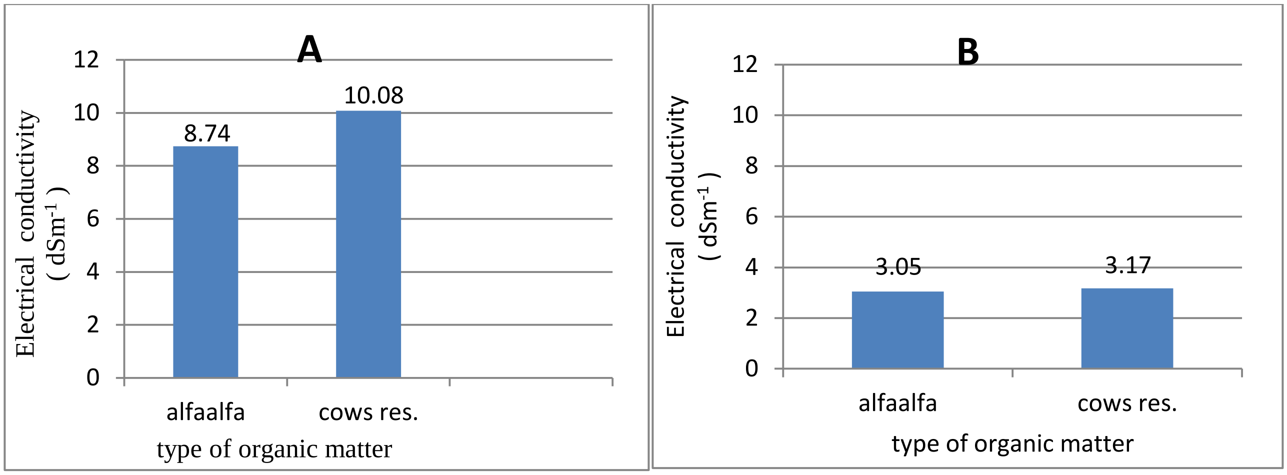


**Figure (1) The effect of the type of organic matter on the electrical conductivity values of the soil solution after the middle (A) and the end (B) of the experiment (dS m$^{-1}$).**

The results also indicate that there is a high significant effect of the leaching requirements on the electrical conductivity values of the soil solution after the middle and the end of the experiment, as it is noted from Figure 2 that the addition of the leaching requirements with the irrigation water has reduced the electrical conductivity rate of the soil at the end of the experiment, with the percentage of addition exceeding 35% ( 7.71 and 3.11 dS m$^{-1}$ after the middle and end of the experiment, respectively) at the 15 and 25% levels, which reached 9.60, 3.49, 10.92, and 3.27 dSm$^{-1}$ after the middle and end of the experiment, respectively. This may come due to the availability of additional quantities of water as a result of the repeated leaching stages added and the increase in soil moisture, which contributed to improving leaching (Rahman *et al*.,2020 ) and the movement of salts, in addition to the possibility of leaching sodium salts that would affect soil properties and reduce its permeability,which may contribute to the provision of nutrients to planting crops and thus increase Absorption of dissolved ions in the soil solution, which leads to a decrease in the electrical conductivity of the soil after the end of the growing season. Pierong *et al*. (2019) indicated that there is a positive correlation between the efficiency of salt leaching and the increase in the amount of leaching water. As for the high soil salinity after the middle of the experiment, it may be due to the high temperatures during the growing season, and thus the increased activity of the capillary feature and the high evapotranspiration (Hoshan, 2021).

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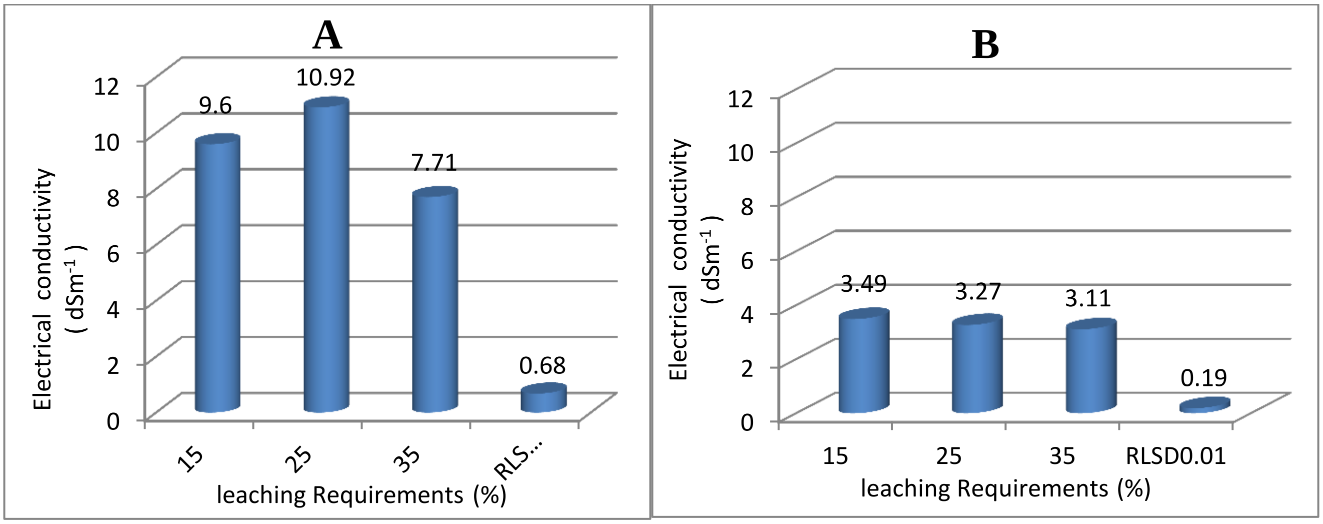


**Figure (2) The effect of soil leaching requirements on the electrical conductivity values of the soil solution after the middle (A) and the end (B) of the experiment ($dSm^{-1}$).**

The results also showed in Figure 3 that there was a high significant effect of the level of added sulfur on the electrical conductivity values of the soil solution after the middle and end of the experiment, as it is noted from Figure 3 that increasing the level of added mineral sulfur increased the rate of electrical conductivity of the soil during the experiment, which amounted to 6.19, 8.81 and 3.22 $dSm^{-1}$ for levels 0, 0.8 and 1.6%, respectively, after the middle of the experiment, while the electrical conductivity values of the soil solution decreased after the end of the experiment to become 2.58, 3.35 and 3.94 $dSm^{-1}$ for the above levels, respectively. The reason for the high salinity of the soil with the increase in the level of sulfur is that the addition of acid conditioners to the soil leads to the displacement of the exchanged ions from the exchange surfaces by hydrogen as a result of the formation of sulfuric acid as a result of the oxidation of sulfur, which dissolves some compounds and releases some of the exchanged ions into the soil solution, as well as what it adds. Sulfur from soil salinity (Heydarnezhad *et al*., 2012) and (Al-Motory, 2018).

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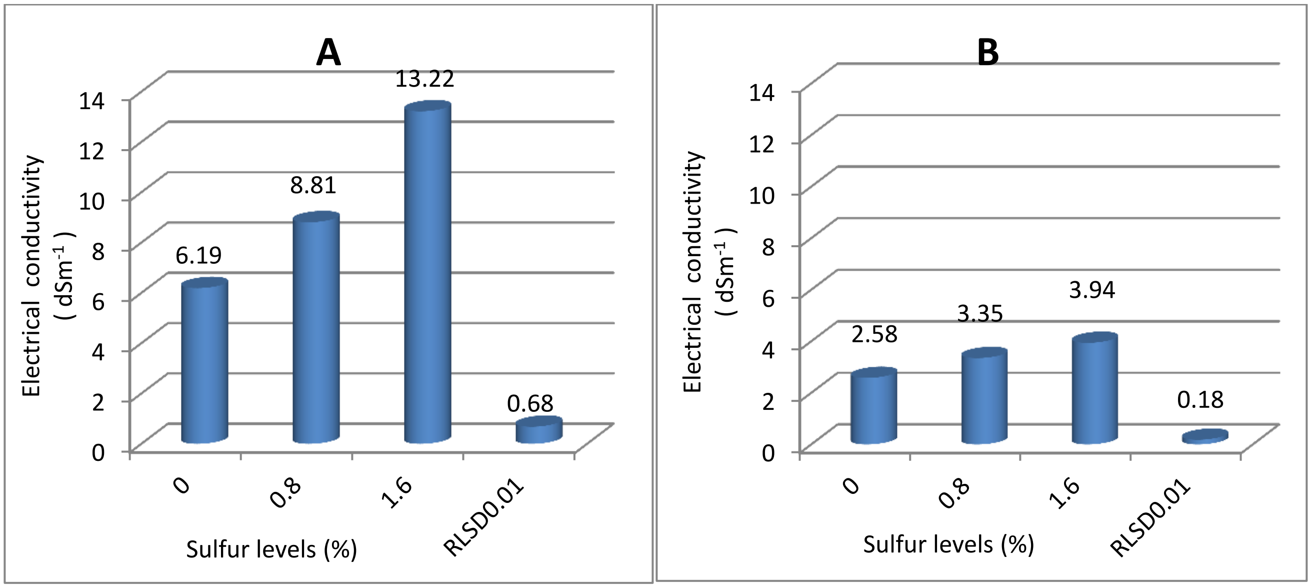


**Figure (3) the effect of the added sulfur level on the electrical conductivity values of the soil solution after the middle (A) and the end (B) of the experiment (dSm$^{-1}$).**

The results also showed in Figure 4 the high significant effect of irrigation water salinity on the values of the electrical conductivity of the soil solution after the middle and the end of the experiment, as it is noted from Figure 4 that increasing the salinity of the irrigation water increased the rate of electrical conductivity of the soil during the experiment, which amounted to 8.85 and 3.01 dSm$^{-1}$, 9.97 and 3.57 dSm$^{-1}$ at irrigation water salinity level 4 and 8 dSm$^{-1}$ after the middle and end of the planting experiment, respectively. As the irrigation water quality treatments 4 dSm$^{-1}$ were exceed in reducing the electrical conductivity values of the soil solution at the end of the planting experiment with a significant difference from the 8 dS m$^{-1}$ treatment. The reason for the Excellence quality of the leach water of good quality may be due to the process of dissolution, movement and displacement of the salts in the depth of the soil on which this treatment was carried out, and thus the increase in the capacity of cation exchange between the low-salinity irrigation water and the exchange surfaces due to the large variation in the concentration of dissolved ions in the solution and exchanged on the surface up to to a state of equilibrium (AL-Taie *et al*., 2021). The results of the experiment conducted by Attia *et al*. (2013) showed an increase in the salinity of the soil surface layer (0-60 cm) by 3.7 times when irrigating with water with an electrical conductivity of 4.2 dSm$^{-1}$, compared to the salinity of the soil irrigated with water with an electrical conductivity of 1.4 dSm$^{-1}$.

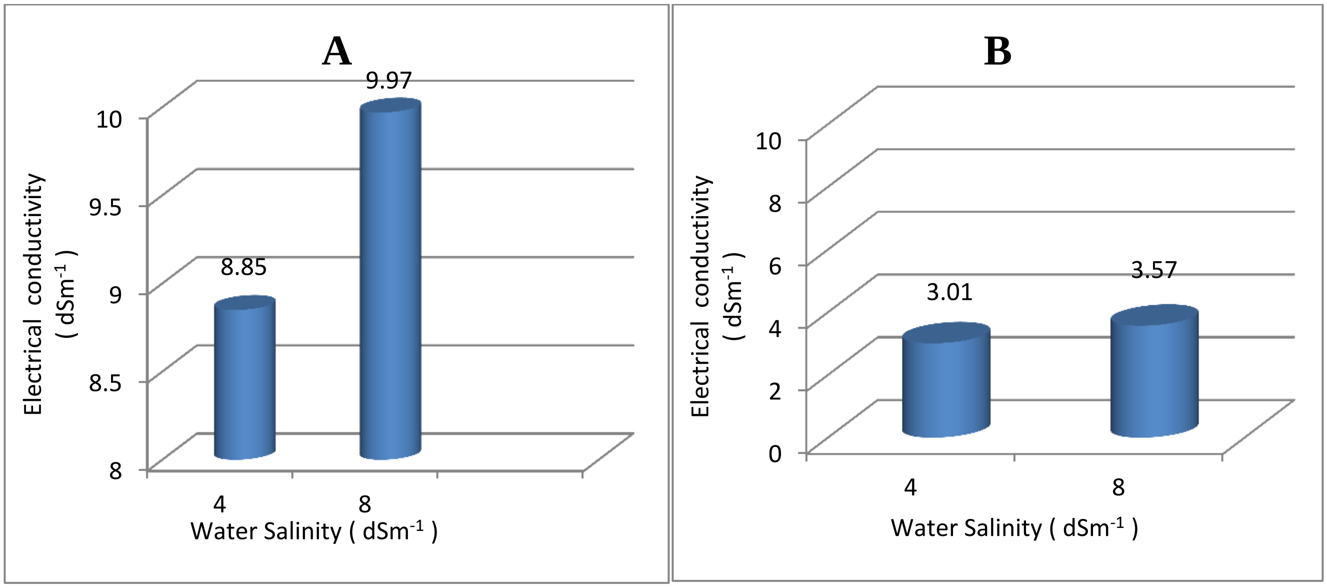


**Figure (4) The effect of irrigation water salinity on the electrical conductivity values of the soil solution after the middle (A) and the end (B) of the experiment ($dSm^{-1}$).**

Figure 5 shows the significant effect of the interaction between the leaching requirements and the type of the organic matter after the end of the experiment on the electrical conductivity values in the soil solution It is clear from the figure that there is a high significant superiority for the treatment of 35% leaching requirements and alfalfa residue in reducing the electrical conductivity of the studied soil (3.05 dS $m^{-1}$) compared to the rest of the treatments, while the highest values were noted for the treatment of 15% leaching requirements and cow residue ,which amounted to 3.62 dS $m^{-1}$. This indicates the possibility of increasing the efficiency of soil salinity reduction by using a larger amount of leaching water, which indicates the role of the amount of leach water requirements in reducing soil salinity (Chu *et al*., 2016). Hussein *et al*. (2010) showed that the addition of 40% leaching requirements led to a decrease in the salinity of the surface layer of the soil (0-30 cm) by 27%, compared to the 20% level of addition. The addition of organic residue (animal and plant) improves the physical and chemical properties of the soil and adjusts the nutritional balance in the soil, thus improving the ventilation conditions for soil microorganisms, thus increasing the biological activity and the availability of the necessary nutrients (Athari *et al*., 2021). Table 2shows that there is no significant effect of the interaction between leaching requirements and the quality of organic matter on the values of electrical conductivity in the soil solution after the middle of the agricultural experiment.

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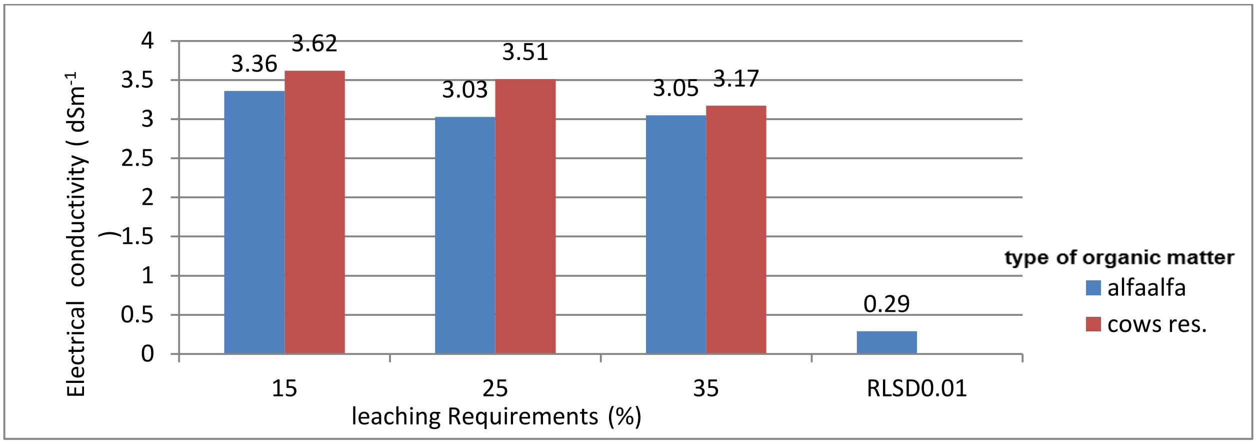


**Figure (5) The effect of the interaction between leaching requirements and the type of organic matter on the electrical conductivity values of the soil solution after the end of the experiment (dSm$^{-1}$).**

Figure 6 shows that there are high significant differences in the values of the electrical conductivity of the soil solution due to the effect of the interaction between the salinity of the irrigation water and the type of organic matter at the end of the experiment. Significantly, which amounted to 2.94 and 3.09 dSm$^{-1}$ for alfalfa and cow residues, respectively. The salinity of irrigation water was 8 dSm$^{-1}$, the highest values (3.35 and 3.78 dSm$^{-1}$ for alfalfa and cow residues, respectively). The reason for the salinity of the irrigation water exceeding 4 dSm$^{-1}$ is due to the low ability of the water to dissolve the largest amount of salts and displace them into the soil solution and thus increase the ion exchange, as well as the change in concentration between the salinity in the soil aggregates and the water flowing into the total pores when the electrical conductivity increases. The water used in leaching affects the process of removing salts from the soil, which indicates the effect of the quality of leaching water in reducing the electrical conductivity of soil affected by salinity, and thus increasing the efficiency of soil leaching ( Tagar *et al.*, 2007). It also indicates the ability of organic residues to reduce the electrical conductivity of the soil (Chitgupekar *et al.*, 2014), while no significant difference was observed in the values of the electrical conductivity of the soil solution due to the effect of the interaction between the irrigation water salinity and the type of organic matter after the middle of the experiment (Table 2).

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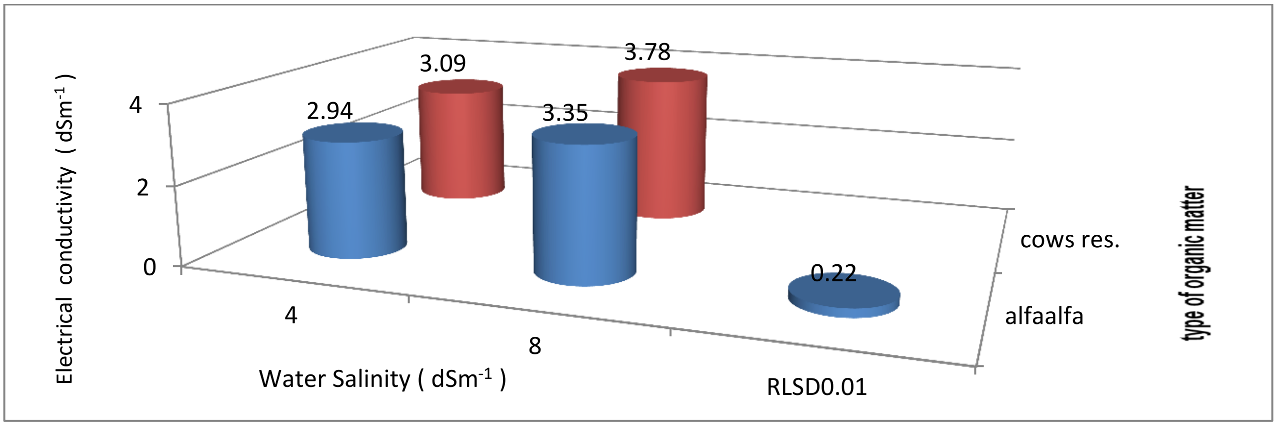


**Figure (6) The effect of the interaction between the salinity of the irrigation water and the type of organic matter on the electrical conductivity values of the soil solution after the end of the experiment (dSm$^{-1}$).**

**Table (2) The effect of the parameters on the electrical conductivity of the soil solution after the middle of the experiment (dSm$^{-1}$).**

| LR | EC-water | S % | Organic matter type | | Organic matter type * S % |
|---|---|---|---|---|---|
| | | | Alfaalfa | Cows | |
| 15 | 4 | **0** | 4.08 | 7.68 | 5.88 |
| | | **0.8** | 8.38 | 8.45 | 8.42 |
| | | **1.6** | 12.99 | 12.80 | 12.90 |
| | 8 | **0** | 4.91 | 8.11 | 6.51 |
| | | **0.8** | 8.74 | 9.65 | 9.20 |
| | | **1.6** | 14.46 | 14.89 | 14.68 |
| 25 | 4 | **0** | 5.64 | 7.85 | 6.75 |
| | | **0.8** | 8.97 | 10.40 | 9.69 |
| | | **1.6** | 15.17 | 15.43 | 15.30 |
| | 8 | **0** | 6.90 | 7.99 | 7.45 |
| | | **0.8** | 9.79 | 10.05 | 9.92 |
| | | **1.6** | 16.20 | 16.63 | 16.42 |
| 35 | 4 | **0** | 3.97 | 5.37 | 4.67 |
| | | **0.8** | 6.50 | 8.68 | 7.59 |
| | | **1.6** | 7.78 | 9.11 | 8.45 |
| | 8 | **0** | 4.45 | 7.35 | 5.90 |
| | | **0.8** | 7.74 | 8.39 | 8.07 |
| | | **1.6** | 10.62 | 12.60 | 11.61 |
| **LR * Organic matter type** | | **15** | 8.93 | 10.26 | |
| | | **25** | 10.45 | 11.39 | |
| | | **35** | 6.84 | 8.58 | |
| **EC-water * Organic matter type** | | **4** | 8.16 | 9.53 | |
| | | **8** | 9.31 | 10.63 | |

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| | | | | | |
|---|---|---|---|---|---|
| **Organic matter type * LR * S %** | 15 | **0** | 4.50 | 7.90 | |
| | | **0.8** | 8.56 | 9.05 | |
| | | **1.6** | 13.73 | 13.85 | |
| | 25 | **0** | 6.27 | 7.92 | |
| | | **0.8** | 9.38 | 10.23 | |
| | | **1.6** | 15.69 | 16.03 | |
| | 35 | **0** | 4.21 | 6.36 | |
| | | **0.8** | 7.12 | 8.54 | |
| | | **1.6** | 9.20 | 10.86 | |
| **Organic matter type * EC-water * S %** | 4 | **0** | 4.56 | 6.97 | |
| | | **0.8** | 7.95 | 9.18 | |
| | | **1.6** | 11.98 | 12.45 | |
| | 8 | **0** | 5.42 | 7.82 | |
| | | **0.8** | 8.76 | 9.36 | |
| | | **1.6** | 13.76 | 14.71 | |
| **S %** | **0** | | 4.99 | 7.39 | |
| | **0.8** | | 8.35 | 9.27 | |
| | **1.6** | | 12.87 | 13.58 | |

**Note: There are no significant differences between the coefficients within the table below the probability level of 0.01**

As for the effect of the interaction between the leaching requirements and the salinity of the irrigation water on the values of the electrical conductivity of the soil solution, it was high significant after the middle and the end of the experiment (Figure 7). The middle of the experiment, which recorded 6.90 and 8.53 $dSm^{-1}$ at irrigation water salinity of 4 and 8 $dSm^{-1}$ respectively, while irrigation water salinity of 4 $dSm^{-1}$ excelled in recording the lowest values after the end of the experiment, which amounted to 2.91 and 2.95 $dSm^{-1}$ for leaching requirements 25 and 35 % respectively, which did not notice any significant differences between them (Fig. 7). While the irrigation water salinity recorded 8 $dSm^{-1}$, the highest values after the middle and end of the experiment (11.26 and 3.79 $dSm^{-1}$ for leaching requirements of 25% and 15% after the middle and end of the experiment, respectively). These results agree with the general trend with a study conducted by Blanco and Foligatti (2002), which showed that the decrease in the electrical conductivity of the leached water has a clear effect on reducing the salinity of the leached soil, as it recorded an increase in the EC. For soil, it amounted to 26, 36, and 52% for the leaching water quality treatments of 1.54, 3.10, and 5.20 $dSm^{-1}$, respectively, at a rate of 0.64, 0.45, and 0.47 $dSm^{-1}$ for depths of 10, 30, and 50 cm, respectively, in addition to that the low salinity water has a role In preserving soil structure and increasing its ability to wash salts (Shabib, 2010 ).

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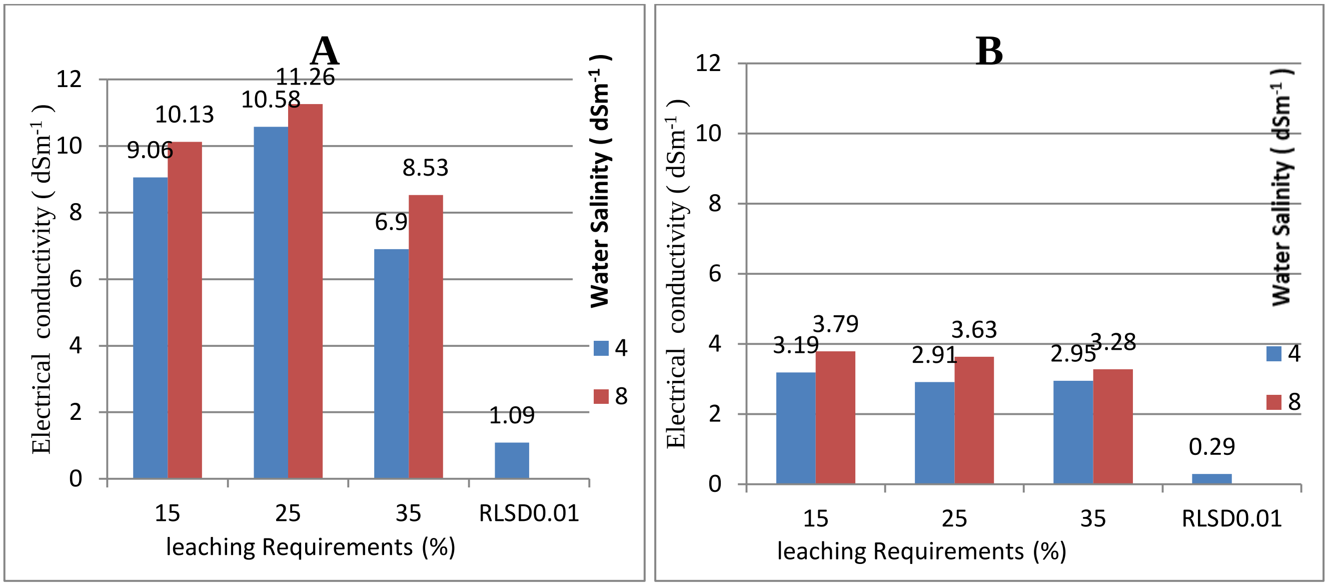


**Figure (7) The effect of the interaction between leaching requirements and irrigation water salinity on the electrical conductivity values of the soil solution after the middle (A) and the end (B) of the experiment ($dSm^{-1}$).**

It appears from Figure 8 that there is a high significant effect of the interaction between the leaching requirements and the percentage of sulfur added after the middle and the end of the experiment on the electrical conductivity values of the soil solution. mineral (no addition), which amounted to 5.29 and 2.45 $dSm^{-1}$ after the middle and end of the experiment in succession, which was significantly superior compared to the rest of the treatments, while the highest values (15.86 and 4.48 $dSm^{-1}$) were recorded for the treatments of the addition rate of 1.6% sulfur when leaching requirements 25% and 15% after the middle and end of the experiment, respectively (Fig. 8). This increase may be attributed to a number of factors, including an increase in the concentration of dissolved ions such as calcium, magnesium, sodium and potassium, in addition to an increase in the concentration of sulfates as a result of oxidation of sulfur, so that the final product is the union of sulfates with dissolved ions and the formation of some salts that contribute to increasing the electrical conductivity of the soil (Ibrahim *et al*., 2015).

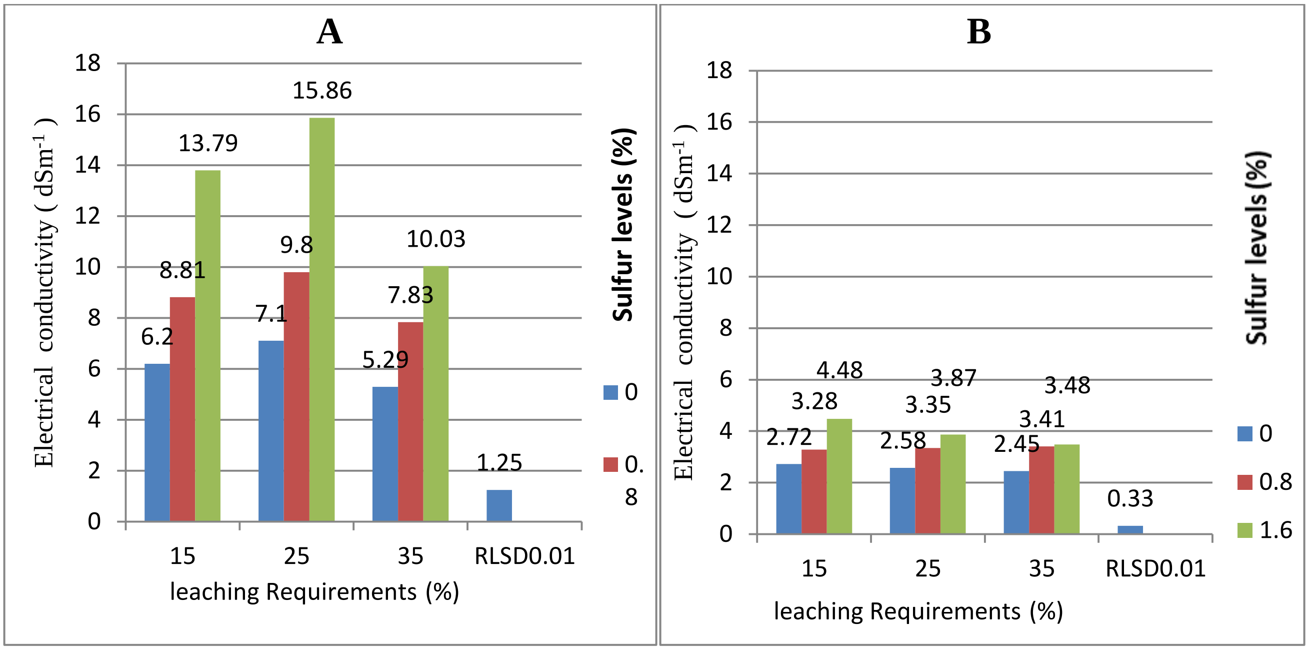


**Figure (8) The effect of the interaction between the leaching requirements and the percentage of added sulfur on the electrical conductivity values of the soil solution after the middle (A) and the end (B) of the experiment ($dSm^{-1}$).**

To demonstrate the effect of the interaction between the salinity of the irrigation water and the percentage of sulfur added after the middle of the experiment on the values of the electrical conductivity of the soil solution, it appears from Figure 9 that this interference is high significant, as it is noted that the coefficients of the percentage of addition 0% sulfur (no addition) recorded the lowest values (5.77 and 6.62 $dSm^{-1}$ for the two treatments of irrigation water salinity 4 and 8 $dSm^{-1}$ respectively) compared to the levels 0.8 and 1.6%, while the salinity of irrigation water 4 $dSm^{-1}$ excelled in recording the lowest values compared to the salinity of irrigation water 8 $dSm^{-1}$, and this is due to the effect of quantities the large amount of added sulfur and high salinity irrigation water increases soil salinity, and the irrigation water exceeds 4 $dSm^{-1}$ due to its suitability in reducing soil salinity and preserving soil structure. It appears from Table 3 that there is no significant effect of the interaction between the irrigation water salinity and the added sulfur percentage after the end of the experiment on the electrical conductivity values of the soil solution.

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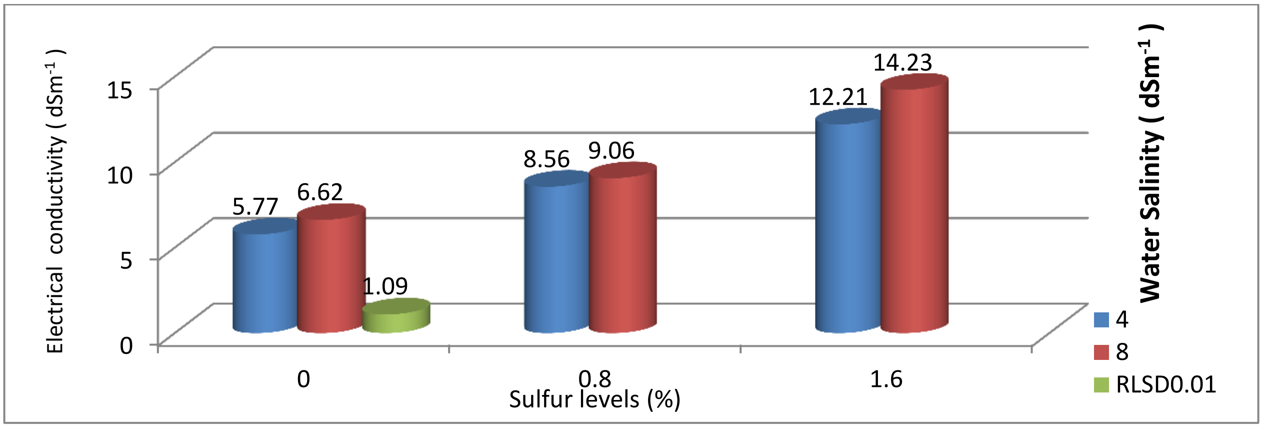


**Figure (9) The effect of the interaction between the salinity of the irrigation water and the level of added sulfur on the electrical conductivity values of the soil solution after the middle of the experiment ($dSm^{-1}$).**

**Table (3) The effect of the parameters on the electrical conductivity of the soil solution after the end of the experiment ($dSm^{-1}$).**

| LR | EC-water | S % | Organic matter type | | Organic matter type * S % |
|---|---|---|---|---|---|
| | | | Alfaalfa | Cows | |
| 15 | 4 | **0** | 2.63 | 2.68 | 2.66 |
| | | **0.8** | 3.01 | 3.13 | 3.07 |
| | | **1.6** | 3.62 | 4.07 | 3.85 |
| | 8 | **0** | 2.83 | 2.73 | 2.78 |
| | | **0.8** | 3.11 | 3.87 | 3.49 |
| | | **1.6** | 4.96 | 5.25 | 5.11 |
| 25 | 4 | **0** | 2.22 | 2.54 | 2.38 |
| | | **0.8** | 3.00 | 3.11 | 3.06 |
| | | **1.6** | 3.25 | 3.31 | 3.28 |
| | 8 | **0** | 2.45 | 3.11 | 2.78 |
| | | **0.8** | 3.28 | 4.02 | 3.65 |
| | | **1.6** | 3.97 | 4.95 | 4.46 |
| 35 | 4 | **0** | 2.21 | 2.27 | 2.24 |
| | | **0.8** | 3.13 | 3.2 | 3.17 |
| | | **1.6** | 3.38 | 3.48 | 3.43 |
| | 8 | **0** | 2.71 | 2.59 | 2.65 |
| | | **0.8** | 3.35 | 3.95 | 3.65 |
| | | **1.6** | 3.51 | 3.54 | 3.53 |
| **Organic matter type * LR * EC-water** | **15** | **4** | 3.09 | 3.29 | |
| | | **8** | 3.63 | 3.95 | |
| | **25** | **4** | 2.82 | 2.99 | |
| | | **8** | 3.23 | 4.03 | |
| | | **4** | 2.91 | 2.98 | |

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| | | | | | |
|---|---|---|---|---|---|
| | **35** | **8** | 3.19 | 3.36 | |
| **Organic matter type * LR * S %** | **15** | **0** | 2.73 | 2.71 | |
| | | **0.8** | 3.06 | 3.50 | |
| | | **1.6** | 4.29 | 4.66 | |
| | **25** | **0** | 2.34 | 2.83 | |
| | | **0.8** | 3.14 | 3.57 | |
| | | **1.6** | 3.61 | 4.13 | |
| | **35** | **0** | 2.46 | 2.43 | |
| | | **0.8** | 3.24 | 3.58 | |
| | | **1.6** | 3.45 | 3.51 | |
| | | | | | **EC-water * S %** |
| **Organic matter type * EC-water * S %** | 4 | **0** | 2.35 | 2.50 | 2.43 |
| | | **0.8** | 3.05 | 3.15 | 3.10 |
| | | **1.6** | 3.42 | 3.62 | 3.52 |
| | 8 | **0** | 2.66 | 2.81 | 2.74 |
| | | **0.8** | 3.25 | 3.95 | 3.60 |
| | | **1.6** | 4.15 | 4.58 | 4.36 |
| **S %** | **0** | | 2.51 | 2.65 | |
| | **0.8** | | 3.15 | 3.55 | |
| | **1.6** | | 3.78 | 4.10 | |

**Note: There are no significant differences between the coefficients within the table below the probability level of 0.01**

To demonstrate the effect of the triple interaction between the type of organic matter, leaching requirements, and irrigation water salinity on the electrical conductivity values of the soil solution after the middle of the experiment, Figure 10 shows a high significant superiority of 35% leaching requirements of 4 $dSm^{-1}$ irrigation water quality in recording the lowest electrical conductivity values of the soil solution(6.08 and 7.72 $dSm^{-1}$ for alfalfa and cow residues, respectively), which significantly outperformed the rest of the treatments, while the highest values were recorded (10.96 and 11.56 $dSm^{-1}$ for alfalfa and cow residues, respectively) for the treatment of 25% leaching requirements with an irrigation water salinity of 8 $dSm^{-1}$. Which may be due to the effect of high quantities of water and the high quality of irrigation water with high electrical conductivity on the increase in the apparent density of the soil with the increase in the salinity of the leaching water, as well as the close of some pores as a result of successive irrigation, which led to asevere decrease in the water conductivity of the soil (Hoshan, 2021). It appears from Table 3 that there is no significant effect of the triple interaction between organic matter type, leaching requirements and irrigation water salinity on the electrical conductivity values of the soil solution after the end of the experiment.

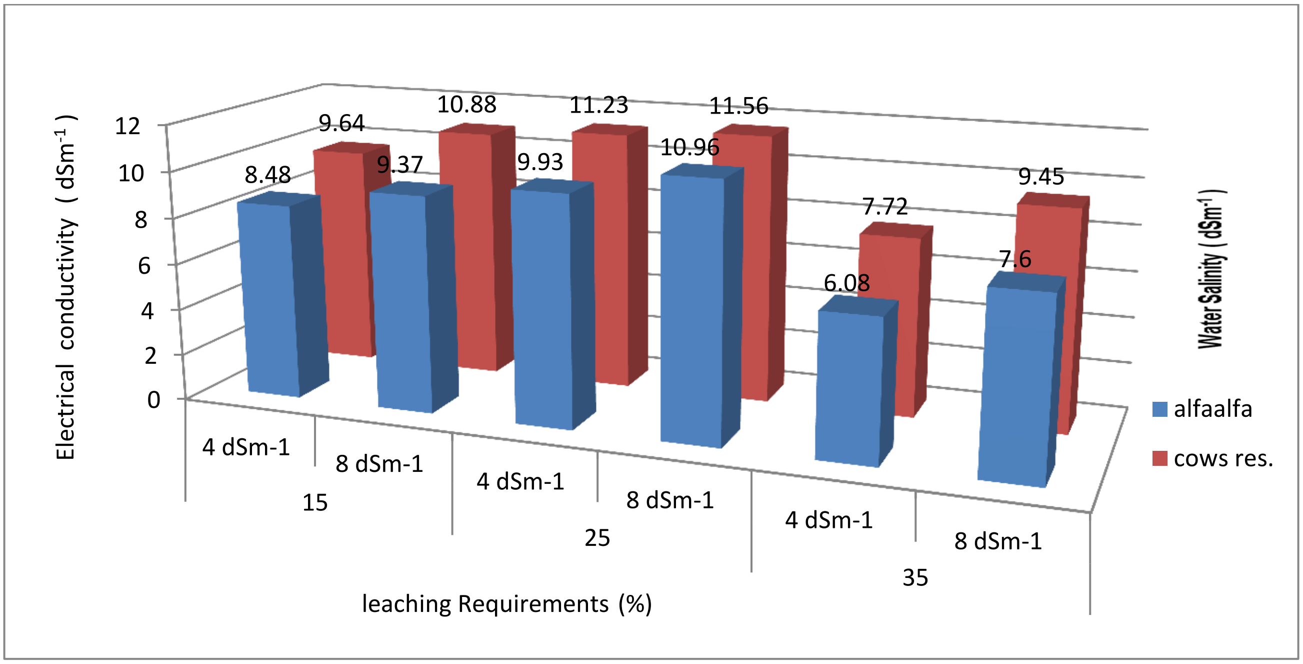


**Figure (10) The effect of the interaction between the type of organic matter, leaching requirements, and irrigation water salinity on the electrical conductivity values of the soil solution after the middle of the experiment ($dSm^{-1}$).**

The results in Tables 2 and 3 show that there is no significant effect due to the interaction between (type of organic matter and leaching requirements after the middle of the experiment) and (type of organic matter and sulfur added after the middle and end of the experiment) and (type of organic matter and salinity of irrigation water after the middle of the experiment) and ( Irrigation water salinity and sulfur added after the end of the experiment) and the triple interaction between (type of organic matter, leaching requirements, and sulfur added after the middle of the experiment) and (type of organic matter, leaching requirements, and irrigation water salinity after the end of the experiment) and (type of organic matter, irrigation water salinity, and sulfur added after the middle and end of the experiment) and (type of organic matter, leaching requirements and sulfur added after the end of the experiment) and (leaching requirements, irrigation water salinity and sulfur added after the middle and end of the experiment) and (type of organic matter, leaching requirements and irrigation water salinity after the middle and end of the experiment) and the interaction between the type of organic matter, leaching requirements, irrigation water salinity, and sulfur added after the middle and end of the experiment in the electrical conductivity values of the soil solution.

## IV. CONCLUSIONS

The results showed the ability of the alfalfa residues and the percentage of added sulfur 1.6 % and the leaching requirements of 35% with an irrigation water quality of 4 $dSm^{-1}$ in reducing the electrical conductivity of the soil solution and improving the soil properties and plant growth conditions in the study soil.

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# تاثير التداخل لمتطلبات الغسل وملوحة ماء الري ومستويات الكبريت المضاف ونوع المادة العضوية على ملوحة التربة المزروعة بنبات الذرة الصفراء

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**الخلاصة**

نفذت تجربة باستخدام السنادين في الظلة الخشبية التابعة الى محطة البحوث الزراعية / كلية الزراعة / جامعة البصرة / موقع كرمة علي خلال العام 2202 م ، لدراسة تاثير اضافة الكبريت المعدني والمادة العضوية ومتطلبات الغسل وملوحة ماء الري على ملوحة التربة المزروعة بنبات الذرة الصفراء. بأستخدام نوعين من المخلفات العضوية ( مخلفات الابقار والجت ) وبثلاثة مستويات من الكبريت المعدني المضاف (0 % و 0.8 % و 1.6 % ) وثلاثة مستويات من متطلبات الغسل ( 15 و 25 و 35 %) زيادة عن السعة الحقلية ومستوين من ملوحة ماء الري( 4 و 8 $dS\ m^{-1}$ )، حيث اضيفت المخلفات العضوية والكبريت المعدني خلطاً مع الطبقة السطحية لتربة الدراسة وحضنت لمدة 60 يوم قبل زراعة نبات الذرة الصفراء (*Zea mays* L.) مع المحافظة على رطوبة التربة عند السعة الحقلية. بعد عملية حضن التربة مع الكبريت المعدني والمادة العضوية في السنادين تمت زراعة بذور الذرة الصفراء مع اجراء عمليات خدمة المحصول من عمليات تسميد وري وحسب المعاملات اعلاه، وبعد 60 يوم من الزراعة تم حش النباتات لتقدير ملوحة التربة ،حيث تم قياس الايصالية الكهربائية لراشح التربة بعد منتصف ونهاية التجربة. اظهرت نتائج الدراسة ان اضافة المخلفات العضوية ادى الى خفض الايصالية الكهربائية للتربة في نهاية التجربة من 6.11 $dS\ m^{-1}$ الى 3.05 و3.17 $dS\ m^{-1}$ لمخلفات الجت والابقار على التتابع، وكان الانخفاض اكثر وضوحا " في نبات الجت، كما تفوق مستوى متطلبات الغسل 35% في خفض الايصالية الكهربائية للتربة قياسا بالمستويين الاخرين ليبلغ 3.16 $dS\ m^{-1}$، كذلك تفوقت وملوحة ماء ري 4 $ds\ m^{-1}$ في خفض الايصالية الكهربائية للتربة المدروسة لتصل الى 3.01 $dS\ m^{-1}$ ،بينما زادت قيمة الايصالية الكهربائية للتربة مع زيادة نسبة اضافة الكبريت المعدني لتصل الى 2.58 و 4.35 و 3.94 $dS\ m^{-1}$ للمستويات 0 و 0.8 و 1.6% على التتابع.

**الكلمات المفتاحية : مخلفات عضوية ، متطلبات غسل ، كبريت معدني ، ملوحة ماء الري.**