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EFFECT OF IRRIGATION WATER AND ORGANIC FERTILIZATION ON SALINITY LEVEL, SOIL SALT ACCUMULATION AND THE GROWTH OF *SORGHUM BICOLOR* L.

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Abstract

A pot experiment was conducted in the plastic house of the Department of Soil Science and Water Resources - College of Agriculture - University of Baghdad for the autumn season 2018 in a silty clay loam soil texture, to study the effect of irrigation water salinity and the addition of different types of organic residues in the accumulation of salts in the soil and the growth of *Sorghum bicolor* L. cultivar Inkath, according to the Randomized Complete Design (CRD) with three replicates. The experiment included two factors, the first factor was three levels of irrigation water salinity (0.75, 4.0 and 8.0) ds.m^{-1} symbolized as (W_1, W_2, W_3) respectively, and the second factor included the addition of f non-decomposed organic residues (without addition (control), sheep manure, corn cobs, and palm leaves) symbolized as (M_0, M_1, M_2, M_3) respectively, at the level of 25 ton.h^{-1} for all treatments. The pot was packed with 20 kg of dry soil in each pot, where chemical fertilizers were added at one level for all treatments according to the special fertilizer recommendation for *Sorghum bicolor* L. cultivation, and the plants were harvested after 60 days of germination. Soil salinity, the degree of soil reaction (pH) and some growth indicators, such as plant height, total area of leaves, and dry weight of vegetative growth were measured. The results showed that: - Increased levels of irrigation water salinity resulted in significant increase in the electrical conductivity values of soil, where the largest was W_3 treatment. Which were positively correlated with increased salt levels added, there was also a significant increase in the values of the degree of soil reaction when adding a salty levels, while the organic additives contributed to increase the values of the soil electrical conductivity and a significant decrease in the degree values of soil reaction and for all treatments. The increasing levels of salinity for irrigation water also led to a significant decrease in the growth of *Sorghum bicolor* L. and the use of all organic residues has reduced the negative impact on plant growth. Corn cobs residues were significantly superior followed by sheep manure and palm leaves in increasing the mean of vegetative growth indicators, and the interaction treatment gave (corn cobs residues and irrigation with tap water) the highest means in plant height, leaf area, dry weight of the vegetative growth traits, reached 107.3 cm, 3236 cm^2, 180 g.plant^{-1}, respectively.

Key words: Salinity, Irrigation, Organic Fertilization

Introduction

Water is one of the important natural resources in human, animal and plant life, as a result of civilization and industrial progress, in addition to the expansion of farming production caused an increasing in the demand of fresh water, which has led to the use of alternative water resources in farming to compensate for freshwater shortages, including the use of saline water, that should be accompanied by good soil, water and crop management (Hassan, 2002). The use of saline water for irrigation have negative effects on the chemical, physical and biological characteristics of the soil, where the most soil characteristics that affected by the quality of irrigation water and the faster changing are the chemical characteristics of the soil, electrical conductivity, the degree of soil reaction, and the sodium adsorption ratio (Hartman, 2002). The addition of organic material to the soil, whether plant or animal residues, plays an important role in improving the chemical properties of the soil, including the availability of nutrients in the soil solution and reduces its adsorption, because of it reduces the degree of soil reaction (pH) in the root zone, through the releasing of hydrogen ion and organic acids. This effect on the minerals solubility and increase of nutrient availability, as well as their ability to holding ions by humus colloids due to its high surface area (Hartman, 2002). The use of organic fertilizers is better than chemical fertilizers, which pollute agricultural crops and are a source of many nutrients (Yung-Hong, 2010; Ali *et al.*, 2014). *Sorghum bicolor* L. was a grain, feed, industrial crop, recently it has become more interested in being a crop characterized by its ability to withstand droughts, high temperatures, soil salinity, and ranked the third among the crops grown in the United States of America and fifth in the world (FAO, 2010). Therefore, this research aims to study the use of different types of organic residues to reduce the harmful effect of saline water irrigation on the growth of *Sorghum bicolor* L.

Materials and methods

A pots experiment was conducted in the autumn season of 2018 at the College of Agriculture - University of Baghdad in a silty clay loam soil texture, where the soil samples were taken from the depth of 0-30 cm representing of the field soil, the mixed well, air- dried and passed from a sieve with 2 mm diameter, then mixed and composite sample was taken for some chemical and physical analyzes as shown in Table 1. The experiment was designed according to Randomized Completely Design (CRD) with three replicates, and included two factors, the first factor was a different levels of irrigation water salinity (0.75, 4.0 and 8.0) ds.m^{-1} symbolized as (W_1, W_2, W_3), respectively. The salinity levels of (4.0, 8.0) ds.m^{-1} were obtained as a result of adding a synthetic salt from Calcium Chloride $CaCl_2$, Magnesium Chloride $MgCl_2$, and Sodium Chloride NaCl with a concentration of (2 : 1 : 1), respectively, as shown in Table 2 that describe the chemical properties of the irrigation water used in the experiment. The second factor was the organic residues (without addition, sheep manure, corn cobs, palm leaves) and symbolized as (M_0, M_1, M_2, M_3) respectively, where the non-decomposed organic residues were obtained from a sheep field in Diyala governorate and the corn cobs, palm leaves from the organic farming in Abu Ghraib. The organic residues (sheep manure, corn cobs residue, and palm leaves residue) has been initialized for addition after air drying, then crushed with a mill and passed through a 0.4 cm diameter sieve, then added to the soil based on dry weight at a level of 25 tons .h^{-1} for all treatments. Furthermore, Table 3 shows some of the chemical properties of the organic residues used in the experiment, thus, the number of experimental treatments was 12 and 36 experimental units. The Soil was taken from the above-mentioned site, then air -dried, crushed and passed through a 4mm diameter sieve and placed in plastic pots of 25 kg with a diameter of 37 cm and a height of 38 cm, filter paper and gravel were placed at the bottom of the pot and filled with soil at a rate of 20 kg / pot. Sorghum bicolor L. Seeds cultivar Inkath class were planted of seven seeds per pot on 9/9/2018, and were reduced after 12 days of germination to three plants and all treatments. Phosphate fertilizer in the form of Di-Ammonium phosphate (DAP) (20% P) was added as a source of phosphorus with a rate of 87 kg P.h^{-1}, and the potassium fertilizer was added in the form of Potassium Sulfate (41.5% k) at 100 kg K.h^{-1}, then mixed with soil during the preparing of soil for planting, in one application. As well as, urea fertilizer (46% N) was added at a rate of 400 kg N. h^{-1} for the purpose of completing the fertilizer recommendation of nitrogen on two applications, the first one after planting and the second 30 days after the first application (Ministry of Agriculture, 2006). The pots were irrigated when 50% of the available water was lost using the weighting method with tap water at the beginning of the experiment until the height of the plants reached 10 cm and then irrigation with water resulting from the saline treatments above. These included manual weeding to control the weeds, and control the *Sesamia cretica* using granulated Diazinon pesticide GR 10%, and aphis uses Acetamiprid 20%. Finally, Plants were harvested after 65 days of planting and soil samples were taken for the purpose of measuring the electrical conductivity, the degree of soil reaction, and taking plant-specific measurements such as plant height, dry weight, and total leaf area of the plant that were calculated according to the following equation: total leaf area = length of the fourth

Table 1: Some physical and chemical properties of study soil before planting.

Volume moisture content at soil shear of 1500 Kpa			**Volume moisture content at soil shear of 33 KPa**			**Texture**			**Soil particle size analysis gKg^{-1} soil**					
cm^3 cm^{-3}									**Clay**		**Loam**		**Salt**	
0.12			0.23			Silty Clay Loam			282		544		174	
Cl	SO_4	HCO_3	K	Na	Mg	Ca	K	P	N	Lime	O.M.	CEC	pH	EC
Cation and anions soluble icons mmol.L^{-1}							Available NPK mg kg^{-1} soil			Available NPK mg. kg^{-1} soil		C Mol_c. Kg^{-1} soil		dSm^{-1}
12.94	1.48	2.33	0.66	1.95	2.45	5.12	0.28	15.5	28.11	229.7	6.9	23.41	7.7	1.87

Table 2: Some chemical properties of water used in the experiment.

Class	SAR	mmol/l							pH	EC	Water
		HCO^{-3}	$SO4^{-2}$	Cl^{-}	Mg^{+2}	Ca^{+2}	K^{+}	Na^{+}		dSm^{-1}	type
$C_2 S_1$	1.15	1.61	0.80	3.64	0.86	1.74	0.04	1.85	7.61	0.75	W1
$C_4 S_1$	3.00	1.82	1.22	34.21	5.48	8.32	0.04	11.14	7.55	4.00	W2
$C_6 S_1$	3.91	1.95	1.45	72.58	12.45	16.33	0.04	20.92	7.78	8.00	W3

Table 3: The characteristics of the organic residues used in the experiment.

Nutrient %			C/N	Organic	pH	EC	Residues
K	P	N		carbon		dSm^{-1}	types
0.61	0.55	1.50	55.48	83.23	6.91	5.00	sheep manure
0.81	0.06	0.52	158.50	80.85	6.90	1.50	corn cobs
0.72	0.22	0.51	153.28	79.71	7.00	7.00	palm leaves

Dilution* 1 : 5 Electrical conductivity of soil in extract 1 : 1 (soil : water).

leaf * maximum width * 6.18 (Al- Sahoki and Saddam, 2015). The three plants in each experimental unit were washed with water, then with distilled water to remove the suspended material, then cut and dried in the oven at a temperature of 65°C until the weight was constant, and recorded their dry weight and the rate was obtained. The results were analyzed statistically by analysis of variance method and the means was compared using Least Significant Difference (L.S.D) at a probability level of 0.05.

Results and Discussion

Table 4 shows the effect of salinity levels of irrigation water and organic residues on soil electrical conductivity, where the results showed that irrigation water levels had a significant effect on soil salinity. The irrigation treatment W_3 gave the highest electrical conductivity value amounted 7.83 ds.m^{-1} compared with treatments W_1 and W_2 level, which reached to 3.07 and 4.78 ds.m^{-1}, respectively. As well as a significant difference between W_1 and W_2, where W_2 level was 46.83% higher than W1 level, this may be due to the high salinity of irrigation water of W_3 level compared to other levels as shown in Table 2. This result was consistent with a number of researchers (Mam Rasul 2000; Maamory, 2004; Ragab *et al.*, 2008). Which they noted that the soil salinity had increased by increasing the salinity of irrigation water by raising the concentration of cation and anions soluble ions in irrigation water and thus an increase in the electrical conductivity of the soil. While the effect of adding organic residues in the electrical conduction of soil was a significant effect on increasing the electrical conductivity values, where M_3 treatment gave the highest electrical conduction value of the soil by 5.53 ds.m^{-1}, and an increase of 11.71, 4.14 and 8.43% compared with M_0, M_1, M_2 respectively. This result resulted from decomposition of organic residues results in an abundance of organic and non-organic acids, which are dissolved salts of humate and sodium, deposited salts of calcium and magnesium humate. On the other hand, the addition of organic material increases the electrical conductivity values depending on its quality and source because it contains salts as shown in Table 3 (Al-Sahaf and Aati, 2007). The interaction results of the same Table showed a significant effect on the increase of electrical conductivity, where the interaction treatment W_3 M_3 gave the highest value of 8.12 ds.m^{-1} compared with the interaction treatment W_1 M_0, which gave the lowest value of 2.75 ds.m^{-1}.

Degree of soil reaction (pH) -2

A significant effect of irrigation water quality on the degree of soil reaction values was observed as shown in Table 5, where increasing the electrical conductivity values of used irrigation water from 0.75 to 4.00 and 8.00 ds.m^{-1} has led to reduce the mean soil reaction values from 7.63 to 7.60 and 7.57, respectively. The decrease in soil reaction values with increased the salinity of irrigation water was due to the accumulation of sulfate and chloride salts of Calcium, Magnesium, and Sodium, which are neutral salts that cause the soil reaction to decrease toward equivalence (Al- Zubaidi, 1989). These results were agreed with (Al-Obaidi 2015) findings, while for the effect of organic residues, there were minor significant differences in the reduction of soil reaction values. However, it is noted that palm leaves residues had a clear effect on this trait at a rate of 7.54 compared with the control treatment which gave 7.63. While the sheep manure and corn cobs gave an a mean of 7.59 and 7.62, respectively, and the addition of organic residues has

Table 4: Effect of irrigation water salinity and type of Organic residues on electrical conductivity (ds. m^{-1}) for soil after planting.

Organic residues	Levels of irrigation water Salinity (ds.m^{-1})			
	W1	W2	W3	Mean
M_0	2.75	4.53	7.58	4.95
M_1	3.19	4.88	7.87	5.31
M_2	2.86	4.68	7.75	5.10
M_3	3.46	5.01	8.12	5.53
Mean	3.07	4.78	7.83	
$L.S.D._{0.05}$	W*M = 0.16 M = 0.09 W = 0.08			

reduced soil reaction due to the release of organic and non-organic acids and the decomposition of amino acids resulting from these residues, then giving ions, NO_2^-, NO_3^-, and release H^+ ions, which is involved in reducing the degree of soil reaction and this result is consistent with the (Al- Jubouri *et al.*, 2002; Abdul *et al.*, 2012) findings. While the effect of interaction between the quality of irrigation water and organic residues on the degree of soil reaction had a significant effect between the treatments where the interaction treatment W_1 M0 gave the highest value of 7.65 compared with the interaction treatment W_3 M_3 which gave the lowest value reached 7.52 and a decrease percentage of 1.7%.

Table 5: Effect of irrigation water salinity and the type of organic residues on soil reaction values.

Organic residues	Levels of irrigation water Salinity ($ds.m^{-1}$)			
	W1	W2	W3	Mean
M_0	7.65	7.63	7.61	7.63
M_1	7.62	7.59	7.56	7.59
M_2	7.66	7.62	7.58	7.62
M_3	7.57	7.54	7.52	7.54
Mean	7.63	7.60	7.57	
L.S.D.$_{0.05}$	W*M = 0.047 M = 0.018 W = 0.016			

Some indicators of plant growth

1- Plant height (cm)

The results of statistical analysis that listed in Table 6 showed that there were significant differences in the salinity levels of irrigation water on the plant height, where the height of the plant decreased significantly when the salinity levels of irrigation water increased from 101.53 cm at level W_1 to 83.06 and 63.13 cm for W_2 and W_3 levels, with a decrease percentage of 18.19 and 37.82%, respectively. As well as, there was a significant difference between the levels W_2 and W_3 with a decrease percentage of 23.99%, the decrease in plant height was due to the role of increasing the irrigation water salinity in raising soil salinity as shown in Table 2. This has a negative effect on plant growth through the effect of osmotic and toxic pressure and nutritional imbalance of nutrients, which caused a lack of water absorption and nutrients, and weakness, then plant growth is which is consistent with what (Al- Jawdhira 2006; Gandahi *et al.*, 2009) findings. While the effect of organic residues on the plant height of *Sorghum bicolor* L. has been found to have a significant effect in this trait, where M_2 treatment gave the best rate of this trait reached to 88.1 cm compared to M_0, M_1 and M_3 and an increase percentage of 13.9, 4.6 and 6.7% respectively. This was due to the role of organic residues and its organic acids in increasing the permeability of cellular membranes and the movement of elements inside the plant, which contributes to the increase in the size, expansion and division of cells, which is positively reflected in the vegetative growth indicators of the plant (Wample *et al.*, 1991; Assi *et al.*, 2018). The results of the interaction of the same Table showed a significant effect on increasing the average plant height, as the interaction treatment corn cobs residues and irrigation with tap water W_1 M_2 has given the highest value reached 107.3cm, while the comparison treatment (without any addition) and irrigation with a saline water (8.00 $ds.m^{-1}$) W_3 M_0 has been given

Table 6: Effect of irrigation water salinity and the type of organic resides on average plant height (cm).

Organic residues	Levels of irrigation water Salinity ($ds.m^{-1}$)			
	W1	W2	W3	Mean
M_0	90.8	79.23	57.50	75.84
M_1	104.8	84.20	62.90	83.97
M_2	107.3	85.00	72.10	88.10
M_3	1.3.2	83.80	60.00	82.33
Mean	101.53	83.06	63.13	
L.S.D.$_{0.05}$	W*M = 7.3 M = 4.2 W = 3.6			

the lowest value of 57.5cm with an increase percentage of 86.61%.

2- Total leaves area (cm^2)

Table 7 indicates that there was a significant difference between the mean values of the leaves area trait of *Sorghum bicolor* L. for the salinity levels of irrigation water treatments. Study results show that the W_1 treatment gave the highest average leaf area reached to 2927 cm^2, while the W_3 treatment gave the lowest average leaf area of 2376 cm^2, the decrease percentage in this trait was 9.15 and 18.82% for W_2 and W_3 treatments, respectively, compared with treatment W_1. This was due to the negative effect of salinity on plant growth and this result was consistent with (Munns and Tester, 2008), while the addition of organic residues had a significant effect on this trait, where M_2 treatment gave the highest average of 2906 cm^2, compared with M_0, M_1, and M_3 treatments with the increase of 21.43, 8.83 and 9.78%, respectively, while there was no significant difference between the treatment of M_1 and M_3. The increase in the total leaf area was due to the addition of organic residues and its role in processing nutrients or dissolving some compounds carrying nutrients after decomposition in the soil by microorganisms that can be absorbed by the plant, these results are consistent with the results of (Al- Arkouzi, 2000; Mohammed, 2013). The interaction results of the same Table showed a significant effect of increasing the average total leaves area of the plant, as the interaction treatment W_1 M_2 gave the highest value of 3236 cm^2, while the interaction

Table 7: Effect of irrigation water salinity and the type of organic residues on average plant height (cm).

Organic residues	Levels of irrigation water Salinity (ds.m^{-1})			
	W1	W2	W3	Mean
M0	2628	2410	2142	2393
M1	2928	2709	2372	2670
M2	3236	2830	2652	2906
M3	2915	2688	2337	2647
Mean	2927	2659	2376	
L.S.D.$_{0.05}$	W*M = 84.66 M = 48.88 W = 42.33			

treatment of W_3 M_0 gave the lowest value of 2142 cm^2 with an increase percentage of 51.07%.

3- Dry weight of the vegetative growth

Table 8 there was a significant decrease in dry weight with increasing salinity levels of irrigation water, reaching to 147 and 126 gm.plant^{-1} for irrigation water salinity levels W_3, W_2, respectively, with a decreasing rate of 10.36% and 23.17% compared to the comparison treatment that recorded 164 g.plant^{-1}, and there were also a significant differences between the two levels, W_2 and W_3, and the W_3 level was 14.28% lower than W_2 as shown in Table 8. The decrease in dry weight by increasing the irrigation water salinity may be attributed to the accumulation of some ions inside the plant such as sodium and chloride to the limits of toxicity and thus lead to poor meristematic tissue activity and inhibit cellular division and cell elongation causing a weakness in vegetative growth and these results are consistent with (Al-Mamori, 2004, Radi 2014) findings. It was noted from the same Table, that the addition of organic residues had a significant effect on increasing dry weight of the plant, where the treatment of M_2 was given the highest average of 161 g. plant^{-1}, compared to M_0, M_1, M_3, with an increase of 26.77, 7.33 and 11.80%, respectively. There were no significant differences between the treatment M_1 and M_2, this was what Table 3 illustrates as the electric conductivity of the corn cobs was 1.5 ds.m^{-1} compared to other organic residues. The increase in dry weight of the vegetative growth when adding organic residues may be due to the positive effect as it contributes to improve soil fertility through its release of nutrients, such as nitrogen, phosphorus and potassium, then absorbed by the plant when decomposed by microorganisms and also be called humus and organic acids that contain a high proportion of the nitrogen element, which works to increase stored carbohydrates , proteins and building new cells and composition the cellular membranes this has led to increases the vegetable growth and leaves area then increases the dry weight of the plant (Odeh, 2007; Al-Fadhli, 2011; Abdulkarim; Al- Delphi, 2017). The below

Table 8: Effect of irrigation water salinity and the type of organic resides on Dry weight of the vegetative growth (gm.plant^{-1}).

Organic residues	Levels of irrigation water Salinity (ds.m^{-1})			
	W1	W2	W3	Mean
M0	148	125	109	127
M1	166	149	134	150
M2	180	166	138	161
M3	160	147	124	144
Mean	164	147	126	
L.S.D.$_{0.05}$	W*M = 23.02 M = 13.29 W = 11.51			

Table indicated that the interaction treatments of the factors under study had a significant effect on the dry weight values of the plant, as the interaction treatment W_1 M_2 gave the highest value of 180g. plant$^{-1,}$ and the lowest value of W_3 M_0 to 109g. plant^{-1} and a decrease of 39.44%. This is due to the unique effect of the irrigation water salinity and organic resides mentioned above.

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