YIELD AND ITS COMPONENTS OF CORN AT SALINE SODIC SOIL WASHED WITH ENRICHED WATER BY A COMBINATIONS OF PHOSPHOGYPSUM AND HUMIC ACIDS

Akram A. H. Al-Hadethi Wisam. A. A. Aftan

Prof. Researcher

College of Agricultuf. Al-Anbar University

akramalhadethi@yahoo.com

ABSTRACT

A field study was conducted during the spring season of 2020 in saline sodic soils with clay loam texture, to study 16 combinations of phosphogypsum and humic acids. A randomized complete block design according to the order of treatment added to the factorial experiment was used with three replications. The experiment included the use of humic acids (HA_1, HA_2, HA_3, and HA_4) and phosphogypsum (G_1, G_2, G_3, and G_4) in four levels (0.5, 1.0, 1.5, 2.0 g L^{-1}) for both of them mixed in washing water to make 16 combinations, in addition to washing with a commercial clean salt (CS) treatment and Euphrates water only (W) to become 18 treatments. All experimental units were washed with enriched water with combinations and with a commercial clean salt and water. The results showed that washing with HA_4G_4 combination showed the highest significant increase in Calcium and Magnesium concentration, which reached 194.20 and 60.40 mmol L^{-1} compared to the rest of the combinations. Also there was a significant decrease in the Sodium adsorption ratio, which reached 0.83. Combination HA_4G_4 gave a highest significant increase in plant height, dry matter weight, grain yield, the weight of 300 grains, and an increase of 84.605%, 67.00%, 190.79%, and 67.92% compared to washing with water alone (W), respectively. The same combination also showed a highest significant increase in the Nitrogen, Phosphorous, and Potassium content of grains, with an increase of 26.23%, 133.83%, and 150.68% compared to washing with water (W), respectively.

Keywords: calcium, magnesium, sodium, clean salt, kernels

حاصل الذرة الصفراء مكوناته في تربة ملحية صودية مغسولة بمياه مخصبة بتولفات من الجبس الفوسفاتي والاحماض الدبالية

اكرم عبد اللطيف حسن الحديثي وسام احمد عبد عفتان

استاذ باحث

كلية الزراعة –جامعة الانبار

المستخلص

أجريت دراسة حقلية خلال الموسم الربيعي من عام 2020 في تربة ملحية صودية نسجتها مزيجة طينية. لدراسة 16 توليفة من الجبس الفوسفاتي والاحماض الدبالية. نفذت التجربة بتصميم القطاعات الكاملة المعشاة وفق ترتيب المعاملات المضافة للتجارب العاملية وبثلاث مكررات التي شملت استخدام الاحماض الدبالية (HA_1 وHA_2 وHA_3 وHA_4) والجبس الفوسفاتي (G_1 وG_2 وG_3 وG_4) وبأربعة تراكيز (0.5 ، 1 ، 1.5 ، 2 غم لتر$^{-1}$) لكليهما خلطت مع بعضها في مياه الغسل لتصبح 16 توليفة، علاوةٍ الى الغسل بمعالج ملوحة تجاري (CS) ومياه نهر الفرات فقط (W) لتصبح 18 معاملة. غسلت جميع الوحدات التجريبية بالمياه المغناة وبمعالج الملوحة التجاري والماء فقط ومن ثم زرعت بمحصول الذرة الصفراء. اظهرت النتائج ان الغسل بتوليفة HA_4G_4 اعلى زيادة معنوية في تركيز الكالسيوم والمغنسيوم والذي بلغا 194.20 و60.40 مليمول لتر$^{-1}$ قياساً بباقي التوليفات، واظهرت نتائج التوليفة نفسها ايضا انخفاض معنوي عالي في نسبة امتزاز الصوديوم والذي بلغ 0.83 قياساً بباقي التوليفات. اعطت التوليفة HA_4G_4 اعلى زيادة معنوية في ارتفاع النبات ووزن النبات الجاف وحاصل الحبوب وزن 300 حبة، وبنسبة زيادة بلغت 84.605% و 67.00% و 190.79% و 67.92% قياساً بالغسل بالماء لوحده (W) حسب الترتيب، وكما اظهرت التوليفة نفسها اعلى زيادة معنوية في محتوى الحبوب من النيتروجين والفسفور والبوتاسيوم وبنسبة زيادة 26.23 و133.83 و150.68 قياساً بالغسل بالماء (W) حسب الترتيب.

كلمات مفتاحية: كالسيوم، مغنسيوم، صوديوم، معالج ملوحة، عرانيص

Received:23/5/2022, Accepted:7/8/2022

INTRODUCTION

Soil salinity is a major factor threatening the ability of crops to support the increasing population growth, and it is one of the biggest global agricultural problems at present due to damage it causes to arable lands and thus the resulting disruptions in growth and productivity of plants in quantity and quality at the local and global level. In central and southern Iraq the area of land affected by salinity are increases to nearly 50% of arable land (15). The salts affect many aspects of plant physiology, as they reduce its ability to absorb the necessary nutrients, decrease its growth rate, decrease its height, its mass weight, and its products (13). Corn is considered cornerstone crop that affects positively food security in Iraq (9). Unfortunately; because maize is susceptible to soil salinity, the quality of the kernels is affected (10, 11, 12) Addition of humic acids in different concentrations to saline water gave good results in yield and components of corn yield. Phosphogypsum is a good source of calcium ions ($CaSO_4.2H_2O$) (23, 33). When added by mixing it with irrigation water or directly to soil, Calcium displaces and replaces the monovalent Sodium present on exchangeable sites, which leads to a decrease in Sodium adsorption ratio. (1, 16, 17, 20). Humic acids the important compounds responsible for many chemical processes that take place in soil, reducing the pH value of soil, as well as containing functional groups, including hydroxyl and carboxylate, which have a role in facilitating the process of washing salts through the formation of complexes with single and diagonal cationic salt ions (19, 28, 29, 32). This study was aimed to find out the effect of washing saline-sodic soil with different combinations of phosphogypsum and the growth and yield of corn.

MATERIALS AND METHODS

This study was conducted during spring season of 2020 in fields of College of Agriculture, University of Anbar, in a saline-sodic soil with clay loam texture and classified according to the modern American classification within the rank Typic Torrifluvents. Table 1 shows some chemical and physical properties of the soil before washing Table 2 shows some chemical characteristics for Phosphogypsum and commercial clean salt. Plowing, smoothing, and soil leveling were carried out. Then the field was divided longitudinally into three blocks. Each block contains 18 experimental units and with an area of 6 square meters with dimensions of 2 x 3 m. The experiment was carried out using factorial experiments within Randomized Complete Block Desing with three replications. The combination included the use of humic acids (HA) with four levels (0.5, 1.0, 1.5, 2.0 g l^{-1}), Phosphogypsum (G), with four levels (0.5, 1.0, 1.5, 2.0 g l^{-1}) mixed in washing water to become 16 combinations, in addition to washing with a commercial clean salt (CS) and Euphrates water only (W). The soil washing process was carried out before planting and after adding study blends through 18 water tanks, one tank capacity of 1000 l $tank^{-1}$, meaning for each combination of one water tank. Washing water was added with a volume equivalent to twice the pore volume of the soil to a depth of 30 cm, to reach a suitable salinity level for cultivating the corn crop, so that the total volume of washing water was 1507.75 l $plot^{-1}$, added in two batches before planting, then the electrical conductivity, concentration of Calcium, Magnesium, and sodium were determined and the Sodium adsorption ratio was calculated in the soil, and the experimental units were planted with seeds of corn (*Zea maize* L.) (Maha).

Table 1. Some chemical and physical properties of soil

$EC_{(1:1)}$ (dS m^{-1})	$pH_{(1:1)}$	Na^+	Ca^{2+}	Mg^{2+} (mmol l^{-1})	K^+	O.M	$CaCO_3$ (g kg^{-1})	$CaSO_4.2H_2O$	CEC (Cmol kg^{-1} soil)
143.57	7.78	882.36	213.86	44.25	2.20	2.33	230.14	—	^{1})28.24

SAR	ESP	N	P Available (mg kg^{-1})	Bulk density (Mg m^{-3})	Texture (g kg^{-1}) sand	silt	Clay
					418.00	283.00	299.00
				1340		clay loam	
54.94	41.44	65.27	8.34				

Table 2. Some chemical properties of phosphogypsum and clean salt

Phosphogypsum						Clean Salt	
$EC_{1:1}$ (dS m^{-1})	$pH_{1:1}$	Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	N	Ca^{2+}
		mmol l^{-1}				%	
3.89	5.67	65.13	11.04	0.32	2.11	10	14

in 15/3/2020. at the field of rows, the length of row is 3.0 m, the distance between the rows is 0.50 m, an average of 5 rows per unit of experimental, each distance of 0.25 m from the other. Fertilization operations included the addition of phosphorus at a level of 200 kg P ha^{-1} in form of mono superphosphate, while urea was added at a rate of 320 kg N $hectare^{-1}$ (46% N) in three batches, the first at planting and the second after 45 days from the emergence of the seeds and the third, after 85 days, according to the fertilizer recommendation for the corn crop (5). Field management plant continued throughout growing season, as the irrigation process was organized with equal quantities of water from the Euphrates River for all commercial units and according to the plant's need, with an addition of 10% as leaching requirements. Plant height was measured and the crop was harvested, and average dry weight measurement of 10 plants representing the experimental unit was taken. As for the yield measurements, the same plants represented above were collected and dried according to grain yield per hectare, the weight of 300 grains, and the grain samples were dried at a temperature of 65 °C for 24 hours, then milled and prepared for chemical analysis, the Nitrogen, Potassium and Phosphorus content of corn seeds were estimated according to the approved methods. The data were analyzed according to an Augmented factorial design in RCBD. The means were compared according to the LSD test at a probability level of 0.05.

RESULTS AND DISCUSSION

The concentration of Calcium, Magnesium, Sodium, Sodium adsorption ratio and electrical conductivity after washing

Table 3 shows significant increase in the concentration of calcium in the soil when washing it with a commercial clean salt, as it reached 26.85 mmol l^{-1} with an increases of 126.58% compared to washing with river water (W). As for washing with combinations of humic acids and phosphogypsum, it is noticed that there was a significant increases in the concentration of Calcium when increasing the level of addition of humic acids with the increases in the level of phosphogypsum in the combination, as washing with HA_4G_4 gave the highest significant increases in the calcium concentration, which reached 194.20 mmol l^{-1} compared to washing with the rest of the combinations of humic acids and phosphogypsum. While washing with HA_1G_1 combination gave the least significant increase, in which the Calcium concentration was 41.91 mmol l^{-1} compared to washing with the rest of the humic acid and phosphogypsum combinations. The reason for the increases in calcium concentration with the increase in phosphogypsum could be due to the increases in the saturation of the soil solution with ions resulting from the dissolution of phosphogypsum, which leads to an increases in its concentration in the soil (18, 30). As for the reason for the increases in the concentration of calcium in the soil solution when increasing the level of addition of humic acids, it is attributed to the fact that it contains effective functional groups such as carboxyl and hydroxyl that work to form complexes with Calcium with low movement, and thus the chance of washing it out of the soil decreases (24, 26, 27). These results are consistent with (2) they indicated that the Calcium concentration was increased by adding phosphogypsum and humic acids mixed with the soil. Table 3 shows that there was a significant increase in concentration of Magnesium in soil when washing it with a commercial clean salt, it was reached 45.40 mmol l^{-1}, with an increases of 363.26% compared to washing with river water (W). As for washing with humic acid and phosphogypsum combinations, HA_4G_4 combination gave the highest significant increases in Magnesium concentration, which reached 60.40 mmol l^{-1} when increasing the level of humic acid addition, with an increases in level of phosphogypsum in mixture compared to doses washing with the rest of humic acid and phosphogypsum combinations. While washing with HA_1G_1 combination gave the least significant increases, in which the

Magnesium concentration reached 26.60 mmol l^{-1} compared to washing with the remaining humic acid and phosphogypsum combinations. The reason for the increases in Magnesium concentrations when increasing the level of phosphogypsum in washing water could be due to phosphogypsum contains a percentage of magnesium in its composition, and thus its increase led to the saturation of the soil solution with magnesium ion (18, 30). The reason for the increases the concentration of Magnesium in soil solution when increasing the level of addition of humic acids, could be due to contains functional groups such as carboxyl and hydroxyl that can form complexes with Magnesium, which are less mobile compared to the complexes formed

Table 3. Effect of washing of saline sodic soil with combinations of humic acids, phosphogypsum, river water and commercial clean salt on some soil chemical properties

humic acids (g l^{-1})	phosphogypsum (g l^{-1})	combination	EC dS m^{-1}	SAR	mmol l^{-1} Ca^{2+}	Mg^{2+}	Na^{+}
	G_1 (0.5)	HA_1G_1	17.83	8.87	41.91	26.60	77.19
HA_1 (0.5)	G_2 (1.0)	HA_1G_2	19.33	7.23	58.50	35.80	69.74
	G_3 (1.5)	HA_1G_3	23.92	5.98	92.20	40.10	53.79
	G_4 (2.0)	HA_1G_4	26.63	4.93	106.67	51.70	44.32
	mean G_1		13.96	5.64	58.26	209.8	44.86
	mean HA_1		21.93	6.75	74.82	38.50	61.26
	G_1 (0.5)	HA_2G_1	14.98	5.98	43.26	28.80	45.98
HA_2 (1.0)	G_2 (1.0)	HA_2G_2	15.84	5.24	69.55	37.40	42.10
	G_3 (1.5)	HA_2G_3	16.92	3.55	101.15	45.90	40.83
	G_4 (2.0)	HA_2G_4	19.98	1.96	117.19	55.00	32.88
	mean G_2		15.81	4.69	87.21	44.80	40.98
	mean HA_2		16.93	4.18	82.79	41.80	40.45
	G_1 (0.5)	$HA_{34}G_1$	11.62	4.75	52.70	30.80	32.72
HA_3 (1.5)	G_2 (1.0)	HA_3G_2	14.88	3.68	90.56	40.10	31.00
	G_3 (1.5)	HA_3G_3	16.15	3.35	102.22	43.30	28.92
	G_4 (2.0)	HA_3G_4	18.11	1.26	119.35	57.10	18.26
	mean G_3		18.21	2.24	169.07	49.60	35.99
	mean HA_3		15.19	1.95	91.21	42.80	27.73
	G_1 (0.5)	HA_4G_1	11.42	2.97	95.18	32.90	23.55
HA_4 (2.0)	G_2 (1.0)	HA_4G_2	13.18	2.61	130.23	44.80	21.09
	G_3 (1.5)	HA_4G_3	15.83	1.40	169.07	49.60	20.42
	G_4 (2.0)	HA_4G_4	17.05	0.83	194.20	60.40	14.52
	mean G_4		20.44	2.24	134.35	56.10	27.50
	mean HA_4		14.37	1.95	147.17	46.90	19.90
		W	11.23	23.57	11.85	9.80	107.89
		CS	14.28	15.28	26.85	45.40	93.26
	LSD_G		0.02	0.07	1.57	11.30	0.74
	LSD_{HA}		0.02	0.07	1.57	11.30	0.74
	LSD_{G*HA}		0.04	0.13	3.14	22.61	1.47

with the Sodium ion, and thus the chance of washing it outside the soil (24, 26, 27). These results are consistent with (2) They indicated that the concentration of Mmagnesium increased by adding phosphogypsum and humic acids mixing with soil. Table 3 also shows that a significant decreases in the sodium concentration in the soil occurred when washing it with a commercial clean salt, as it reached 93.26 mmol l^{-1} with a decreases of 13.56% compared to washing with river water (W). As for washing with humic acid and phosphogypsum mixtures, HA_4G_4 combination gave the highest significant decreases in Sodium concentration, which reached 14.52 mmol l^{-1} when increasing the level of humic acid addition, in addition to the increases in the level of phosphogypsum in the mixture compared to washing with the rest of humic acid and phosphogypsum combinations. Whereas, washing with HA_1G_1 combination gave the least significant decreases, in which the sodium concentration was 77.19 mmol l^{-1} compared to washing with the rest of humic acid and phosphogypsum combinations. The reason for the decrease in sodium concentrations when increasing the level of addition of phosphogypsum could be due to the presence of a di-charged Calcium ion in its composition, which leads to the displacement of the monovalent Sodium ion from the exchange surfaces, and thus the Sodium concentration decreases (1, 17, 30). As for the reason for increase in concentration of Sodium in the soil solution when increasing the level of humic acid addition, it is because Sodium forms easy-to-move complexes in the soil with functional groups such as carboxyl and hydroxyl in contrast to the complexes formed by Calcium and Magnesium ions, which are less mobile in the soil, (24, 26, 27). These results are consistent with (2) they indicated that Sodium concentration was reduced by adding phosphogypsum and humic acids mixed with soil at different levels. Table 3 shows the effect of washing with combinations of humic acids, Phosphogypsum, and a commercial clean salt on the sodium adsorption ratio. It was noted from the Table a significant decreases in the Sodium adsorption ratio when adding a commercial clean salt (CS) to washing water, as the Sodium adsorption ratio reached 15.28, with a decrease It reached 35.17% compared with washing with water treatment (W). Soil washing with HA_4G_4 combination showed the highest significant decrease in the sodium adsorption ratio, which reached 0.83, with a decrease of 94.56% and 96.47% compared to the two treatments of soil washing with commercial clean salt (CS) and washing with water treatment whereas, washing with HA_1G_1 combination gave the least significant decreases, as the Sodium adsorption rate reached 8.87, with a decreases of 41.62 and 62.36% compared with washing with a commercial clean salt (CS) and washing with river water (W), respectively. In reducing the Sodium adsorption ratio on all the washing mixtures by 90.64% compared to HA_1G_1 leaching mixture. The substitution thus decreases the Sodium adsorption ratio (17, 18, 30). Table 3 also shows that a significant increases in the electrical conductivity of the soil occurred when adding a commercial clean salt to the washing water, as the electrical conductivity reached 14.28 dS m^{-1}, with an increases of 27.15% compared to its value when washing with river water (W), in which the electrical conductivity was 11.23 dS m^{-1}. Soil washing with HA_1G_4 combination showed the highest significant increase in electrical conductivity, reaching 26.63 dS m^{-1}, with an increase of 86.48% and 137.13% compared to the two treatments of soil washing with commercial clean salt (CS) and washing with water (W), respectively, When washing with HA_4G_1 combination gave the least significant increase, as the electrical conductivity reached 11.42 dS m^{-1}, with an increases of 1.69% compared to the washing with river water (W), according to the order. HA_1G_4 had a significant increases in overall wash combinations, by 132.98% compared to the combination. The washing of HA_1G_1 in which the electrical conductivity was 11.42dS m^{-1}. The reason for the increases in the electrical conductivity values with the increases in level of phosphogypsum in the mixture is due to the increase in saturation of the soil solution with ions Ca^{2+} and SO_4^{2-},which leads to an increases in concentration of electrolyte solution thus increases the electrical conductivity values (18, 30). As for the reason for the decreases in the electrical conductivity values with the increases in the level of humic acids in the combination, it is attributed to the fact that humic acids contain functional groups such as carboxyl and hydroxyl that form complexes with Sodium that are easy to move while the complexes formed with Calcium are less mobile, and thus the values of electrical conductivity decreases (24, 26, 27). These results are consistent with (2, 11, 25) who indicated that the electrical conductivity values increased with addition of phosphogypsum to soil, and decreased when humic acids were mixed with soil.

yield and some of its components of corn crop: Table 4 shows the effect of combinations of humic acids, phosphogypsum, water, and a commercial clean salt on plant height (cm), and from it is noticed that there was a significant increases in plant height of corn plants when adding a soil wash treatment with a commercial clean salt (CS), where the plant height reached 123.67 cm. with a percentage of 12.09% compared with the washing with water treatment (W), in which the plant height was 110.33 cm. Soil washing with HA_4G_4 combination showed the highest significant increases in plant height, reaching 203.67 cm, and an increase of 64.69% and 84.60% compared to two treatments of soil washing with commercial clean salts (CS) and washing with water treatment (W), in which the plant height reached 123.67 and 110.33 cm, respectively, while washing with HA_1G_1 combination gave least significant increase, as the plant height reached 137.33 cm, with a rate of 11.04%, 24.47% compared with the soil washing treatment. With a salinity processor commercial clean salts (CS) and wash with water (W), respectively. HA_4G_4 exceeded all wash blends with a significant increases of 48.30% compared to HA_1G_1 washing combination, which reached a height of 137.33 cm. These results are consistent with findings of (2) they indicated that there was a significant increases in plant height when humic acids and phosphogypsum were mixed with the soil at different levels. The reason for the increases in corn plant height when increasing the level of addition of humic acids could be due to its important role in activating cell division and stimulating the metabolic processes of plant. This leads to an increase in growth of the growing apex, elongation of plant cells, and then an increase in plant height, in addition to increasing the readiness of nutrients in soil, and then increasing their absorption by the roots of the plant, as well as the role of humic acids in enhancing plant resistance to salt stresses and reducing the effect of toxic elements in plants (14, 18, 21, 22). As for the reason for the increase in maize sprouts when increasing the addition of phosphogypsum to the washing water it is attributed to its effect on reducing the effect of Sodium by replacing Sodium with Calcium present in Phosphogypsum and reducing pH, which is positively reflected in readiness of nutrients (8). These results are consistent with (2, 3, 4) they indicated that plant height increased by adding humic acids and phosphogypsum mixed with soil at different levels.Table 4 also shows, washing with HA_1G_1 combination showed the least significant increases in weight of dry matter yield of the plant, which reached 1059 g plot^{-1},with an increases of 33.88% compared to the treatment of washing soil with water (W), in which the weight of the dry matter yield of the plant reached 791 g plot^{-1}, while the same combination did not show a significant increases compared to soil wash treatment with the commercial salinity treatment (CS). Washing with HA_4G_4 combination showed the highest significant increases in dry matter yield, which reached 1321 g plot^{-1}, with an increase of 39.78% and 67.00% According to the two treatments of soil washing with a commercial clean salt (CS) and washing with river water (W), in which the weight of the dry matter yield of the plant reached 945 and 791 g plot^{-1} could be due to the order, it is noticed from the tabley that a non-significant increases in average weight of the dry matter yield of corn plants when the addition of commercial clean salt (CS) treatment to washing water, compared with the washing with river water treatment (W), while washing the soil with a combination HA_2G_1 gave least significant increase in the weight of dry matter yield of the plant, as it reached 1059 g plot^{-1}, and by 22.96% compared with the treatment Soil washing with a commercial clean salt (CS) that has reached a shared weight Plant dry matter 945 g plot^{-1}. The HA_4G_4 combination significantly increased all the washing blends, with a percentage of 24.74% compared to the HA_1G_1 wash formula, in which the average plant dry matter yield was 1059 g. The reason for the increase in weight of the dry matter yield of maize plant when increasing the level of humic acids of leaching combinations is due to their role in activating cell division, and increasing the permeability of cell membranes, which leads to the ease of transport of nutrients to the sites that require their presence, thus improving growth and its role in increasing the readiness of elements Important nutrients in vegetative growth (14, 21, 22). As for the reason for increases in weight of dry matter yield in corn plant, by increasing levels of phosphogypsum in mixture, it is because phosphogypsum works to reduce the effect of Sodium and reduce the pH, which was positively reflected on readiness of nutrients and the plant growth characteristics. (8). These results are in agreement with (2) they indicated that the weight of dry matter yield of the barley crop was increased by adding humic acids and phosphogypsum mixed with soil at different levels. Table 4 shows that there was a significant increases in the grain yield (Mg ha^{-1}), as washing with a combination HA_4G_4 showed the highest significant increases in grain yield, reaching 9.66 Mg ha^{-1}, with an increases of 115.69% and 190.79% compared to two treatments of soil washing with a treated treatment a commercial clean salt (CS) and washing with river water treatment (W), in which the grain yield was 4,48 and 3,32 Mg ha^{-1}, respectively, while washing with HA_1G_1 combination gave least significant increase, as grain yield reached 4,58 Mg ha^{-1}, with a percentage of 2.38% and 38.03%, compared with treatment of soil washing with a commercial clean salt (CS) and washing with river water (W). It can be noted from Table 4, there was a significant increases in the grain yield when washing with a commercial salinity treatment (CS), in which the grain yield was 4,48 Mg ha^{-1}, with an increase of 34.81% compared to the washing with water treatment (W), in which the grain yield reached 3,32 tons ha^{-1}, according to the order. The reason for increases in the grain yield when increasing the level of addition of humic acids; attributed his role in increasing the transport of nutrients to sites that require their presence as well as his role in increasing the readiness of important nutrients such as Nitrogen, Phosphorous and Potassium, improving physiological growth, and biochemical reactions (14, 21, 22). As for the reason for the increases in the grain yield when increasing the level of addition of phosphogypsum, it is attributed to its effect on reducing the effect of Sodium content and reducing the pH, which was positively reflected in nutrient readiness and plant growth characteristics, which led to an increases in grain yield (8). These results are consistent with (2) they indicated that the grain yield was increased by adding humic acids and phosphogypsum mixed with the soil at different levels.

Table 4. Effect of washing a saline sodic soil with combinations of humic acid and phosphogypsum, commercial clean salts and river water on the yield and some components of the Maize

humic acid (g l^{-1})	phosphogypsum (g l^{-1})	combination	Plant height) (cm)	Dry matter (g $plot^{-1}$)	Grain yield (Mg ha^{-1})	Weight of 300 grain (g)
	G_1 (0.5)	HA_1G_1	137.33	1059	4.58	42.56
HA_1 (0.5)	G_2 (1.0)	HA_1G_2	139.33	1068	5.25	43.97
	G_3 (1.5)	HA_1G_3	141.33	1090	5.38	48.03
	G_4 (2.0)	HA_1G_4	145.00	1093	5.84	48.89
	mean G_1		168.17	1181	7.13	52.25
	mean HA_1		140.75	1078	5.26	45.86
	G_1 (0.5)	HA_2G_1	159.00	1162	6.68	50.33
HA_2 (1.0)	G_2 (1.0)	HA_2G_2	165.67	1167	7.23	53.06
	G_3 (1.5)	HA_2G_3	168.33	1182	7.36	53.91
	G_4 (2.0)	HA_2G_4	173.67	1188	7.66	54.81
	mean G_2		172.17	1188	7.53	53.77
	mean HA_2		166.67	1175	7.23	53.02
	G_1 (0.5)	HA_3G_1	180.00	1206	7.80	55.44
HA_3 (1.5)	G_2 (1.0)	HA_3G_2	182.67	1212	8.07	56.97
	G_3 (1.5)	HA_3G_3	186.67	1226	8.54	58.20
	G_4 (2.0)	HA_3G_4	188.33	1237	9.27	59.02
	mean G_3		174.75	1204	7.72	55.53
	mean HA_3		184.42	1220	8.42	57.41
	G_1 (0.5)	HA_4G_1	196.33	1298	9.48	60.68
HA_4 (2.0)	G_2 (1.0)	HA_4G_2	201.00	1305	9.58	61.07
	G_3 (1.5)	HA_4G_3	202.67	1316	9.61	62.00
	G_4 (2.0)	HA_4G_4	203.67	1321	9.66	62.94
	mean G_4		177.67	1210	8.11	56.41
	mean HA_4		200.92	1310	9.58	61.67
		W	110.33	791	3.32	37.48
		CS	123.67	945	4.48	39.95
	LSD_G		3.48	11	0.16	0.47
	LSD_{HA}		3.48	11	0.16	0.47
	LSD_{G*HA}		6.96	21	0.33	0.94

Table 4 also shows that washing with HA_4G_4 combination showed the highest significant increase in the weight of 300 grains, which reached 62.94 g, with an increase of 57.54% and 67.92% compared to the two soil washing treatments with commercial clean salt (CS) and washing with water treatment (W), in which the weight reached 300 grain of 39.95 and 37.48 g, respectively, while washing with a combination HA_1G_1 gave the least significant increase, with a weight of 300 grains of 42.56 g, with a ratio of 6.53% and 13.55%, compared with the soil washing treatment with a commercial clean salt (CS) and washing with water (W.) as well. It is noted from the table that there was a significant increase in the weight of 300 grains of the corn crop when adding the washing treatment with a commercial clean salt (CS), in which the weight of 300 grains reached 39.95 g, and by 6.59% compared to the water washing treatment (W), in which the weight of 300 grains reached 37.48%, respectively. The HA_4G_4 combination exceeded significantly all the wash combinations, with a significant increase of 47.88% compared to HA_1G_1, with a weight of 300 grains of 42.56 g. The reason for the weight gain of 300 when increasing the level of addition of humic acids is attributed to the role of humic acids in Increase nutrient transport to sites requiring It also has a role in increasing the readiness of important nutrients such as nitrogen, phosphorous, and potassium, improving physiological growth, and biochemical reactions leading to an increases in the protein content of grains (14, 21, 22). The reason for increasing the weight of 300 grains of the corn crop when increasing the level of addition of phosphogypsum; It was attributed to its effect on reducing the effect of sodium through the ion exchange between Calcium and Sodium and reducing the pH, which was positively reflected in readiness of necessary nutrients, which was reflected in the weight of grains (8). These results are in agreement with (2) they indicated that the weight of 300 grains increased with the addition of humic acids and phosphogypsum mixed with the soil at different levels.

Grains content of nitrogen, phosphorous, and potassium : Table 5 shows data in the effect of combinations of humic acids, phosphogypsum, water, and a commercial clean salt on the Nitrogen content of grains (g kg^{-1}). from the Tabals that a significant increases in the average of Nitrogen content of corn grains occurred when washing the soil with a commercial clean salt (CS). The average Nitrogen was 15.47 g kg^{-1}, and a rate of 1.70% compared with the river water wash treatment (W) in which the average Nitrogen was 15.21 g kg^{-1}. Soil washing with HA_4G_4 combination showed highest significant increases in average Nitrogen content, reaching 19.20 g kg^{-1}. With an increases of 24.11% and 26.23% compared to the two treatments of soil washing with a commercial clean salt (CS) and washing with river water treatment (W), in which the Nitrogen rate was 15.47 and 15.21 g kg^{-1}, respectively, while washing with HA_1G_1 combination gave lowest significant increases, as it reached with average Nnitrogen of 15.92 g kg^{-1}, with a percentage of 2.90%, 4.66% compared to the soil washing treatment with a commercial clean salt (CS) and washing with river water (W) respectively. HA_4G_4 outperformed with a significant increase overall wash combinations, by a rate of 20.60% compared to washing combination HA_1G_1 it reached Nitrogen neutralization 15.92 g kg^{-1}. The reason for the increase in nitrogen concentration in the kernels of the corn plant by increasing level of addition of humic acids is due to large role of humic acids in reducing the Sodium concentration in the root zone, which reduces the process of competition between Sodium and Ammonium for the sites of absorption, which led to an increases in the availability of Nitrogen and nutrients by others, (10). As for the reason for increases in Nitrogen concentration in the kernels of the corn plant by increasing the level of addition of phosphogypsum, it is attributed to its role in reducing the concentration of Sodium ion at the exchange sites in the presence of Calcium, which leads to a decreases in the pH value of soil, and thus the readiness of Nitrogen and other nutrients in soil increases (8). These results are consistent with (2) they indicated an increases in the Nitrogen content of the grains with an increases in the level of addition of humic acids and phosphogypsum mixed with soil. Table 5 also shows the effect of the same combinations on the content Phosphorous corn grains (g kg^{-1}), as soil washing with a commercial clean salt (CS) showed a significant increases in Phosphorus content, which reached 2.17 g kg^{-1}, with an increases of 9.91% in comparison with its content in the water washing treatment (W), in which the average Phosphorus content was 1.97 g kg^{-1}. Soil washing with HA_4G_4 combination showed highest significant increase in rate of phosphorus, reaching 4.62 g kg^{-1}, with an increases of 112.74% and 133.83% compared to with its content by washing the soil with a commercial clean salt (CS) and washing with river water treatment (W), in which the average Phosphorus content was 2.17 and 1.97 g kg^{-1} according to the order, while washing with a combination HA_1G_1 gave the least significant increase, as the average Phosphorus content reached 2.21 g kg^{-1}, with a ratio of 1.84% and 11.73%, as compared to content of soil washing with a commercial clean salt (CS) and washing with river water (W), in which the mean Phosphorus content was 2.17 and 1.98 g kg^{-1}, respectively. The combination HA_4G_4 outperformed with a significant increase. All wash blends, at a rate of 108.90% compared to HA_1G_1 washing combination, in which the average Phosphorus content was 2.21 g kg^{-1}. The reason for increasing the concentration of Phosphorus in the grains of the corn plant by increasing the level of addition of humic acids is due to its role in increasing the readiness of phosphorus and reducing its precipitation through phosphorus chelating and reducing its adsorption on the exchange sites, which facilitates its absorption by the roots (31). The reason for increasing the concentration of Phosphorus in Maize kernels by increasing the level of addition of phosphogypsum could be due to its role in lowering pH of soil, which leads to an increases in readiness of it. Also, it contains 5% Phosphorus in its composition (1, 6, 31). These results are in agreement with (2) they indicated that the Phosphorous content in grains increased with the addition of humic acids and phosphogypsum mixed with soil at different levels.

Table 5. Effect of washing saline sodic soil with combinations of humic acids, phosphogypsum, commercial clean salt and water on the content of corn seed of Nitrogen, Phosphorous and Potassium (g kg^{-1})

g l^{-}) humic acids (1	g l^{-}) phosphogypsum (1	combination	N	P (g kg^{-1})	K
HA_1 (0.5)	G_1 (0.5)	HA_1G_1	15.92	2.21	3.81
	G_2 (1.0)	HA_1G_2	16.13	2.35	3.91
	G_3 (1.5)	HA_1G_3	16.32	2.47	4.02
	G_4 (2.0)	HA_1G_4	16.35	2.54	4.03
	mean G_1		17.23	3.02	4.36
	mean HA_1		16.18	2.39	3.94
HA_2 (1.0)	G_1 (0.5)	HA_2G_1	16.59	2.65	4.21
	G_2 (1.0)	HA_2G_2	17.23	2.73	4.31
	G_3 (1.5)	HA_2G_3	17.27	2.84	4.35
	G_4 (2.0)	HA_2G_4	17.65	2.96	4.39
	mean G_2		17.47	3.22	4.46
	mean HA_2		17.19	2.79	4.32
HA_3 (1.5)	G_1 (0.5)	HA_3G_1	17.73	3.33	4.50
	G_2 (1.0)	HA_3G_2	17.79	3.46	4.67
	G_3 (1.5)	HA_3G_3	18.48	3.68	4.82
	G_4 (2.0)	HA_3G_4	18.66	3.82	4.89
	mean G3		17.79	3.35	4.63
	mean HA3		18.17	3.57	4.72
HA_4 (2.0)	G_1 (0.5)	HA_4G_1	18.67	3.91	4.93
	G_2 (1.0)	HA_4G_2	18.71	4.33	4.93
	G_3 (1.5)	HA_4G_3	19.10	4.41	5.34
	G_4 (2.0)	HA_4G_4	19.20	4.62	5.49
	mean G4		17.97	3.48	4.70
	mean HA4		18.92	4.32	5.17
	W		15.21	1.97	2.19
	CS		15.47	2.17	3.76
	LSD_G		0.53	0.34	0.42
	LSD_{HA}		0.53	0.34	0.42
	LSD_{G*HA}		1.06	0.67	0.85

Table 5 also shows that a significant increases in the averag of Potassium content of corn kernels occurred when adding a soil wash treatment with a commercial clean salt (CS), in which the average Potassium content was 3.76 g kg^{-1}, and a rate of 71.68% compared to the water river washing treatment (W), which average Potassium content was 2.19 g kg^{-1}. Soil washing with HA_4G_4 combination showed the highest significant increase in rate of Potassium, reaching 5.49 g kg^{-1}, with an increases of 46.01% and 150.68% compared to two treatments of soil washing with a commercial clean salt (CS) and washing with a treatment. river water (W) according to the arrangement, while washing with HA_1G_1 combination gave least significant increase, as the Potassium rate reached 3.81 g kg^{-1}, with a percentage of 1.32%, 73.97% compared to soil washing with a commercial salinity treatment (CS) and washing with river water (W) according to ranking the HA_4G_4 combination outperformed with a significant increase in all the leaching combinations, with an increases of 44.09% compared to the HA_1G_1 wash mixture, in which average Potassium content was 3.81g kg^{-1}. increase Potassium readiness, also, the increase and depth of root system lead to an increases in absorption of Potassium and other nutrients, in addition to washing the sodium ion, which competes with potassium for absorption by the roots (31). The reason for the increase in the Potassium concentration in the grains of the corn plant by increasing the level of addition of phosphogypsum is attributed to its role in the displacement of the Sodium ion from the exchange complexes that compete with Potassium ion in its absorption sites, which led to an increase in readiness of potassium in the soil (31). These results are in agreement with (2) they indicated that the Potassium content in grains increased with the addition of humic acids and phosphogypsum mixed with soil at different levels**.**

REFERENCES

1. Agar, A. I. 2011. Reclamation of saline and sodic soil by using divided doses of phosphogypsum in cultivated condition. African Journal of Agricultural Research, 6(18): 4243-4252.

2. Al-Alwani, Z. S., and A.A. Al-Hadethi, 2019. Role of phosphogypsum and humic acids in the growth and yield of barley and grain content of N P K in saline soil. anbar Journal of Agricultural Sciences, 17(2), 206–219.

3. Al-Khafagy, A. M. H. and K. D. H. Al-Gebory. 2010. Influences of fertilizers and organic nutrients on growth and seed yield of onion. Diyala Journal of Agricultural Sciences. 2 (2): 64 – 84.

4. Al-Khafaji, A. M. H. H., N. J. K. Al-Amri, and N. H. A. Al-Dulaimi. 2022. Growth, yield, and antioxidant traits of different parts of beetroot as affected by vermicompost and glutathione. Iraqi Journal of Agricultural Sciences, 53(5): 1107-1114. https://doi.org/10.36103/ijas.v53i5.1623

5. Ali, N. S., S.R. Hamdallah., and A. R. Abdel Wahab, 2014. Soil Fertility. Ministry of Higher Education and Scientific Research. University of Baghdad - College of Agriculture. Scientific Books House for Publishing and Distribution. Baghdad, Iraq. pp: 305.

6. Al-Grairy, F.A. 2012. Utilization of Phosphogypsum for Reclamation of Saline-Sodic Soils Using Saline Ground Water. Ph. D. Dissertation, College of Agriculture-University of Baghdad, Iraq pp: 30-35.

7. Aydin, A., C. Kant., and M. Turan, 2012. Humic acid application alleviate salinity stress of bean (*phaseolus vulgarisms*.) plants decreasing membrane leakage. African Journal of Agricutural Research,7(7),1073-1086.

8. Al-Naser, Y. H. 2018. Effect of phosphogypsum on formation and development of soil surface crust and wheat crop growth. Journal of Tikrit University for Agriculture Sciences, 18(3): 90-95.

9. Alkazaali H.A., M. M. Elsahookie, and F. Y. Baktash. 2016. Flowering syndrome - Hybrid performance relationship in maize: 1-Field traits and growth rates, 47(4): 900 - 909. https://doi.org/10.36103/ijas.v47i4.518

10. Alkazaali H.A., and F. Y. Baktash. 2016. Impact of corn grain moisture at harvesting to agronomic traits in subsequent generation Iraqi Journal of Agricultural Sciences 48: (Special Issue): 11-23. https://doi.org/10.36103/ijas.v48iSpecial.240

11. Baktash, F. Y., and H.A. Alkazaali. 2016. Effect of grain moisture of corn at harvesting on some agronomic traits. Iraqi Journal of Agricultural Sciences, 47(5): 1334 - 1339. https://doi.org/10.36103/ijas.v47i5.514

12. Baktash, F. Y., and H.A. Alkazaali. 2016. Grain yield and yield components of corn as influenced by harvesting moisture. Iraqi

Journal of Agricultural Sciences, 47(5): 1340 - 1345. https://doi.org/10.36103/ijas.v47i5.514
13. Blanco, F. F., M. V. Folegtti, H. R Ghey and, P. D. Fernandez, 2007. Emergency and growth of corn sorghum under saline stress. Sci. Agric. (piracicoba, braz). 64(5):451-459
14. Canellas, L. P., and F. L. Olivares, 2014. Physiological responses to humic substances as plant growth promoter. Chemical and Biological Technologies in Agriculture, 1(3): 2-11.
15. 11.FAO. 2015. FAOSTAT. Online statistical database: Production (available at http:// faostat3.fao.org/download/Q/QC/E).
16. 12.CIMMYT. 2013. Water-saving techniques salvage wheat in drought-stricken Kazakhstan. In: Wheat research, Asia.
17. Dick, W. A. 2000. Land Application of Agricultural, Industrial, and Municipal By-Products. Soil Science Society of America., Inc., Madison, Wisconsin, USA, pp343-361.
18. Hasoon, E.A., F. S. Al-Kinany, and S. R. J. Al-Jeboory, A. and H. Al-Hadithy, 2017. Effect of irrigation water of the main out full with addition phosphogypsum on growth of Barley (*HordeumVulgare*). Journal of Kerbala for Agricultural Sciences, 4(2), 133-144.
19. Khaled, H.; and H. A. Fawy, 2011. Effect of different levels of humic acids on the nutrient content, plant growth, and soil properties under conditions of salinity.Soiland Water Research. 6(1):21-29.
20. Mace, J. E., C. Amrhein, and J. D. Oster. 1999. Comparison of gypsum and sulfuric acid for sodic soil reclamation. Arid Soil Research and Rehabilitation, 13(2), 171-188.
21. Pizzeghello, D., O. Francioso, A. Ertani, A. Muscolo, and S. Nardi, 2013. Isopentenyladenosine and cytokinin-like activity of different humic substances. Journal of Geochemical Exploration, 129, 70-75.
22. Rady, M. M. 2012. A novel organo-mineral fertilizer can mitigate salinity stress effects for tomato production on reclaimed saline soil. South African Journal of Botany. 81, 8-14.
23. Rashad, A. M. 2015. Potential use of Phosphogypsum in alkali-activated fly ash under the effects of elevated temperatures and thermal shock cycles. Journal of cleaner production. 87 (4), 717-725.
24. Rosa. A. H., M. L. Simoes., L.C. de OLiveira, J.C. Rocha., L. M. Neto, and D. M. Milori, 2005. Multime thod study of the dgree of humification of humic substances extracted from different tropical soil profiles in Bazils Amazonian Region.Geoderma.127(1-2),1-10
25. Shaaban, M., M. M. Abid, and R.A.I. Abou-Shanab, 2013. Amelioration of salt affected soil sin rice paddy system by application of organic and inorganic amendments.plants,. Soil and Environment 59(5).227-233.
26. Tan, H. Kim. 2003. Humic Matter in Soil and the Environment Principles and Controversies. Library of Congress Cataloging-in-Publication Data. New York, USA. pp. 124-132.
27. Tchiadje, N. F. T. 2007. Strategies to reduce the impact of salt on crops (rice, cotton and chili) production: A case study of the tsunami-affected area of India.Desalination, 206(3), 524-530.
28. Turan, M. A.; A. V. KATKAT, and, H. ÇELİK 2011. The effects of soil-appliedhumic substances to the dry weight and mineral nutrient uptake of maize plants undersoil-salinity conditions. NotulaeBotanicaeHorti Agro. Botanici Cluj-Napoca, 39(1), 171-177.
29. Weber, J. B. and C. T. Miller, 1989. Organic Chemical Movement Over and Through Soil. Proceedings of a Symposium Sponsored by Divisions A-5 of the SoilScience Society of America and the American Society of Agronomy inAtlant PP: 350-348.
30. Yasien, M. F., K. O. Omar, and J.A. Mustafa. 2014. The effect of interaction between phosphogypsum and soil texture and saline type on some soil properties chemical after binary leaching. Tikrit University Journalof Agricultural Sciences, 14(1), 138-149.
31. Yasen, M.F., and A.J. Khames, 2013. Effect of phosphogypsum, irrigation water salinity, cotton cultivars and interaction among them on availability and uptake of NPK in soil affected with saline. Al - Furat Journal of Agricultural Sciences, 5(4): 176-187.
32. 28. Zhang, W.Z. X. Q. Chen, J.M. Zhou, D.H. Liu, H. Y. Wang and C.W. Du. 2013.Influence of humic acid on interaction of ammonium and potassium ions on clay minerals. Pedosphere 23(4), 5-193.