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Response of wheat plants (*Tritium astrium* L.) to NPK Nano fertilizer under saline soil conditions in Nineveh Governorate

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Abstract

Three sites were chosen from Nineveh Governorate within the (Tal Abta) area due to the importance of these sites from an agricultural standpoint as they are grown with grain crops and irrigated supple-mentally depending on the difference (rainfall range, vegetation cover, variation in salt distribution). Excited samples were taken at a depth of (0 - 30) cm. On 10/5/2023 ,from the study sites, samples were prepared for cultivation, analysis and laboratory studies. The experiment was carried out according to a completely randomized design with three replications as a factorial experiment with three factors. The first factor is: three levels of soil salinity, a non-saline comparison soil less than (0.6 dS m^{-1}). The western Tell Abta site (S_1), soil with an electrical conductivity of (4.1 dS m^{-1}) ,the southern Tell Abta site (S_2), soil with an electrical conductivity of (7.8 dS m^{-1}) the southern Tell Abta site (S_3). The second factor: Ground fertilization: Neutral NPK Nano-fertilizer (20:20:20) will be used at three levels (G1=0, 10, G2=, G3=18) kg/h-1. Third factor: Foliar fertilization: Neutral NPK Nano-fertilizer (20:20) will be used. : 20) At three levels (0 F1 = 2 F2 = 3 F3 = 3) g L-1, the results showed that the highest plant height reached 61.33 cm in the S1F3 treatment, which was significantly superior to the other treatments and the comparison treatment at a height of 55.26 cm, and the lowest value. For plant height, it was recorded in the S_2F_3 treatment and amounted to 36.33 cm. As for the effect of the bilateral interaction between salinity and ground on the leaf area, the S_1G_3 treatment was significantly superior to the rest of the treatments and amounted to 10.71 cm2, with an increase of 88.22% compared to the comparison treatment, which amounted to 5.69 cm2, the lowest value recorded in the treatment. $S_3G_3F_2$ at the third salinity level and reached 3.73 cm^2. The results showed that using Nano fertilizer with ground fertilizer reduced the effect of soil salinity on both plant height and leaf area.

Keywords: *soil salinity, foliar fertilizer, ground fertilizer, wheat plants.*

Introduction

Wheat is an essential source for the production of bread in many countries of the world. It is also considered an important source of proteins, calories, fats, vitamins, and mineral salts [11]. Wheat protein contains approximately 35% gluten, which helps in producing good types of bread compared to the resulting of bread. Among other grain crops, the wheat crop is also used in the production of some medicines, while wheat waste is used as animal feed. Because of the importance of the wheat crop and its nutritional role, it is called the king of grains , Nano fertilizer technology is one of the recent discoveries that provides solutions to many problems in the agricultural field [15]. Nano refers to a unit of measurement that denotes one billionth (10-9) of a meter. Nanotechnology means the technology of extremely small materials. Or microscopic technology. Scientists and engineers deal with matter at this scale at the level of atoms and Nanoparticles [25]. The Nano unit is used to measure microscopic particles, atoms, and diameter dimensions [2]. The difference in the behavior of Nanomaterials is due to two basic factors: The first factor is the increase in area. The surface area of the material, which will lead to an increase in the specific surface area, so the interaction of the material increases, and then its chemical activity becomes higher [8]. The second factor is the quantitative effects in these Nanomaterials, and because of their small dimensions, they are not subject to the laws of classical physics, but they are subject to the laws of quantum physics, so they affect... in their properties, which is reflected in the optical, electrical, magnetic and mechanical behavior of materials [14].

Salinization is the process of gathering or accumulating dissolved salts to a degree exceeding their natural rates in the soil. The cause of salinization may be natural or due to conditions resulting from poor management processes [6]. Saline soils are characterized by chemical, physical, biological, and morphological characteristics different from non-saline soils. They are also characterized by a predominance of Certain types of cations and anions [19]. The area of land affected by salts reached (340 million hectares) at the global level, while the area of sodic lands reached (560 million hectares). Salinity, in addition to the osmotic effect, is an ionic effect that is often associated with high levels of sodium to potassium (K^+ /Na^+) and sodium to calcium (Ca^{++} /Na^+), magnesium to calcium (Ca^{++} /Mg^{++}), and chloride to nitrate (NO3 / Cl^-), which means the accumulation of both sodium and chloride in the plant tissue in addition to the soil, which affect water stress and cause the absorption of the main nutrients to be affected. Interactions, ionic competition, or influence the integrity of the cell membrane [27]. Sodium competes with potassium, calcium, and magnesium, in addition to manganese, and reduces the amount available to the plant or replaces the calcium ion in the binding

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sites in the cytoplasmic membranes, which negatively affects their selective property, while chloride restricts the absorption of nitrates and phosphates in addition to sulfates [20].

Materials and Methods

Collecting soil samples and preparing them for study:

Three sites were chosen from Nineveh Governorate within the (Tel Abta) area due to the importance of these sites from an agricultural standpoint as they are grown with grain crops and irrigated supple mentally depending on the difference (rainfall range, vegetation cover, variation in salt distribution). Excited samples were taken at a depth of (0 - 30) cm. On 10/5/2023 from the study sites, Table (3), samples were taken to prepare them for cultivation for analyzes and laboratory studies according to the methods mentioned in [22].

Table 1: The spatial and geographical location, nature of agricultural exploitation, degree of salinization, and type of irrigation used for the study sites

Location	Soil type	geographical location	agricultural exploitation	type of irrigation
Western Tell Abta (S_1)	Non-salty	35°523.5N 42°3246.3E	Field crops	Without irrigation
Southern Tell Abta(S_2)	Salty	35°5131.9N 42°3157.8E	Field crops	Well water irrigation
Southern Tell Abta(S_3)	Salty	35°5132.5N 42°3158.8E	Field crops	Well water irrigation

Chemical and physical analyses

The soil extract (1:1) was used to estimate dissolved ions. The electrical conductivity (EC) and the degree of soil reaction (pH) were measured using the WTW Multi 4001 device [20]. Calcium and magnesium were calibrated with (0.01N) of ferricin (EDTA di -Na) [20], I use a Shewood model 410 flame photometer to measure both sodium and potassium in the soil extract after adjusting the device with standard solutions and based on [26], carbonates and bicarbonates by calibration with (0.01N). Of sulfuric acid and using the phenolphthalein index to estimate carbonates and the methyl orange index in the case of bicarbonate. Chlorides were estimated by titration with (0.01N) of silver nitrate (AgNO3 [26]. Sulfates were calculated from the difference between the sum of dissolved positive ion equivalents and dissolved negative ion equivalents [22], organic matter was estimated by the wet oxidation method using potassium dichromate ($K_2Cr_2O_7$) [20], total carbonates (lime) were estimated by titration method with hydrochloric acid at a concentration of (1M) phenolnaphthalene index [10], it was Gypsum was estimated by the acetone precipitation method according to the method used by [18]. The hydrometer method was used to estimate soil separations of clay, silt, and sand, according to what was mentioned by [13]. The bulk density was estimated by the paraffin wax method [17].

Implementation of the experiment

Plastic pots with a diameter of (25 cm) and a depth of (35 cm) were filled with (7) kg of air-dry soil and sifted through a sieve with a diameter of (4 mm). (10 seeds) of wheat variety (durum desf) were planted in each pot at a depth of (1 cm) from the soil surface, taking into account the selection of healthy seeds of similar sizes. After (10) days of planting, the plants thinned to only three plants per pot. As for the irrigation process, the experimental plants will be placed below 75% of the field capacity of the soil, using water (the Tigris River) throughout the experiment period, and the irrigation process will be conducted using the gravimetric method by weighing each pot and then adding water to the pot for the purpose of obtaining the wet weight.

Experiment design: The experiment will be implemented according to a completely randomized design with three replications as a factorial experiment with three factors:

The first factor: Three levels of soil salinity are: A non-saline comparison soil of less than (0.6 dS m^{-1}) at the western Tell Abta (S_1), a soil with an electrical conductivity of (4.1 dS m^{-1}) at the southern Tell Abta (S_2), a soil with an electrical conductivity of (7.8 dS m^{-1}) The southern Tell Abta (S_3).

The second factor: ground fertilization: The neutral NPK Nano fertilizer (20:20:20) will be used, which is produced by Al-Khadra Nano Fertilizer Company, at three levels as a ground additive mixed with the soil before planting. The comparative added levels are (0) kg ha^{-1}, (10) kg ha^{-1}, and (18). kg ha-^{1}, noting that the manufacturer's fertilizer recommendation is (8 - 15) kg ha^{-1}.

The third factor: foliar fertilization: Neutral NPK Nano fertilizer (20:20:20) will be used at three levels, noting that the fertilizer recommendation for the manufacturer's foliar application is (2) gm L^{-1} (Ali et al., 2016). The foliage of the plants will be sprayed using Nano-fertilizer in two stages of the plant's life. The first spray is in the branching stage, the second spray is in the stem elongation stage, spraying evenly and in all directions until complete wetness, with the addition of a spreading material to the fertilizer solution in the form of drops of liquid washing powder to increase the efficiency. Absorption process, spraying the control plants with distilled water only with the diffuser, the concentration added to the comparison treatment is (0) gm L^{-1}, (2) gm L-1, (3) gm $^{L-1}$.

Statistical analysis: The results are analyzed statistically according to the design used, using the computer, and using the Duncan test.

Results and Discussion

Soil salinity and ionic composition:

The results shown in Table (2) show that the ionic composition and electrical conductivity at the western Tel Abta site (S_1) is that the site is not saline, which gives a clear indication that the soil in this site was subject to washing due to the rain falling during that year and the lack of use of salty irrigation water. . As for the southern site of Tell Abta (S_2), the table shows that the electrical conductivity value is at the critical level (4.1 dS m^{-1}), unlike the site of Tell Abta al-Dimi, which indicates the active role of the rise of water through capillary action, since this site is agriculturally exploited and was irrigated with salt water from wells. At the southern Tel Abta site (S_3), the electrical conductivity value was high (7.8 dS m^{-1}) due to the use of salty well water and the failure to use sufficient leaching requirements. The results showed high values in its content of sodium, calcium, magnesium, chlorine, and sulfate, while the potassium ions and bicarbonate were The behavior is opposite, with a lower content than other ions of the site (S_3). As for the southern Tel Abta site (S_2), which was at the beginning of the salinization process, Table (2) shows that the behavior of the ion distribution was an increase in the concentration of sodium and chloride, more than the concentration of other ions.

The accumulation of dissolved salts is a common characteristic in the soil of the region because the rate of evaporation from it is greater than the rate of rainfall. Therefore, the mechanism of movement and distribution of salts is an important matter in exploiting dry soils and improving their management. The accumulation of salts as a function of electrical conductivity in the cores of the studied soils classifies them classified among the soils affected by salts. Because the value of electrical conductivity in the two sites of southern Tel Abta (S_2 and S_3) is greater than (4 ds m^{-1}), and the increase in the concentration of salts in the surface layers indicates that the movement of salts occurs upward by capillary action, and that the temperatures in the region are high, there is intense evaporation, and there is no Effective drainage that allows the accumulated salts to be transferred out of the soil Bedon.

The concentration of dissolved ions in the non-saline and saline study sites. As shown in Tables (2), the dissolved sodium in the soils not affected by salts ranged between (1.1-25.5) $mmol_c\ L^{-1}$, while the values of dissolved potassium ranged between (0.07-0.20) $mmol_c\ L^{-1}$. The values of dissolved calcium ranged between (3.0 - 30.1) $mmol_c\ L^{-1}$, while the values of dissolved magnesium ranged between (2.1 - 25.1) $mmol_c\ L^{-1}$. The sequence of positive ions according to their dominance in the western Tel Abta site (S_1), which is not affected by salts, is as follows: :

$$Ca^{+2} > Mg^{+2} > Na^{+1} > K^{+1}$$

The sequence of positive ions according to their dominance in the southern Tel Abta site (S_2) affected by salts was as follows:

$$Na^{+1} > Ca^{+2} > Mg^{+2} > K^{+1}$$

The sequence of positive ions according to their dominance in the southern Tel Abta site (S_3) affected by salts was as follows:

$$Na^{+1} > Ca^{+2} > Mg^{+2} > K^{+1}$$

As for the distribution of dissolved ions, their distribution in the study sites was: the values of dissolved chlorides ranged between (2.2 - 58.2) mmol, charge L-1, and the values of dissolved sulfates ranged between (2.9 - 20.1) mmol, $_c\ l^{-1}$. Finally, the values of dissolved bicarbonate ranged between (1.1 - 2.1 mmol, $_c\ l^{-1}$, and this clearly reflects the role of the prevailing salinization processes due to the effect of incorrect and suboptimal irrigation of these soils on the dissolved ionic species content of the soil. The sequence of negative ions according to their dominance in Western Tell Abta (S_1), soils not affected by salts, was as follows:

$$SO_4^{-2} > Cl^{-1} > HCO_3^{-1}$$

While its sequence in the southern Tel Abta site (S_2), which was affected by salts, was as follows:

$$Cl^{-1} > SO_4^{-2} > HCO_3^{-1}$$

While its sequence in the southern Tel Abta site (S_3), which was affected by salts, was as follows:

$$Cl^{-1} > SO_4^{-2} > HCO_3^{-1}$$

Table 2: Physicochemical properties of the liquid phase of the soils of the study sites

Soil type / Properties		S1	S2	S3
		Non-salty	Salty	Salty
Depth		0 – 30 cm	0 – 30 cm	0 – 30 cm
pH		7.2	7.0	7.0
EC_e (dS m^{-1})		0.6	4.1	8.0
CEC $cmol_c\ kg^{-1}$		29.5	28.5	25.6
OM (g kg^{-1})		10.6	10.20	9.2
$CaCO_3$ (g kg^{-1})		37.1	35.5	34.0
$CaSO_4$ (g kg^{-1})		0.45	2.30	4.65
ρb (Mg m^3)		1.2	1.2	1.2
gm 100 gm^{-1}	**Clay**	59.7	59.5	57.2
	Silt	20.3	10.5	15.3
	Sand	20.0	30.0	27.5
texture		Clay	Clay	Clay
dissolved ions mmocl L^{-1}	**Na^{+1}**	1.1	16.1	25.5
	K^+	0.07	0.12	0.20
	Ca^{2+}	3.0	13.2	30.1
	Mg^{2+}	2.1	12.5	25.1
	HCO_3^{-1}	1.1	1.5	2.1
	CO_3^{-2}	Nil	Nil	Nil
	Cl^{-1}	2.2	22.3	58.2
	SO_4^{-2}	2.9	18.1	20.1
%	**N**	0.0058	0.0053	0.0049
gm k^{-1}	**P**	1.70	1.45	1.30

Table (3) shows the theoretical correlation of salts for the study sites, and it was in the presence of the predominant salts in the non-salt Western Tell Abta site (S_1), in the following order: ($MgCl_2$, $CaSO_4.2H_2O$, $Ca(HCO_3)_2$, Na_2SO_4, NaCl, K_2SO_4) at a rate of (33.8). %, 30.6, 17.7, 15.0, 1.0, 1.6)%, As for the western Tel Abta saline site (S_2), the sequence of salts was in the following order: ($MgCl_2$, CaSO4.2H_2O, NaCl, Na_2SO_4, $Ca(HCO_3)_2$, K_2SO_4) at a rate of (29.7, 28.5, 23.8, 14.0, 3.5, 0.2).)%, and in the western Tel Abta saline site (S3), the sequence of salts was in the following order: ($CaSO_4.2H_2O$, NaCl, $MgCl_2$, $CaCl_2$, $Ca(HCO_3)_2$, Kcl) at a rate of (32.0, 29.2, 28.7, 7.3, 3.5, 0.2)%.

Based on the results of theoretical correlation, the salts in the western Tell Abta (S_3) salt site are sulfate composed of sodium chloride mixed with magnesium chloride sabkha. Likewise, the soil solution is saturated with calcium sulfate when the ratio of soil to water is (1:1), which is the product of precipitation. Chemistry at different depths of freshwater and near-surface terrestrial water with calcium and sulfate ions. This is during the rise of this water by capillary action and being subjected to evaporation until it reaches the point of saturation. Then these salts decompose into positive and negative ionic species after dissolving in the soil solution.

When the water evaporates from its electrolyte solutions, the ions will move toward precipitation, forming multiple salts depending on the result of dissolution, and that the first The salts that are least soluble in water precipitate, while the most soluble and highly hydrated salts remain that precipitate in the end. Accordingly, the percentages of the dominant salts out of the total total salts were calculated by the theoretical combination of positive and negative ions according to what was reported by [28]. The ions combine and salts are formed according to the solubility of these salts. The more soluble the less precipitated, and vice versa. The appearance of a salt Magnesium chloride may be due to cation exchange between sodium in the soil solution with calcium in the exchange complex, and this confirms the fact reached by [3] [16] when discussing the source of magnesium chloride and its appearance in the soil solution at levels High salinity means the displacement of magnesium chloride from the exchange complex by sodium.

Table 3: The theoretical correlation of salts for the study sites

Type of salt	Soil type					
	S_1		S_2		S_3	
	concentration	%	concentration	%	concentration	%
$CaHCO_3$	1.1	17.7	1.5	3.5	2.1	2.4
$CaSO_4.2H_2O$	1.9	30.6	11.7	28.5	20.1	32.0
K_2SO4	0.07	1.1	0.12	0.2	---	---
Na_2SO_4	0.93	15.0	6.28	14	---	---
$Mgcl_2$	2.03	33.8	12.4	29.7	25.1	28.7
Nacl	0.1	1.6	9.82	23.8	25.5	29.2
Kcl	---	---	---	---	0.2	0.2
$Cacl_2$	---	---	---	---	6.4	7.3

Table 4: Effect of salinity and NPK Nano composite fertilizer on plant height (cm) of wheat plants

Salinity	Ground fertilization	Foliar fertilization			Salinity effect	effect of ground fertilization		salinity x ground fertilization
		F1	F2	F3				
S_1	**G1**	**50.33**	**47.67**	**52.33**	**55.26**	**G1**	**47.41**	**50.44**
	G2	**58.00**	**58.33**	**54.33**				**56.89**
	G3	**58.67**	**55.33**	**61.33**				**58.44**
S_2	**G1**	**42.67**	**43.67**	**38.67**	**44.59**	**G2**	**48.85**	**41.67**
	G2	**48.00**	**47.00**	**36.33**				**43.78**
	G3	**51.67**	**47.00**	**46.33**				**48.33**
S_3	**G1**	**51.67**	**54.00**	**44.67**	**48.22**	**G3**	**51.81**	**50.11**
	G2	**52.00**	**41.00**	**44.67**				**45.89**
	G3	**54.33**	**52.00**	**39.33**				**48.66**
Effect of foliar fertilization		**51.93**	**49.56**	**46.59**	Minimum significant difference: LSD at 0.05 For salinity: 4.094 For ground fertilization: 4.094 For foliar fertilization: 4.094 For salinity x ground: 7.091 For salinity x foliar: 7.091 For ground x paper: 7.091 For salinity x ground x foliar: 12.282			
salinity x foliar fertilization	**S1**	**55.67**	**53.78**	**56.33**				
	S2	**47.44**	**45.89**	**40.44**				
	S3	**52.67**	**49.00**	**42.66**				
ground x foliar fertilization	**G1**	**48.22**	**48.44**	**45.56**				
	G2	**52.67**	**48.78**	**45.11**				
	G3	**50.33**	**47.67**	**52.33**				

Table 5: Effect of salinity and NPK Nanocomposite fertilizer on the leaf area (cm^2) of wheat plants

Salinity	Ground fertilization	Foliar fertilization			Salinity effect	effect of ground fertilization		salinity x ground fertilization
		F1	F2	F3				
S_1	G1	5.83	6.09	5.83	7.52	G1	5.84	5.69
	G2	5.67	6.12	5.67				6.16
	G3	9.88	10.77	9.88				10.71
S_2	G1	6.01	3.81	6.01	4.90	G2	5.55	4.40
	G2	4.27	6.60	4.27				4.86
	G3	7.01	6.24	7.01				5.45
S_3	G1	7.63	8.26	7.63	5.80	G3	6.84	7.43
	G2	8.33	4.21	8.33				5.63
	G3	5.28	3.73	5.28				4.35
Effect of foliar fertilization		6.66	6.20	6.66	Minimum significant difference: LSD at 0.05 For salinity: 1.802 For ground fertilization: 1.802 For foliar fertilization: 3.121 For salinity x ground: 3.121 For salinity x foliar: 3.121 For ground x paper: 3.121 For salinity x ground x foliar: 5.406			
salinity x foliar fertilization	S1	7.13	7.66	7.13				
	S2	5.77	5.55	5.77				
	S3	7.08	5.40	7.08				
ground x foliar fertilization	G1	6.49	6.06	6.49				
	G2	6.06	5.64	6.06				
	G3	7.39	6.91	7.39				

The effect of NPK Nano fertilizer on growth indicators
Plant height (cm)

Table (4) shows the effect of salinity and the Nano-complex fertilizer NPK on plant height (cm). It is noted from the table that the levels of salinity and the levels of ground and foliar fertilization had an effect on the character of plant height, as the plant height at the comparison level S1 was 55.26 cm compared to the salinity treatment S_2, which The lowest plant height was recorded at 44.59 cm. As for the effect of ground addition, it is noted that the highest plant height was in the G_3 fertilization treatment, as it reached 51.81 cm, which did not significantly exceed the comparison treatment, which recorded the lowest value of 47.41 cm. As for foliar fertilization, it is noted that the highest height was The plant height was 51.93 cm in the F_1 fertilization treatment (comparison treatment), and the lowest value was in the F_3 treatment, which was 46.59 cm. The bilateral interaction between salinity and ground fertilization in plant height. It is noted from the table that the lowest plant height was 41.67 cm in the comparison treatment S_2G_2, while the highest plant height. It was 58.44 cm in treatment S_1G_3, which was significantly higher than the other treatments. The bilateral interaction between salinity and foliar fertilization also led to the highest height of wheat plants at the comparison level in treatment S_1F_1, which reached 55.67 cm, which was significantly superior to some treatments, and the lowest value in treatment S_2F_3, which reached 40.44 cm. The bilateral interaction between fertilization by ground addition and fertilization by foliar spray increased the plant height in the G_3F_1 treatment and reached 54.89 cm, which was significantly superior to the G_2F_3 treatment, which gave the lowest value and amounted to 45.11 cm. As for the triple interaction between salinity and the levels of ground and foliar fertilization, it was noted that the highest plant height reached 61.33 cm in treatment S1F3, which was significantly superior to some treatments, and the lowest value was in treatment S_2F_3, which reached 36.33 cm. Salinity levels have a clear effect on the height of the plant, as the height of the plant decreases when the salt concentration increases, and thus the efficiency of vital processes decreases. Plant growth requires the expenditure of great energy in order to compensate for all the salt ions, so the efficiency of vital processes decreases, and thus this leads to a decrease in the height characteristic. Plant [24].

The plant's response to ground fertilization and the increase in plant height may be due to an increase in the concentrations of ready-made NPK nutrients in the soil as a result of the ground addition of fertilizer and their effective absorption by the plant roots, which reflects positively on the increase in the activity of the plant's vital processes and thus increases in growth indicators. Including the characteristic of germination [6] [1].

Paper area (cm^2)

The results of Table (5) show the effect of levels of salinity with levels of ground and foliar fertilization with NPK Nano fertilizer on the leaf area cm_2. It is noted from the table that salinity has an effect on this characteristic if the leaf area at (the comparison treatment) reached 7.52 S_1 cm^2 and the lowest value at Treatment S_2 reached 4.90 cm^2.

As for the effect of ground fertilization with Nano fertilizer, it had an effect on the leaf area of wheat plants, as the ground addition of fertilizer caused a significant increase in the leaf area. The highest leaf area of the plant was in treatment G_3, which amounted to 6.84 cm^2 compared to the comparison treatment, which recorded a leaf area of 5.84 cm^2.

As For the effect of foliar spraying, it did not significantly outperform at all levels of spraying, as the highest value was in the comparison treatment F_1 and amounted to 6.66 cm^2, while the lowest value of treatment F_3 was recorded in its leaf area over the rest of

the treatments and amounted to 5.37 cm^2. As for the effect of the bilateral interaction between salinity and land, treatment S1G3 was superior. Significantly over the rest of the treatments and amounted to 10.71 cm^2, with an increase of 88.22% compared to the comparison treatment and amounted to 5.69 cm^2. The bilateral interaction between salinity and foliage recorded the highest value of 7.79 cm^2 in treatment S1F3, and the lowest value reached 3.39 cm^2 in treatment S_2F_3. As for the interaction between the two methods of ground and foliar addition the highest value was 7.39 cm^2 in treatment G_3F_1, which was significantly superior to some treatments, and the lowest value was in treatment G_2F_3, which amounted to 4.92 cm^2. The three-way interaction between salinity levels and levels of ground and foliar addition shows that the highest value was in treatment $S_1G_3F_3$, which amounted to 11.49 cm^2, surpassing most treatments. It was also significantly higher in the comparison treatment $S_1G_1F_1$, with an increase rate of 182.85%, and the lowest value was in the treatment $S_3G_3F_2$, which amounted to 3.73 cm^2. The increase in leaf area when adding non-salt compared soil with levels of ground and Nano fertilization in both ground and foliar application methods may be due to the high speed with which the Nano fertilizer particles penetrate the plant tissues and thus enter into vital processes, which in turn leads to improving plant growth and increasing the area. Paper, and this result agreed with the findings of [4] [23] [5].

Reference

1. Al-Ajili, Amra Abdel-Rahim Abbou (2021). The effect of Nanofertilizer N20 P20 K20 and the method of addition on the growth and yield of two varieties of potatoes, Solanum tuberosum L.. Master's thesis. College of Agriculture and Forestry. Iraq.

2. Al-Araji, Hawraa Talal Mohsen (2019). The effect of Nano-fertilizers of zinc oxide and humic acid on the processing efficiency of zinc and phosphorus and the growth of yellow maize (L. mays (Zea), Master's thesis, College of Agricultural Engineering Sciences, University of Baghdad, Iraq.

3. Al-Morsi, Al-Sayyid Ahmed, and Nader Nour El-Din Muhammad Ramadan (2015). Land Reclamation. Faculty of Agriculture, Cairo University. https://pdf.usaid.gov/pdf_docs/PA00KPVG.pdf

4. Al-Hassan, Muhammad Fawzi Hamza (2011). Understanding the branching mechanism in several varieties of bread wheat, Triticum aestivum L. The effect of seed rate and nitrogen level and its relationship to grain yield and its components. Doctoral dissertation. faculty of Agriculture. Baghdad University. https://www.researchgate.net/publication/370166255

5. Al-Saeedan, Khudair Jouda Yasser (2019). The effect of fractionation of mineral and Nano-fertilizers (P, N) and the stages of their addition on the stages of growth, yield and its components for two varieties of wheat, Triticum aestivum L, field crops section. faculty of Agriculture. Al-Muthanna University.

6. Al-Akabi, Saad Ali Hussein (2016). The effect of ground fertilization and foliar feeding with NPK fertilizer on the growth and yield of yellow maize plants. Master Thesis. Department of biology. College of Education for Pure Sciences. Diyala University.

7. Al-Hassan, Muhammad Fawzi Hamza (2011). Understanding the branching mechanism in several varieties of bread wheat, Triticum aestivum L. The effect of seed rate and nitrogen level and its relationship to grain yield and its components. Doctoral dissertation. faculty of Agriculture. Baghdad University.

8. Agrawal, S., & Rathore, P. (2014). Nanotechnology pros and cons to agriculture: a review. *Int J Curr Microbiol App Sci*, *3*(3), 43-55.

9. Costa, M. F., & Barletta, M. (2015). Microplastics in coastal and marine environments of the western tropical and sub-tropical Atlantic Ocean. *Environmental Science: Processes & Impacts*, *17*(11), 1868-1879.Rengasamy p.,;(2018). Irrigation water quality and soil structural stability: a perspective with some new insights. Peer-reviewed version available Agronomy . 8-72. https://pubs.rsc.org/en/content/articlelanding/2015/em/c5em00158g.

10. FAO.;(1974).The Euqhrates pilot irrigation project.Methodds of Soil Anlysis, Gadeb Soil Laboratory (A laboratory manual). Food and AgricutureOrganization, Rome , Italy.

11. FAO.;(2008).Harmoized World Soil Database(version 1.0) .Rome Italy and Iiasa , Laxenburg, Austria.

12. Farzamian, M., Paz, M. C., Paz, A. M., Castanheira, N. L., Gonçalves, M. C., Monteiro Santos, F. A., & Triantafilis, J. (2019). Mapping soil salinity using electromagnetic conductivity imaging—A comparison of regional and location-specific calibrations. *Land Degradation & Development*, *30*(12), 1393-1406. https://www.researchgate.net/publication/332322813

13. Gee,A.L.; and G . w. Bauder (1986) partical size analysis InA,Klute (ed) Method of Soil Anlysis , Part (1) ,physical method ,Madison ,Soil Sci .Soc. Am and Am.Soc. of Agronomy. https://www.scirp.org/reference/ReferencesPapers?ReferenceID=1898399

14. Golovina, N. B., & Kustov, L. M. (2013). Toxicity of metal Nanoparticles with a focus on silver. *Mendeleev Communications*, *2*(23), 59-65. https://www.sciencedirect.com/science/article/abs/pii/S095994361300031X

15. Kheir, A.S.; Abou elsoud, H.M.; Hafez, E.M.; Ali, O.A.(2019) Integrated effect of nano-Zn, nano-Si, and drainage using crop straw-filled ditches on saline sodic soil properties and rice productivity. Arab. J. Geosci. 2019, 12, 471.

16. Kovda, V.A.; (1973) . Irrigations, Drainage and Salinity An International Source Book. FAO. https://www.fao.org/4/x5870e/x5870e04.htm

17. Klute, A.; R. C. Dinauer; D. R. Buxton and J.J. Mortvedt (1986). Methods of soil analysis, Aaron, (part1), Madison, Wisconsin, USA. Aaron., (part1), Madison, Wisconsin, USA. https://www.scirp.org/reference/referencespapers?referenceid=267539

18. Leppert, R.H.; and R.L. Suarez (1996). Carbonate and Gypsum. In Bartels (ed.), Methods of Soil Analysis Chemical Methods, Soil Sci Soc. Am. And Am. Soc. of Agronomy, Madison, Wisconsin.

19. Osman, K.T.; (2018). Saline and Sodic Soils, in: Osman, K.T. (Ed.), Management of Soil Problems. Springer International Publishing, Cham, pp. 255–298.

20. Rowell, D.L.; (1996).Soil science methods and application. Welsy, Longman, London.

21. Romero, R., Mazor, M., Munoz, H., Gomez, R., Galasso, M., & Sherer, D. M. (1994). The preterm labor syndrome. *Annals of the New York Academy of Sciences-Paper Edition*, *734*, 414-429. https://www.scirp.org/reference/referencespapers?referenceid=1959165

22. Salem, S. J and Ali, N. S. (2017). Directory of chemical analyzes of soil, water, plants and fertilizers, Ministry of Higher Education and Scientific Research, University of Baghdad - College of Agriculture.

23. Sabir, S.M. Arshad and S.K. Chaudhar.(2014) Zinc oxide Nanoparticles for revolutionizing agriculture: synthesis and applications The Scientific World Journal, 1-8. https://onlinelibrary.wiley.com/doi/full/10.1155/2014/925494

24. Shaheen, Reda Ragab, Mohamed Ibrahim Desouki (2010). Land Chemistry. Faculty of Agriculture. Cairo University.

25. Suppan, S. (2013). Nanomaterials in soil: our future food chain? Minneapolis, MN: Institute for Agriculture and Trade Policy.

26. Tandon, T.L.S.; (1999). Methods of Analysis of soil, plant, water and Fertilizers. Fertilizer development and consultation organization New Delhi, India.

27. Tester, M., & Davenport, R. (2003). Na+ tolerance and Na+ transport in higher plants. Annals of botany, 91(5), 503-527.Munns, R., & Termaat, A. (1986). Whole-plant responses to salinity. *Functional Plant Biology*, *13*(1), 143-160. https://www.scirp.org/reference/referencespapers?referenceid=1742485

28. Zakharina, G. V.; (1963). Proplem concerning the classification of natural water and solution. Sov. Soil. Sci. 4: 351-365.