Egypt. J. Chem. **Vol. 66**, No. 7 pp. 465 - 477 (2023)

Egyptian Journal of Chemistry

http://ejchem.journals.ekb.eg/

Response of Wheat Plants Grown Under Salinity to Nano Fertilizers Application

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Abstract

In the National Research Center's greenhouse at Dokki, Cairo, Egypt, a pot experiment was carried out. This work designed to explore the effect of nano-fertilizer and potassium citrate on yield and mineral status of wheat plants Gemmaza 12. The main Data were: Spike length and weight, No of spikes/plant and 1000 grain weight (seed index) decreased with the increase in salt stress. Also spike eight/plants showed approximately the same response. Total weight, plant height, yield and yields traits i.e No of spikes , grain weight/spike, seed index (1000 grain weight), spike weight /plant and grains weight /plant increased by both potassium citrate and nano-fertilizers in comparable with the control plants. While grains of spike increased by potassium citrate more than nano-fertilizer but the differences in spikes length did not reach the level of significant. Under fresh water treatment, yield and yield traits except spike length increased by both chemical treatments but the increment with nano-fertilizer more than that with potassium citrate but on reverse spike length decreased by both foliar treatments. The increment in grain of spike with potassium citrate was more than that of nano-fertilizers. However, grains/plant the increment seemed to be equal. Both sprayed materials improved yield and most of yield attributes under salinity caused an increase in N and Mg%, but it caused a drop in K, Mn, and Zn% when the salinity of irrigation water increased. Fe content, however, only dropped at the first salinity level. The weight of grains was significantly impacted by the combination of salt stress and either nano or potassium citrate fertilizer.

Keywords: Wheat (Triticum aestavum L.)-Salinity-nano fertilizer-Potassium citrate-yield-Yield components-Nutrients status.

Introduction

The process of grain germination and plant vigour as well as productivity are affected by salinity, which is one of the factors affecting crop productivity as a result of the use brackish water in many irrigated areas in most parts of the world, as it leads to damage to large areas of land by salinity, as the world loses annually the equivalent of 1.5 million hectares Because of high salinity [1], However, a lot of artificial inputs are needed for the majority of the primary crops that are farmed. Although most traditional fertilizers have low nutrient utilization and uptake efficiency, plants nonetheless absorb nutrients from them. Therefore, Nano fertilizers are engineered to be target oriented and not easily lost **[2]**. Wheat (*Triticum aestivum* L.) is consider one of the winter grain crops that occupies the first place in food commodities for consumers because it contains 25-50% of the energy and protein that needs by adults, which has an economic role in food security because it contains salt, vitamins and amino acids **[3]**. Moreover, is considered as the first strategically crop in the world and in Egypt.

Benzon, [4] reported that as a result of using high-productivity varieties require large quantities of inorganic fertilizers, where fertilizers play a role, which increases production and improves its quality.

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Received date 29 December 2021; revised date 21 September 2022; accepted date 31 October 2022
DOI: 10.21608/EJCHEM.2022.113651.5162

According to **Liu and Lal,** [5], nano fertilisers are materials that have a single unit between 1 and 100 nm that contain one or more nutrients to promote growth and yield. Some studies have proven the importance of these fertilizers, as they include some beneficial effects to increase the efficiency use of nutrients, improve productivity, and reduce soil pollution **[6]**. Since nano fertilisers are smaller than plant cell walls (5–20 nm), they are easier to absorb and enter directly into plant cells, which is why they are so important for enhancing crop growth and development. Still, no study has disproved phenolic compounds and phytochemicals **[7,8,9]**. Potassium (K) has an effective effect in many vital activities of the plant such as cell division and also plays an important role in the stages of growth as it increases the activity of many enzymes in carbohydrate metabolism, and also works to increase the nutritional value of the plant and improve the quality of the crop and increase production **[10]**.

According to **Aguilar-Garcia [8],** citric acid (CA) is an intermediary of the tricarboxylic acid cycle (TCA) that provides the carbon skeleton and cellular energy needed for the respiratory cycle and other metabolic pathways. Salt stress is linked to the enzyme carbonic anhydrase **[11]**.

Thus, the goal of this investigation is to assess how wheat plants react to potassium citrate and nano fertilisation under salt conditions.

MATERIALS AND METHODS

A pot experiment was conducted in the greenhouse of the National Research Centre, Dokki, Cairo, Egypt. Wheat (*Triticum aestavim* L.) seeds var. Gemmeza 12 was sown at November, 15 (winter season of 2019/2020). Calcium super phosphate (15.5 % P_2O_5) and potassium sulphate (48.5% K_2O) were added before sowing (1.5g/pot) from each. Ammonium nitrate (33.5 % N) added in the rate of 2 g/pot in two equal portions, the 1st at 21 days and the second at 36 days after sowing. The experiment included 9 treatments which were the interaction between salinity (3 levels) and fertilizers application (nano N, P and potassium citrate 9KV). The salinity treatments were started three weeks after sowing till harvest. Plants were sprayed with 100and 200 ppm nano N and P fertilizer at three and fifth weeks after sowing and the control plants were spray by distilled water. Analysis of soil and water used are illustrated in (Table 1).

Table (1): Physico-chemical characteristics of the experimental soil

Variable	2019/2020		Methods used for preparation evaluation and analysis
Texture	Clay Loam		measured by hydrometer method **[12]**
pH	8.37	H	measured by pH meter **[13]**
EC ds/m	2.01	vH	measured by conductivity meter **[13]**
Calcium Carbonate %	1.16	L	measured by calcimeter **[12]**
Organic Matter %	0.37	vL	determined by Walkly and Black method **[12]**
K (mg/100g soil)	7.40	vL	(**NH_4OAC-Extractable**) and measured using Flame photometer **[14]**
Ca	240	H	
Mg	1.83	vL	
Fe	2.1	vL	**(DTPA-Extractable)** and measured using Atomic absorption **[15]**
Mn (ppm)	3.8	vL	
Zn	3.2	L	
Cu	0.9	M	

vL= Very Low, L = Low, M = Moderate, H = High, v H = Very High **[16]**

Grains from two plants picked from every treatment with three replicates, cleaned, washed, dried in an electric oven at 70 C and ground with stainless steel mill. The determinations of nutrients were done as the methods described by **Cottenie, [17]**.

Statistical analysis was done as the methods described by **Snedecor and Chocran [18]**.

RESULTS AND DISCUSSION

1. Growth Yield and yield Components

1.1 Salinity

Data illustrated in (Table 2) indicated that, Spike length and weight, No of spikes/plant and 1000 grain weight (seed index) decreased with the increase in salt stress. Also spike weight/plants showed approximately the same response. Spike and grains weight/plant considerably decreased with salt stress. In this regard, yield and yield traits at low salt concentrations, yields are mildly affected or not affected at all **[19]**. Productivity of most crops and plants decreases as a result of the increase in the concentration of salts, whether in soil or irrigation water, and their growth decreases or does not grow in the presence of high concentrations of sodium chloride around 100-200 ml The reason is that they have evolved under conditions of low soil salinity and do not display salt tolerance **[20]**. The harmful effects of high salinity on plants occur as a result of several factors, including a change in the processes of photosynthesis and a reduction in cell division, water stress as well as oxidative stress **[21,22]**, where all of these factors reduce plant growth, development and survival, which result in the death of plants or a decrease in their productivity **[23,24]**.

On another words, salinity affected plant growth through different effects in metabolic processes. Disturbance of osmotic potential and water absorption **[25];** changes in mineral status as in this work **[26,27];** photosynthesis and carbohydrate accumulation **[28];** protein building **[29];** inhibition of enzyme activity **[30]**; oxidative defense disturbance **[28,31];** and disruption of protein building **[29]. Hussein [26]** mentioned that the increase in the concentration of salts leads to a decrease in the dry matter of stems and spikes, but there were no significant differences in the dry weight of the leaves as well as the vegetative parts. **Hussein, [27]** reported that the dry weight of the leaves increases with the increase of salt concentration up to 500 ppm and after that tends to decrease to become equal to the control.

Table (2): Effects of salt stress on growth, yield and yield components of wheat plants.

	Total Weight /plant (g)	Plant Height (cm)	No of Spike / plant	Spike length (cm)	Spike Weight (g)	G.W. of Spikes (g)	1000 Grains weight (g)	Spike Weight (g/plant)	Grains weight (g/plant)
S_0	37.61	70.17	10.56	9.23	21.86	15.109	55.1	231.4	160.5
S_1	34.66	71.38	9.11	9.31	19.45	14.500	42.7	179.3	133.5
S_2	35.12	68.60	9.67	8.86	19.66	13.332	40.4	193.2	129.3
$LSD_{0.05}$	**1.2**	**0.98**	**1.11**	**0.66**	**1.6**	**0.95**	**0.26**	**31.9**	**21.05**

S_0= distilled water, **S_1=** 2000 ppm, **S_2=** 4000 ppm

1.2 Nano fertilizer

Examination of Data in Table (3) revealed that total weight, plant height and yield and yields traits i.e. No of spikes, weight, grain weight/spike, seed index (1000 grains weight), spike weight /plant and grains weight /plant increased by both potassium citrate and nano fertilizers in comparable with the control plants. While grains of spike increased by potassium citrate more than nano fertilizer while the differences in spikes length did not reach the level of significant.

Nano fertilizers application promoted the growth, development, TPC, and antioxidant activity in rice, demonstrating the potential to improve crop production and plant nutrition. **Liu and Lal [5]** used synthesized NPs and found that the chlorophyll increased. Increases of chlorophyll and its sufficiency help to produce more photovoltaic compounds responsible for the growth and development of plants. **Benzon, [4]** showed significant effect when application of conventional fertilizers and its combination with nano fertilizer on number of reproductive tillers, number of panicles, and total number of grains .This may be attributed to the effect on source to sink **[32]** concluded that nano fertilizer may have effect these processes through its nutrients transportation capacity in terms of penetration and movement of a wide range of nutrients from root uptake to foliage penetration and movements within the plants. **Benzon, [4]** also added that nano-fertilizer improved the antioxidant activity of rice plants. **Hussein, [26]** found that on wheat plants nano-fertilizer had significant effect on spikes and top dry matter in dry weight of stem and leaves not great enough to reach the level of significant. Spike weight increased by 19.15 and 39.36% and in top dry weight it was increased by 19.27 and 27.75%, respectively compare to the control ones when nano-fertilizer sprayed by 1 and 2 concentrations. **Hussein and Abu Bakr [33]** observed that, with the exception of root dry weight and T/R ratio, the measured growth coefficients rose as nano-form zinc concentration increased. The application of 100 ppm nano zinc oxide resulted in maximum root dry weight. When 200 ppm of nano-Zn was used which was greater than the control, the T/R ratio tended to grow greatly and declined with the initial nano-Zn concentration. When compared to the plants receiving distilled water (NZn0), the apparent improvements in growth metrics, such as stem, leaf, almond, and whole plant DW, were seen with increases in nano-fertilizer rates to the greatest level (NZn2).

1.3 Potassium citrate

Citric acid is an essential organic acid, but citrate complex is one of the mobile forms of iron that helps plants carry iron throughout. Furthermore, it has been shown that the complex raises the amount of chlorophyll and vaseli in plants **[34]**, which has an impact on photosynthesis and the accumulation of carbohydrates. When compared to control plants, plants treated with citric acid showed considerably reduced lipid peroxidation and electrolyte leakage **[35].**

When compared to potassium chloride, potassium sulfate had a more favorable impact on the antioxidant activities, polyphenol, flavonoid, carotenoid, and chlorophyll concentrations; nevertheless, its contribution was not as significant as it was for the plants that were not sprayed with fertilizer **[28]**. Results obtained by **Noaemba, [36]** showed that the concentration of potassium nano fertilizer in the foliar fertilizer solution significantly increased the biological yield, with the higher concentration K2 giving the highest mean average of 14533 kg. ha-1 and the control treatment K0 giving 12452 kg. ha-1. The increase in biological yield may have been caused by a rise in plant height (Table 3), as well as an increase in grain yield, which positively correlated with the increase in biological yield **[37]**. Because potassium competes with sodium to bind and maintain plant water status, it helps plants tolerate salinity **[38]**.

Table (3): Effects of Potassium Citrate and Nano Nitrogen &Phosphorus on growth, yield and yield components.

	Total Weight /plant (g)	Plant Height (cm)	No of Spike / plant	Spike length (cm)	Spike Weight (g)	G.W. of Spikes (g)	1000 Grains weight (g)	Spike Weight (g/plant)	Grains weight (g/plant)
Control	29.31	64.63	8.44	8.66	18.83	12.27	38.88	160.39	103.79
Potassium Citrate	35.32	71.93	9.22	9.36	20.18	15.74	46.51	186.68	146.12
Nano N+P	42.76	73.59	11.67	9.38	21.96	14.93	52.82	256.86	173.47
LSD $_{0.05}$	**0.77**	**0.69**	**0.7**	**n.s**	**0.72**	**0.74**	**0.51**	**17.2**	**11.5**

1.4 Interaction

It is clearly shown in Table (4) that under fresh water treatment, yield and traits except spike length increased by both chemical treatments but the increment with nano fertilizer more than that with potassium citrate but on reverse spike length decreased by both foliar treatments. The increment in grain of spike with potassium citrate was more than that of nano fertilizers. while the increment of grains/plant seemed to be equal. Under the 2500ppm all recorded parameters of the yield and yield attribute gave approximately the same responses. Meanwhile, also most measured of parameters responded similarly with foliar fertilizers as under the moderate salinity or control plants. Nevertheless, weight of grains/spike showed higher values with potassium citrate.

As salinity decreased chlorophyll **[39]** in contrast nano fertilizers improved it,**Taiz and Zeiger [32]** stated that the maturation of leaves was accompanied by a large number of functional and anatomical and anatomical changes resulting in a reversal from importing to exporting. They added that nano fertilizer may have these processes through its transportation in term of penetration capabilities in term of penetration and movements within the plant systems. These reactions affect the accumulation of dry matter in different plant organs and this intern affected yield and its attributes.

Hussein, [26] reported that top and spikes dry weight increased with increasing nano fertilizer concentration spraying under saline irrigation or tap water irrigation except for top under moderate salinity which the highest value with 100 ppm fertilizer spraying. Application of N nano particles with 100 ppm increased spikes weight by: 13.75, 17.83 and 43.87 % while when nano fertilizer applied with 200 ppm it was increased by: 22.74, 28.32 and 89.89 % compare to the control, under, fresh water, moderate salinity or high salinity, respectively. Furthermore, **Hussein [26]** reported that adding nano-zinc under 20% diluted saltwater treatment is more effective than 10% freshwater irrigation on the entire dry mass of the plant. Even with the negligible variations, applying nano-fertilizer at varying salinity levels increased the dry weight (DW) and total dry mass of several cotton plants. The interaction S0 × NZn2 provided the greatest values of all the observed growth parameters, with the exception of root and stem dry weight, which was created by the second interaction S1 × NZn1 and S1 × NZn2.

Citric acid mitigates the harmful effects of heat stress by improving plant growth under stress conditions in addition to reducing chloride content, Fv/Fm, SOD, POD, CAT and roots activity of plants treated with citric acid **[35]**.

According to data gathered by **Hussein, [27]**, sugar beet yield when citric acid or citric acid + algal extraction were used, but the rise was greater when citric acid + algal extraction was used in combination. With the first salinity treatment, the weight of the leaves/plant grew, and with the second, it tended to decrease. Regarding the R/L and R/Whole dry weight of plants, the opposite was true. Furthermore, compared to the control, the pretreatment of seeds with CA resulted in an increase in the dry weight, shoot length, vigor, and chlorophyll content of the seedlings. Salinity stress caused a sharp rise in the activity of the enzymes catalase, proline dehydrogenase, and ascorbate oxidase. Moreover, at a NaCl rate of 2000 ppm, the greatest concentrations of proline dehydrogenase and catalase were seen in conjunction with citric acid. They came to the conclusion that soaking seeds in 100 ppm CA greatly lessens the negative effects of salt and enhances every measurable parameter **[35]**.

Table (4): Effect of interaction between potassium citrate, nano PK and salinity on growth, yield and yield traits of wheat plants.

		Total Weight / plant (g)	Plant Height (cm)	No of Spike / plant	Spike length (cm)	Spike Weight (g)	G.W. of Spikes (g)	1000 Grains weight (g)	Spike Weight (g/plant)	Grains weight (g/plant)
S_0	**Control**	34.2	68.7	9.3	9.8	21.7	13.1	49.67	202.1	122.7
	K.C	37.3	70.6	10.7	8.9	20.7	16.8	53.60	220.9	179.2
	Nano+N+P	41.3	71.3	11.7	9.0	23.2	15.4	62.00	271.1	179.7
S_1	**Control**	27.2	67.7	8.0	8.6	18.0	12.9	35.27	144.7	102.8
	K.C	33.8	71.8	8.3	9.3	19.5	14.6	44.43	162.7	121.4
	Nano+N+P	43.0	74.6	11.0	10.0	20.9	16.1	48.37	230.6	176.4
S_2	**Control**	26.6	57.5	8.0	7.6	16.8	10.8	31.70	134.5	85.9
	K.C	34.8	73.4	8.67	9.8	20.4	15.9	41.50	176.4	137.8
	Nano+N+P	44.0	74.9	12.3	9.10	21.8	13.3	48.10	268.9	164.3
LSD $_{0.05}$		**1.33**	**1.20**	**1.21**	**0.67**	**1.24**	**1.28**	**0.89**	**n.s**	**19.96**

S_0= distilled water, **S_1**= 2000 ppm, **S_2**= 4000 ppm**, K.C = Potassium Citrate**

2. Mineral status

2.1 Salinity

Data in Table (5) indicated that salinity led to decrease K, Mg, and Zn concentration but increased Na P and Cl. However Mn and Fe did not showed any clear response.

As Na concentration in the root media in wheat plants, Na% in grains increased, also N, Fe, and Cu concentrations in grains increased up to the highest salt concentration used. P and Mn concentration were increased and then decreased with the 2nd concentration used. However, K concentration was decrease by the 1st level of salinity and tended to increase by the 2nd level of salinity (500ppm) but still less than the control **[40,26]**.

Hussein, *et al*., [27] revealed that the content of N, P, K, and Fe in fooder beet leaves dropped with increasing salt. Conversely, increasing the quantity of salts in plant root medium led to a rise in Ca, Na, Mn, and Cu concentrations. Concentration of Mg and Zn %, meanwhile, show a minor impact.

Table (5) Effect of salt stress on nutrients status of wheat grains.

	N	P	K	Ca	Mg	Na	Cl	Fe	Mn	Zn
	(%)							(ppm)		
S_0	2.44	0.37	0.73	0.84	0.30	0.031	1.91	100.2	45.0	26.9
S_1	2.29	0.30	0.70	0.81	0.26	0.032	1.95	103.8	46.2	29.5
S_2	2.31	0.48	0.66	0.71	0.28	0.052	1.95	99.9	45.8	25.6
LSD 0.05	**0.08**	**0.01**	**n.s**	**0.08**	**0.01**	**0.001**	**0.003**	**2.9**	**0.53**	**0.61**

S_0= distilled water, **S_1**= 2000 ppm, **S_2**= 4000 ppm

2.2 Nano fertilizer

Data in Table (6) revealed that Na and Mg concentration decreased with potassium citrate or nano fertilizer but N, P, K and Zn reversely responded. However, Ca and Fe showed its lower concentration by potassium citrate compared with those received nano fertilizer or distilled water. Meanwhile, on wheat plants, application of the 1st level of nano nitrogen (100ppm) showed the highest values of all macro and micro nutrients concentrations in grains except that of N, Zn and Mn ppm compared to control or the highest level of fertilizer. The concentration of N and Zn increased with increasing in the fertilizer concentration but for Mn concentration, no difference between that from the 1st level of fertilizer or that sprayed by distilled water. However, there is clear depression when the 2nd level of fertilizer spraying than the control treatment **[26].**

Table (6) Effect of potassium citrate and nano nitrogen & phosphorus on nutrient status of wheat grains.

	N	P	K	Ca	Mg	Na	Cl	Fe	Mn	Zn
	(%)							(ppm)		
Control	2.16	0.32	0.65	0.74	0.29	0.040	1.89	97.50	44.89	26.05
Potassium Citrate	2.32	0.40	0.69	0.69	0.28	0.038	1.85	93.60	44.44	26.15
Nano N+P	2.57	0.42	0.75	0.94	0.27	0.037	2.06	112.80	47.67	29.80
LSD 0.05	**0.08**	**0.03**	**0.03**	**0.04**	**0.01**	**0.001**	**0.02**	**5.8**	**1.26**	**1.06**

Hussein, *et al*., [41] found that when Zn nano was sprayed on cotton, the ratios of Na to Ca and K to Ca reduced without appreciable variations in application rates. However, the ratio of Ca to (K++Na+) decreased. Na:K ratio did not affect by nano Zn application; meanwhile, **Hussein and Abu Bakr [33]** demonstrated that the value of K:Na; Ca:Na and Ca:(Na+K) ratios in leaves of cotton gave their higher or similar values with the 1st nano P concentration (100 ppm) compared with the second level (200 ppm). The reverse was true with that of the branches. **Hussein, *et al*. [27]** showed that Na:K and Na:P ratios decreased with the first concentration of nano nitrogen (100 ppm) and tended to increase with second concentration of nano particles (200 ppm). Moreover, Na:Mg and Ca:(Na+K) ratios decreased as the concentration of nano nitrogen spraying increased but the reverse was true for Na:Ca ratio which the values of this ratio increased as the level of N nano fertilizer increased up to the highest level used compare to that in seeds of untreated plants. Meanwhile, the

Na:N ratio seemed to be without effect with the two levels of fertilizer.

Fleischer, *et al*. [42] concluded that cell wall of plants acts as a barrier for easy entry of several external agent including nano particles into plant cells. The pore diameter was used to determine the sieving properties of cell wall which ranging from 5 to 50 nm. Hence, nano particle aggregates or only nano particles with diameter less than the cells wall pore diameter could easily pass through and reach the plasma membrane (Navarro et al 2008). There is also a chance for induction of new cell wall pores or enlargement of pores upon interaction with engineered nano particles which in turn enhance the uptake of nano particle **[43]**.

Abd El-Aziz, *et al*. [9] showed that nano particles as chitosan-NPK enter in the stomata are translocate in the phloem system. The phloem consists of living vascular tissues that translocate photosynthetic products including sucrose, proteins and some mineral ions for plant growth **[44]**. The nano particles are carried in the flow of sugar through the phloem sieve tubes to root and shoots as a result of pressure different between source and sink based on pressure flow hypothesis or mass flow, which explains the found of chitosan-NPK nano particles inside the tissue of phloem wheat plants and their absence in the xylem tissue. The observed results indicate that phloem tissue is the main and unique pathway for translocation of nano particles and in consequence, sport the penetration of plant leaves and lead to a strong support to the observed changes in growth, development and life span of wheat plants affected by nano-NPK fertilizers. **Hussein and Abu Bakr [34]** reported that using nano fertilizers led to clearly increase the concentration of nitrogen, potassium, calcium and zinc, while phosphorous increased slightly with the first treatment NZn1 and decreased sharply with NZn2 due to the antagonism between phosphorous and zinc.

2.3 Potassium Citrate

Both antioxidant treatments raised the concentrations of P and Cu, but the benefits of CA + algal extract outweighed the benefits of CA alone. Both the CA treatment and the Citric acid + algal extract raised the amounts of Na and Mn; however, the rise from CA was more than the combined effect of both. K concentration showed the opposite pattern, but Fe, Zn, and Mg had marginal effects. While N increased when CA was applied and tended to decrease when Citric acid + algal extract was applied, Ca dropped by CA and tended to rise by Citric acid + algal extract **[27]**.

Also, Hussein, *et al*., [45] showed that the rise in K concentration followed the rise in K fertilizer applied topically to plants. All other nutrients that were identified for this study, however, did not exhibit any discernible effects. The content of jatropha leaves of nitrogen, phosphorous and potassium increased by increasing the concentration of potassium treatments up to 200 ppm as compared with the control, and potassium treatments showed an equal effect on the content of sodium and calcium.

2.4 Interaction

Although the application of nanotechnology is in its early stages in agriculture, this technology has the potential to bring about a change in agricultural systems with regard to the use of fertilizers. It enhances the applications of nanotechnology in agriculture to improve crop productivity, and therefore the results of this research will be useful for other research in the application of nanotechnology in agriculture **[4]**.

Data on wheat obtained by **Hussein, *et al*.[26]** showed that under fresh water treatment, the highest percentages of P, K, Na,Ca, Mg, and Cu in wheat grains were by spraying the nano N fertilizer in the rate of 100 ppm/L while N, Zn, Mn and Fe concentration were by 200 ppm level. However, under the moderate level of salinity, the P,Ca, Mn, Na and Fe high concentration by the first concentration of nano fertilizer but for Zn, Mn and Cu it was by the highest level of fertilizer (200 ppm). Also it is clear from Data of the same Table, the highest concentration of macro and micronutrients were by application of 100 ppm nano nitrogen except for Mg and Mn it was by 200 ppm nano fertilizer used when plants irrigated by water contains 5000 ppm salts.

Table (7): Effect of interaction between potassium citrate and nano-nitrogen & phosphorus on nutrient status of wheat grains.

		N	P	K	Ca	Mg	Na	Cl	Fe	Mn	Zn	Na / Ca	Na / K	Ca/ (Na+K)
		(%)						(ppm)						
S_0	Control	2.20	0.41	0.64	1.07	0.32	0.032	1.82	100.8	45.0	28.7	33.7	20.1	1.60
	K.C	2.43	0.35	0.68	0.68	0.30	0.032	1.80	88.2	41.7	23.3	21.4	21.6	0.95
	Nano+N+P	2.70	0.35	0.88	0.78	0.29	0.029	2.10	111.6	48.3	28.9	27.3	30.8	0.86
S_1	Control	2.17	0.24	0.61	0.70	0.30	0.033	1.9	100.8	45.0	27.0	21.3	18.5	1.09
	K.C	2.27	0.35	0.76	0.70	0.24	0.031	1.99	92.7	46.3	29.1	22.6	24.6	0.89
	Nano+N+P	2.43	0.32	0.72	1.03	0.24	0.031	1.99	117.9	47.3	32.3	33.4	23.3	1.39
S_2	Control	2.10	0.33	0.69	0.45	0.25	0.056	1.97	90.9	44.7	22.5	7.98	12.4	0.60
	K.C	2.27	0.51	0.64	0.68	0.29	0.051	1.77	99.90	45.33	26.10	13.49	12.7	0.99
	Nano+N+P	2.57	0.60	0.64	1.00	0.29	0.051	2.10	108.9	47.3	28.2	19.7	12.7	1.44
$LSD_{0.05}$		**n.s**	**0.04**	**0.05**	**0.07**	**0.02**	**0.002**	**0.04**	**9.97**	**2.18**	**1.84**	**1.81**	**2.57**	**0.11**

S_0= distilled water, **S_1**= 2000 ppm, **S_2**= 4000 ppm**, K.C =** Potassium Citrate

Many investigations were done by: **[46,40,47,48,27]** on the interactive effects of potassium addition under salinity condition. The interaction effects of salinity and nano fertilizer and potassium citrate on nutrient concentration in grains of wheat illustrated in Table (7). Data cleared that all nutrients so macro or micro significantly responded. When wheat plants received tap water the concentration of N, K, Mg, Na and Cl increased by foliar applications while Ca, Fe, Mn and Zn decreased by potassium citrate application and tended to increase by nano fertilizer application. N, P, K, Mn and Zn concentration increased by both sprayed materials but the increment by nano material induced more increment. Mg and Na responded similarly by both chemicals. This previous effects induced under the moderate salinity levels. Furthermore, when salts in irrigation raised to be 5000 ppm, N, P Ca, Na Cl Fe and Zn concentrations showed its higher values by NP nano fertilizer added via leaves compared to plants received either tap water or potassium citrate. Several researches were done by **Hussein, *et al*. [26]**

Hussein and Abu Bakr [33] showed that while salt stress reduced the mineral content and vice versa when treated with nano-zinc, found that the interaction between salinity and nano-fertilizer was significant on the mineral content of cotton leaves except for nitrogen, S2 × NZn0 provided the lowest values of Ca, Na, and Zn contents, whereas S2 × NZn1 produced the lowest values of N, P, and K content. The results of **Hussein, *et al*. [27]** found that the content of N, P, K, and Fe in sugar beet leaves decreases with increasing salt. On the other hand, increasing the quantity of salts in plant root medium led to a rise in Ca, Na, Mn, and Cu concentrations. Meanwhile, Mg and Zn % were slightly affected. The content of macro and micronutrients were decreased parallel to the increase in salt concentration in irrigation solution.

We are only now beginning to understand the complicated role that carboxylic acids play in plants' responses to environmental stressors like CA. The most potent organic anion for phosphorus mobilization in soil is thought to be citrate, which is followed by oxalate and malate **[49].** The creation of stable molecular complexes between carboxylic acids and metallic cations favors the availability and sorption with an increase in plant vigor, which can be used to explain the beneficial effect of these physical-chemical reactions in the roots of wheat, buckwheat, triticale, and legumes **[50]**.

The P+ and K+ shortages in tomatoes **[51]** and cucumbers **[52]** are caused by sodium chloride (NaCl) in the soil. Increasing the K+/Na+ ratio by fertilization is a useful strategy for strengthening plants' resistance to salt stress **[53]**. In sunflower **[54]**, sugar beet **[55]**, eggplant **[56]**, ryegrass **[57]**, tomato **[58,59]**, sunflower **[60]**, and wheat **[61]**, potassium is applied foliarly to lessen the salinity stress in these plants. Potassium applied foliarly increases the plant's potassium content, which helps the plants express membrane potential and potassium ions selectivity when stressed and counteract elevated sodium ion concentrations **[62]. Hussein, *et al*., [45]** highlighted that when plants were watered with mixed drainage water (saline water), the content of minerals grew continuously, with the exception of the N content, as the rate of K concentration in the sprayed solution increased. When it came to the Na ratios, adding K increased the K: Na and Ca:Na ratios under various irrigation conditions, while the Ca:(K+Na) ratio did the reverse. The plants that were routinely watered with fresh water had the greatest K: Na, Ca:(K+Na), and K: Na ratios when 100 ppm K and 200 ppm K were sprayed, respectively.

Heidari and Jamshidi [63] showed that whereas potassium application increased potassium content in millet leaves, salinity inhibited potassium absorption.

CONCLUSION

In view of the above-mentioned results, it appears that the both foliar application of nano fertilizer and potassium citrate had a positive effect on growth and yield parameters as well as plant nutritional status of wheat and these essential nutrients should be used in proper doses for increasing crop production. Generally these findings suggest that the combination of potassium citrate with nano fertilizer increases nutrient concentrations. While salinity enhanced the concentration of N and Mg in irrigation water, it lowered the concentration of K, Mn, and Zn. However, Fe percentage decreased only with the 1st level of salinity, and the interaction effects of either nano or potassium citrate fertilizer and salt stress on grains were significant. Salt stress affected yield and yield attribute. Both of fertilizers affected significantly the yield and yield traits, Application of nano fertilizer and potassium citrate generally improved yield and yield components under salinity condition.

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