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Response of Wheat Plants Grown Under Salinity to Nano Fertilizers Application

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Abstract

A pot experiment was conducted in the greenhouse of the National Research Centre at Dokki, Cairo, Egypt. This work designed to investigate 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 and weight/plants showed approximately the same response. total weight, plant height and yield and yields traits i.e No of spikes , weight, 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 traits except spike length increased by both chemical treatments but the increment with nano-fertilizer more than that with potassium citrate but on reverse length of spike decreased by both foliar treatments. The increment in grain of spike with potassium citrate was more than that of nano-fertilizers. In the case of grains/plant the increment seemed to be equal. Both sprayed materials improved yield and most of yield attributes under salinity. N and Mg % increased by salinity but K, Mn and Zn % decreased with the increase in salt concentration in water of irrigation. However, Fe percentage decreased only with the 1st level of salinity, and that N and Mg % increased by salinity but K, Mn and Zn % decreased with the increase in salt concentration in water of irrigation. The interaction effects of either nano or potassium citrate fertilizer and salt stress on grains were significant.

Keywords: Wheat (*Triticumaestavum* L.)-Salinity-nano fertilizer-Potassium citrate-yield=Yield components-Nutrients status.

1. Introduction

Salinity is one of the most serious factors limiting the productivity of agricultural crops, with adverse effects on germination, plant vigour and crop yield. Salinization affects many irrigated areas mainly due to the use of brackish water. Worldwide, more than 45 million hectares of irrigated land have been damaged by salt, and 1.5 million hectares are taken out of production each year as a result of high salinity levels in the soil (Munns& Tester, 2008) Most of the major crops grown require large quantities of inorganic inputs.Plants absorb nutrients from fertilizers, but most conventional fertilizers have low nutrient use and uptake efficiency. Nanofertilizers are, therefore, engineered to be target oriented and not easily lost (Elemike, et al.,2019).

Wheat (*Triticumaestivum* L.) is one of the winter cereal crops belonging to family of Poaceae, which its important and economic role in food security; as its grains have the first number in list of consumers food commodities because it's give adult persons about 25% and 50% of their energy and protein needs. The sequence in addition to containing some mineral salts, vitamins and amino acids(Saudi, 2017).Also, wheat is considered as the first strategically crop in the world and in Egypt.

Benzon, et al., (2015) reported that fertilizers have an important role in enhancing food production and quality especially after the introduction of high-yielding and fertilizer responsive varieties. Most of

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the major crops grown require large quantities of inorganic inputs.

NMs are defined as materials with a single unit between 1 and 100 nm in size in at least one dimension (Liu and Lal, 2015). Hence, nanofertilizers are either NMs which can supply one or more nutrients to the plants resulting in enhanced growth and yield, or those which facilitate for better performance of conventional fertilizers, without directly providing crops with nutrients (Liu and Lal, 2015). Some studies already proved the significance of nanofertilizers. Some beneficial effects include increase in nutrient use efficiency, better yield and reduced soil pollution (Naderi and Danesh-Sharaki, 2013). The potential contribution of nanofertilizers in improving growth and development of crops lies on its ability for greater absorbance and high reactivity. Nanofertilizers can possibly enter the plant cells directly through the sieve-like cell wall structures if the particle sizes are smaller than the sizes of cell wall pores (5-20 nm). However, no research has refuted phytochemicals and phenolic compounds (Tian et al., 2005; Aguilar-Garcia et al.,2007).

Potassium (K) is one of the major nutrients and important in plant nutrition as it helps plant roots to grow and plays important roles in the stages of growth and reproduction as well as its effective effect in many vital activities such as cell division and expansion and activation of many important enzymes in carbohydrate metabolism, nitrate reduction,pollen tube growth and works to increase the nutritional value of plants increases the seed weight and size as well as improves yield quality and leads to increased production (Malvi, 2011).

Citric acid (CA)is one of the TCA intermediates which serve as the source of carbon skeleton and cellular energy which areutilized in the respiratory cycle and other biochemical pathways (da Silva, 2003). Carbonic anhydrase as a vital organic acid is related to salt stress (Sun and Hong, 2011).Therefore, the objective of this work is to evaluate the response of wheat plants to nano fertilization and potassium citrate under salinity condition.

2. Materials and Methods

A pot experiment conducted in the greenhouse of the National Research Wheat (*Triticumaestavim* 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) in the rate of 1.5 g/pot of each fertilizer were added before sowing. 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 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.

The experiment for study the interaction between salinity and nano nitrogen exogenous application, included 9 treatments, 3 salinity levels and 3 nano nitrogen and phosphorus. The experiment design is split plot design with three replicates. The analysis of soil and water used properties 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 **(Black,1965)**
pH	8.37	H	measured by pH meter **(Jackson,1973)**
EC ds/m	2.01	vH	measured by conductivity meter **(Jackson,1973)**
Calcium Carbonate %	1.16	L	measured by calcimeter **(Black,1965)**
Organic Matter %	0.37	vL	determined by Walkly and Black method **(Black,1965)**
K (mg/100g soil)	7.40	vL	(**NH4OAC-Extractable**) and measured using Flame photometer **(Chapman and Bratt,1978)**
Ca	240	H	
Mg	1.83	vL	
Fe	2.1	vL	(**DTPA-Extractable**) and measured using Atomic absorption **(Lindsay and Norvell,1978)**
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 (Ankerman and Large, 1974)

Grains from two plants picked from every treatment with three replicates, cleaned, washed, dried in an electric oven at 70 ºC and ground with stainless steel mill. The determinations of nutrients were done as the methods described by Cottenie, et al., (1982).

Statistical analysis was done as the methods described by Snedecor and Chocran (1992).

3. Results and Discussion

1. Growth and yield

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 yieldtraits at low salt concentrations, yields are mildly affected or not affected at all (Maggio,et al., 2001). As the salt concentrations increase, the yields move towards zero, since most plants, glycophytes, including most crop plants, will not grow in high concentrations of salt and are severely inhibited or even killed by 100-200 mMNaCl. The reason is that they have evolved under conditions of low soil salinity and do not display salt tolerance (Munns&Termaat, 1986).High salinity affects plants in several ways: water stress, ion toxicity, nutritional disorders, oxidative stress, alteration of metabolic processes, membrane disorganization, reduction of cell division and expansion, genotoxicity(Munns, 2002 and Zhu, 2007). Together, these effects reduce plant growth, development and survival. The detrimental effects of high salinity on plants can be observed at the whole-plant level in terms of plant death and/or decrease in productivity (Parida and Das, 2005 and Carillo, et al., 2011).

Table (2)

Effects of salt stress on yield and attributes of wheat plants

	Total Weight (g)	Plant Height (cm)	No of Spike	Spike length (cm)	Spike Weight (g)	G.W. of Spikes (g)	100 grains weight (g)	1000 Grains weight (g)	Spike Weight/ plant (g/plant)	Grains weight/ plant (g/plant)
S_0	37.61	70.17	10.56	9.23	21.86	15.109	5.51	55.1	231.4	160.5
S_1	34.66	71.38	9.11	9.31	19.45	14.500	4.27	42.7	179.3	133.5
S_2	35.12	68.60	9.67	8.86	19.66	13.332	4.04	40.4	193.2	129.3
$LSD_{0.05}$	**1.2**	**0.98**	**1.11**	**0.66**	**1.6**	**0.95**	**0.03**	**0.26**	**31.9**	**21.05**

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

On another words, salinity affected plant growth through different effects in metabolic processes.Disturbance of water absorption and osmotic potential (Khalil, et al., 2012); Photosynthesis and carbohydrate accumulation (Adhikaria, et al., 2020); protein building (Hussein, et al., 2004); Enzymes activity inhibition (Hussein and El-Greatly,2007); oxidative defense disturbance (Adhikaria, et al., 2020 and Hussein, and Orabi 2008) and changes in mineral status as in this work (Hussein, et al., 2019 and 2020).

Hussein, et al., (2019) showed that dry mater of stem and spikes decreased with the increase in salts concentration up to the highest level used but differences in leaves and vegetative parts dry matter was not significant.Hussein, et al., (2020) reported that Dry weight of leaves increased with 5000ppm salts treatment and tended to decrease to be approximately equal of the control. However, the whole sugar beet plant dry weight did not affect with the first salinity treatment but decreased markedly with the second salinity level.

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.

Benzon, et al., (2015) mentioned that alternatively, a strong positive correlation appeared between TPC and reducing power (94%), as well as ABTS radical scavenging activity (89%). Nanofertilizers application promoted the growth, development, TPC, and antioxidant activity in rice, demonstrating the potential to improve crop production and plant nutrition.Liu and Lal (2015) used synthesized NPs and found that the chlorophyll increased. Increased of chlorophyll whichconsidered is the light harvesting pigment responsible for photosynthesis. Sufficient amount of chlorophyll means greater production of photosynthates responsible for the growth and development of plants. Benzon, et al., (2015) showed significant effect was observed 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(Taiz and Zaigar, 2006) 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, et al., (2015)alsoadded that nano-fertilizer improved the antioxidant activity of rice plants. Hussein, et al., (2019) on wheat plants found thatapplication of nano-fertilizer affected significantly spikes and top dry matter but the differences in dry weight of stem and leaves of wheat plants 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 (2018) observed that the measured growth parameters increased with increasing zinc concentration in the form of nano, except for root dry weight, or T/R ratio. The highest DW of root was obtained by spraying 100 ppmnano-zinc oxide. T/R ratio decreased with the first nano-zinc concentration and tended to increase markedly by using 200 ppmnano-zinc to be clearly more than the control. Pronounced increases in growth parameters, i.e. stem, leaves, bolls and whole plant DW, were shown with the increases in nano-fertilizer rates up to the highest level (NZn_2) compared to plants receiving distilled water (NZn_0).

Table (3)

Effects of Potassium Citrate and Nano Nitrogen &Phosphorus on growth, yield and yield attributes

	Total Weight (g)	**Plant Height (cm)**	**No of Spike**	**Spike length (cm)**	**Spike Weight (g)**	**G.W. of Spikes (g)**	**100 grains weight (g)**	**1000 Grains weight (g)**	**Spike Weight/ plant (g/plant)**	**Grains weight/ plant (g/plant)**
Control	29.31	64.63	8.44	8.66	18.83	12.27	3.89	38.88	160.39	103.79
Potassium Citrate	35.32	71.93	9.22	9.36	20.18	15.74	4.65	46.51	186.68	146.12
Nano N+P	42.76	73.59	11.67	9.38	21.96	14.93	5.28	52.82	256.86	173.47
LSD $_{0.05}$	**0.77**	**0.69**	**0.7**	**n.s**	**0.72**	**0.74**	**0.05**	**0.51**	**17.2**	**11.5**

1.3 Potassium citrate

More than citric acid is a vital organic acid; citrate complex is one of mobile form iron that participates in iron transportationinside plants. Additionally, the complex has been confirmed increase vaseli and chlorophyll content of plants (Darandeh and Hadavi, 2011)and this intern affected photosynthesis and carbohydrate accumulation.Citric acidtreated plants displayed significantly lower electrolyte leakage and lipid peroxidation in comparison with control plants (Hu, et al., 2016).

Potassium sulfate showed better positive effect on the antioxidant activities, polyphenol, flavonoid, carotenoid, and chlorophyll contents compared to those of potassium chloride although the contribution was not noteworthy in comparison to the fertilizer unsprayed plants(Adhilari, et al., 2020).Results obtained by Noaemba, et al., (2020)revealed that the biological yield took a significant increase in its averages with an increase in the potassium Nano fertilizer concentration in foliar fertilizers solution, as the higher concentration K2 gave the highest mean average of 14533 kg.ha-1, while control treatment K0 gave 12452 kg. ha-1, the increase in the biological yield perhaps because of an increase in height of plant (Table 3), also increase in grain yield which reflected positively on the increase in the biological yield, and this result agreed with findings of (Gomaa, et al., 2015). Potassium contributes for tolerance against salinity as it has competing nature to sodium for binding and maintaining plant water status (Capula-Rodríguez et al., 2016).

1.4 Interaction

It is clearly shown from Data 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 morethan that with potassium citrate but on reverse length of spike decreased by both foliar treatments. The increment in grain of spikewith potassium citrate was more than that of nano fertilizers. In the case of grains/plant the increment seemed to be equal. Under the 2500ppm all recorded 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 its higher values with potassium citrate.

As salinity decreased chlorophyll (Hussein, et al.,2014) in contrast nanofertilizers improved it,Taiz and Zeiger (2006) 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 nanofertilizer 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, et al., (2019) reported that top and spikes dry weight increased as the concentration of nanofertilizer 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 in the rate of 100 ppm increased spikes weight by: 13.75, 17.83 and 43.87 % while when nano fertilizer applied at the rate of 200 ppm/L it was increased by: 22.74, 28.32 and 89.89 % compare to that of sprayed by distilled water, under, fresh water, moderate salinity or high salinity, respectively. Also,Hussein, et al., (2019) mentioned that as for the interaction effect between nano-zinc application under two levels of salinity when compared with irrigation with fresh water as a control, it could be stated that the addition of nano-zinc is more effective in the whole plant dry mass under 20% diluted seawater treatment than that of 10% diluted seawater treatment or freshwater irrigation. In spite of the insignificant differences, DW of different cotton plants as well as total dry mass was improved by the application of nano-fertilizer under different salinity levels. The highest values of all the measured growth parameters were produced by the interaction $S_0 \times NZn_2$ except for root and stem dry weight that produced their highest values by the second interaction $S_1 \times NZn_1$ and $S_1 \times NZn_2$.

External citric acid alleviated the detrimental effects of heat stress on tall fescue, which was evidenced by decreased EL and MDA content, and improved plant growth under stress conditions. Additionally, the reduction in Chl content, Fv/Fm, SOD, POD, CAT and root activity were ameliorated in citric acid treated plants under heat stressed condition. These results suggest that exogenous citric acid application may alleviate growth and physiological damage caused by high temperature. In addition, the exogenously applied citric acid might be responsible for maintaining membrane stability, root activity, and activation of antioxidant response and HSP genes which could contribute to the protective roles of citric acid in tall fescue responses to heat stress(Hu, et al., 2016).

Data obtained by Hussein et al., (2020) showed that increased either with citric acid or citric acid + algal extraction but the increment with the combined of citric acid+algal extraction was more than that of citric acid alone. Weight of leaves/plant increased with the 1st salinity treatment and tended to decrease with the second one. The reverse was true for the R/L and R/Whole dry weight of plants. In addition, the pretreatment of seedswith CA induced increase in seedling dry weight,shoot length, seedlings vigor and chlorophyllcontent compared to control. The activities ofcatalase, proline dehydrogenase and ascorbateoxidase enzymes dramatically increased owingto salinity stress. Furthermore, the highestvalues of catalase and proline dehydrogenasewere observed with citric acid, respectivelyat NaCl rate (2000 ppm). This concludedthat pretreatment of seeds with 100ppm, CAas soaking significantly reduces the harmfuleffect of increased salinity and improves all theobserved parameters (Hu, et al., 2016).

Table (4)

Effect of interaction between potassium citrate, nano PK and salinity on growth, yield and yield attributes of wheat plants

		Total Weight (g)	**Plant Height (cm)**	**No of Spike**	**Spike length (cm)**	**Spike Weight (g)**	**G.W. of Spikes (g)**	**100 grains weight (g)**	**1000 Grains weight (g)**	**Spike Weight/ plant (g/plant)**	**Grains weight/ plant (g/plant)**
	Control	34.2	68.7	9.3	9.8	21.7	13.1	4.97	49.67	202.1	122.7

S_0	**K.C**	37.3	70.6	10.7	8.9	20.7	16.8	5.36	53.60	220.9	179.2
	Nano+N+P	41.3	71.3	11.7	9.0	23.2	15.4	6.20	62.00	271.1	179.7
S_1	**Control**	27.2	67.7	8.0	8.6	18.0	12.9	3.53	35.27	144.7	102.8
	K.C	33.8	71.8	8.3	9.3	19.5	14.6	4.44	44.43	162.7	121.4
	Nano+N+P	43.0	74.6	11.0	10.0	20.9	16.1	4.84	48.37	230.6	176.4
S_2	**Control**	26.6	57.5	8.0	7.6	16.8	10.8	3.17	31.70	134.5	85.9
	K.C	34.8	73.4	8.67	9.8	20.4	15.9	4.15	41.50	176.4	137.8
	Nano+N+P	44.0	74.9	12.3	9.10	21.8	13.3	4.81	48.10	268.9	164.3
LSD $_{0.05}$		**1.33**	**1.20**	**1.21**	**0.67**	**1.24**	**1.28**	**0.09**	**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 Na, K, Mg, and Zn concentration but the reverse was true for Na P and Cl. However Mn and Fe in ppm did not showed any clear respons.

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 (El-Diewny, et al., 2013 and ussein, et al., 2019). Hussein, et al., (2020) reported that increased salinity decrease the concentration of N, P, K and Fe in leaves of fooder beet. On the opposite side, Ca Na, Mn and Cu concentrations increased by raising salts concentration in the root media of plants. Meanwhile, Mg and Zn % were slightly affected.

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% and Zn and Mn ppm compared to resulted in the control or the highest level of fertilizer. The concentration of N and Zn concentrations increased as the increase 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 (Hussein, et al., 2019). Hussein, et al., (2015) on cotton, indicated that the ratios Na:Ca and K:Ca decreased with spraying of Zn nano without significant differences within the application rates, but the opposite was true for Ca:(K^++Na^+) ratio. Na:K ratio did not affect by nano Zn application; meanwhile, Hussein and Abu Bakr(2018)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., 2019) 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 nanofertilizer increased up to the highest level used compare to that in seeds of untreated plants. Meanwhile,theNa:N ratio seemed to be without effect with the two levels of fertilizer.

Fleischer,et al., (1999) concluded that cell wall of plants acts as a barrier for easy entry of several external agent including nanoparticles into plant cells. The pore diameter was used to determine the sieving properties of cell wall which ranging from 5 to 50 nm. Hence, nanoparticle aggregates or only nanoparticles 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 nanoparticles which in turn enhance the uptake of nanoparticle (Nair,et al., 2010). Abd El-Aziz, et al., (2016) showed that nanoparticles 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 (Wang,et al., 2013). The nanoparticles 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 nanoparticles 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 nanoparticles 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 (2018) reported that N, K, Ca, Na and Zn concentrations augmented with nano-Zn treatments, while P% slightly increased with NZn1 and sharply decreased with NZn_2. This may be due to the antagonistic effect between P and Zn.

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**

2.3 Potassium Citrate

The concentration of P as well as Cu increased by both antioxidant treatment but the values by the combination of CA and algal extract were more than that of CA alone. Na and Mn increased by CA treatment and Citric acid + algal extract but the increase with CA more than that of the combined between them. The reverse was true of K concentration. Fe, Zn and Mg slightly affected with these treatments. Ca % decreased by CA and tended to increase by Citric acid + algal extract but still more than the control while N% increased by the application of Ca and tended to decrease by Citric acid + algal extract to be less than the control one (Hussein, et al., 2020).

Also, Hussein, et al., (2014) indicated that K concentration increased parallel to the increased of K fertilizer as a spray on foliage. Nevertheless, the all other elements determined in this work did not showed any clear response. The content of P and K content in jatropha leaves increased as the K foliar increased up to 200 ppm. However, both K treatments showed the same effect on the content of Na and Ca but N content increased by application of 100 ppm K fertilizer and tended to decreased to be less than the control treatment.

2.4 Interaction

Application of nanotechnology in agriculture is still in its budding stage. However, it has the potential to revolutionize agricultural systems particularly where the issues on fertilizer applications are concerned. Nano-fertilizer application promoted the growth, development, TPC and antioxidant activity in rice and has the potential to improve crop production and plant nutrition. The outcome of this research would be beneficial for other studies involving the application of nanotechnology in the field of agriculture(Benzon, et al., 2015).Data on wheat obtained by Hussein, et al., (2019) 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/L). Also it is clear from Data of the same Table, the highest concentration of all macro and micronutrients were by application of 100 ppm/L nano nitrogen except for Mg and Mn it was by 200 ppm nano fertilizer used when plants irrigated by water contains 5000 ppm salts. Many investigations were done by: Hussein, et al., (2012); El-Diweny, et al., (2013);Shhabaan, et al., (2010); Abu Talb, et al., (2020)and Hussein, et al., (2020) on the interactive effects of potassium addition under salinity condition. The interaction effect 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 previouseffects 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 and Abu Bakr (2018) showed that the interaction effect of nano-fertilization and salinity on the mineral content of cotton leaves. This interaction significantly affected the content of minerals in leaves except for nitrogen. It is clear that salt stress decreased the content of minerals and vice versa for nano-zinc treatment. The lowest values of N, P and K content were produced by S2 × NZn1, while the lowest values of Ca, Na and Zn contents were produced by S2 × NZn0.It is clear from Data of Hussein, et al., (2020) it can be observed that increased salinity deceases the concentration of N, P, K and Fe in leaves of sugar beet. In the opposite side, Ca Na, Mn and Cu concentrations were increased by raising salts concentration of salts in the root media of plants. Meanwhile, Mg and Zn % were slightly affected. The content of macro and micronutrients content were decreased parallel to the increase in salt concentration inirrigation solution.

The function of carboxylic acids in plant responses to environmental of CA, stress is complex and is just beginning to be understood. Citrate is considered to be the most powerful organic anion, followed by oxalate and malate, to mobilize phosphorous in the soil (Bolan,et al., 1994). The function of carboxylic acids in plant responses to environmental of CA, stress is complex and is just beginning to be understood. Citrate is considered to be the most powerful organic anion, followed by oxalate and malate, to mobilize phosphorous in the soil (Bolan,et al., 1994). The beneficial effect of this physical-chemical reactions in the roots of wheat, buckwheat, triticale and legumes can be interpreted by the formation of stable molecular complexes between carboxylic acids and metallic cations favoring the availability and sorption with an increase in the plant vigor (Yang, et al., 2000). Beneficial effect of these physical-chemical reactions in the roots of wheat, buckwheat, triticale and legumes can be interpreted by the formation of stable molecular complexes between carboxylic acids and metallic cation favoring the availabilityand absorption with an increase in the plant vigor (Yang,et al., 2000).

NaCl concentration in soil induces the P+ and K+ deficiencies in tomato (Adams, 1991) and in cucumber (Sonneveld and De Kreij, 1999). Fertilizing plants with K+ in order to raise the K+/Na+ ratio is an effective way for increasing the plants tolerance against salinity stress (Elhindi, et al., 2016). Foliar application of potassium is carried out to reduce the salinity stress in sunflower (Arshadullahet al., 2014), sugar beet (Zakiet al., 2014), eggplant (Elwan, 2010), ryegrass (Tabatabaei and Fakhrzad, 2008), tomato (Amjadet al., 2014, Kaya et al., 2001), sunflower and endives (Tzortzakis, 2010), and wheat (Bybordi, 2015). Foliar application of potassium supplements the potassium content in the plant due to which the plants, under stress, also express potassium ions selectivity and membrane potential which help to overcome the increased sodium ion concentrations (Duarte et al., 2014).Hussein, et al., 2014) emphasized that the content of estimated minerals showed continuous increases when plants irrigated by mixed drainage water (saline water) as the rate of K concentration increased in the sprayed solution except for N content. For the P, K, Ca and N under fresh water regular irrigation and N content under all irrigation treatments showed its higher values by 100 ppm K treatment. Regarding the Na ratios, addition of K improved the K:Na and Ca:Na ratios under different irrigation treatment while the opposite was truefor Ca:(K+Na) ratio. The highest K:Na ,and Ca:(K+Na) ratios were by spraying 100 ppm K and for Ca:Na by spraying 200 ppm K and plants irrigated regularly by fresh water. However, the lowest values of K:Na, Ca:Na and Ca:(K+Na) were in samples taken from plants without K application and irrigated by %0% mixed water, 25% mixes water and those plants received fresh water, respectively.Heidari and Jamshidi (2011) demonstrated thatsalinity treatment decreased potassium uptake butapplication potassium increased potassium content in leaves of milletat two stages.

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, S1= 2000 ppm, S_2= 4000 ppm, K.C = Potassium Citrate

CONCLUSION

In view of the aforementioned results, it appears that the both foliar application of nanofertilizer and potassium citrate had a positive effect on growth and yield parameters as well as plant nutritional status of wheat crop and these essential nutrients should be used in proper doses for increasing crop production. Generally From these results it can be concluded that nanofertilizer and potassium citrate interaction improves nutrient concentrations, N and Mg % increased by salinity but K, Mn and Zn % decreased with the increase in salt concentration in water of irrigation. 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 all yield and yield and its attribute. Both of fertilizers affected significantly the yield and yield traits, Application of nanofertilizer and potassium citrate generally improved yield and yield components under salinity condition.

REFERENCES

1. Abdel-Aziz, H.M.M.; Hasaneen, M.N.A. and Omer, A.M. (2016). Nano chitosan-NPK fertilizer enhances the growth and productivity of wheat plants grown in sandy soil. Spanish Journal of Agricultural Research, 14(1):e0902. http://dx.doi.org/10.5424/sjar/2016141-8205
2. Abu Talb, N.H.; Hussein, M.M. and El-Ashry, S.M. (2020). Comparison between nano iron and iron EDTA as foliar fertilizers under salt stress conditions. Plant Cell Biotechnology and Molecular Biology, 2 (49-60): 17-32.
3. Adams, P. (1991). Effects of increasing the salinity of the nutrient solution with major nutrients or sodium chloride on the yield, quality and composition of tomatoes grown in rockwool. Journal of Horticultural Science Volume 66, 1991 - Issue 2 https://doi.org/10. 1080/00221589.1991.11516145
4. Adhikari, B.; Dhungana, S.K.; Kimb, II-D. and Shina, DH. (2020). Effect of foliar application of potassium fertilizers on soybean plants under salinity stress. Journal of the Saudi Society of Agricultural Sciences, 19: 261–269.
5. Aguliar-Garcia C; Gavino, G.; Baragaño-Mosqueda, M.;Hevia, P. andGavino V. (2007). Correlation of tocopherol, tocotrienol, γ-oryzanol, and total polyphenol content in rice bran with different antioxidant capacity assays. Food Chemistry, 102: 1228-1232.
6. Amjad, M.; Akhtar, J.,; Haq, M.A.U.; Imran, S. and Jacobsen, S.E. (2014).Soil and foliar application of potassium enhances fruit yield and quality of tomato under salinity Turkish J. Biol., 38 (2): 208-218.
7. Ankerman D. and Large R. (1974). Soil and plant analysis. Tech. Bull. A&L. Agricultural laboratories. Inc., New York, USA. pp. 42-44, 74-76
8. Arshadullah, M.; Ali, A.; S.I. Hyder, S.I.; Mahmood, I.A. and Zaman, B.U. (2014).Effect of different levels of foliar application of potassium on Hysun-33 and Ausigold-4 sunflower (Helianthus annuus L.) cultivars under salt stress. Biol. Sci.-PJSIR, 57 (1): 1-4
9. Benzon, H.R; Rubenecia, R.U.; Ultra, Jr., V.U. et al, (2015). Nano-fertilizer affects the growth, development, and chemical properties of rice. Hiyasmin Rose L. Int. J. Agri. and Agri. Res., 7 (1): 105-117.
10. Black , C.A. (ed.) (1965). Method of Soil Analysis. agronomy, No. 9 , part 2 : Amer. Soc. , Agronomy , Madison , Wisconsin.
11. Bolan, N.S., Naidu, R.; Mahimairaja, S and Baskaran, S. (1994). Influence of low molecular weight organic acids on the solubilization of phosphates. Biology and Fertility of Soils, Italy, 18:311-31.
12. Bybordi, A. (2015). Influence of exogenous application of silicon and potassium on physiological responses, yield, and yield components of salt-stressed wheat. Commun. Soil Sci. Plant Anal., 46 (1): 109-122.
13. Capula-Rodríguez,R.; Valdez-Aguilar, L.A.; Cartmill, D.L.; Cartmill, and I. Alia-Tejacal ,A.n (2016). Supplementary calcium and potassium improve the response of tomato (Solanumlycopersicum L.) to simultaneous alkalinity, salinity, and boron stressCommun. Soil Sci. Plant Anal., 47 (4) (2016), pp. 505-511.
14. Carillo, P.; Annunziata, M.G.; Pontecorve, C.; Fuggi, A. and Woodrow, P. (2011). Salinity stress and salt tolerance. Abiotic Stress in Plants Mechanism and Adaptation. Intecopen.www.intechopen.com.pp:21-38.
15. Chapman H.D. and Pratt P.F. (1978). Methods of analysis for soils, plants and waters. Division of Agric. Sci., Univ. California, Berkeley, USA 309 p.
16. Cottenie, A.; Verlo, M. and Kiekens, L. (1982). Chemical analysis of plants and soils. Lab. of Analytical and Agrtochem, State Univ. Ghent.

Belgium.

17. da Silva J. A. T. (2003). The cut flower: postharvest considerations. J. Biol. Sci., 3 406–442. 10.3923/jbs.2003.406.442.
18. Darandeh, N. and Hedavi, E. (2011). Effect of Pre-Harvest Foliar Application of Citric Acid and Malic Acid on Chlorophyll Content and Post-Harvest Vase Life of Lilium cv. Brunello. Frontiers in Plant Science 2(106):106.https://doi.org/10.3389/fpls.2011.00106
19. Duarte, B.; Sleimi, N. and Caçador, I. (2014).Biophysical and biochemical constraints imposed by salt stress: learning from halophytes. Front. Plant Sci., 5: 746. https://doi.org/10.3389/fpls.2011.00746
20. El-Dewiny; C.Y.; Hussein, M.M. and Awad, F. (2013). Influence of Mono Potassium Phosphate Fertilizer on Mitigate The Negative Effects of High Saline Irrigation Water on Onion Crop. Middle East Journal of Agriculture Research, 3(1): 19-25.
21. Elemike, E.E.; Uzoh, F.M.; Onwudiwe. D.C. and Babalola. O.O. (2019). The Role of Nanotechnology in the Fortification of Plant Nutrients and Improvement of Crop Production. Appl. Sci., 9(3): 499; https://doi.org/10.3390/app9030499
22. Elhindi, K.M.; El-Hendawy, S.; Abdel-Salam, E.; Schmidhalter, U.; Rahman, S.U. and Hassan, A.A. (2016).Foliar application of potassium nitrate affects the growth and photosynthesis in coriander (Coriander sativum L.) plants under salinity Progress in Nutrition, 18 (1) (2016), pp. 63-73
23. Elwan, M.W. (2010).Ameliorative effects of di-potassium hydrogen orthophosphate on salt-stressed eggplant. J. Plant Nutr., 33 (11): 1593-1604.
24. Fleischer, A.; O'Neill, M.A. and Ehwald. R. (1999). The pore size of non-graminaceous plant cell wall is rapidly decreased by borate ester cross-linking of the pectic polysaccharide rhamnogalacturon II. Plant Physiol.,121: 829-838.
25. Gomaa, M.A., Radwan, F.I., Kandil E.E. and El-Zweek S. M.A. (2015). Effect of some macro and micronutrients application methods on productivity and quality of wheat (triticumaestivum, L.). Middle East J. of Agri. Res., 4(1); 1-11.
26. Heidari, M. and Jamshidib, P. (2011). Effects of Salinity and Potassium Application on Antioxidant Enzyme Activities and Physiological Parameters in Pearl Millet. Agricultural Sciences in China, 10, Issue 2: 228-237. https://doi.org/10.1016/S1671-2927(09)60309-6
27. Hu, L.; Zhang, Z.; Xiang, Z. and Yang, Z.(2016). Exogenous Application of Citric Acid Ameliorates the Adverse Effect of Heat Stress in Tall Fescue (Loliumarundinaceum).Front Plant Sci.,18;7:179.https://doi.org/10.3389/fpls.2016.00179
28. Hussein, M.M.; M.M. Gaballah and S.Y. El-Faham (2004). Amino acids in grains of barley as affected by benzyl adenine and salinity from diluted seawater. Accepted for presentation in the Cereal and Bread Congress, May, 2004, Harrogete, England and Published in The J. of Plant Sci., 5 Issue 4: 655-658.
29.
30. Hussein, M.M. ; Abd El-Khader, A.A. and N.M. Badr (2008). Effect of irrigation by diluted seawater on growth and some macronutrients of different wheat varieties. Egypt. J. Agron., 29
31. Hussein, M.M. and Abu Bakr, N.H. (2018). The contribution of nano-zinc to alleviate salinity stress on cotton plants. Royal Society Open Science, 5(8):171809.https://doi.org/10.1098/rsos.171809
32. Hussein, M.M. and El-Greatly, N.H. (2007). Influences of Alpha-tochopherol and potassium dihydrogen phosphate on growth and endogenous photohormones of onion plants grown under salinity stress. J. Agric. Sci., Mansoura Univ., 32(11):9741-9151.
33. Hussein, M.M.; A. El-Saady, A.; Gobarah, M. and Abo El-Khier, A. (2020). Nutrient content and growth responses of sugar beet plants grown under salinity condition to citric acid and algal extract. Egypt. J. Agron., 42(2): 209-224.
34. Hussein, M.M.; Al-Ashry, S.M. and Dalia M. Mobarak (2015). Effect of some potassium sources on growth and mineral status of Egyptian clover. Amarican-Euracian J. of Sustainable Agric., 9(8):1-7.
35. Hussein, M.M.; El-Ashry, S.M.; El-Faham, S.Y.; Sabbour, M.M. and El-Dok, S. (2019).Wheat plant dry matter and grains nutritional status relation to nano fertilizer under salinity condition. Plant Archives, 19 supplement 2:2053=2063.
36. Hussein, M.M.; El-Faham, S.Y. and Alva, A.K. (2012). Pepper plants growth, yield, photosynthetic pigments, and total phenols as affected by foliar application of potassium under different salinity irrigation water. Agricultural Sciences, 3 (2): 241-248.
37. Hussein, M.M.; Mehana, H.M.; Zaki, S. and Abd El-Hadi, N. (2014). Influences of salt-stress and foliar fertilizers on growth chlorophyll and

carotenoids of jojoba plants. Middle East Journal of Agric., 3(2):Research.221-226.

38. Hussein, M.M.; Youssef, R.A. and Nesreen H. Abo-Bakr (2014). Influences of potassium foliar fertilization and irrigation by diluted seawater on growth and some chemical constituents of cotton. IJSR, 3(11):3127-3134
39. Jackson , M. L. (1973) . Soil Chemical Analysis. Prentice – Hall Inc. N.J.
40. Kaya C, Kirnak H. and Higgs D (2001). Enhancement of growth and normal growth parameters by foliar application of potassium and phosphorus on tomato cultivars grown at high (NaCl) salinity. J Plant Nutr 24: 357–367.
41. Khalil, S.E, Hussein, M.M. and da Silva, J.T. (2012). Roles of antitranspirants in improving growth and water relations of Jatropha curcas L. grown under water stress conditions. Plant Stress, 6(1): 49-54.
42. Lindsay, W. L. and W. A. Norvell (1978). Development of A DTPA micronutrient soil testes for zinc, iron, manganese and copper. Soil Sci. Amer. J. 42: 421 – 428.
43. Liu, R. and Lal, R. (2015). Potentials of engineered nano-particles as fertilizers for increasing agronomic productions. A review. Science of the Total Environment, 514: 131–139.
44. Maggio, A.; Hasegawa, P. M.; Bressan, R. A.; Consiglio, M. F. and Joly, R. J. (2001). Unravelling the functional relationship between root anatomy and stress tolerance. Australian Journal of Plant Physiology, 28(10): 999-1004.https://doi.org/10.1071/PP0109
45. Malivi, A. (2011).Interaction of micronutrients with major nutrients with special reference to potassium. Karnataka J. Agric. Sci. 24: 106 –10.
46. Munns, R. (2002). Comparative physiology of salt and water stress. Plant, Cell & Environment, 25(2), 239-250.
47. Munns, R. and Tester, M. (2008). Mechanisms of salinity tolerance. Annual Review of Plant Biology, 59, 651-681.
48. Munns, R., and Termaat, A. (1986). Whole-Plant Responses to Salinity. Functional Plant Biology, 13(1): 143-160.
49. Naderi, M.R. and Danesh-Sharaki, A. (2013). Nanofertilizers and their role in sustainable agriculture. International Journal of Agriculture and Crop Sciences. 5(19): 2229-2232.
50. Nair, R.; Varghese, S.H.; Nair, B.G.; Maekawa, T.; Yoshida,Y. and Kumar. D.S. (2010). Nano particulate material delivery to plants. Plant Sci., 179: 154-163.
51. Noaemba, A.H.; Leiby, H.R. and Alhasany, A.R. (2020). Effect of Spraying Nano Fertilizers of Potassium and Boron on Growth and Yield of Wheat (Triticumaestivum L.). The First International Conference of Pure and Engineering Sciences (ICPES2020)IOP Conf. Series: Materials Science and Engineering871 (2020) 012012IOP Publishing https://doi.org/10.1088/1757-899X/871/1/1/012012
52. Parida AK, Das AB. (2005). Salt tolerance and salinity effects on plant: a review. Ecotoxicol Environ Safe. 60:324–349.
53. Saudi, A. H. (2017). Effect of seeds priming treatments in viablity and vigour of soybean (glycine max l.) seeds under salinity stress. Anbar Journal of Agricultural Sciences, 15(1): 111-130
54. Shaaban, M.M.; Hussein, M.M. and El-Saady, A.A. (2010). Growth of sugar beet as affected by diluted sea irrigation water and possible enhancement of salinity stress tolerance with KMP foliar fertilization. Fruit, Vegetable and Cereal Science and Biotechnology, 4(1)(Special issue):88-92.
55. Snedsecor, C.M. and Cochran, W.G. (1992). Statistical Methods. 8 Ed., Iowa State Univ., Iowa, USA.
56. Sonneveld, C. and De Kreij, C.(1999).Response of cucumber (Cucumissativus L.) to an unequal distribution of salts in the root environment Plant Soil., 209 (1): 47-56
57. Sun, Y. L. and Hong, S. K. (2011). Effects of citric acid as an important component of the responses to saline and alkaline stress in the halophyte Leymuschinensis (Trin.). Plant Growth Regul., 64 129–139.https://doi.org/10.1007/s10725-010-9547-9
58. Tabatabaei, S.J. and Fakhrzad, F. (2008).Foliar and soil application of potassium nitrate affects the tolerance of salinity and canopy growth of perennial ryegrass (Lolium perenne var Boulevard). Am. J. Agric. Biol. Sci., 3 (3): 544-550. https://doi.org/10.3844/ajabssp.2008.544.550
59. Taiz, L. and Zeiger, E. (2006). Plant Physiology. 4th Edition. Sinauer Associates, Inc. Sunderland, Massachusetts, USA.
60. Tian, S.; Nakamura, K.; Cui, T. and Kayahara, H. (2005). High performance liquid chromatographi determination of phenolic compounds in rice. Journal of Chromatography A 1063: 121-128.
61. Tzortzakis, N. (2010).Potassium and calcium enrichment alleviate salinity-induced stress in hydroponically grown endives J. Hortic. Sci.,

37:155-162

62. Wang, W.; Tarafdar, J.C. and Biswas, P. (2013). Nanoparticle synthesis and delivery by an aerosol route for watermelon plant foliar uptake. J. Nanopart. Res.,15: 1-13.
63. Yang, Z.M..et al. (2000) Aluminum tolerance is achieved by exudation of citric acid from roots of soybeans (Glycine max L. Merr). PhysiolgiaPlantarum, Sweden, 110, 72-77.
64. Zaki, N.M.; Hassanein, M.S.; Amal, G.A.; Ebtsam, A. and Tawfik, M.M.(2014). Foliar application of potassium to mitigate the adverse impact of salinity on some sugar beet varieties. 2: effect on yield and quality. Middle East J., 3 (3): 448-460.
65. Zhu, J.-K. (2007). Plant Salt Stress: John Wiley & Sons, Ltd.