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WHEAT PLANT DRY MATTER AND GRAINS NUTRIENTS STATUS AND ITS RESPONSES TO NANOFERTILIZER UNDER SALINITY CONDITION

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Abstract

A pot experiment conducted at the winter season of 2017/2018 in the greenhouse of the National Research Center, Dokki, Cairo, Egypt to evaluate the response of plant growth and grains mineral status of wheat grown under salinity condition and sprayed with nano nitrogen fertilizer. The salinity treatments were irrigation by water contains 2500 and 5000 ppm more than by tap water (280 ppm salts) as a control. Nano fertilizer sprayed at twice times, the first one was at 21 days from sowing and the second done at two weeks later in the rate of 100 and 200 ppm more than distilled water as a control. Results 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. As Na concentration in the root media 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. Application of the first 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. Application 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.

Keywords: Wheat (*T. austavum L.)*-Salinity- Nano fertilizer-Dry mater- Grains macro nutrients- Grains micronutrients.

Introduction

The extent of agricultural land to face the increasing demand for food that is affect by high salinity as adverse environmental condition is increasing worldwide, due to both natural phenomena and agricultural practices such as irrigation systems (Munns and Tester, 2008) also by bad drainage. In Salinity poses two major threats affected on plant growth: osmotic stress and ionic stress (Flower and Colmer, 2008). In addition, it also manifested an oxidative stress. The salinity deleterious effects led to affect different physiological and metabolic processes of plants.. The responses to these mentioned changes are often accompanied by many variety of symptoms, such as the increase of leaf thickness and succulence, leaves abscission, necrosis of root and shoot, and decrease the internode lengths and also leaf area, (Parada and Das, 2005).

Nano fertilizers as nano materials are found that can supply plants by one or more nutrients resulting in enhanced growth and yield, increase nutrient use efficiency, better yield quality which facilitate for better performance of conventional fertilizers, play a role in depressive pollutions without directly providing crops with nutrients (Naderi and Danesh-Sharaki, 2013 and Liu and Lal, 2014). Moreover, to increase the fertilizer use efficiency in the conventional fertilizers which still remains constant for the past several decades, now a day nano-fertilizers intended to improve this character with exploiting unique properties of nanoparticles (Sabramaniani *et al.,* 2015).

Wheat (*Triticum aestavium L.)* is one from the main cereal crops in the world as area and production. In Egypt wheat is the first strategical food crop in winter season. Its area was 3475669 fed 2014 season (Egyptian Ministry of Agric, Statistics Book, 2014). The increasing production and technological properties of its grain are considered as from the main national targets to face the increasing demands caused by the continuous increasing in human population. Abd El-Aziz *et al*., (2016) found that treated wheat plant with Chitosan NPK nano fertilizer to significant progressive increase in all measured growth variables throughout the adult and reproductive growth and developmental stages. The growth parameters i.e. root length, shoot length and fresh weight, dry weight, water content and area of leaves. In addition, they concluded that the life cycle of wheat was shorter in plants treated with nano-fertilized than normal-fertilized plants of wheat with the ratio of 23.5% (130 days from sowing compared with 170 days for yield production). Therefore, accelerating plant growth and productivityresulted from spraying of nano-fertilizers can open new perspectives in agricultural practice. This conclusion depending on the response of plants to nano-fertilizers, varies with the plant species types and their growth stages or nature of nanomaterials.

Many authors reported the improving in biotic and abiotic stress tolerance in plant using nanomaterials: Ma (2004); Sabbour and Hussein (2015 &2016); Saxsena *et al*., 2016); Hussein and El-Faham, (2018); Hussein *et al.* (2015 & 2017) and El-Sharkhawy *et al.* (2018).

Salinity stress causes the negative impact on various biochemical and physiological of crops as found by: Ma (2004); al (2013); Jaberzadeh *et al.* (2013); Hussein and Abu Bakr (2018) and Rahneshan *et al.* (2018).

Salinity lowering osmotic potential of soil, creation of nutritional imbalance, enhancing specific ionic toxicity or one or more combination of these factors, are some of the common implications of salinity stress experienced by plants (Ashraf, 1994). Nano fertilizers application could be a potential approach to address different issues of soil toxicity and other associated stress problems (Saxena *et al*., 2016).

Several investigations were conducted to study the effect of nano ferilization on alleviation of salt tolerance in different plants: Saxena *et al.* (2016); Yassen *et al.* (2017) and Hussein *et al.* (2018).

Thus, this work aimed to investigate the effect of nano-fertilizer on growth and mineral status of shoots and grains of wheat grown under salinity condition.

Materials and Methods

A pot experiment conducted at the winter season of 2017/2018 in the greenhouse of the National Research Center, Dokki, Cairo, Egypt to evaluate the response of plant growth and grains mineral status of wheat grown under salinity condition and sprayed with nano nitrogen fertilizer. The salinity treatments were irrigation by water contains 2500 and 5000 ppm more than tap by water (280 ppm salts) as a control. Nano fertilizer sprayed twice, the first one was at 21 days from sowing and the second two weeks later in the rate of 100 and 200 ppm more than distilled water as a control.

The experiment for study the interaction between salinity and nano nitrogen exogenous application, included 9 treatments, 3 salinity levels and 3 nano nitrogen. The experiment design is split plot in three replicates. The analysis of soil and water used properties are illustrated in Table 1.

Table 1a: Analytical properties of clay soil

$CaCO_3$ %	4.6
pH (1.25)	7.6
EC (dSm^{-1}) (1.5)	0.22
Soluble Cations (mM/L)	
Ca^{++}	0.3
Mg^{++}	0.2
Na^{+}	1.4
K^{+}	0.2
Soluble anions (MM/L)	
CO_{3}_	-
HCO_3-	0.5
Cl-	1.0
SO_4-	0.6
Available N (ppm)	24.2
Available P (ppm)	5.6
Available K (ppm)	87.9
Available Fe (ppm)	6.9
Available Mn (ppm)	4.2
Available Zn (ppm).	0.41
Available Cu (ppm)	0.9

Table 1b: Analysis of irrigation water used

Source	pH	EC dSm^{-1}	Soluble cations (meq/l)				Soluble anions(meq/l)			
			Na^{+}	K^{+}	Mg^{++}	Ca^{++}	CO^{--}_3	HCO^-_3	Cl-	$SO^{=}_4$
Seawater	7.3	66.1	554.3	4.1	143.5	28.5	-	3.3	625.0	102.4

Wheat (*Triticum aestavim L.*) seeds var. Gmmeza 9 were sown at November, 15 (winter season of 2017/2018). Calcium super phosphate (15.5 P2O5) and potassium sulphate (48.5% K_2O) in the rate of 1,5 g/pot for each fertilizer were added before sowing. Ammonium nitrate (33.5 N) added in the rate of 6 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 100 and 200 ppm nano fertilizer at three weeks and fifth weeks after sowing and the s control plants were spray by distilled water.

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. Digestion and determination of nutrients were done as the methods described by Cottenie, *et al.* (1980). Statistical analysis done as the methods described by Snedecor and Chocran (1980).

Therefore, the goal of this work is evaluate the response of wheat dry matter and seeds nutritional stats as affected by nano fertilizer and salt stress.

Results and Discussion

Salinity

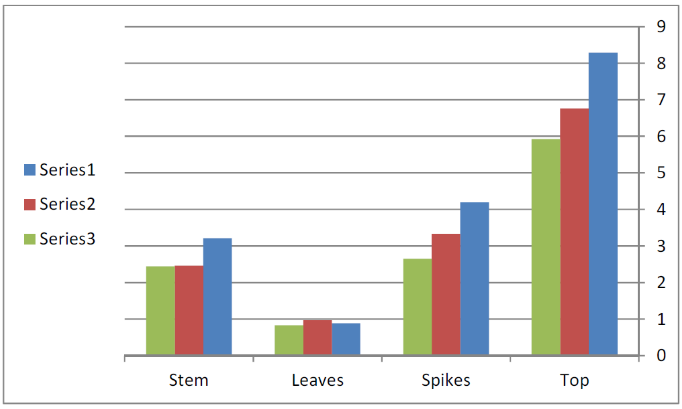
Dry matter

Data presented in Table (2) and Fig 1 noticed that dry the matter of stem, spikes and above ground parts decreased with the increase in salts concentration up to the highest level used but differences in leaves dry matter was not significant. Salinity negatively affected soil properties especially the availability of water and nutrients which intern reflected on reduce the different plants metabolic processes (Marschener, 1995). Soil salinity influences the soil available water range, and intern in water use of plants, and addition to soil water content. Salinity, through reduction of soil water potential and ionic toxicity, dramatically reduces the photosynthetic rate, root hydraulic conductance, rate and stomata conductance. Therefore, plant water uptake and productivity decrease significantly (Ding *et al.,* 2004). Khataar *et al.* (2004) reported that low levels of salinity enhanced nutrients and uptake through extending of its roots but under high salinity root and shoots of wheat decreased severely. The responses to the growth changes as the result of salt stress in most cases accompanied by different types of symptoms, such as the decrease in area of leaf, thickness increases, decrease of internode lengths and succulence of leaf, abscission of leaves and necrosis of root and shoot (Parada and Das, 2005).

Table 2 : Dry matter of wheat plants as affected by salinity.

Sal.	DW g			
ppm	Stem	Leaves	Spikes	Top
TW	3.21	0.88	4.19	8.28
2500	2.46	0.97	3.33	6.76
5000	2.44	0.83	2.65	5.92
LSD at5%	0.223	N.S	1.708	N.S

Sal.=Salinity Tw= Tap water DW= Dry weigh



Series 1: Tap water, **Series 2:** 2500 ppm salts, **Series 3:**5000 ppm salts

Fig. 1: Dry matter in grams of wheat plants as affected by salinity

Salinity stress (so from soil salinity or by saline water irrigation) causes the negative impact on various biochemical and physiological processes which are associated with plant growth, yield and yield components (Marshener, 1995; Munns *et al*., 2006 and Husseien *et al*., 2008). Lowering of soil osmotic potential, creation of nutritional imbalance, enhancing specific ionic toxicity (salt stress) or one or more combination of these factors, are some of the common implications of salinity stress experienced by plants (Ashraf, 1994 and Hussein and Abu Bakr, 2018). Some other vital processes like photosynthesis, protein synthesis and lipid metabolisms etc. badly affected by salinity stress within a plant (Parada and Das, 2005). The crop cells which suffered from the reactive oxygen species (ROS) accumulation, which led to severe oxidative damage on plants, due to environmental stresses. ROS are toxic molecules exist in different subcellular compartments. The equilibrium between the production and detoxification of ROS is sustain by enzymatic and non-enzymatic antioxidants (Abd El-Baky *et al.,* 2008 and Orabi *et al.,* 2018). Caversan *et al.* (2016) reported that wheat plants increase mechanisms of antioxidant defense under abiotic stresses, such as cold, heat, drought, salinity and UV-B radiation, to diminish oxidative damage. Moreover, H_2O_2 signaling is consider as an important factor contributing to stress tolerance in cereal plants.

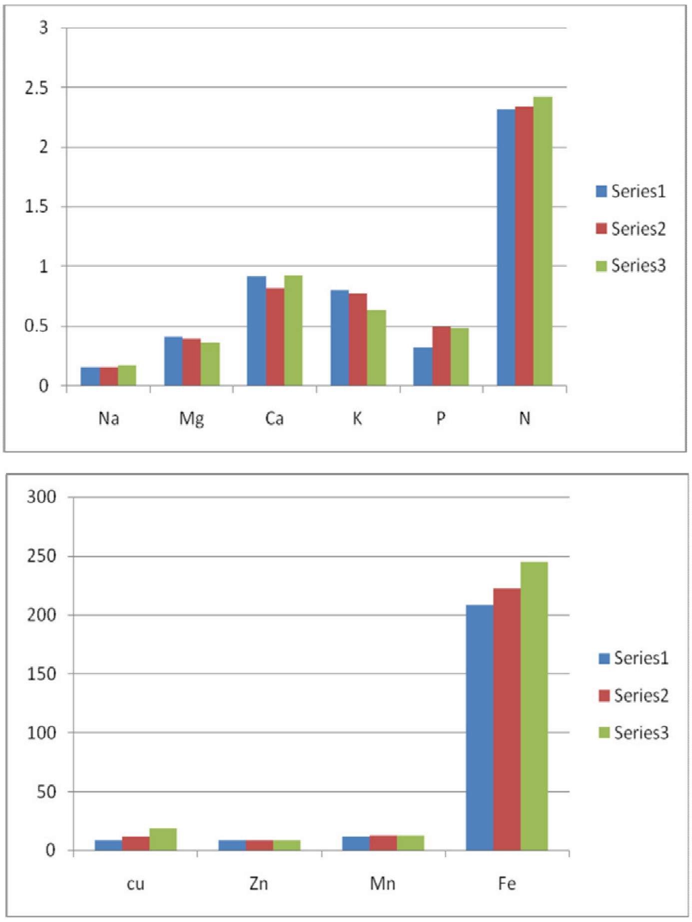
b)-Mineral status

Examination of Data in Table 3 and Fig 2 revealed that N, Na, Fe and Cu increased parallel to the increase of salinity up to the highest level used The reverse was true for K and Mg concentration. However, the concentration of P, Mn and Zn in wheat plants showed its higher values when plants irrigated by 2500 ppm salty solution while the opposite was shown with Ca concentration.

Table 3 : Macronutrients (%) and micronutrients (ppm) concentrations of wheat grains as affected by salinity.

Salinity	N	P	K	Ca	Mg	Na	Fe	Mn	Zn	u
Tw	2.31	0.313	0.793	0.91	0.41	0.147	208	11.33	7.98	8.26
2500	2.34	0.487	0.772	0.81	0.39	0.152	222	12.63	8.56	11.31
5000	2.42	0.484	0.626	0.92	0.36	0.163	245	12.53	8.50	18.42

T.W.: Tap water



Series 1: Tap water, **Series 2:** 2500 ppm salts, **Series 3:**5000 ppm salts

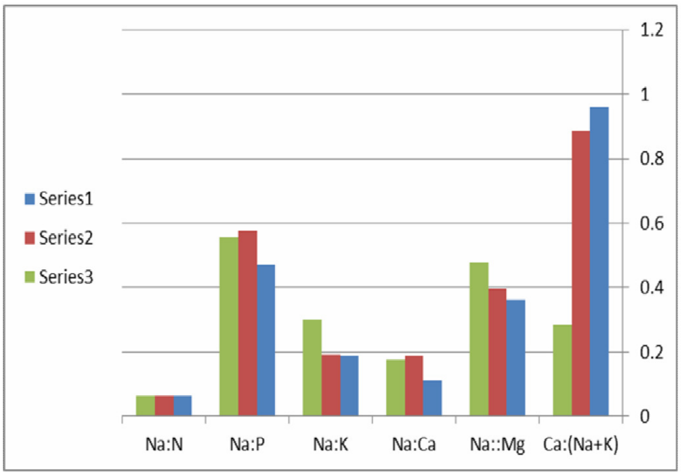
Fig. 2 : Macronutrients and micronutrients concentrations (%) of wheat grains as affected by salinity

The disturbance in mineral status reported in many works: Hussein *et al.* (2008); Shabaan *et al.* 2008, El-Dieweny *et al.* (2013); Saleh *et al* (2016); and Hussein and Abu Bakr (2018). In both cultivars under study done by Rahneshan *et al.* (2018), Na^+ content increased in plant organs with increasing Na^+ in the media. Salinity treatment decreased the Fe and Pi contents in BS cultivar, while they remained unchanged in BZ. However, in addition, the high amounts of salt uptake by the plant leads to the osmotic pressure increase in the cytosol. Thus, cell homeostasis is maintained by an osmotic adjustment mechanism which leads to consists the sequestration of large amounts of ions in vacuoles or/and synthesis of organic osmolytes (Munns, 2002). Sodium and potassium ions homeostasis plays a vital role in both growth and development of higher plants under salt stress due to potassium & sodium (K^+–Na^+) interaction. This often associated with K^+ deficiency (Parida and Das, 2005). K is indispensable for several physiological processes, including the membrane maintenance turgor and potential, enzyme activation, regulation of osmotic pressure, stomatal movement and tropisms (Golldack *et al.,* 2003). A high ratio of K^+ to Na^+ in the leaves is often consider as a salt tolerant marker (Maathuis and Amtmann, 1999). Under salt stress, the calcium (Ca^{2+}) content condition is depending on the specific physiology of the plant organs and its duration. Melgar *et al.* (2006) reported that the role of Ca^{2+} in the salt toxicity alleviation is relate to effect K^+/Na^+ selectivity through controlling the Na^+ influx via nonselective ion channels.

Table 4 : Sodium ratios with the other macronutrient (in concentration basis) as affected by salinity.

Salinity ppm	Na:N	Na:P	Na:K	Na:Ca	Na::Mg	Ca:(Na+K)
T.W.	0.064	0.470	0.187	0.161	0.362	0.959
2500	0.065	0.576	0.216	0.188	0.394	0.885
5000	0.068	0.558	0.302	0.176	0.457	1.281

T.W.: Tap water



Series 1: Tap water, **Series 2:** 2500 ppm salts, **Series 3:**5000 ppm salts

Fig. 3: Sodium ratios with the other macronutrients (in concentration basis) as affected by salinity.

Date illustrated in Table (4) and Fig 3 indicated that Na:Mg and Na:K increased continuously with the increase in sprayed fertilizer, however Ca(Na+K) ratio was reversely responded by this treatment. In addition, Na/Ca ratio increased with the 1st fertilizer concentration and tended to decrease but still more than that of the control. Furthermore, the ratio of Na/N values with the two levels of nano fertilizer and that of plants did not received nano particles seemed to be approximately equal. **Chipa and Lal (1995)** concluded that this fact confirmed by applying presoaking treatments of plant hormones to test susceptibility of varieties. On the basis of the results obtained in two pot experiments, the limit of the Na/K ratio of grain and straw of wheat for designating a variety as tolerant is <0.15 and <0.4, respectively, while this ratio at, the tillering stage is 0.5. Walia (2005) stated that it found by applying 100 of Sodium chloride in the hydroponic solution, the K^+/Na^+ ratio was significantly reduced in two rice varieties. Morales *et al.* (2012) emphasized that more than the effects in growth and yield the lowest Na/K ratio in stem recorded as result of salt stress in wheat. Fakhrefshani *et al.* (2015) revealed that under salt stress the loss of availability, toxicity of Na+ and ion imbalance cause growth limitation so plants adapted divert mechanisms to salinity tolerant. It is repeatedly reported that K deficiency and Na^+ are major restriction of global crop production. Fakhrefshani *et al.* (2015) added also that K^+ is a major agent that can counteract Na^+ stresses. That the potential plant to tolerant salinity is strong dependant of their potassium nutrition.

Nano Fertilizer

Dry matter

Application 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 and27.75%, respectively compare to the control ones when nano fertilizer sprayed by 1 and 2 concentrations (Table 4). Nano fertilizer application promoted the growth, development, TPC, and antioxidant activity in rice, which intern demonstrating the potential to improve crop production and plant nutrition (Benzon *et al*., **2015).**

Therefore, results showed increase in nitrogen and phosphorus, content and uptake and on reverse decrease in Na content and uptake when adding SiO_2 nano fertilizer. This has identified that silicon dioxide nano fertilizer can have a positive effect on the growth of plant and yield of cucumber *(*Yassen, *et al.,* 2017). Sidiqui *et al.* (2015) recorded that, in the field of electronics, energy, medicine, and life sciences, nanotechnology offers an expanding research, such as reproductive science and technology, conversion of agricultural and food. Nanoparticles causing many morphological and physiological changes, depending on the properties of NPs. The NPs efficiency is determined by their chemical composition, surface covering, size, reactivity, and the most importantly is the doseat which they are effective (Khodakovskaya *et al.,* 2012). Benzon *et al.* (2015) revealed that the conventional and nano fertilizer in the full recommended rate (FRR) enhanced the height of plant, chlorophyll content and the number of reproductive tillers, panicles, and spikelets. Similar results can seen in panicle weight and grain weight, total shoot dry weight and harvest index.

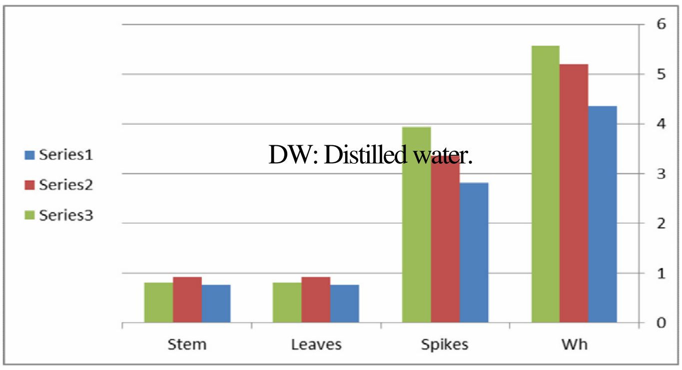
Nano fertilizer using caused promotion the growth, development, TPC, and antioxidant activity in rice, this demonstrating the potential led to improve crop production and plant nutrition (Benzon *et al.,* 2015). Salinity stress causes the negative impact on different biochemical and physiological processes which are related to creation plant growth and yield. Lowering of soil osmotic potential, nutritional imbalance creation, increasing specific ionic toxicity or one or more combination of these factors (salt stress), are some of the common implications of salinity stress experienced by plants (Ashraf, 1994). In addition, some vital processes like enzymes reactions, photosynthesis, protein synthesis and lipid metabolisms or some other physiological processes were badly affected by salinity stress within a plant (Hussein *et al.*, 2008 and Parada and Das, 2005). As mentioned by Govorov and Carmeli (2007) nano particles from different metal sources can found the efficiency of chemical energy production in photosynthetic systems. Meanwhile, the nano-fertilizers have higher surface and reactive area it is mainly due to very less or smallest size of particles which provide more sites to facilitate different metabolic process in the plant system result production of more photosynthesis and intern more growth and yield (Qureshi *et al.,* 2018).

Salt stress in plants is aggravat by the generation of reactive oxygen species (ROS) such as superoxide (O−2), hydrogen peroxide (H_2O_2) and hydroxyl radicals (OH-) (Smirnoff, 1995). In order to prevent oxidative damages, plants mobilize antioxidant enzymes such as superoxide dismutase (SOD) and catalase (CAT) to scavenge ROS (Foyer and Graham, 2003). Application of K nano particles significantly enhanced the activity of both SOD as well as CAT enzymes in the two genotypes, suggesting a possible positive interaction of these enzymes with the rise of cytosolic K. (Gholizadeh *et al.,* 2012). The transported compounds need for penetration through the cell wall prior to membrane invagination. Plants are able to take up nanoparticles from environment and transport them through the vascular system to various shoots and stems (Corredor *et al.* 2009). Also, Navarro *et al.* (2008) reported that nanoparticles induced formation of new pores larger in the cell wall of plants to allow the entrance of large nanoparticles.

Table 5 : Dry matter of wheat plants as affected by nano fertilizer.

Nan	DW g			
	Stem	**Leaves**	**Spikes**	**Wh**
DW	0.77	0.77	2.82	4.36
Na1	0.92	0.92	3.36	5.20
Nan2	0.82	0.82	3.93	5.57
LSD	**N.S.**	**N.S.**	**0.715**	**0.241**

DW: Dry weight Na1=NP100 Nan2=NP300 lSD= Least significant difference



Series1: Distilled water Series 2: 100 ppm Nano N Series 3:2 00 ppm Nano N fertilizer

Fig. 4 : Dry matter of wheat plants as affected by nano fertilizer.

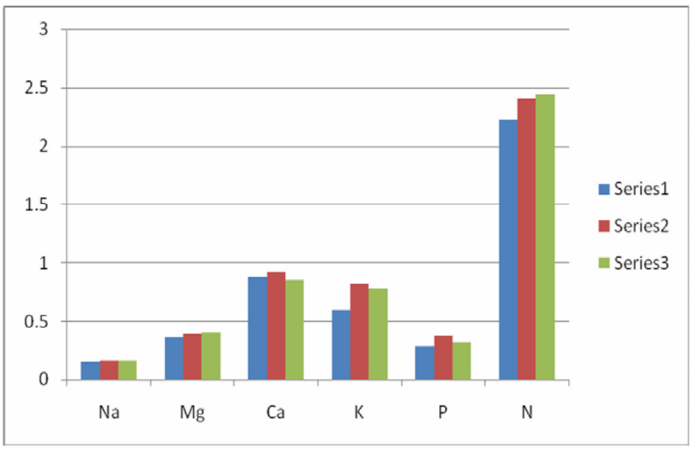
Mineral status

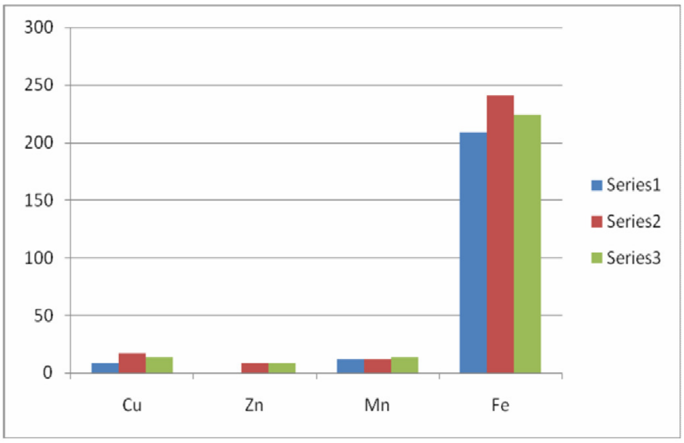
It is clear from Data illustrated in Table (3) and Fig 4 that the application of the first level of nano nitrogen showed the highest values of all macro and micro nutrients concentrations in grains except that of N% and Zn and Mn ppm compared to resulted in the control or the highest level of fertilizer. The concentration of N and Zn concentration 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.

At nano scale physical and chemical properties are differ than bulk material. If fertilizers use as nano form, it increase the availability of elements, may prevent fixation and increased absorption and uptake through different plant parts (Hussein, et al 2008 a & b; Hussein *et al.,* 2017; Qurashi *et al.*, 2018 and Hussein *et al.,* 2018). Nano fertilizers are capable to release nutrient slowly to the crop plant, which intern increase nutrients availability to the crop plants though out the growth period which could prevent loss of nutrient from denitrification, volatilization, leaching and fixation in the soil area especially NO_3-N and NH_4-N (Qurashi *et al.,* 2018). The use of nanostructured elements incorporated in a carrier complex that may or may not be a nanomaterial, as is the case of NPs of essential elements incorporated by absorption or adsorption in a matrix such as chitosan, polyacrylic acid, clay or zeolite (Federenko *et al.,* 2015). Use the element per se in a nanostructured form (in suspension or encapsulated), such as for the NPs of Fe or Zn for application to soil, substrate or by foliar spray (Mohamed *et al.,* 2016). Both types of NF contributions have certain advantages, such as greater solubility and rapid absorption or less leaching, compared with traditional fertilizers. The first method is preferred because it provides greater control over the speed and timing of release of the nutrient element. Yassen *et al.* (2017) stated that Si sources (as nano fertilizers) seems promising to supply this element to plants for its effectiveness and feasibility, low doses lower cost, ease of application and good quality of fertilizers used, also depression of contaminations by the 1st level of NZn and decreased with the highest level of nano-Zn. In addition its value became less than the control.

Table 6 : Macronutrients (%) and micronutrients (ppm) concentrations of wheat grains as affected by Nano nitrogen.

Nano Fer. ppm	N	P	K	Ca	Mg	Na	Fe	Mn	Zn	Cu
Dw	2.22	0.286	0.593	0.88	0.36	0.148	209	11.63	7..95	7.99
100	2.41	0.380	0.822	0.92	0.39	0.159	241	11.63	8.32	16.33
200	2.44	0.315	0.776	0.85	0.40	0.155	224	13.23	8.77	13.68





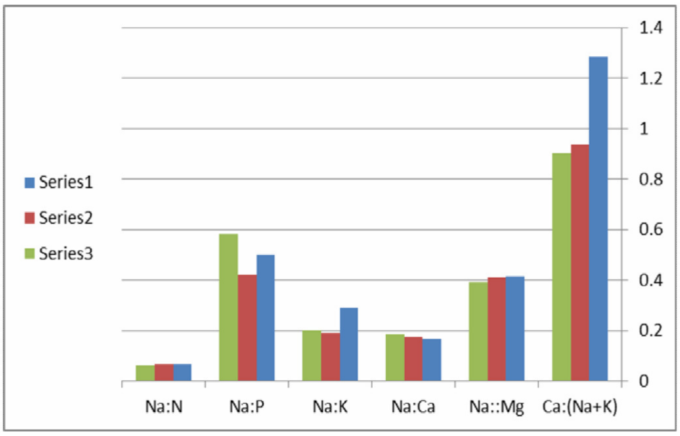
Series 1 : Distilled water Series 2: 100 ppm Nano N Series 3 : 2 00 ppm Nano N fertilizer

Fig. 5: Macro (%) and Micronutrients concentration (ppm) in wheat grains as affected by salinity

Table 7 : Sodium ratios with the other macronutrients (in concentration basis) as affected by nano fertilizers application.

Nano Fer.ppm	Na:N	Na:P	Na:K	Na:Ca	Na::Mg	Ca:(Na+K)
D.W.	0.066	0.527	0.291	0.169	0.413	1.286
100	0.066	0.422	0.287	0.174	0.409	0.938
200	0.064	0.492	0.202	0.186	0.393	0.904

DW=Distilled water



Series1: Distilled water water Series 2: 100 ppm NanoN Series 3: 200 ppm Nano nitrogen fertilizer

Fig. 8 : Na ratios with the other macronutrients (in concentration basis) as affected by nano nitrogen application

Data in the above Table 7 and Fig 8 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 to levels of fertilizer .

Hussein *et al.* (2015) 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 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. 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 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 nano particles which in turn enhance the uptake of nanoparticle (Nair *et al.,* 2010). Concerning the effect of salinity on nutrients concentration, the low concentration of N, P and K recorded in shoots and fruit of cucumber plants grown under agricultural drainage water (Yassen *et al.,* 2017). Foliar spray with Silicon dioxide increased potassium contents increase compared to the control, although Ca and N contents were reduce in comparable with the control and uptake of N, P, K Ca and Na increased reaching maximum at 60 mg (Yassen *et al.,* 2017). K_2SO_4 in different rates nanoparticles affected significantly Na/K ratio and the concentrations of calcium, phosphorus, copper, manganese, and zinc in plant tissue (El-Sharkawy *et al.,* 2017).

Interaction

Dry matter

Table 8 : Dry matter of wheat plants as affected by nano fertilizer and salinity.

Sal. ppm	Nan F. ppm	DWg			
		Stem	Leaves	Spikes	Top
TW	**Dw**	3.27	0.89	3.71	7.87
	100	3.14	0.98	4.22	8.34
	200	3..21	0.78	4.55	8.54
2500	**Dw**	2.22	0.67	2.86	5.75
	100	2.61	0.87	3.37	6.85
	200	2.55	0.85	3.67	7.07
5000	**Dw**	2.04	0.74	1.88	4.66
	100	2.62	0.90	2.49	6.01
	200	2.65	0.84	3.57	7.06
LSD at 5%		N.S	N.S	N.S	0.417

Sal.: Salinity Dw: Dry weight TW: Tap water DW: Distilled water LSD: Least significant difference

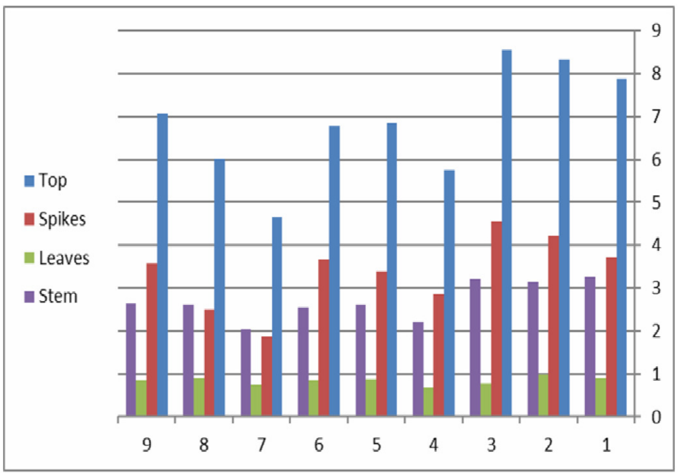


Fig. 9 : Dry matter of wheat plants as affected by nano fertilizer and salinity.

The Data illustrated in Table (3) indicated that top and spikes dry weight increased as the concentration of nano fertilizer 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. Adding K2SO4 nanoparticles at the low level led to the highest shoot dry weight, relative yield, root length and dry weight of roots in used genotypes. The application of potassium sulphate nanoparticles at the 1/8 rate enhanced the plant's physiological response to salt stress by lowering electrolyte leakage, increasing catalase and proline content, and increasing antioxidant enzymes and activity (El-Sharkawy *et al.,* 2017). The salt presence in soil solution affects plants through reducing their ability to take up water, leading to slower growth as well as the toxic effects of salt ions accumulating inside the plant roots (Munns *et al.,* 2006). In some species of some crops, these phases may occur simultaneously. Mian *et al.,* (2014) reported that an increase in K supply corresponded with higher K accumulation in plant tissue, which reduced Na- concentration and resulted in a higher K^+/Na-ratio. Munns and Tester (2008) suggested that plants have a Na ions exclusion mechanism that maintains a low level of Na in the leaves during salt stress. Potassium is, also, consider as a major osmolyte in plant tissue and plays an important role in osmotic adjustment and maintaining cell turgor. El-Sharkawy *et al.* (2017) noticed that the low concentrations of K nanoparticle level also maintained lower electrolyte leakage and higher proline, relative water content, and activities of higher level of superoxide dismutase and catalase. These findings suggest that the application of K nanoparticles may have better efficiency than conventional K fertilizer through providing adequate plant nutrition and overcoming the negative effects of salinity stress in alfalfa plants. Abd El-Aziz *et al.* (2016) noticed that nano particles were taken up which transported through phloem tissues. Wheat plants treated with nanoparticles grown on sandy soil (chitosan-NPK) nano fertilizer cases significant increases in harvest, mobilization and crop indexes of the determined variables of wheat yield, in comparable with control yield characters of wheat plants treated with normal non- nano fertilizers which intern can open new perspectives in agricultural practice. However, the plant response to nano fertilizers varies according to the type of plant species, their stages of growth and nanomaterials nature. Xiao *et al* (2008) emphasized that leaching NO3--N was decrease by applying SRF coated with nano-materials in a rotation of wheat-maize. Liu *et al* (2009) indicated that increases in rice grain yields (10.29%), spring maize (10.93%), soybean (16.74%), but in winter, season wheat (28.81%) and vegetables (12.34-19.76%) after applying fertilizer corporate with nano-materials. As noticed by Liu *et al* (2007), mentioned that germination and rooting promoted early for rice seedling and seeds and the growth of rice at tillering stage was affect clearly by nano-composites. Additionally, they indicated that the rice grain yield and nitrogen agronomic utilization efficiency was increase after applying nano-carbon in corporation with SRF.

Mineral content

Examination of Data in Table (7) 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.

Table 9 : Macronutrients (%) and micronutrients (ppm) concentrations of wheat grains as affected by Nano nitrogen and salinity.

N	P	K	Ca	Mg	Na	Fe	Mn	Zn	Cu
2.12	0.287	0.735	0.92	0.36	0.136	199	11.7	8.20	6.73
2.27	0.333	0.908	0.94	0.44	0.150	195	10.6	7.53	10.23
2.55	0.320	0.737	o.88	0.42	0.150	230	11.7	8.20	7.83
2.23	0.237	0.712	0.81	0.38	0.149	214	11.6	7.81	8.13
2.33	0.410	0.733	0.88	0.39	0.155	237	12.6	8.56	9.00
2.46	0.330	0.87	0.74	0.39	0.153	214	13.7	9.31	16.80
2.30	0.333	0.333	0.91	0.34	0.159	214	11.6	7.83	9.10
2.63	0.397	0.824	0.93	0.35	0.167	292	11.7	8.86	29.77
2.32	0.293	0.721	0.93	0.38	0.162	229	14.3	8.80	16.40

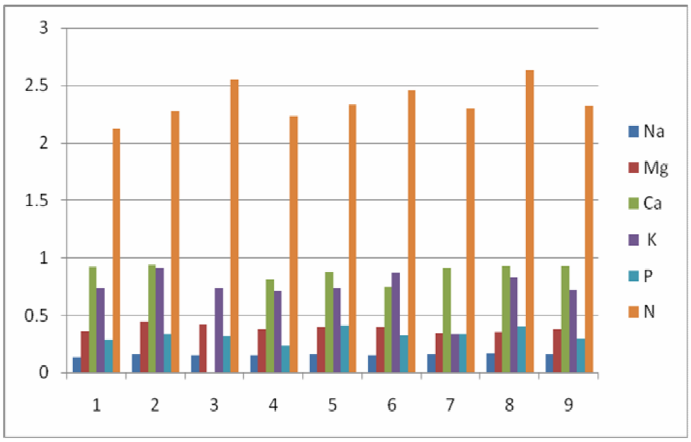


Fig. 10 : Macronutrients concentrations (%) of wheat grains as affected by Nano nitrogen and salinity

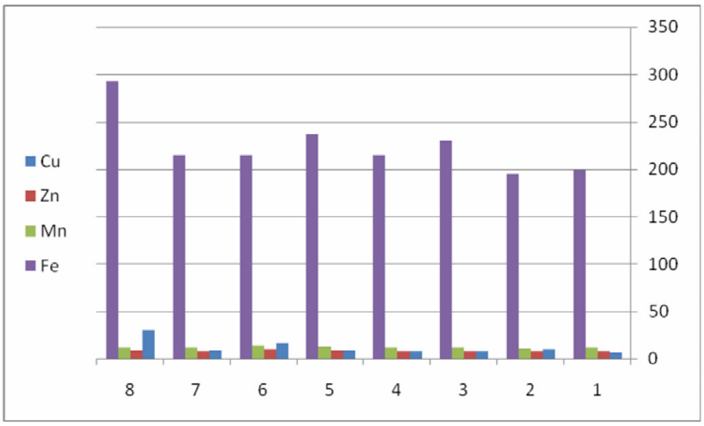


Fig. 10 : Micronutrients concentrations (ppm) of wheat grains as affected by Nano nitrogen and salinity

Decrease of nitrogen (N) especially nitrate nitrogen might be related to the antagonistic relation between toxic (Guntzer *et al*., 2012). The application of SiO2 nanoparticle spraying have a benefit role in nutrients status, which consequently increased the absorption of different nutrients and alleviatingdamagesof salinity.These results are in accordance with previous investigation indicated by: Siddiqui *et al*. (2014), Gui *et al.* (2015) and Lui *et al.* (2015). El-Sharkawy *et al.* (2017) reported that the different rates of potassium nanoparticles affected significantly Na/K ratio and the concentrations of calcium, phosphorus, copper, manganese, and zinc in plant tissue. The application of K2SO4 nanoparticles at the 1/8 rate enhanced the plant's physiological response to salt stress by reducing electrolyte leakage, increasing catalase and proline content, and increasing antioxidant enzymes, activity. These results suggest that the application of K nanoparticles may have better efficiency than conventional K fertilizers in providing adequate plant nutrition and overcoming the negative effects of salt stress in alfalfa. Abd El-Aziz *et al.* (2017) 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 flow 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. The results obtained by Siddique *et al.,* (2014) concluded the nano fertilizer induced the best growth results. Therefore, plant growth and productivity enhancing through the exigently applied of nano fertilizers can open new perspectives in future of agricultural practices. This because nano fertilizers promise to be a safe way to the availability of nutrients and supplied strongly nutrients to plants without doing and/or minimized damages to the environment. Nevertheless, we can advise to conduct further field studies to investigate the effect of such concentration on growth and metabolism of wheat plants and to ensure the safety of the nano-treated plants for t animals and human using. A significant decrease in the K^+ content observed in root and stem of both cultivars with increasing salt concentration. It is known that K^+ can play an important role in plant growth and development as well as in the maintenance of osmotic adjustment and cell turgor (Marschener, 1995). For the plant response to high salinity, another indicate is the Na^-/K^+, is reported to increase in many plants after treatments (Shabala and Cuin, 2008). Roots of the both cultivars had higher Na^+/K^+ ratio than that of stem and leaves.

Calcium (macronutrient) playing a vital role in maintaining the plasma membrane integrity in cells of plant, thus, this led to restricts the toxic effect of Na^+ (Rengel, 1992 and Gucci and Tattini, 1997). Calcium (Ca) acts as a secondary messenger of signal transduction pathways regulation for the response of abiotic stressand in the promotion of K^+:Na^+ selectivity (Rengel, 1992; Maathuis and Amtmann, 1999 and Shabala *et al.,* 2006).

Table 10 : Sodium ratios with the other macronutrients (in concentration basis) in grains of wheat as affected by application of nano fertilizer and salinity

Salinity ppm	Nano Fer.	Na:N	Na:P	Na:K	Na:Ca	Na::Mg	Ca: (Na+K)
T.W.	D.W.	o.064	0.474	o.185	0.148	0.378	1.056
	100	0.068	0.466	0.172	0.165	0.352	0.884
	200	0.059	0.469	0.204	0.171	0.357	0.937
2500	D.W.	0.067	0.629	0.209	0.184	0.392	0.941
	100	0.067	0.378	0.212	0.176	0.397	0.991
	200	0.062	0.454	0.176	0.210	0.393	0.723
5000	D.W.	0.069	0.478	0.478	0.175	0.468	1.850
	100	0.064	0.421	0.203	0.180	0.477	0.939
	200	0.698	0.553	0.225	0.174	0.426	1.053

Sal.: Salinity Dw: Dry weight TW: Tap water DW: Distilled water LSD: Least significant difference

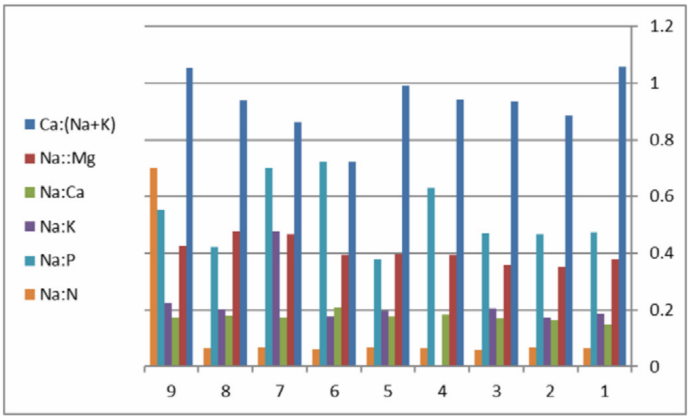


Fig. 11: Sodium ratios with the other macronutrients (in concentration basis) in grains of wheat as affected by application of nano fertilizer and salinity

Conclusion

This work aimed to evaluate the response of wheat plant growth and grains content of minerals under saline water irrigation and application of nano fertilizer. Salinity affected adversely the dry matter of the above ground parts of wheat plants (stem, leaves and spikes, furthermore, it increased Na/K ratio. Reversely, the application of nano fertilizer improved the dry matter weights of the mentioned plant part but depressed the Na/K ratio in grains. Moreover, the nutrient content of grains also affected by both treatments. This means that nano nitrogen fertilizer improved the nutrient status of above ground parts, grains and the tolerant of wheat plants on adverse effect of salt stress.

References

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.

Abd El-Baky, H.H.; Hussein, M.M. and Baroty, G.S. (2008). Algal extraction improve antioxidants defense Abilities and salt tolerance of wheat plant irrigated with seawater. Electronic Journal of Environmental Agriculture and Food Chemistry, 7(4): 281–2832.

Ashraf, M. (1994). "Organic substances responsible for salt tolerance in Eruca sativa," Biol. Plant., 36: 255–259.

Benzon, H.R.; Rubenecia, M.R.; Ultra, V.U. and Lee, S.C. (2015). Nano-fertilizer affects the growth, development, and chemical properties of rice. International Journal of Agronomy and Agricultural Research (IJAAR), 7 (1): 105-117.

Caverzun, A.; Casassola, A. and Brammer, S.P. (2016). Antioxidant responses of wheat plants under stress Genet. Mol. Biol., 39(1): 1-10.

Chipa, R.S. and Lal, P. (1995). N/K. ratios as the basis of salt tolerance in wheat. Australian Journal of Agricultural Research, 46(3): 533 539.

Cobrredor, E.; Testillano, P.S.; Coronado, M.J.; González-Melendi, P.; Fernández-Pacheco, R.; Marquina, C.; Ibarra, M.R.; de la Fuente, J.M.; Rubiales, D.; Pérez-de-Luque, A. and Risueño, M.C. (2009). Nanoparticle penetration and transport in living pumpkin plants: in situ subcellular identification. BMC Plant Biol., 9: 1-11.

Cottenie, A.; Nerlo, M.; Kiekeus, L.; Velghe, G.; and Caunek, R. (1992). Chemical analysis of plants and soils. Lab. of Analytical and Agrtochem, State Univ. Ghent. Belgium.

DeRosa, M.R.; Monreal, C.; Schnitzer, M.; Walsh, R. and Sultan, Y. (2010). Nanotechnology in fertilizers. National Nanotechnology Journal, 5: 91.

Ding, X.; Liu, G., Li, Z.; Li, Z. and Chen, Y. (2004). Ground subsidence monitoring in Hong Kong with satellite SAR interferometry. Photogrammetric Engineering and Remote Sensing, 70: 1151–1156.

Egyptian Ministry of Agric, Statistics Book, Ministry of Agriculture, Dokki, Cairo, Egypt, 2014.

El-Dewiny; C.; 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.

Elsakhawy, T.; Omara, A.E.; Alshaal, T. and El-Ramady, H. (2018). Nanomaterials and Plant Abiotic Stress in Agroecosystems Env. Biodiv. Soil Security, 2: 73 – 94.

El-Sharkawy, M.S.; El-Beshsbeshy, T.R.; Mahmoud, E.K.; Abdelkader, N.I.; Al-Shal1, R.M. and Missaoui, A.M. (2017). Response of alfalfa under salt atress to the application of potassium sulfate nanoparticles. American Journal of Plant Sciences, 8: 1751-1773.

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.

Flowers, T.J. and Colmer, T.D. (2008). Salinity tolerance in halophytes. New Phytol., 179:945–963.

Fedorenko, V. F.; Buklagin, D. S.; Golubev, I. G. and Nemenushchaya, L. A. (2015). Nanotechnologies Russ., 10: 318.

Foyer, C.H. and Graham, N. (2003). Redox Sensing and Signalling Associated with Reactive Oxygen in Chloroplasts, Peroxisomes and Mitochondria. Physiologia Plantarum, 119: 355-364.

Fakhrefshani, M.; Shahriare-Ahmed, F.; Niazi, A.;Moshtaghi, N. and Zare-Mehrejerdi, M. (2015). The Effect of salinity on N^+, K^+ concentration, N^+/K^+ a ratio, electrolet leakage and HKT expression profile in roots of *Aeluropus littoralis.* Intr. J. of Plant Molecular Breeding, 3(20): 1-10.

Fakhrefshani, M.; Shahriare-Ahmed, F.; Niazi, A.; Moshtaghi, N. and Zare-Mehrejerdi, M. (2015). The Effect of salinity on N^+, K^+ concentration, N^+/K^+ a ratio, electrolet leakage and HKT expression profile in roots of *Aeluropus littoralis.* Intr. J. of Plant Molecular Breeding, 3(20): 1-10.

Gui, X.; He, X.; Ma, Y.; Zhang, P. and Li, Y. (2015). Quantifying the distribution of ceria nanoparticles in cucumber roots: The influence of labeling. RSC Adv., 5: 4554-4560.

Golldack, D.; Quigley, F.; Michalowski, C.B.; Kamasani, U.R. and Bohnert, H.J. (2003). Salinity stress tolerant and -sensitive rice (*Oryza sativa* L.) regulate AKT1-type potassium channel transcripts differently. Plant Mol Biol., 51: 71-81.

Golldack, D.; Li, C. and Mohan, H. (2014). Tolerance to drought and salt stress in plants: unraveling the signaling networks. Front Plant Sci.,5: 1–10.

Gholizadeh, S.; Nemati, I. and Moradi, F. (2012). Effect of Supplemental Calcium and Potassium on Organic and Inorganic Solutes and Antioxidant Enzymes Activity in NaCl Stressed Alfalfa Seedlings. IJACS, 7: 377-385.

Govorov, A.O. and Carmeli, I. (2007). Hybrid structures composed of photosynthetic system and metal nanoparticles: plasmon enhancement effect. Nano Lett., 7(3): 620–625.

Gucci, R. and Tattini, M. (1997). Salinity Tolerance In Olive. In: Janik. J. (Ed.), Horticultural reviews, John Wiley & sons, Inc., USA, 21: 177–214.

Guntzer, F.; Keller, C. and Meunier, J.D. (2012). Benefits of plant silicon for crops: A review. Agron. Sustain. Dev., 32: 201-213.

Hussein, M.M.; Shaaban, M.M. and A.M. El-Saady, (2008a). Response of cowpea plants grown under salinity stress to PK-foliar application. American J. of Plant Physiol., 3(2): 81–88.

Hussein, M.M.; Sawsan Y. El-Faham; Elham Z. Abd El-Moti and Nesreen H. Abu-Baker (2017). Research Article Jojoba Irrigated with Diluted Seawater as Affected by Ascorbic Acid Application. International Journal of Agricultural Research, Journal of Agricultural Research, DOI: 10.3923/ijar.2017.1.9.

Hussein, M.M.; Shaaban, M.M. and El-Saady, A.M. (2008b). Response of cowpea plants grown under salinity stress to PK-foliar application. American J. of Plant Physiol., 3(2): 81–88.

Hussein; M.M.; Abd El-Haddy, M.S. and EL-Nagar, H.H. (2008). Ascorbic acid and its effect on growth and protein pattern in leaves of lupine plants grown under different salinity. Egypt. J. Agron.30.

Hussein, M.M.; El-Ashry, S.M.; Haggag, W.M. and Mobark, D. (2015). Response to moisture stress and nano fertilizer during different growth stages of cotton plants. Intr. J. of Chem. Tech. Research, 8(12): 643-650.

Hussein, M.M.; El-Saady, A.M. and Nesreen, H. Abo-Talb (2015). Castor bean plants response to phosphorus sources under irrigation by diluted seawater. Intr. J. of Chem. Tech. Res., 8(9): 261-271.

Hussein, M.M. and El-Faham, S.Y. (2018). Chlorophyll, carotenoids pigments and growth of three onion cultivars as affected by saline water irrigation. Egypt. J. Agron., 40 (3): 285-296.

Hussein, M.M.; El-Faham, S.Z.; El-Moti, E.Z. and Abu-Baker, N.H. (2017). Research Article Jojoba Irrigated with Diluted Seawater as Affected by Ascorbic Acid Application. International Journal of Agricultural Research, DOI: 10.3923/ijar.2017.1.9.

Hussein, M.M. and Abu-Baker, N.H. (2018). The contribution of nano-zinc to alleviate salinity stress on cotton plants. R. Soc. Opensci., 5: 1-11.171809.

Jaberzadeh, A.; Moaveni, P.; Moghadam, H.R.T. and Zahedi, H. (2013). Influence of bulk and nanoparticles titanium foliar application on some agronomic traits, seed gluten and starch contents of wheat subjected to water deficit stress, Not. Bot. Horti. Agrobo.

Khodakovskaya, M.V.; de Silva, K.; Biris, A.S.; Dervishi. E, and Villagarcia. H. (2012). Carbon nanotubes induce growth enhancement of tobacco cells. ACS Nano, 6(3): 2128–2135.

Khataar, M.; Mohhamadi, M.H. and Shabani, F. (2018). Soil salinity and matric potential interaction on water use, water use efficiency and yield response factor of bean and wheat. Scientific Reports (2018) 8:2679.

Liu, J.; Zhang, Y.D. and Zhang, Z.M. (2009). The application research of nano-biotechnology to promote increasing of vegetable production. Hubei. Agric. Sci., 48: 123-127.

Liu, A.X.; Lu, Q.M and Cao, Y.J. (2007). Effects of composite nano-materials on rice growth. Plant Nutrit. Fertil. Sci., 13: 344-347.

Liu, R. and Lal, R. (2014). Synthetic apatite nanoparticles as a phosphorus fertilizer for soybean (*Glycine max*). Scientific Reports, 4: 686–691.

Liu, P.; Yin, L.; Wang, S.; Zhang, M.; Deng, X.; Zhang, S. and Tanaka, K. (2015). Enhanced root hydraulic conductance by aquaporin regulation accounts for silicon alleviated salt-induced osmotic stress in *Sorghum bicolor L.* Environ. Exp. Bot., 111: 42-51.

Ma, J.F. (2004). Role of processes which are associated with plant growth and yield. Soil Sci. Plant Nutr., 50 (1): 11–18.

Maathuis, F.J.M. and Amtmann, A. (1999). K + nutrition and Na+ toxicity: the basis of cellular K^+/Na^+ ratios. Ann Bot., 84:123–133.

Morales, S.G.; Trejo-Tillez, L.I.; Merino, F.C.; Caldana, C.; Espinosa-Victoria, D. and Cabrera, E.H. (2012). Growth, photosinthetic activity and potassium concentration in rice plants under salt stress. Moringa, 34(3): 317-324.

Martínez-Alcántara, B.; Martínez-Cuenca, M.R.; Quiñones, A.; Iglesias, D.J.; Primo-Millo, E. and Forner-Giner, M.A. (2015). Comparative expression of candidate genes involved in sodium transport and compartmentation in citrus. Environ. Exp. Bot., 111: 52–62.

Marschener, H. (1995). Mineral Nutrition of Higher Plants. Acad. Press. Londen. New York.

Melgar, J.C.; Benlloch, M. and Fernandez-Escobar, R. (2006). Calcium increases sodium exclusion in olive plants. Sci. Hort., 109: 303–305.

Mian, A.; Oomen, R.J.; Isayenkov, S.; Sentenac, H.; Maathuis, F.J. and Very, A.A. (2011). Over-Expression of an Na+- and K+-Permeable HKT Transporter in Barley Improves Salt Tolerance. The plant Journal, 68: 368-497.

Mohammad, G.; Hossein, S.; Iraj, A.; Hossein, N. and Morteza, H. (2016). Synthesis of highly intercalated urea-clay nanocomposite via domestic montmorillonite as eco-friendly slow- release fertilizer Arch. Agron. Soil Sci.

Munns, R. (2002). Comparative physiology of salt and water stress. Plant Cell Environ., 25:239–250.

Munns, R.; James, A.J. and Lauchli, A. (2006). Approaches to Increasing the Salt Tolerance of Wheat and Other Cereals. Journal of Experimental Botany, 57: 1025-1043.

Munns, R. and Tester, M. (2008). Mechanisms of Salinity Tolerance. Annual Review of Plant Biology, 59: 651-681.

Naderi, M.R. and Danesh-Sharaki, A. (2013). Nano fertilizers and their role in sustainable agriculture. International Journal of Agriculture and Crop Sciences, 5(19): 2229-2232.

Navarro, E.; Baun, A.; Behra, R.; Hartmann, N.B.; Filser, J.; Miao. A.; Quigg, A.; Santschi, P.H. and Sigg. L. (2008). Environmental behavior and ecotoxicity of engineered nanoparticles to algae, plants and fungi. Ecotoxicology, 17: 372-386.

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.

Orabi; S.H.; Hussein, M.M.; Abd El-Motty, E.Z. and El-Faham, S.Y. (2018). Effect of Alpha-Tochophyrol and glutamic acid on total phenols, antioxidant activity, yield and fruit properties of mango trees. Middle East G. 0f Applied Sci., 8(4): 1229-1239.

Parada, A.K. and Das, A.B. (2005). Salt tolerance and salinity effects on plant: A review. Ecotoxicol Environ Safe., 60: 324–349.

Qureshi1, A.; Singh, D.K. and Dwivedi, S. (2018). Nano-fertilizers: A Novel Way for Enhancing Nutrient Use Efficiency and Crop Productivity. Int. J. Curr. Microbiol. App. Sci., 7(2): 3325-3335.

Rahneshan, Z.; Nasibi, F. and Moghadam, A.A. (2018). Effects of salinity stress on some growth, physiological, biochemical parameters and nutrients in two pistachio (*Pistacia vera L.*) rootstocks. Journal of Plant Interactions, 13(1): 73-82.

Rengel, Z. (1992). The role of calcium in salt toxicity. Plant Cell Environ., 15: 625–632.

Sabramaniani, K.S.; Manikandan, A., Thirunavukkarasu, M. and Rahale, C.S. (2015). Nano-fertilizers for Balanced Crop Nutrition. Nano Technologies in Food and Agriculture, 69-80.

Sabbour, M.M. and Hussein, M.M. (2016). Determinations of the effect of using silica gel and nano silica gel against Tutaabsoluta (Lepidoptra: Gelechildae) in tomato fields. J. of Chemi. and Pharmac. Res., 8(4): 506-512.

Sabbour, M.H. and Hussein, M.M. (2015). Usage of nano phosphorus fertilizers in enhancing the corn crop and its effect on corn borers infestation after fungi treatments. Intr. J. of Chem. Tech. Res., 8(6): 167-173.

Saleh A.L.; Khater A.M.; El-Hassanin A.S.; Hussein M.M. and Hanan H. Abdel–Kader (2016). Some Impact of Organic Fertilization and Water Requirements on Olive Fruit Productivity and Mineral Concentration in Sandy Soil. International Journal of Pharm. Tech., 9 (12); 42-51.

Saxena, R.; Tomar, R.S. and Kum, M. (2016). Exploring Nano biotechnology to Mitigate Abiotic Stress in Crop Plants. Raghvendra Saxena et al /J. Pharm. Sci. and Res., 8(9): 974-980.

Shabala, S.; Demidchik, V.; Shabala, L.; Cuin, T.A.; Smith. S.J.; Miller. A.J.; Davies, J.M. and Newman, I.A. (2006). Extracellular Ca^{2+} ameliorates NaCl-induced K^+ loss from Arabidopsis root and leaf cells by controlling plasma membrane K^+-permeable channels. Plant Physiol., 141:1653–1665.

Shabala, S. and Cuin, T.A. (2008). Potassium transport and plant salt tolerance. Physiol Plant, 133:651–669.

Shabaan; M.M.; Hussein, M.M. and El-SaadyA.M. (2008). Nutritional status in shoots of barley genotypes as affected by salinity of irrigation water. American J. of Plant Physiol., 3(2): 89 – 95.

Siddiqui, M.H.; Al-Whaibi, M.H.; Firoz, M. and Al-Khaishany, M.Y. (2015). Role of Nanoparticles in Plants © Shapter 2. Springer International Publishing Switzerland 2015 M.H. Siddiqui et al. (eds.), Nano technology and Plant Sciences.

Siddiqui, H.; Al-Whaibi, M.H.; Faisal, M. and Al Sahli, A.A. (2014). Nano silicon dioxide mitigates the adverse effects of salt stress on *Cucurbita pepo* L. Environ. Toxicol. Chem., 33: 2429-2437.

Smirnoff, N., (2005). Antioxidants and Reactive Oxygen Species in Plants. Blackwell Publishing, New York, USA.

Snedsecor, C.M. and Cochran, W.G. (1992). Statistical Methods. 8 Ed., Iowa State Univ., Iowa, USA.

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.

Walia, H.; Wilson, C.; Condamine, P. Liu, X.; Ismail. A.; Zing, L.; Wanamaker, S.L.; Cui, X. and Close, T.J. (2005). Comparative transcriptional profiling of two contrasting rice genotypes under salinity stress during the vegetative stage. Plant Physiology, 139(2): 822-836.

Xiao, Q.; Zhang, F.D.; and Wang, Y.J. (2008). Effects of slow/controlled release fertilizers felted and coated by nano-materials on nitrogen recovery and loss of crops. Plant Nutr. Fertil. Sci., 14: 778-784.

Yassen, A.; Abdallah, E.; Gaballah, M. and Sahar, Z. (2017). Role of Silicon Dioxide Nano Fertilizer in Mitigating Salt Stress on Growth, Yield and Chemical Composition of Cucumber (*Cucumis sativus L.).* Intr. J. Agric. Res., 12 (3): 130-135.