Effect of Nitrogen, Phosphorus and Potassium Fertilizers as Nano and Regular Mineral on Maize Growth (*Zea mays* L.) Plants Grown in Saline-Sodic Soil, at North Sinai, Egypt

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ABSTRACT

Field experiments were conducted to compare nano NPK fertilizers with ordinary mineral NPK fertilizers on maize (*Zea mays* L. Triple hybrid Giza 320) grown on a saline sodic sandy loam soil. Two experiments were conducted on 2018 and 2019 seasons at Romanh Village, North Sinai Egypt. The design was a randomized complete block, factorial (split plot). Factor1: Source (i.e. mineral 'S_1' and nano 'S_2'). Factor2 Dose "rate" (i.e. $kgha^{-1}$ NPK of 0/0/0, 120/180/60; 180/36/120 and 240/72/180 for D_0, D_1, D_2 and D_3 respectively. The fertilized treatments using the nano forms were much superior then those of the regular mineral ones. Superiority was up to the followings for each 8 and 12% for grain and straw yields respectively. For the other traits, superiorities for uptakes were up to 29% (straw N) 3% (grains N), 41% (straw P), 7 % (grain P), 27% (straw K) and 34% (grain K.). Fertilization enhanced plants to sustain salinity stress conditions. The mineral fertilization caused plants to accumulate more proline "g kg^{-1} fresh matter": average of 44.3 for the mineral and 27.4 for the nano.

Key words: Maize, Saline-sodic Soil, nano fertilizers and regular mineral NPK.

INTRODUCTION

Maize as one of the important cereal crops in Egypt needs high rate of N-application reached to 714 kg urea ha^{-1} in normal soils (Nofal, 2003). El- Bana and Gomaa (2000) obtained increases in grain yield by ncreasing levels of nitrogen from 238 to 286 kg N ha^{-1}. Soil salinity is a major concern in agriculture all over the world because it affects almost all plant functions. More than 6% of the world land and one third of the world irrigated land are adversely affected by soil salinity (FAO, 2008). It has been reported that coastal regions of Bangladesh are very much lower in soil fertility than the other parts of the country (Haque, 2006). Accumulation of proline in plant tissues helps in alleviating the negative effect of salinity stress on plants (Moussa and Abdel-Aziz, 2008).

Chemical compounds are increasingly used all over the world to enhance crop productivity. Mineral fertilizers are among such compounds. Nitrogen fertilization plays a key role in plant growth, yield and hence crop water productivity (Ahmed et al., 2014). The most widely used water soluble source of nitrogen fertilizers is urea (460 g N kg^{-1}). However, it is subject to heavy losses through leaching but can be used with lower leaching loss if modified by treatment with hydroxyapatite particles (Subbaiya et al., 2012). Phosphorus is a major plant nutrient usually supplied in many different forms (Abou El-Yazeid and Abou-Aly, 2011). Potassium is another major essential nutrient (Chandra, 1989). Heavy application rates of chemical fertilizers result in many serious environmental problems (Abdel Wahab et al., 2017). A number of up-to-date methods and techniques in fertilization are recently being used in order to avoid environmental pollution and relieve heavy dependence of chemical fertilization. On of such methodologies and techniques is the use of nano fertilization (Ditta 2012). Nanotechnology relates to using materials, systems and processes which operate at a scale of 100 nanometers (nm) or less (Srilatha 2011). One of the most important uses of nanotechnology is nano-fertilization which enhances the ability of plants to absorb nutrients (Mousavi and Rezai 2011, Srilatha 2011 and Ditta 2012).

The aim of the current study was to investigate the effect of nano and ordinary methods of NPK fertilizer on maize grown on a saline sodic soil.

MATERIALS AND METHODS

A filed experiment on maize (*Zea mays* L. Triple hybrid Giza 320) was conducted on a saline-sodic sandy loam soil at Romanh Village, North Sinai Governorate, Egypt (31.0°N 32.41°E) for two successive growing seasons of 2018 and 2019. The design was randomized complete block (factorial) with three replicates. Factor1 was the N- Source (i.e. mineral 'S_1' and nano 'S_2') while factor2 was the dose "rate' (i.e. kg ha^{-1} NPK of 0/0/0, 120/180/60; 180/36/120 and 240/72/180 for D_0, D_1, D_2 and D_3 respectively.

Preparation of nano Fertilizers

According to De Moura et al. (2008) and Corradini et al. (2010), chitosan polymerizing meth-acrylic acid (CS-PMAA) nanoparticles were prepared by polymerizing the meth-acrylic acid (MAA) in s chitosan

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solution (CS) as a carrier coated in a buffer solution for 5 hrs in a two-step process. In the first step, 0.23 g chitosan was dissolved in meth-acrylic acid solution (0.5%, v/v) for 18 hrs using a magnetic stirrer. In the second step, with continued stirring, 0.2 mmol of $K_2S_2O_8$ were added until the solution became clear. Polymerization was subsequently carried out at 75°C using a magnetic stirrer for 4 h leading to formation of nano-particle solution, then centrifuged at 500 rpm for 30 min., then cooled in an ice bath. Urea, NH_4NO_3, Ca $(H_2PO_4)_2$ and KCl were used separately. The loading of N salt in chitosan nanoparticles was obtained by dissolving of 2m into 100 mL of chitosan nanoparticle solution under magnetic stirring for 8 hrs at 25°C; subsequently dried at 50 ºC for 72 hrs. The following concentrations of 1000 mg kg^{-1} of N, P and K were finally obtained in each solution. The resulting solutions had a pH of 5.50. Nano fertilizers were sprayed 3 times at 35, 50 and 75 days after seeding (DAS) at a rate of 20L/950L water ha^{-1}.

Agronomic operations and analytical methods:

Sowing was done on 10th and 12th of May 2018 and 2019, or the first and second seasons respectively. Plot size was 50 m^2 (5x10m) having 14 ridges of 5 m in length and 0.7 m in width, with two plants $hill^{-1}$ and 20 cm between hills. Nitrogen fertilizer was applied as urea (460 g N kg^{-1}) in 3 equal splits at seeding, then 30 and 50 days after. P was added as superphosphate fertilizer (68g P kg^{-1}) during seedbed preparation and potassium was as potassium sulphate (420 g K kg^{-1}) in two equal splits 30 and 45 days after seeding.

Agricultural practices were carried out as recommended by the Ministry of Agriculture. Crop maturity occurred on the 15th and 27th September for 2018 and 2019 seasons, respectively. Maize ears were collected on the 20th October. Total chlorophyll content was determined as described by Witham et al (1971). Total proline content was determined as described by Bates et al. (1973) and oil content in seeds was determined using the Soxhelt method (AOAC, 1990). Plant samples were subjected to digested by a mixture of conc. H_2SO_4 and $HClO_4$ acids after drying in an oven at 70º C (Ryan et al. (1996). Protein in plant was calculated by multiplying grain N contents by 6.25 (FAO, 2003). Main soil properties were determined according to methods cited by Black *et al.,* (1982) and the results were shown in Table 1.

RESULTS AND DISCUSSION

Results show differences between sources and rates with regard to different parameters, yields and yield components. as shown by Tables 2 to 3. Differences between the non-fertilized nano and the nonfertilized mineral for all results and parameters were not statistically significant.

Plant attributes (Table2):

Table 2 showed that plant height (cm) ranged from 94.3 due to nano non-fertilized S_2D_0 to as high as 170.6 by the nano-highest rate (S_2D_3) with an increase of 80.9%. Increased rate of application was associated with increased plant height averaging as high as 65.5% caused by D_3. The increase was particularly evident where the nano source was used. The nano source surpassed the regular mineral one by an average of 17.6 % and such superiority occurred where fertilizers were applied. Nano forms surpassed the mineral one by as average of 17.6%.

As shown in Table 2 ear length (cm) was lowest (15.95) by the mineral non-fertilized S_1D_0 highest by the nano-highest rate (S_2D_3) which caused 101% increase.

Table 1. Physical and chemical properties of soil of the study in Romanh, North Sinai.

Coarse sand (%)	Fine sand (%)	Silt (%)	Clay (%)	Texture		O.M (gkg^{-1})	SAR	$CaCO_3$ (gkg^{-1})
8.90	60.55	12.22	18.33	Sandy loam		5.7	14.4	105.5
pH (1:2.5)	EC ($dS\ m^{-1}$)	Soluble ion (mmolc L^{-1})						
		Ca^{++}	Mg^{++}	Na^{+}	K^{+}	HCO_3^{-}	Cl^{-}	SO_4^{--}
8.12	9.54	13.9	20.8	60.0	0.8	10.9	52.4	32.2
Available nutrients (mg kg^{-1})								
N	P	K	Fe	Mn			Zn	
40	4	185	2.38	1.50			0.58	
Notes:	Extracts for available nutrients: K_2SO_4 (N); Na bicarbonate (P); NH_4Ac (K); DTPA (Fe, Mn, Zn). No soluble CO_3^{--} was detected							

Table 2. yield component and yield of maize grown in a saline sodic soil as affected by N-source and rate

NPK–source, S	NPK fertilization rate (D)									
	D_0	**D_1**	**D_2**	**D_3**	**Mean**	**D_0**	**D_1**	**D_2**	**D_3**	**Mean**
	Plant height (cm)					**Ear length (cm)**				
Mineral, S_1	95.6	112.6	123.1	143.5	118.7 b	15.95	22.34	23.56	24.85	21.68 b
Nano, S_2	94.3	138.5	155.0	170.6	139.6 a	16.23	26.63	30.14	32.25	26.31 a
Mean	94.9d	125.6c	139.1b	157.1a		16.09d	24.49c	26.85b	28.55a	
F-test	S:	**	D:	**		S:	**	D:	**	
			SD: **					SD: **		
	weight of ears (g plant^{-1})					**Grains weight ear^{-1} (g)**				
S_1	159.1	236.0	245.2	248.0	222.1b	110.4	123.0	132.0	135.0	125.1b
S_2	159.8	244.0	251.3	255.0	227.5a	109.5	137.0	144.2	150.0	135.2a
Mean	159.5d	240.0c	248.3b	251.5a		109.9d	130.0c	138.1b	142.5a	
F-test	S:	**	D:	**		S:	**	D:	**	
			SD: **					SD: **		
	100-grain weight (g)					**Straw yield (Mg ha^{-1})**				
S1	25.63	30.15	32.18	32.99	30.24b	2.679	4.410	5.007	5.022	4.279b
S2	25.84	33.14	34.56	36.20	32.44a	2.726	5.381	5.595	5.976	4.920a
Mean	25.74c	31.65b	33.37a	34.60a		2.703b	4.895a	5.300a	5.500a	
F-test	S:	**	D:	**		S:	*	D:	**	
			SD: **			SD:		NS		
	Grain yield (Mg ha^{-1})									
S1	2.338	3.079	3.426	3.691	3.133					
S2	2.230	3.310	3.405	3.719	3.166					
Mean	2.284b	3.195a	3.416a	3.705a						
F-test	S:	NS	D:	**						
			SD: NS							

Notes:1. Rates of NPK are 'kgha^{-1}': 0/0/0, (120/18/60), (180/36/120) and (240/72/180) for D_0 D_1,D_2 and D_3 respectively. 2. Mineral sources for NPK are urea, K-sulphate and Ca-superphosphate

Increasing the rate of fertilization was associated with increased ear height with an average of as high as 77.4% caused by D_3 and such a pattern was particularly evident under conditions of the nano source which surpassed the mineral one 21.4 % and such superiority was more evident where plants were fertilized.

Weight of ears per plant (g plant^{-1}) was the lowest due to 159.1 by the mineral-nonfertilized (S_1D_0) and highest by the nano-highest rate (S_2D_3) which caused 60.3% increase. Increased ear weight was with increased fertilization and the increased fertilization was as high as 60.0% on average. The nano source surpassed the mineral one by 2.4 % the superiority was more evident where plants were fertilized.

Grains weight per ear (g ear^{-1}) followed a pattern similar to that of the ear weight. It was lowest of 109.5 by the S_1D_0 and highest by the S_2D_3 which caused 38.0% increase. The increase in grain weight was parallel with the increase in fertilization rate and was as high as 30.1% on average at the highest rate. The nano source surpassed the mineral one by 8.1 % and the superiority was more evident where plants were fertilized.

The 100-grain weight (g) ranged from 25.63 by the mineral non-fertilized S_1D_0 to as high as 36.20 by the S_2D_2 nano-highest rate with an increase of 41.2%. Increased application was associated with increased 100-grain weight. The highest D_3 rate caused an average of 34.4% in the 100-grain weight. The nano source surpassed the mineral one by 7.3% and the surpass occurred only where fertilizers were given.

Grains and straw yields (Mg ha^{-1}):

Grain yield followed a pattern similar to that of the above mentioned plant attributes. It was lowest of 2.230 by the S_2D_0 and highest by the S_2D_3 which caused 59.1% increase. The increase was parallel with the increase in fertilization rate reaching as high as 49.1% on average at the highest rate. The nano source surpassed the mineral one by an average of 18.7 %; and the superiority was more evident where plants were fertilized.

Straw yield:

The straw yield (Mg ha^{-1}) followed a pattern similar to the grain yield. It was lowest of 2.670 by the S_1D_0 and highest by the S_2D_3 which caused 23.1% increase. The increase was progressive as that of the increase in fertilization and reached as high as 103% on average at the highest rate. The nano source surpassed the mineral one by an average of 19.0 %; and the difference was more evident where plants were fertilized.

Assessment of response to growth and productivity of plant.

The positive response obtained by application of fertilizers which is caused by the significant increases caused by fertilization, particularly with the progressive increase in the rate, is an indication of the need for fertility enhancement of the soil. The evident superiority of the nano source over the ordinary mineral source is a demonstration of the high efficiency of former over the latter. Subbaiya et al. (2012) reported that nano fertilizers on improved seed germination, which reflected positively on all crop traits. Other researchers (Ekinci et al. ,2014, Abdel Wahab et al. 2019 and Merghany et al. 2019) found that application of macronutrients to maize caused high increases in values of traits and yields of maize particularly when applied in nano forms.

Chlorophyll, proline, oil, and protein in maize grains (Table 3)

As shown in Table 3, Chlorophyll contents was lowest (8.23) by the non-fertilized mineral S_1D_0 and highest by the highest fertilized nano S_2D_3 which caused an increase of 147%.

Table 3. Chlorophyll, proline, oil and protein in maize as affected by N-sources and rates

NPK–source, S	NPK fertilization dose (D)									
	D_0	**D_1**	**D_2**	**D_3**	**Mean**	**D_0**	**D_1**	**D_2**	**D_3**	**Mean**
	Chlorophyll (mg g^{-1} f.w)					**Proline (mg g^{-1} f.w)**				
Mineral, S1	8.23	12.14	14.56	16.32	12.81 b	43.63	40.34	43.15	39.52	41.66a
Nano, S2	8.52	13.68	17.52	20.36	15.02 a	43.25	32.10	29.85	20.14	31.34b
Mean	8.38d	12.91c	16.04b	18.34a		43.44a	36.22b	35.60c	29.83d	
F-test	S:	**	D:	**		S:	**	D:	**	
	SD: NS					SD: **				
	Oil content (g kg^{-1})					**Grain protein content (g kg^{-1})**				
S1	48.6	53.4	58.6	59.8	55.1	73.7	90.6	92.5	94.4	87.8
S2	44.4	55.9	59.8	61.2	55.4	75.0	91.2	95.0	96.9	89.5
Mean	46.5b	54.7a	59.2a	60.5a		74.4b	90.9a	93.8a	95.7a	
F-test	S:	NS	D:	**		S:	NS	D:	**	
	SD: NS					SD: NS				
	Protein yield (kg ha^{-1})									
S1	173	279	317	348	279					
S2	167	302	323	360	288					
Mean	170 b	291 a	320 a	354 a						
F-test	S:	NS	D:	**						
	SD: NS									

See footnote of Table 2.

The increase was progressive in line with the increase in fertilization and reached as high as 119% on average at the highest rate. The nano source surpassed the mineral one by an average of 17.3 %; and the difference was more evident where plants only under fertilization. N and K are essential for photosynthesis particularly with nano systems (Abdel Wahab et al., 2019).

Contents of proline

Contents of proline followed a general trend of decrease due to application of fertilizers (Table 3). The nonfertilized contained about 43 mg proline g^{-1} fresh weight, while most of the other treatments contained lower contents. A high proline in plant indicates a stress caused by salinity (Moussa and Abdel-Aziz 2008). The soil was saline and results show a steady decrease in proline contents with increased application of fertilizers. The decreases averaged 5.1, 18.0 and 68.7% caused by D_1, D_2 and D_3 respectively. This may indicate that fertilization contributed in alleviating the stress of soil salinity.

The mineral source surpassed the nano one by an average of 32.5 %; and the difference occurred only under fertilization indicating a positive role of the nano source. Proline is a major source of energy inducing salinity tolerance (Gad 2005).

Contents of oil (g kg^{-1}):

Oil contents was lowest (48.6) by the nonfertilized mineral S_1D_0 and highest. 61.2 by the highest fertilized nano S_2D_3 which caused an increase of 28.9% increase (Table 3). The increase was progressive in line with the increase in fertilization and reached as high as 30.1% on average at the D_3 rate. The two sources were rather similar in their effect. Fertilizer NPK application increases oil contents in maize seeds (El- Shimy et al. 2006 and Hussein, 2007).

Contents of protein in grains

As shown in Table 3 protein ranged from 73.7 by the nonfertilized mineral S_1D_0 to 96.9 by the highest fertilized nano S_2D_3 i.e. an increase of 31.5%. The increase was associated with the increased fertilization. The average increase was as high as 28.6% at the highest rate. The two sources were rather similar in effect.

Table 4. Macronutrients content (g kg^{-1}) in straw and grains of maize.

NPK–source,	NPK fertilization dose (D)									
	D_0	D_1	D_2	D_3	Mean	D_0	D_1	D_2	D_3	Mean
					N-content					
	In Straw					In Grains				
Mineral, S1	16.5	19.8	20.3	20.5	19.3 b	11.8	14.5	14.8	15.1	14.1
Nano, S2	16.6	21.4	21.9	22.3	20.6 a	11.6	14.6	15.2	15.5	14.2
Mean	16.6 b	20.6 a	21.1 a	21.4 a		11.7 b	14.6 a	15.0 a	15.3 a	
F-test	S:	**	D:	**		S:	NS	D:	**	
			SD: NS					SD: NS		
					P- content					
	In Straw					In Grains				
S1	2.20	2.50	2.80	3.20	2.68 b	3.40	3.90	4.40	4.80	4.13
S2	2.15	2.90	3.40	3.80	3.06 a	3.60	4.20	4.80	5.10	4.43
Mean	2.18 d	2.70 c	3.10 b	3.50 a		3.50 b	4.05ab	4.60 a	4.95 a	
F-test	S:	**	D:	**		S:	NS	D:	*	
			SD: NS					SD: NS		
					K-content					
	In Straw					In Grains				
S1	21.0	22.3	22.5	22.8	22.2	8.90	9.60	10.2	10.6	9.83b
S2	21.6	23.1	23.8	24.4	23.2	8.60	10.4	10.8	11.2	10.3a
Mean	21.3	22.7	23.2	23.6		8.75 b	10.0ab	10.5 a	10.9 a	
F-test	S:	NS	D:	NS		S:	*	D:	*	
			SD: NS			SD:		NS		

See footnote of Table 2

Table 5. Micronutrients content (mg kg^{-1}) in straw and grains of maize plants

NPK–source, S	NPK fertilization dose (D)									
	D_0	D_1	D_2	D_3	Mean	D_0	D_1	D_2	D_3	Mean
Fe-content										
	In Straw					**In Grains**				
Mineral, S1	110	125	132	136	126	57.5	63.9	75.2	78.1	68.7 b
Nano, S2	110	129	135	139	128	57.4	78.2	82.1	85.3	75.8 a
Mean	110 b	127 a	134. a	138 a		57.5 c	71.1 b	78.7 a	81.7 a	
F-test	S:	NS	D:	**		S:	**	D:	**	
			SD: NS					SD: **		
Mn- content										
	In Straw					**In Grains**				
S1	40.3	43.3	44.9	46.3	43.7 b	29.3	32.6	35.5	37.3	33.7 b
S2	40.3	46.8	49.2	51.1	46.8 a	29.6	38.1	42.0	43.1	38.2 a
Mean	40.3 b	45.0 c	47.1 b	48.7 a		29.5 d	35.3 c	38.7 b	40.2 a	
F-test	S:	**	D:	**		S:	**	D:	**	
			SD: **					SD: *		
Zn-content										
	In Straw					**In Grains**				
S1	21.4	24.4	28.3	34.1	27.1 b	33.5	36.2	38.5	39.2	36.8 b
S2	21.6	29.4	33.0	34.9	29.7 a	33.4	39.6	40.2	41.3	38.6 a
Mean	21.5 d	26.9 c	30.7 b	34.5 a		33.5 b	37.9 a	39.3 a	40.3 a	
F-test	S:	**	D:	**		S:	**	D:	**	
			SD: **			SD:		NS		

See footnote of Table 2.

Yield of protein

Protein yield ranged from 173 by the nonfertilized mineral S_1D_0 to 360 by the highest fertilized nano S_2D_3 causing 108%. Increased fertilization was accompanied with increased protein uptake and there was no difference between the two sources (Table 3).

Protein content in cereal grain crops respond to application of NPK (Siam, et al. 2013). Other researchers reported positive effects on plant protein as a result of applying NPK (Abedi et al. 2010 and Rana et al. 2012).

Macro and micronutrients content and uptake by straw and grains.

Tables 4 to 7 show status of N, P, K, Fe, Mn, Zn and Cu in maize grains and straw as affected by application of NPK fertilizers in the two forms of ordinary mineral and nano fertilizers. With regard to the contents, results (particularly in the straw component) show increases with fertilizer application, due to application of fertilizers.

However, regarding the uptake, the pattern of response was rather similar to that of the yield, since the uptake is mainly a function of the yield quantity in the first place.

Table 6. Macronutrients uptake (kg ha^{-1}) by straw and grains of maize plants

NPK–source, S	NPK fertilization dose (D)									
	D_0	D_1	D_2	D_3	Mean	D_0	D_1	D_2	D_3	Mean
N-uptake										
	In Straw					**In Grains**				
Mineral, S1	44.2	87.3	102	103	84.1 b	27.6	44.6	50.7	55.7	44.7
Nano, S2	45.3	115	123	133	104 a	25.9	48.3	51.8	57.6	45.9
Mean	44.8 b	101 a	113 a	118 a		26.7 b	46.5 a	51.2 a	56.7 a	
F-test	S:	**	D:	**		S:	NS	D:	**	
	SD: NS					SD: NS				
P- uptake										
	In Straw					**In Grains**				
S1	5.89	11.0	14.0	16.1	11.8 b	7.95	12.0	15.1	17.7	13.2b
S2	5.86	15.6	19.0	22.7	15.8 a	8.03	13.9	16.3	18.9	14.3a
Mean	5.88 c	13.3 b	16.5ab	19.4 a		7.99 c	13.0bc	15.7ab	18.3a	
F-test	S:	**	D:	**		S:	*	D:	**	
	SD: *					SD: NS				
K-uptake										
	In Straw					**In Grains**				
S1	56.3	98.3	113	115	95.6 b	20.8	29.6	34.9	39.1	31.1 b
S2	58.9	124	133	146	116 a	19.2	34.4	36.8	41.7	33.0
Mean	57.6 b	111 a	123 a	130 a		20.0 b	32.0 a	35.9 a	40.4 a	
F-test	S:	*	D:	**		S:	NS	D:	**	
	SD: NS					SD:		NS		

See footnote of Table 2

Table 7. Micronutrients uptake (g ha^{-1}) by straw and grains of maize plants

NPK–source, S	NPK fertilization dose (D)									
	D_0	D_1	D_2	D_3	Mean	D_0	D_1	D_2	D_3	Mean
Fe-uptake										
	In Straw					In Grains				
Mineral, S1	295	551	661	683	548 b	134	197	258	288	219 b
Nano, S2	300	694	755	831	645 a	128	259	280	317	246 a
Mean	297 b	623 a	708 a	757 a		131 c	228 b	269ab	303 a	
F-test	S:	*	D:	**		S:	*	D:	**	
	SD: NS					SD: NS				
Mn- uptake										
	In Straw					In Grains				
S1	108	191	225	233	189 b	68.5	100	122	138	107 b
S2	110	252	275	305	236 a	66.0	126	143	160	124 a
Mean	109 b	221 a	250 a	269 a		67.3 c	113 b	132ab	149 a	
F-test	S:	**	D:	**		S:	*	D:	**	
	SD: NS					SD: **				
Zn-uptake										
	In Straw					In Grains				
S1	57.3	108	142	171	119 b	78.3	111	132	145	117
S2	58.9	158	185	209	153 a	74.5	131	137	154	124
Mean	58.1 d	133 c	163 b	190 a		76.4 b	121 a	134 a	149 a	
F-test	S:	**	D:	**		S:	NS	D:	**	
	SD: NS					SD:		NS		

See footnote of Table 2

CONCLUSION

The current study shows that using nano forms of fertilizers can cause significant improvement in the efficiency of the use of NPK fertilizers. Nanotechnology can also help in improvement of crop plants grown under salinity stress. (De Rosa et al., 2010).

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الملخص العربي

تأثير أسمدة النيتروجين والفسفور والبوتاسيوم في صورتي النانو والمعدنيه العاديه علي نمو نباتات الذرة الشامية (*Zea mays* L.) المزروعة في ارض ملحية صودية

ساره السيد السيد فوده

تم دراسة تأثيرالتسميد بأسمدة النيتروجين والفسفور والبوتاسيوم من مصادر نانونية مقارنة بالتسميد المعدني على الذرة الشامية (هجين ثلاثي جيزة ٣٢٠) المزروعة في ارض ملحية صوديه بقرية رمانه، محافظة شمال سيناء – جمهورية مصر العربية خلال موسمي الصيف ٢٠١٨ و٢٠١٩. تصميم التجربة أستخدم فيه تصميم القطاعات المنشقة كاملة العشوائية والتي تحتوي علي عاملين للدراسة وهما: العامل الأول مصادر التسميد ويحتوي علي مصدرين هما المعدني S1 والنانو S2 والعامل الثاني هو معدلات التسميد وهي ٠/٠/٠، ١٢٠/١٨٠/٦٠، ١٨٠/٣٦/١٢٠ و٢٤٠/٧٢/١٨٠ وتم الإشارة لها بـ D1 , D0, D3 and D2 علي التوالي. أوضحت النتائج بأن المعاملات التي تم تسميدها بالصورة النانوية كانت أحسن تأثيرا وأفضل بصورة كبيرة من تلك التي أستخدم التسميد فيها بالصورة المعدنية التقليدية. كانت الأفضلية بنسبة ٨ و١٢٪ زيادة في محصول القش والحبوب علي التوالي. بالنسبة للقياسات الأخري كانت الزيادات في الكمية الممتصة هي ٢٩٪ (ن في القش)، ٣٪ (نيتروجين في الحبوب)، ٤١٪ (فوسفات في القش)، ٧٪ (فوسفات في الحبوب)، ٢٧٪ (بوتاسيوم في الحبوب) و٣٤٪ (بوتاسيوم في الحبوب). أدي التسميد إلي تحسين مقاومة النباتات لظروف الإجهاد الملحي بالتربة. أدي التسميد المعدني إلي زيادة تراكم البرولين بالنباتات بالأجزاء الطازجة (جم كجم⁻١) والتي تراوحت الزيادة في التراكم ب ٤٤.٣٪ للتسميد المعدني و٢٧.٤٪ للتسميد بالنانو.