Interaction effect between mineral zinc-nitrogen fertilization mixture and organic fertilization as compost on yield, nutrients uptake of rice and some soil properties

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Abstract: To study the effect of organic fertilization as compost (48 m^3 ha^{-1}), mineral Zinc-Nitrogen fertilization mixture (three Zinc levels (0, 20 and 40 kg Zn ha^{-1}) and three nitrogen rates (0, 72 and 144 kg N ha^{-1} were mixed alternately) on growth, grain and straw yields, N, P and K uptake for rice crop (*Oryza sativa* L.), variety Giza 178, two field trials at El-Serw Agricultural Research Station, Damietta governorate were conducted through summer seasons of 2015 and 2016. Plant height, dry matter, grain and straw yields also, N, P and K-uptake in grain and straw yields increased with increasing levels of zinc and nitrogen fertilization. Moreover, use organic fertilization as compost gave the highest values of the previous parameters. Applying of 40 kg Zn ha^{-1} + 144 kg N ha^{-1} with 48 m^3 compost ha^{-1} gave the highest plant height, dry matter, grain and straw yields and N, P and K-uptake in grain and straw. Therefore, it preferably adds 40 kg Zn ha^{-1} + 144 kg N ha^{-1} with 48 m^3 compost ha^{-1} to produce a high crop of rice under saline soil condition in North Delta. Concerning to soil properties after rice harvest, mixture 40 kg Zn ha^{-1} + 144 kg N ha^{-1} with 48 m^3 compost ha^{-1} surpassed all other treatments in improving soil properties, since available NPK and organic matter content had increased while soil EC and pH in the root zone was decreased.

Keywords: Rice, organic, mineral, zinc, nitrogen, nutrients, uptake

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1 Introduction

More than half the world's population depends on rice, which is produced on nearly 150 million hectares of land for a global production of more than 520 million t. Wetlands rice grows in flooded fields during all or part of the cropping period make up close to 80% of the world's rice area, accounting for 93% of all rice yield (Roger, 1996).

From crop residues, leaves, grass chippings, plant stalks, wines, weeds, twigs and branches were used to prepared the compost, which are a very good alternative which proved useful in many countries of the globe. Utilization of compost has not merely been adopted to enhance soil organic matter and enrich it with different nutrients but also to control the environmental pollution from debris (Kuepper, 2003). Compost proved greatly helpful in increasing the yield of the rice crop and N-P-K-uptake (Jeyabal and Kuppuswamy, 2001; Satyanarayana et al., 2002).

In higher plants, Zn is either required for or at least modulates, the activity of a large number of various types of enzymes, including dehydrogenases, aldolases, isomerases, transphosphorylases and RNA and DNA polymerases. Some examples are given below (Broadley et al., 2012).

Globally, more than 30% of soils are low in plant-available Zn (Figure 1) (Hacisalihoglu and Kochian, 2003; Alloway 2008). Cereals are generally more prone to Zn deficiency leading to a significant reduction in grain yield and nutritional quality, compared with legumes (Cakmak et al. 1999). However, a frequency of

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Zn deficiency is greater in rice than other crops, with more than 50% of the crop worldwide prone to this nutritional disorder (Dobermann and Fairhurst 2000; Fageria et al., 2002; Quijano-Guerta et al., 2002).

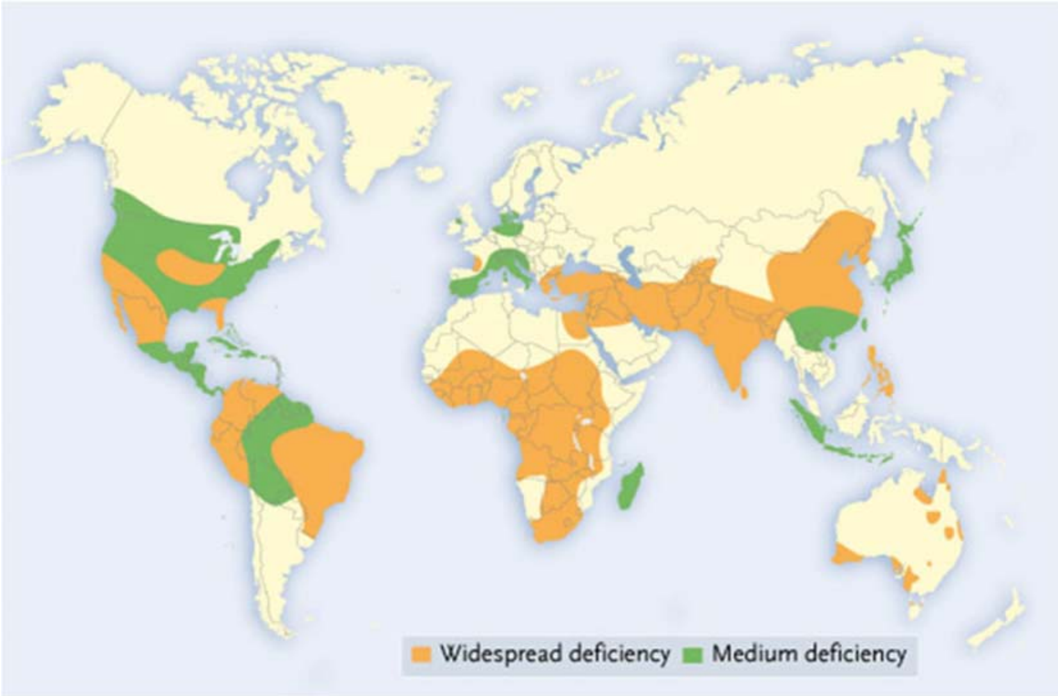

Figure 1 Zinc deficiency in crops around the world: major areas of reported problems (adapted from Alloway, 2008 with permission)

Shehata et al. (2009) under saline soil condition, found that zinc fertilizer had a positive effect on rice growth traits, e.g. dry matter production, leaf area index and yield attributes, i.e. panicle number/hill, plant height, panicle length, panicle weight, filled grains/panicle, 1000-grain weight, straw and grain yields. Many previous investigators reported that increasing zinc rates increased grain yield and its properties (Ghose et al., 1999; Rao and Shukla, 1999; Zia et al., 2000; Tariq et al., 2007; Khan et al., 2009; and Metwally, 2011).

Plants exhibit a dramatic response to nitrogen amendments since nitrogen is a major building block of amino acids and proteins (Wilkinson, 2000). Grain and straw yield and nitrogen, phosphorus and potassium uptake of paddy increased with increasing doses of nitrogen (Manjappa, 2004; Walker et al., 2008; and Artacho et al., 2009).

The aim of this investigation is studying the combined effect of using Organic Matter as compost, mineral Zinc-Nitrogen fertilization mixture on growth, yield, and nutrients uptake, for rice crop.

2 Materials and Methods

Two field trials were borne at El-Serw Agricultural Research Station, Damietta Governorate during the two summer seasons of 2015 and 2016. The experimental design was a split plot with four replications. The main effect was conducted to study the effect of mineral Zinc-Nitrogen fertilization mixture (three zinc levels (0, 20 and 40 kg Zn ha^{-1} as $ZnSO_4$) and three nitrogen rates (0, 72 and 144 kg N ha^{-1} as urea 46.5% N) were mixed alternately) and using organic matter as compost treatments (the sub plots) (Without organic matter and organic matter at a level of 48 m^3 ha^{-1} of compost), on rice (*Oryza sativa* L.) variety Giza 178, growth, nutrients uptake.

Rice nurseries were on 17^{th} May and 12^{th} May and it's transplanting on 24^{th} June and 19^{th} June, while rice harvesting was done on 8^{th} October and 5^{th} October in 2015 and 2016 seasons, respectively.

Mineral zinc and nitrogen fertilizer treatments were added to the dry soil before rice transplanting. Uniform application of superphosphate (15% P_2O_5) at the rate of 240 kg ha^{-1} was applied as basal of each plot before rice transplanting.

Mature compost (rice straw and farmyard manure) (48 m^3 of compost ha^{-1}) were added to the soil and mixed with the upper layer after transplanting (Table 1).

Table 1 Analysis of compost at 2014 and the 2015 seasons

Season	pH	EC dS m^{-1} at 25^oC	O.C., %	Total N, %	Total P, %	C/N
2014	7.49	2.83	29.85	1.58	0.27	19.12
2015	7.51	2.85	30.02	1.62	0.26	18.79

2.1 Soil analysis

Disturbed soil samples were studied from the experimental site before conducting the experiment from 0-30 cm depth. Soil samples were air-dried and ground to pass through a 2 mm screen. The different determinations of soil chemical and physical properties were held out as follows:

Particle size distribution, available N, P and K in the soil were determined according to the methods of Haluschak (2006) as well as electrical conductivity values of the 1:5 soil paste extracts were measured by EC, pH value, $CaCO_3$ and organic matter contents were determined according to Sahlemedhin and Taye (2000). Soil physical and chemical properties of the experimental soil are presented in Table 2.

Table 2 Physical and chemical attributes of the soil samples taken from the experimental field before rice cultivation in the 2015 and 2016 growing season

2015									
Particle size distribution					O.M, g kg^{-1}	$CaCO_3$, %	C.E.C, cmolc kg^{-1}	pH^*	EC^{**}, dS m^{-1}
Coarse sand, %	Fine sand, %	Silt, %	Clay, %	Texture					
1.45	10.34	22.28	65.93	Clayey	8.8	1.33	44.3	8.2	5.42

Soluble Cations and anions*, cmolc kg^{-1}										
Cations				Anions				N, mg kg^{-1}	P, mg kg^{-1}	K, mg kg^{-1}
Ca^{++}	Mg^{++}	Na^+	K^+	CO_3^{--}	HCO_3^-	Cl^-	SO_4^{--}			
3.12	2.79	11.40	0.28	n.d.	1.70	12.21	3.68	34	7.94	479

2016									
Particle size distribution					O.M, g kg^{-1}	$CaCO_3$, %	C.E.C, cmolc kg-1	pH^*	EC^{**}, dS m^{-1}
Coarse sand, %	Fine sand, %	Silt, %	Clay, %	Texture					
1.09	11.23	21.67	66.01	Clayey	7.7	1.41	44.1	8.1	5.32

Soluble Cations and anions*, cmolc kg^{-1}										
Cations				Anions				N, mg kg^{-1}	P, mg kg^{-1}	K, mg kg^{-1}
Ca^{++}	Mg^{++}	Na^+	K^+	CO_3^{--}	HCO_3^-	Cl^-	SO_4^{--}			
2.95	2.81	11.21	0.27	n.d.	1.59	12.02	3.63	31	8.01	483

Note: n.d. Not detected. * in the soil-water suspensions (1:2.5). ** in the soil extract (1:5).

2.2 Plant analysis

At harvest stage of wheat plant, representative samples were randomly taken from each experimental plot. Plant growth parameters in an expression of plant height (cm), dry weight of plant (g $plant^{-1}$) and grain and straw yield (t ha^{-1}) were determined. The plant samples were oven dried at 70^oC till constant weight. Chemical analysis of plant expressed as N, P and K (%) determined according to the methods described by Mertens (2005a, b) and AGRILASA (2002).

N, P and K uptake in wheat grains and straw were calculated by the following equation:

Nutrient element uptake $_{(kg\ ha^{-1})}$ =

(nutrient element% × yield $_{(kg\ ha^{-1})}$) 100^{-1}

2.3 The statistical analysis

Data were compiled for statistical analysis according to Snedcor and Cochran (1980). Average values were compared at the 5% and 1% levels of significance by using the Least Significance Difference (LSD) test. Cohort Software (2008) was applied for statistical analysis for data.

3 Results and Discussion

3.1 Rice growth parameters

Table 3 shows that rice plant height and dry weight as affected by the mixture of mineral Zn-N fertilization treatments, organic fertilization as compost and their interactions.

Table 3 Effect of mixture Zn-N and Organic fertilization and their interaction on rice plant height (cm), dry weight (g) and yield of grain and straw (t ha^{-1}) in 2015 and 2016 seasons

Treatments		2015				2016			
		Plant height	Dry weight	Grain yield	Straw yield	Plant height	Dry weight	Grain yield	Straw yield
		mixture Zn-N Fertilization							
$Zn_0 \times N_0$		77.0	60.30	2.92	3.20	77.7	65.92	7.18	7.94
$Zn_0 \times N_{72}$		80.9	70.80	3.39	3.84	81.6	77.66	8.33	9.58
$Zn_0 \times N_{144}$		83.3	80.41	3.71	3.97	84.0	88.48	9.10	9.84
$Zn_{20} \times N_0$		77.9	71.51	3.27	3.69	78.5	73.09	8.11	9.24
$Zn_{20} \times N_{72}$		81.9	84.14	3.67	4.16	82.4	86.12	9.10	10.39
$Zn_{20} \times N_{144}$		82.1	89.40	3.77	4.26	82.6	89.29	9.34	10.68
$Zn_{40} \times N_0$		78.1	76.00	3.35	3.88	78.7	75.82	8.33	9.72
$Zn_{40} \times N_{72}$		84.3	95.74	3.89	4.42	84.9	98.13	9.62	11.04
$Zn_{40} \times N_{144}$		84.5	101.72	3.96	4.60	85.1	101.69	9.82	11.52
LSD 005		ns	ns	0.53^{*}	0.71^{*}	ns	ns	1.02^{**}	1.44^{**}
		Organic fertilization							
C_0		80.4	71.32	3.32	3.86	81.1	79.16	8.21	9.65
C_1		81.8	90.91	3.77	4.14	82.3	88.88	9.31	10.32
LSD 005		4.8^{ns}	5.36^{**}	0.25^{**}	0.31^{ns}	ns	5.70^{**}	0.55^{**}	0.65^{*}
$Zn_0 \times N_0$	C_0	76.2	48.43	2.77	2.86	76.8	60.32	6.82	7.10
	C_1	77.8	72.16	3.06	3.54	78.5	71.51	7.51	8.78
$Zn_0 \times N_{72}$	C_0	80.0	58.87	3.23	3.83	80.8	73.33	7.94	9.60
	C_1	81.8	82.73	3.55	3.85	82.4	81.99	8.71	9.55
$Zn_0 \times N_{144}$	C_0	82.4	69.10	3.50	3.87	83.1	86.07	8.59	9.60
	C_1	84.2	91.72	3.91	4.06	84.9	90.89	9.60	10.08
$Zn_{20} \times N_0$	C_0	77.3	62.16	3.08	3.54	77.9	67.00	7.63	8.86
	C_1	78.5	80.86	3.46	3.84	79.0	79.17	8.57	9.60
$Zn_{20} \times N_{72}$	C_0	81.2	75.57	3.36	4.00	81.8	81.45	8.33	9.98
	C_1	82.5	92.71	3.98	4.31	83.0	90.78	9.84	10.78
$Zn_{20} \times N_{144}$	C_0	81.5	79.77	3.51	4.15	82.1	83.00	8.71	10.39
	C_1	82.6	99.04	4.02	4.37	83.1	95.58	9.96	10.94
$Zn_{40} \times N_0$	C_0	77.6	65.62	3.15	3.62	78.2	68.27	7.82	9.07
	C_1	78.6	86.38	3.55	4.13	79.1	83.36	8.81	10.34
$Zn_{40} \times N_{72}$	C_0	83.6	88.70	3.61	4.35	84.3	95.61	8.93	10.87
	C_1	84.9	102.78	4.16	4.48	85.5	100.64	10.30	11.21
$Zn_{40} \times N_{144}$	C_0	83.9	93.64	3.67	4.54	84.6	97.42	9.10	11.38
	C_1	85.0	109.80	4.24	4.65	85.6	105.96	10.51	11.64
LSD 005		ns	ns	ns	ns	ns	ns	ns	ns

Note: C = organic fertilization as compost. C_0 = without compost. C_1= with 48 m^3 compost ha^{-1}.

Data shows that rice plant height and dry matter are non-significant increase by using mixture mineral Zn-N fertilization in the both seasons. The highest values of these parameters were obtained by Zn_{40}-N_{144}. While, rice plant height was non-significant by applying organic fertilization, but the rice dry weight was significantly by applying organic fertilization in the both seasons. The highest values were obtained when it used by 48 m^3 compost ha^{-1}. Shehata et al. (2009) under saline soil condition, found that zinc fertilizer had a positive effect on rice dry matter production and plant height.

While to date shows that the interaction effect between a mixture of mineral fertilization and organic fertilization. This interaction effect was non-significant on rice plant height and dry weight in the both seasons. The highest values of plant height and dry weight Zn_{40}-N_{144} and 148 m^3 compost ha^{-1} following by Zn_{40}-N_{72} and $Zn_{20}N_{144}$, respectively when it's applied with compost.

3.2 Rice grain and straw yield t ha^{-1}

Data pertaining to rice grain and straw yield recorded in t ha^{-1} as affected by the mixture of mineral Zn-N fertilization treatments, organic fertilization as compost, and their interactions are presented in Table 3.

Data shows that rice grain and straw yield are significant increase by using the mixture mineral Zn-N fertilization. The highest value of this parameter was obtained by Zn_{40}-N_{144} and applying organic fertilization increased the previous parameters when it used by 20 m^3 compost ha^{-1}. Ali et al. (2014) showed that N and Zn interaction significantly improved the grain yield, yield components, also they indicated that a combined application of 120 kg N ha^{-1} and 14 kg Zn ha^{-1} produced the maximum grain yields.

There was a non-significant increase in rice grain and straw yield by using mineral fertilization mixture and organic fertilizers, in both seasons 2015-2016. The highest values of these parameters were obtained when applying mixture 40 kg Zn ha^{-1} + 144 kg N ha^{-1} and 48 m^3 compost ha^{-1}. In general, these results agree with those obtained by Hussain et al. (2006), when he indicated that compost proved greatly helpful in increasing the yield of rice and wheat crops in saline sodic soils.

3.3 Nitrogen, phosphor and potassium uptake in rice grain and straw

Data in Table 4 shows that the effect of mixture mineral Zn-N fertilizer levels, organic fertilization treatments, and their interaction on the NPK uptake in grains and straw. There was a significant increase in NPK uptake in rice grain and straw by using mixture mineral fertilization and organic fertilization in both seasons 2015-2016. The highest values of these parameters were obtained when applying Zn_{40}-N_{144} and 48 m^3 compost ha^{-1}. Ofori et al. (2005) and Fahmy et al. (2008) showed that the application of organic amendments to all the soils improved uptake of nitrogen. While Pooniya and Shivay (2013) indicated that Zn fertilization had significant effects on the concentrations and uptake of N and K in basmati rice grain and straw. The results in Table 4 show that the interaction effect between mixture mineral Zn-N fertilization and organic manure treatments was a non-significant on NPK-uptake in rice grain and straw in both seasons except P-uptake in rice grains in the second seasons, it was significant. Data in Table 4 indicated that nutrients uptake for rice grains and straw in both seasons 2015 and 2016 were obtained by applying Zn_{40}-N_{144} with 48 m^3 compost ha^{-1}.

3.4 Some soil chemical properties after rice harvest

Data in Table 5 indicated that mixture mineral zinc-nitrogen and organic matter treatment improved some soil properties and this effect was higher than that of control treatment. Soil EC and pH values in the rice root zone were 4.95 & 4.89 and 8.1 & 8.0 after 2014 and 2015 seasons, respectively in control plots while EC values were 4.29 & 4.24, 4.36 & 4.31, 4.39 & 4.34 and 4.43 & 4.38 after 2014 and 2015 seasons, respectively, and pH values in the rice root zone were 7.5 after 2014 and 2015 seasons, respectively with when applying organic fertilization as compost with $Zn_{40}\times N_{144}$, $Zn_{40}\times N_{72}$, $Zn_{20}\times N_{144}$ and $Zn_{20}\times N_{72}$, respectively. The previous results may be attributed to effects of zinc fertilizers and organic matter on soil pH by organic acids and effect of mixture mineral Zn-N on rice growth enhancing, therefore, increasing in bio activity of plants for improving soil properties.

Interesting, the soil organic matter and available NPK in the soil after rice harvesting, data in Table 5 revealed that soil organic matter and available NPK increased with mixture mineral Zn-N fertilization and organic matter. These results could be attributed to:

1-NPK elements could be increased with a pH value reduction in the root zone by organic matter.

2-Potassium element in soil could be released from soil (clay) minerals due to organic acids by hydrolysis or solution processes caused by organic acids.

3-Available phosphorus could be increased in soil because of the excretions of organic acids by organic matter decomposition which convert slight soluble $Ca_3(PO_4)$ 2 to be more soluble di-and monobasic phosphates.

4-the effect of mixture mineral Zn-N on rice growth enhancing, therefore, increasing in bio activity of plants for improving soil properties such as increasing in soil organic matter.

5-The rapid oxidation of the organic matter formed by applying organic matter, which applied and from organic matter treatments due to height temperature in arid and semi-arid regions.

Table 4 Effect of mixture Zn-N and Organic fertilization and their interaction on N, P and K uptake (kg ha^{-1}) in rice grain and straw in 2015 and 2016 seasons

Treatments		2015						2016					
		Grain			Straw			Grain			Straw		
		N Uptake	P Uptake	K Uptake	N Uptake	P Uptake	K Uptake	N Uptake	P Uptake	K Uptake	N Uptake	P Uptake	K Uptake
Mixture Zn-N Fertilization													
$Zn_0 \times N_{72}$		77.59	13.06	8.04	36.26	1.44	74.64	80.57	22.56	8.47	38.47	1.82	79.27
$Zn_0 \times N_{72}$		101.28	17.76	17.02	57.14	2.35	100.66	105.14	16.03	17.81	60.91	3.07	109.20
$Zn_0 \times N_{72}$		117.77	24.91	25.27	69.48	3.91	117.22	122.14	22.44	26.30	73.61	4.94	129.62
$Zn_0 \times N_{72}$		90.38	15.65	9.72	43.01	2.23	92.16	94.51	20.86	10.30	45.96	2.78	95.16
$Zn_0 \times N_{72}$		117.26	20.47	19.63	62.71	3.41	110.59	122.52	19.42	20.66	66.96	4.49	120.00
$Zn_0 \times N_{72}$		124.10	21.36	20.45	64.73	3.86	113.74	129.82	21.74	21.46	69.29	4.92	123.43
$Zn_0 \times N_{72}$		95.45	16.39	10.32	46.15	2.54	98.88	100.08	19.44	10.87	49.46	3.29	102.89
$Zn_0 \times N_{72}$		131.93	27.17	27.67	78.77	5.52	121.73	137.81	23.26	29.06	84.07	6.58	134.71
$Zn_0 \times N_{72}$		139.15	27.72	28.97	82.42	6.19	129.19	145.58	28.97	30.50	88.08	8.30	143.14
LSD 0.05		16.03^{**}	3.10^{**}	3.29^{**}	8.95^{**}	1.56^{**}	14.98^{**}	16.80^{**}	3.43^{**}	3.48^{**}	9.55^{**}	1.20^{**}	16.34^{**}
Organic fertilization													
C_0		100.06	18.79	17.02	58.08	3.00	97.78	104.57	20.11	17.88	61.99	4.03	106.25
C_1		121.03	22.20	20.09	62.06	3.98	115.27	126.14	23.16	21.10	66.19	4.87	124.27
LSD 0.05		6.07^{**}	1.42^{**}	1.30^{**}	3.48^{*}	0.58^{**}	5.95^{**}	6.29^{**}	1.34^{**}	1.37^{**}	3.70^{**}	0.46^{**}	6.55^{**}
Mix. Zn-N Fert. × Organic Fert.													
$Zn_0 \times N_0$	C_0	70.80	12.17	7.39	32.33	1.18	66.02	73.68	30.67	7.85	34.32	1.42	70.54
	C_1	84.38	13.94	8.66	40.18	1.70	83.26	87.43	14.42	9.10	42.60	2.21	88.01
$Zn_0 \times N_{72}$	C_0	91.18	16.68	15.96	57.07	2.02	94.87	94.85	12.60	16.68	61.15	2.78	102.91
	C_1	111.36	18.84	18.07	57.19	2.69	106.44	115.44	19.44	18.91	60.65	3.34	115.49
$Zn_0 \times N_{144}$	C_0	110.98	23.18	23.52	67.61	3.43	110.16	115.06	17.23	24.48	71.62	4.42	121.82
	C_1	124.54	26.64	27.02	71.33	4.39	124.25	129.22	27.65	28.13	75.60	5.45	137.40
$Zn_{20} \times N_0$	C_0	81.77	14.42	8.95	41.04	1.87	84.12	85.63	24.05	9.46	43.85	2.40	89.81
	C_1	98.98	16.85	10.46	44.98	2.59	100.18	103.42	17.64	11.14	48.10	3.17	100.51
$Zn_{20} \times N_{72}$	C_0	106.44	18.22	17.74	60.29	2.78	101.09	111.50	15.12	18.58	64.30	3.98	109.73
	C_1	128.09	22.73	21.50	65.16	4.03	120.10	133.54	23.71	22.73	69.62	4.97	130.27
$Zn_{20} \times N_{144}$	C_0	112.37	19.37	18.70	62.95	3.29	105.38	117.70	19.08	19.68	67.34	4.46	114.41
	C_1	135.84	23.35	22.20	66.50	4.42	122.09	141.94	24.41	23.21	71.26	5.35	132.43
$Zn_{40} \times N_0$	C_0	85.87	15.05	9.53	42.58	2.09	86.62	90.22	20.30	10.01	45.62	2.71	90.62
	C_1	105.05	17.71	11.09	49.75	2.98	111.12	109.92	18.58	11.71	53.28	3.84	115.13
$Zn_{40} \times N_{72}$	C_0	116.78	24.96	25.39	77.57	4.92	111.82	122.14	15.82	26.62	82.73	6.31	123.62
	C_1	147.07	29.35	29.95	79.99	6.12	131.62	153.50	30.67	31.51	85.42	6.84	145.82
$Zn_{40} \times N_{144}$	C_0	124.37	25.01	26.06	81.38	5.35	119.86	130.25	26.06	27.55	87.02	7.85	132.86
	C_1	153.96	30.43	31.85	83.47	7.03	138.50	160.94	31.85	33.43	89.16	8.74	153.41
LSD 0.05		ns	ns	ns	ns	ns	ns	ns	4.03^{**}	ns	ns	ns	ns

Note: C = organic fertilization as compost. C_0 = without compost. C_1= with 48 m^3 compost ha^{-1}.

Table 5 Effect of interaction between mixture Zn-N and Organic fertilization on some soil chemical properties after rice harvest in 2015 and 2016 seasons

Organic fertilization	Zn×N	EC, dS m^{-1}		PH (1- 2.5)		O.M, g kg^{-1}		N, mg kg^{-1}		P, mg kg^{-1}		K, mg kg^{-1}	
		2015	2016	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016
C_0	$Zn_0 \times N_{72}$	4.95	4.89	8.1	8.0	8.9	8.8	27	26	7.82	8.07	475	490
	$Zn_0 \times N_{72}$	4.95	4.89	8.1	8.0	9.1	9.0	28	27	8.21	8.48	475	490
	$Zn_0 \times N_{72}$	4.95	4.89	8.0	7.9	9.3	9.2	32	31	8.53	8.81	476	491
	$Zn_0 \times N_{72}$	4.94	4.88	8.0	7.9	9.5	9.4	29	28	8.31	8.58	479	494
	$Zn_0 \times N_{72}$	4.92	4.86	8.0	7.9	9.7	9.6	36	35	8.63	8.91	481	496
	$Zn_0 \times N_{72}$	4.93	4.87	7.9	7.8	10.2	10.1	41	40	9.02	9.31	485	500
	$Zn_0 \times N_{72}$	4.95	4.89	7.9	7.8	9.5	9.4	35	34	8.79	9.08	486	501
	$Zn_0 \times N_{72}$	4.94	4.88	7.8	7.8	10.9	10.8	42	41	9.53	9.84	490	505
	$Zn_0 \times N_{72}$	4.92	4.86	7.8	7.8	11.2	11.1	53	52	10.65	11.00	491	506
C_1	$Zn_0 \times N_{72}$	4.53	4.47	7.6	7.6	11.6	11.5	49	48	9.52	9.83	495	510
	$Zn_0 \times N_{72}$	4.51	4.45	7.6	7.6	11.9	11.8	59	58	10.23	10.56	509	525
	$Zn_0 \times N_{72}$	4.48	4.42	7.6	7.6	12.3	12.2	72	70	10.99	11.35	514	530
	$Zn_0 \times N_{72}$	4.53	4.47	7.6	7.6	11.9	11.8	62	61	10.75	11.10	512	528
	$Zn_0 \times N_{72}$	4.43	4.38	7.5	7.5	12.6	12.5	73	71	10.99	11.35	521	537
	$Zn_0 \times N_{72}$	4.39	4.34	7.5	7.5	13.2	13.1	81	79	11.61	11.99	528	544
	$Zn_0 \times N_{72}$	4.45	4.40	7.6	7.6	12.4	12.3	76	74	11.33	11.70	524	540
	$Zn_0 \times N_{72}$	4.36	4.31	7.5	7.5	13.6	13.5	83	81	11.79	12.17	529	546
	$Zn_0 \times N_{72}$	4.29	4.24	7.5	7.5	14.5	14.4	95	93	12.3	12.70	535	552

4 Conclusion

It could be concluded that using mineral zinc and nitrogen fertilization with organic fertilizer to produce the highest rice crop under the saline soil in North Delta.

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