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Influence of Integrated In-soil Zinc Application and Organic Fertilization on Yield, Nitrogen Uptake and Nitrogen Use Efficiency of Rice

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ZINC deficiency is the most widespread challenge in rice cultivation, as well as the shortage of agricultural soil in organic matter, especially in Egypt. So, there was an experimentation for compost treatment (12 t ha^{-1}) and in-soil zinc applications at three rates (0, 8 and 16 kg $ZnSO_4.7H_2O$ ha^{-1}), on growth, yield, total nitrogen uptake, agronomic nitrogen efficiency and nitrogen recovery efficiency of rice crop (*Oryza sativa*), variety Giza 178. Using organic fertilization as compost has recorded the highest values of plant height, dry weight, grain yield, straw yield, total nitrogen uptake, agronomic nitrogen efficiency and nitrogen recovery efficiency. In addition, in-soil zinc application rates are increasingly applied to the previous parameters. The increase in rice grain and straw yield by applying 12 t compost ha^{-1} was 13.4% and 7.14%, respectively, while applying 16 kg $ZnSO_4.7H_2O$ ha^{-1} increased the rice grain yield by 12.31% and 17.55% increase in rice straw yield. Remarkable results have been registered when examining 16 kg Zn ha^{-1} with 12 t compost ha^{-1} on total nitrogen uptake and nitrogen recovery efficiency have been enhanced even under saline soil conditions.

Keywords: Rice, Organic, Mineral. Zinc, Nitrogen, Uptake, Efficiency.

Introduction

Rice (*Oryza sativa* L.) is a very essential cereal crop of the world, grown in wide scope of climatic zones. It is a staple food for nearly half of the world's population, most of whom live in developing countries. The crop occupies one-third of the world's total area planted to cereals and provides 35 to 60% of the calories consumed by 2.7 billion people. (Mandana et al., 2014). The production of an economic crop of rice without high rates of mineral fertilizers suitable for new varieties of rice distinguished in the high yield in the soil is poor content of organic matter is one of the most important challenges faced by researchers, especially in Egypt. Compost is a mixture from crop wastes, leaves, grass chippings, plant stems, grapes, weeds, twigs and branches it's a very good alternative which proved helpful in many countries all over the world, compost application has not merely been used to improve soil organic matter and refine it with different nutrients but also to render the environmental pollution from trash (Kuepper, 2003). Compost tested greatly useful in enhancing the yield of the rice crop and N-P-K-uptake (Jeyabal and Kuppuswamy, 2001; Satyanarayana et al., 2002 and Khafagy et al. 2017).

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 polymer-ases. Some examples are given below (Broadley et al., 2012). Globally, more than 30 % of soils are poor in plant-available Zn (Hacisalihoglu and Kochian, 2003 and Alloway 2008). Egyptian soil

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is considered to be among the soils are poor in zinc (Alloway, 2008 and Khafagy et al., 2017). In general, cereals such as rice are more exposed to Zn deficiency leading to a serious decline in grain yield and nutritional quality, compared with legumes (Cakmak et al., 1999). Zinc deficiency causes severe yield reduction in rice, so the application of Zn such as foliar or soil application caused significant improvement in growth and yield attributes and yield of rice (Suman and Sheeja, 2018). Moreover, a constancy of Zn lack is higher in rice than other crops, with more than 50 % of the yield worldwide prone to this nutritional mess. In addition, Paddy soil conditions are usually not supportive for attainable zinc, therefore, zinc insufficiency has been announced countrywide in rice soils (Dobermann and Fairhurst 2000; Fageria et al. 2002; Quijano-Guerta et al. 2002 and El-Hissewy et al. 2016).

In-soil zinc application is the principal method and a simple and effective solution for Zn supply in rice production systems (Naik & Das 2007 and Ghasal et al., 2016). Zinc fertilizer had a decisive influence on rice growth features, e.g dry matter creation, leaf area indicator and yield traits, i.e. panicle number/hill, plant height, panicle length, panicle weight, filled grains/panicle, 1000-grain weight, straw and grain yields under saline soil condition (El-Hadidi et al. 2016 and Khafagy et al., 2017). In additions, Bharat (2006) stated that zinc employment had raised rice grain and straw yields and harvest index under saline sodic conditions. A lot of investigators announced that escalated zinc rates expanded grain yield and its properties (Tariq et al., 2007; Metwally, 2011 and El-Hissewy et al., 2016).

Therefore, our experiments were conducted to study the interaction effect between organic fertilization as compost and in-soil zinc application as $ZnSO_4.7H_2O$ on rice in saline soils in the northern Delta of Egypt. The hypotheses were: (i) zinc deficiency is the most widespread micronutrients disorder in rice cultivation in the northern Delta of Egypt (ii) also, the poverty of the soil in organic matter, therefore (iii) the use of organic fertilization in the form of compost on saline soils and the use of in-soil zinc application as $ZnSO_4.7H_2O$ can increase rice production by improving the efficiency of nitrogen use, which at the same time helps to protect the natural environment.

Materials and Methods

Preparation and experimental design

Field experiments were conducted for two seasons (2017-2018) on a clayey soil at the experimental farm of El-Serw Agriculture Research Station, Agriculture Research Center, Damietta governorate (31°14′N and 31°48′E) in the northern Egypt. The region has a sub-tropical climate with hot, dry summers and cool wet winters. The weather conditions (Average precipitation, humidity percentage, maximum and minimum temperature and Dew/Forest Point) at the experimental location during rice growing seasons were quite variable in the two years of experimentation (Fig. 1 A and B). The experimental design is a split plot with four replications. The main scheme is planned to study the effect of compost application, at 2 rates 0 (unfertilized control) and recommended dose at 12 t ha-1 of compost on rice (*Oryza sativa L.*) variety Giza 178, growth and nutrients uptake. The chemical analysis of the compost is shown in Table 1. When the subplot deals with testing the consequences of applying in-soil zinc application at three zinc levels (0, 8 and 16 kg Zn ha^{-1} as $ZnSO_4.7H_2O$) on rice (*Oryza sativa L.*) growth and nutrients uptake.

Before rice transplanting mineral zinc fertilizer treatments were added to the dry soil. Moreover, equable application of superphosphate (15% P2O5) at the rate of 240 Kg ha-1 was applied too as basal of each plot. All agronomic practices in rice such as, land preparation, fertilization and irrigation were done as recommended (nitrogen fertilizer at 140 kg N ha-1 and applied as urea 46.5% N) in three equal doses after sowing.

TABLE 1. Analysis of compost at 2017 and the 2018 seasons

Season	pH	EC dS/m at 25 °C	Total N %	Total P %	C/N
1st	7.52	2.79	1.53	0.28	19.07
2nd	7.50	2.82	1.59	0.27	18.53

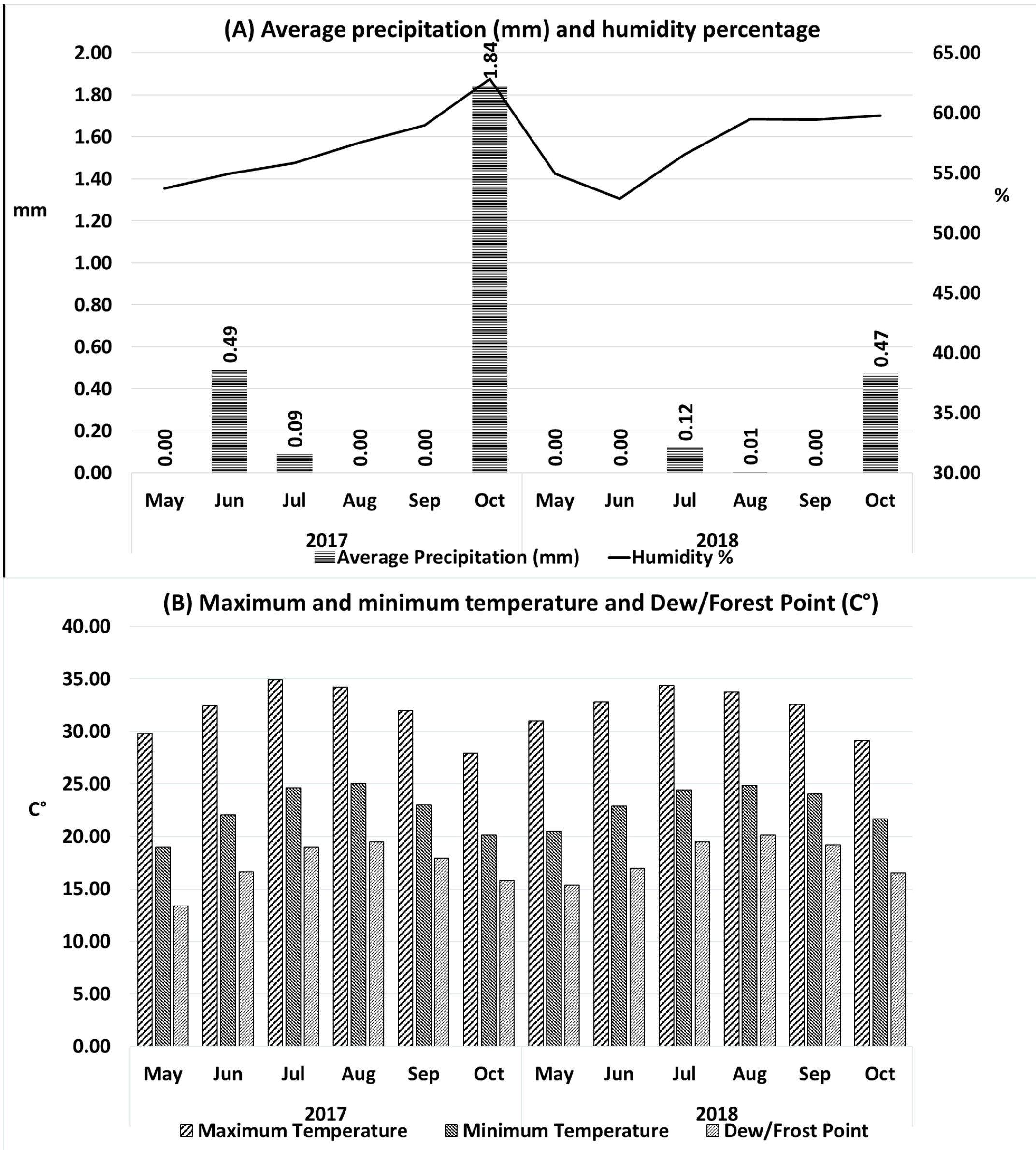

Fig. 1. (A) Average precipitation (mm) and humidity (%) and (B) Maximum and minimum temperature and Dew/Forest Point (C°) of experimental site during crop growth during two years

The 2017 summer season, rice nurseries were planted on 14th May when their transplanting was on 21th June and their harvest was on 8th October. While rice nurseries in the second season were planted on 16th May and they were transplanted on 24th June and their harvest was on 9th October,2018.

Mature compost (rice straw and farmyard manure) (12 t of compost ha-1) were added to the soil and mixed with the upper layer (30 cm) after transplanting.

Soil analysis

The surface soil (0–30 cm) layer at the initiation of experiments was saline (electrical conductivity 5 dS m^{-1}) with pH 8.1 and contained 7.6 kg^{-1} Walkley-Black carbon, 7.94 mg kg^{-1} 0.5M NaHCO3-extractable P (Olsen et al. 1954) and 479 mg kg^{-1} 1N NH_4OAc-extractable K (Jackson, 1967). Irrigation from El-Serw drainage from a point away from the start of the drainage about 20 km (EC 3.2:3.3 ds m^{-1}, SAR 10.5:11.3), therefore it's considered to cause increase salinity problems (Tagour and Mosaad 2017).

Plant analysis

At harvest stage, rice plant representative samples had randomly taken from each experimental plot. Plant height growth parameters, dry weight of plant and grain and straw yield were acquired by (cm), (g plant^{-1}) and (t ha^{-1}), orderly. plant samples were oven dried at 70°C till constant weight. N (%) in plant were Chemically analyzed according to Mertens (2005a, b) methods and Agrilasa (2002).

Nitrogen uptake and use efficiencies

Nitrogen uptake in rice grains and straw are calculated by the following equation:

Nutrient element uptake (kg ha^{-1}) = (nutrient element% × yield (kg ha^{-1})) / 100.

Agronomic efficiency AE kg grain/kg N applied, and apparent recovery efficiency (RE), of added fertilizer N were calculated as:

AE = (grain yield in plot) / (quantity of N fertilizer applied in plot)

RE (%) = [(total N uptake in plot) / (quantity of N fertilizer applied in plot)] × 100

Statistical analysis

Data were collected for statistical analysis according to Snedecor and Cochran (1981). Mean values were compared, at a level of P<0.05 by using the Least Significance Difference (LSD) test. CoStat (v. 6.400 CoHort software., California, USA) was used for statistical analysis for data.

Results

Rice growth parameters

Table 2 showed rice plant height and dry weight as affected by organic fertilization as compost, soil mineral Zn fertilization treatments and their interactions.

Applying organic fertilization has insignificant effect ($p<0.05$) on rice plant height apart from rice dry weight which was significantly influenced in both seasons as well as in the pooled analysis. The highest values were obtained by using 12 t ha^{-1} compost ha^{-1} under saline soil condition.

Also, data in Table 2 showed that rice plant height was non-significantly increased ($p<0.05$) by applying mineral Zn fertilization in both seasons as well as in the pooled analysis, but the dry weight of rice was very significant ($p<0.01$) in both seasons as well as in the pooled analysis. The highest values of these parameters are obtained by 16 kg of $ZnSO_4.7H_2O$. In line with data, there is an interaction resulted from organic fertilization as compost and in-soil zinc application. Its outcome was non-significant on rice plant height and dry weight in both seasons as well as in the polled analysis.

TABLE 2. Effect of organic fertilization as compost, soil mineral Zn fertilization and their interaction on rice plant height (cm) and dry weight (g)

Treatments	Plant Hight						Dry weight					
	2017		2018		Pooled of analysis		2017		2018		Pooled of analysis	
	Mean	Std. E. of Mean	Mean	Std. E. of Mean	Mean	Std. E. of Mean	Mean	Std. E. of Mean	Mean	Std. E. of Mean	Mean	Std. E. of Mean
Organic fertilization (t compost ha^{-1})												
0	80.41	±3.42	81.07	±4.23	80.74	±3.81	71.32	±3.85	79.16	±3.89	75.24	±3.83
12	81.77	±3.46	82.34	±4.26	82.06	±3.85	90.91	±3.96	88.88	±3.91	89.89	±3.93
Total	81.09	±2.41	81.71	±2.97	81.40	±2.68	81.11	±3.05	84.02	±2.81	82.57	±2.90
LSD 0.05	ns		ns		ns		4.61**		5.01**		5.82**	
Mineral Zinc Fertilization (kg $ZnSO_4.7H_2O$ ha^{-1})												
0	80.40	±4.23	81.08	±5.23	80.74	±4.72	70.50	±4.84	77.35	±4.47	73.93	±4.56
8	80.60	±4.21	81.15	±5.21	80.88	±4.70	81.69	±4.74	82.83	±4.49	82.26	±4.60
16	82.27	±4.31	82.88	±5.30	82.58	±4.79	91.15	±5.33	91.88	±5.24	91.52	±5.26
Total	81.09	±2.41	81.71	±2.97	81.40	±2.68	81.11	±3.05	84.02	±2.81	82.57	±2.90
LSD 0.05	ns		ns		ns		5.77**		5.93**		4.79**	
Organic fertilization × Zinc fertilization												
LSD 0.05	ns		ns		ns		ns		ns		ns	

Rice grain and straw yield ton ha-1

ANOVA in Table 3 showed that the interaction effect between compost application and in-soil zinc application was insignificant ($p<0.05$) on rice grain and straw yield in both seasons and pooled analysis. While rice grain yield was significant ($p<0.05$) and rice straw yield was very significant ($p<0.01$) by employing mineral Zn fertilization parameter. On the other hand, the effect of organic fertilization was highly significantly ($p<0.01$) on rice grain yield in both seasons and pooled analysis, while the effect of organic fertilization on rice straw yield was non-significant ($p<0.05$) in the 1st season and significant ($p<0.05$) in the 2nd season and in the pooled analysis.

Furthermore, data in Table 3 pointed that applying of 16 kg $ZnSO_4.7H_2O$ ha^{-1} gave the highest rice grain and straw yield in both season and pooled analysis. Applying 8 and 16 kg $ZnSO_4.7H_2O$ ha^{-1} increased the rice grain yield by (7.34 and 12.31%, respectively) and (10.35 and 17.55%, respectively) increasing in rice straw yield. The highest rice grain and straw yield were obtained with applying organic fertilization at 12 t compost ha^{-1}. The increase in rice grain and straw yield by applying 12 t compost ha^{-1} was 13.4% and 7.14%, respectively in pooled analysis.

Total nitrogen uptake in rice

According to the data in Table 4, the interaction effect between organic fertilization and in-soil zinc application was significant ($p<0.05$) on total N-uptake in rice in both seasons and pooled analysis. While the effect of organic fertilization and in-soil zinc application factors separately were very significant ($p<0.01$) on total N-uptake in rice in both seasons and pooled analysis. The highest values were obtained when 12 t compost ha^{-1} and 16 kg $ZnSO_4.7H_2O$ ha^{-1} treatments were used separately in both seasons.

Moreover, total nitrogen uptake in rice affected by the interaction between organic fertilization and in-soil zinc application was explaining in Figure 2. The highest values of total nitrogen uptake in rice were obtained by applying 12 t compost ha^{-1} with 16 kg $ZnSO_4.7H_2O$ ha^{-1} followed by 12 t compost ha^{-1} with 8 kg $ZnSO_4.7H_2O$ ha^{-1} and 12 t compost ha^{-1} without in-soil zinc application, respectively (Fig. 2).

TABLE 3. Effect of organic fertilization as compost, soil mineral Zn fertilization and their interaction on rice grain and straw yield (t ha-1)

Treatments	Grain Yield						Straw Yield					
	2017		2018		Pooled of analysis		2017		2018		Pooled of analysis	
	Mean	Std. E. of Mean	Mean	Std. E. of Mean	Mean	Std. E. of Mean	Mean	Std. E. of Mean	Mean	Std. E. of Mean	Mean	Std. E. of Mean
Organic fertilization (t compost ha^{-1})												
0	7.90	±0.39	8.14	±0.36	8.02	±0.38	9.20	±0.55	9.57	±0.48	9.38	±0.52
12	8.98	±0.44	9.24	±0.41	9.11	±0.42	9.85	±0.55	10.24	±0.47	10.05	±0.51
Total	8.44	±0.30	8.69	±0.28	8.57	±0.29	9.52	±0.39	9.91	±0.34	9.72	±0.36
LSD 0.05	0.50**		0.45**		0.48**		ns		0.57*		0.62*	
Mineral Zinc Fertilization (kg $ZnSO_4.7H_2O$ ha^{-1})												
0	7.94	±0.51	8.13	±0.47	8.04	±0.49	8.73	±0.65	9.05	±0.56	8.89	±0.60
8	8.50	±0.52	8.77	±0.48	8.63	±0.50	9.61	±0.66	10.01	±0.57	9.81	±0.61
16	8.88	±0.54	9.17	±0.50	9.03	±0.52	10.23	±0.69	10.67	±0.60	10.45	±0.64
Total	8.44	±0.30	8.69	±0.28	8.57	±0.29	9.52	±0.39	9.91	±0.34	9.72	±0.36
LSD 0.05	0.69*		0.67*		0.69*		0.88**		0.79**		0.84**	
Organic fertilization × Zinc fertilization												
LSD 0.05	ns		ns		ns		ns		ns		ns	

TABLE 4. Effect of organic fertilization as compost, soil mineral Zn fertilization and their interaction on total nitrogen uptake (kg N ha-1), agronomy nitrogen efficiency (kg grain/ kg N applied) and apparent nitrogen recovery efficiency (%)

Treatments	Total N Uptake						AE						RE%					
	2017		2018		Pooled of analysis		2017		2018		Pooled of analysis		2017		2018		Pooled of analysis	
	Mean	Std. E. of Mean	Mean	Std. E. of Mean	Mean	Std. E. of Mean	Mean	Std. E. of Mean	Mean	Std. E. of Mean	Mean	Std. E. of Mean	Mean	Std. E. of Mean	Mean	Std. E. of Mean	Mean	Std. E. of Mean
Organic fertilization (t compost ha^{-1})																		
0	48.51	±1.34	51.01	±1.43	49.76	±1.38	23.71	±1.18	24.43	±1.08	24.07	±1.13	34.65	±0.96	36.43	±1.02	35.54	±0.99
12	76.43	±2.08	79.57	±2.19	78.00	±2.13	26.93	±1.31	27.71	±1.22	27.32	±1.27	54.59	±1.48	56.84	±1.56	55.72	±1.52
Total	62.47	±2.28	65.29	±2.35	63.88	±2.31	25.32	±0.90	26.07	±0.84	25.70	±0.87	44.62	±1.63	46.63	±1.68	45.63	±1.65
LSD 0.05	2.86**		2.99**		2.92**		1.51**		1.39**		1.44**		2.04**		2.14**		2.09**	
Mineral Zinc Fertilization (kg $ZnSO_4.7H_2O$ ha^{-1})																		
0	53.79	±2.92	55.92	±2.98	54.86	±2.95	23.83	±1.53	24.39	±1.40	24.11	±1.46	38.42	±2.09	39.94	±2.13	39.18	±2.11
8	62.87	±3.62	65.98	±3.73	64.43	±3.68	25.49	±1.56	26.31	±1.44	25.90	±1.50	44.91	±2.59	47.13	±2.67	46.02	±2.63
16	70.75	±4.28	73.96	±4.39	72.35	±4.33	26.64	±1.62	27.51	±1.50	27.08	±1.56	50.54	±3.06	52.83	±3.13	51.68	±3.10
Total	62.47	±2.28	65.29	±2.35	63.88	±2.31	25.32	±0.90	26.07	±0.84	25.70	±0.87	44.62	±1.63	46.63	±1.68	45.63	±1.65
LSD 0.05	0.55**		0.59**		0.57**		2.09*		2.03*		2.05*		0.39**		0.42**		0.41**	
Organic fertilization × Zinc fertilization																		
LSD 0.05	*		*		*		ns		ns		ns		*		*		*	

AE = Agronomy nitrogen efficiency
RE = Nitrogen apparent recovery efficiency

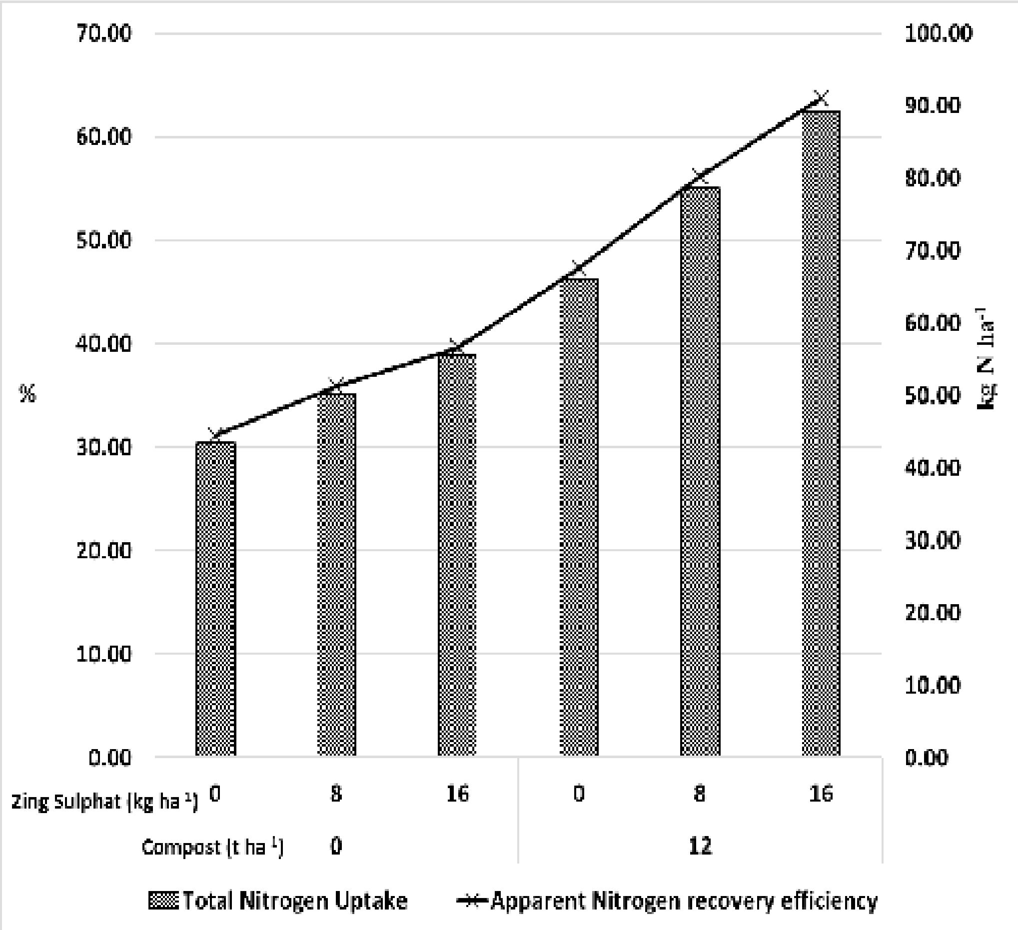

Fig. 2. Total nitrogen uptake (kg N ha-1) and apparent nitrogen recovery efficiency (%) of rice by the interaction effect between organic fertilization as compost and soil mineral Zn fertilization

Nitrogen use efficiency

Data in Table 5 showed that there was a very significant ($p<0.01$) increment in agronomic efficiency (AE kg grain/kg N applied) and recovery efficiency RE% in both seasons and pooled analysis by compost. Applying 12 t compost ha^{-1} gave the highest values of AE and RE% in both seasons and pooled analysis. Pooled analysis an increase of 13.5% in agronomic nitrogen efficiency and 56.8% in recovery nitrogen efficiency of rice when applying 12 t compost ha^{-1}.

While the effect of in-soil zinc application was a significant ($p<0.05$) on AE and highly significant ($p<0.01$) on RE% in both seasons and pooled analysis. The highest values of AE and RE% were obtained with 16 kg $ZnSO_4.7H_2O$ ha^{-1} followed by 8 kg $ZnSO_4.7H_2O$ ha^{-1}. When applying of 16 kg $ZnSO_4.7H_2O$ ha^{-1} increased of AE and RE) by 12.3% and 31.9%, respectively. While the increasing in AE and RE% when used 8 kg $ZnSO_4.7H_2O$ ha^{-1} was 7.4% and 17.5%, respectively.

Also, ANOVA in Table 5 showed that there was non-significant ($p<0.05$) increment in AE in both seasons and pooled analysis by the interaction effect between organic fertilization and in-soil zinc application, while this effect was a significant ($p<0.05$) on RE% in both seasons and pooled analysis.

Moreover, RE% of rice affected by the interaction between organic fertilization and in-soil zinc application was explained in Fig. 2. Where the diagram shows that the highest values of RE% were obtained by applying 12 t compost ha^{-1} with 16 kg $ZnSO_4.7H_2O$ ha^{-1} followed by 12 t compost ha^{-1} with 8 kg $ZnSO_4.7H_2O$ ha^{-1} and 12 t compost ha^{-1} without in-soil zinc application, respectively (Fig. 2).

Discussion

Our result reported that using 12 t compost ha^{-1} resulted in the highest plant height, dry weight (Table 2), yield (Table 3), total N-uptake and nitrogen efficiencies (Table 4) of rice in both seasons and pooled analysis. Where, the increase in rice grain and straw yield by applying 12 t compost ha^{-1} was 13.4% and 7.14%, respectively in pooled analysis (Table 3). While, pooled analysis in table 4 shows an increase of 13.5% in agronomic nitrogen efficiency and 56.8% in recovery nitrogen efficiency of rice when applying 12 t compost ha^{-1}. This results may be attributed that a compost tested greatly useful in enhancing the yield of the rice crop and N-P-K-uptake (Jeyabal and Kuppuswamy, 2001 and Satyanarayana et al., 2002). This explanation is also supported by (Liang et al., 2012) who reported that the application of organic fertilization to all the soils improved the uptake of nitrogen (N) which was significantly enhanced by nutrient amendments. Kafagy et al. (2017) found that the use 12 t ha^{-1} of organic matter as a compost gave the highest values of rice plant height, dry weight yield and nitrogen uptake in rice grain and straw. While Kalaivanan and Hattab (2016) reported that 1.25 t ha^{-1} of enriched pressmud compost gave the highest values of growth, yield and nitrogen efficiency parameters of rice where, enriched pressmud compost was prepared from raw press mud using windrow composting technique and enriched by adding rock phosphate, gypsum, $ZnSO_4$, $MgSO_4$, Azospirillum, Pseudomonas, Phosphobacteria and cow dung slurry.

Also, our result indicated that applying of 16 kg $ZnSO_4.7H_2O$ ha^{-1} gave the highest values of plant height, dry weight (Table 2), yield (Table 3), total N-uptake and nitrogen efficiencies (Table 4) of rice in both seasons and pooled analysis. On the other hands, data in Table 3 shows that applying 8 and 16 kg $ZnSO_4.7H_2O$ ha^{-1} increased the rice grain yield by (7.34 and 12.31%, respectively) and (10.35 and 17.55%, respectively) increasing in rice straw yield. When applying of 16 kg $ZnSO_4.7H_2O$ ha^{-1} increased of AE and RE% by 12.3% and 31.9%, respectively, while the increasing in AE and RE% when used 8 kg $ZnSO_4.7H_2O$ ha^{-1} was 7.4% and 17.5%, respectively (Table 4). This effect is due to the large role played by the zinc element in supporting the growth and yield of crops, especially rice, this role is increased when enriched with the zinc element, especially in the poor soil of this element, as in most of the Egyptian soils. Ali et al (2016) reported that zinc deficiency is a barrier in achieving higher rice yield when they found that the highest rice growth parameters and yield were obtained with applying 14 kg $ZnSO_4.7H_2O$ ha^{-1}, this result is close to (Farooq et al. 2016) who reported that all Zn application methods increased grain yield of rice by around 30% compared with the control (no added Zn), while (Suman and Sheeja 2018) have recognized that zinc deficiency causes severe yield reduction in rice, so the application of Zn such as foliar or soil application caused significant improvement in growth and yield attributes and yield of rice.

Moreover, total nitrogen uptake and recovery nitrogen efficiency RE% in rice affected by the interaction between compost and in-soil zinc application and the highest values of total nitrogen uptake in rice were obtained by applying 12 t compost ha^{-1} with 16 kg $ZnSO_4.7H_2O$ ha^{-1} followed by 12 t compost ha^{-1} with 8 kg $ZnSO_4.7H_2O$ ha^{-1} and 12 t compost ha^{-1} without in-soil zinc application, respectively (Fig. 2). These results can be attributed to the combined and effective effect of organic fertilization and soil zinc fertilization on the support of the nitrogen nutrient in the rice plant nutrition and supplying the plant with the necessary nitrogen nutrient at the time needed and in the appropriate quantities. Previous research has shown the importance of organic fertilization and zinc enrichment in the growth and nitrogen uptake of rice, but individually. Compost application has not merely been used to improve soil organic matter and refine it with different nutrients but also to render the environmental pollution from trash (Kuepper 2003). Compost tested greatly useful in enhancing the yield of the rice crop and N uptake (Satyanarayana et al. 2002; Khafagy et al. 2017). While (Suman and Sheeja 2018) have recognized that zinc deficiency causes severe yield reduction in rice, so the application of Zn such as foliar or soil application caused significant improvement in growth and yield attributes and yield of rice. Also, El-Hadidi et al (2016) and Kafagy et al (2017) who found that zinc fertilizer had a positive effect on rice dry matter production, plant height yield and nitrogen uptake.

Conclusion

Using compost at 12 t ha^{-1} with in-soil 16 kg $ZnSO_4.7H_2O$ ha^{-1} produced the highest rice crop, as well as increase the efficiency of nitrogen use under the saline soil in North Delta. The increase in rice grain and straw yield by applying 12 t compost ha^{-1} was 13.4% and 7.14%, respectively, while applying 16 kg $ZnSO_4.7H_2O$ ha^{-1} increased the rice grain yield by 12.31% and 17.55% increasing in rice straw yield.

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تأثير الإستخدام المتكامل للتسميد الأرضى بالزنك والتسميد العضوى على محصول, امتصاص النيتروجين وكفاءة استخدام النيتروجين للأرز.

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نقص الزنك وفقر التربة الزراعية من المواد العضوية من أكثر المشاكل انتشارا في زراعة الأرز خاصة في مصر. لذلك تم تجريب التسميد العضوي بمعدل ١٢ طن كمبوست هكتار-١ والتسميد الأراضي بالزنك تحت معدلات (٠, ٨ و١٦ كجم كبريتات زنك هكتار-١) على نمو، محصول، وامتصاص النيتروجين الكلى، الكفاءة المحصولية للنيتروجين وكفاءة استرداد النيتروجين للأرز صنف جيزة ١٧٨. سجل استخدام التسميد العضوي أعلى النتائج في ارتفاع النبات، الوزن الجاف، محصول الحبوب والقش، والامتصاص الكلى للنيتروجين، الكفاءة المحصولية للنيتروجين وكفاءة استرداد النيتروجين. أيضا أدى استخدام ١٦ كجم كبريتات زنك هكتار أعلى القيم في القياسات السابقة. الزيادة في محصول حبوب وقش الأرز عند استخدام ١٢ طن كمبوست هكتار-١ كانت ١٣,٤٪ و٧,١٤٪ على التوالي، بينما أدى استخدام ١٦ كجم كبريتات زنك هكتار-١ إلى زيادة في محصول الحبوب بـ ١٢,٣١٪ و١٧,٥٥٪ زيادة في محصول القش. تم تسجيل نتائج ملحوظة عند استخدام ١٦ كجم كبريتات زنك أرضى هكتار مع ١٢ طن كمبوست هكتار على الامتصاص الكلى للنيتروجين وكفاءة استرداد النيتروجين حيث كان هناك تحسنا تحت ظروف الأراضي الملحية.