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Bio-fertilizer and Organic Manure Affects Rice Productivity in Newly Reclaimed Saline Soil

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ABSTRACT

Bio-fertilizers and organic manure are two known enhancers of soil quality and productivity. Agriculture in newly reclaimed soils usually encounters a high level of salinity which hinders plant productivity and causes substantial economic losses. In this field experiment, the effect of applying different rates of bio-fertilizers, either a special isolate of *Azospirillum brasilense* (NO40), chicken manure (10 m^3/feddan; 1 feddan = ~0.42 million ha) or mineral nitrogen fertilization, were studied in rice (*Oryza sativa* cv. 'Sakha 101') straw and grain production. Overall rice productivity in newly reclaimed saline soil was estimated in two successive summer seasons of 2007 and 2008 at a newly reclaimed experimental farm in Sah-El-Hossinia, El-Sharkia governorate, Egypt. The land area was irrigated with El-Salam canal water, which contains a 1: 1 mix of water from the Nile River and drainage water. All applied fertilization treatments resulted in significant increases in the productivity of straw and grain/plant and in the total weight of 1000-grains. In addition, the N, P and K concentrations in grains and straw increased by increasing the rate of N addition, but decreased by adding bio-fertilizer. Concomitantly, there was a more pronounced increase in Fe, Mn, Zn, and Cu concentrations with a resulting decrease in soil pH. Bio-fertilizers significantly increased N, P and K content in plants, and increased the Fe, Mn, Zn and Cu concentration in the soil compared to the control experiment in which the land was singularly treated with mineral N.

Keywords: *Azospirillum brasilense*, chicken manure, rice productivity, saline soil

Abbreviations: Fed, feddan; **FCM**, farm chicken manure; **FYM**, farm yard manure; **ICP**, inductively coupled plasma; **NPK**, nitrogen: phosphate: potassium; **PGPR**, plant growth-promoting *Rhizobacterium*

INTRODUCTION

Currently, there is an urgent need for horizontal and vertical expansion in agricultural production to meet the demands of increasing populations. Recently, many agricultural projects aim to target newly reclaimed land, with salt-affected soils, to augment new crop productive land areas. For this purpose, reusing agriculture drainage water for reclamation and irrigation purposes is applied in salt-affected soils as an economic strategy to reduce water consumption. In this regard, Egypt's El-Salam canal project is ahead in this project by using 2.3 billion m^3 of agricultural drainage water annually to reclaim new land in Sinai, Egypt. Notably, the total water of the El-Salam Canal Project is almost 4.45 billion m^3 annually which originates from 2.11 billion m^3 of the Damietta Nile branch, 0.435 billion m^3 from the lower El-Serw drain and 1.905 billion m^3 from the Bahr Hadoose drain (Shaban 2005).

Rice is one of the most water-consuming crops in agriculture worldwide. However, rice production plays a significant strategy in overcoming food shortage and hunger in the developing world (Ram 2000). In Egypt, for instance, it is grown on almost one million feddan (fed; 1 fed = ~0.42 million ha) to feed a population of about 75-80 million people. There was a gradual increase in the national average of grain yield from 3.4 tons/fed in 1995 to 4.5 tons/fed in 2006 (final Report of Egyptian rice National Campaign). This increase was mainly due to newly improved rice cultivars which are significantly different in grain yield (Ibrahim 1995). Because of the limited agricultural land available for cultivation in Egypt, a further increase in rice production per unit area is needed to feed the growing population. This could be achieved through a variety of improvements, and optimization of agricultural practices such as the control of weeds, diseases and insects (Abassi *et al*. 1991).

For instance, organic manures are involved in the fertilization of plants worldwide due to their beneficial effects on soil physical, chemical and biological characteristics, which in turn influence the growth and production of plants (Youssef *et al.* 2001). Moreover, it was found that application of farmyard chicken manure (FCM) has a long-term improvement on soil pH, EC and humus content. This improvement was reflected by increasing the N, P and K as well as trace elements content either in straw or in grains of wheat (El-Maghraby *et al*. 1997). Application of FCM with or without *Azolla penta*, a plant growth-promoting *Rhizobacterium* (PGPR) caused a higher increase in %NPK, and its uptake in turn, enhanced the crude protein of rice grains (cv. 'Giza 178') compared with inorganic fertilizer treatment (Mahmoud *et al.* 2004). Recently, Kavitha and Subramanian (2007) reported that available soil N content was higher in plots where enriched compost (bio-fertilizer) was applied alone, or in combination with inorganic fertilizer at 38.87 and 32.87 mg/kg, respectively. The available P and K in the soil also increased with enriched compost application to about 22.46 and 647 kg/ha compared with control values of 19.44 and 518 kg/ha, respectively.

The available N in the soil content was enhanced as the mineral N fertilization level increased during rice cultivation with maximum levels applied as 100 Kg N/fed (Ali *et al*. 2005). Biological N-fertilization increased the soil content of available N and P even at the lowest level (<50% of the recommended value, i.e. 100 Kg N/fed) or without mineral N-fertilization. However, the soil content of available N and P declined at the highest levels (>100 Kg N/fed) of mineral N-fertilization (Rashed 2006). pH and EC values decreased slightly by applying 2-3% FCM to sandy soil after the maize crop harvest (Ali *et al*. 2005). In wheat,

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using NPK with organic fertilizer (farm manure) was more effective and increased the total yield of grain and straw by about 30% (El-Meneasy *et al.* 2005). In wheat, the application of FCM at 5.0 tons/fed produced the highest mean plant height, 1000-grain weight, number of panicles/m^2, panicle weight, and filled grains/panicle number, as well as grain and straw yield, higher than other FCM treatments (Zayed *et al*. 2005).

Bio-fertilizers have been also reported to enhance plant production under salinity. Inoculation of rice (cv. 'Sakha 101') with *Azospirillum brasilense* under different levels of salinity resulted in a significant improvement in the fresh and dry mass of shoots, roots and N content (El-Rewainy 1994).

Uyanöz *et al*. (2006) used a sandy clay loam treated with garbage and mushroom composts, cattle and chicken manures, or municipal sludge at rates of 0, 30, or 60 ton/ha. The organic materials were applied to pots and incubated for 15 d. The soil samples were watered at field capacity. In this experiment, wheat (*Triticum aestivum* L.) was used as the test crop. At the end of the experiment, it was found that treating sandy clay loam with the organic materials increased plant total and grain yields, protein content, 1000-kernel weight, number of grains in spike, and accumulation of nitrogen (N), phosphorus (P), potassium (K), iron (Fe), zinc (Zn), and manganese (Mn) by wheat compared with the control treatment, depending on the organic material applications**.**

The current field study is a comparative analysis among different fertilization systems to enhance plant production under salinity. Briefly, this study aims to investigate and compare the effects of applying bio-fertilizer of newly isolated *A. brasilense* NO40 (salt-tolerant) PGPR (Omar *et al*. 2000) and FCM, in combination with N mineral fertilization, on different growth rates and chemical composition of rice (var. 'Sakha 101'), which was grown under salt-affected soil, irrigated with drainage water from the El-Salam Canal, Egypt.

MATERIALS AND METHODS

Two field experiments were conducted on salt-affected clay soil during two successive summer growing seasons of 2007 and 2008 in the Khaled Abn El-Waled village of Sahl El-Hossinia district, El-Sharkia Governorate, Egypt. The effects of FCM, bio-fertilizer and N-mineral fertilizer on the improvement of the saline soil, and rice productivity were evaluated in plain regions with an area of about 12,000 ha (30,000 fed). The targeted area was irrigated from the El-Salam canal, which includes Nile river water mixed with agriculture drainage water (1: 1). Chemical analyses of El-Salam canal water were made during two rice cultivating seasons within a 4-month period between May and September (**Table 2**). In the first plot, additional treatments were made at the rate of 25–50 and 100 kg N/fed (urea 46% N) at 3 equal doses, after 21–45 and 65 days of rice planting, respectively. In the second plots, grains were inoculated with *A. brasilense* NO40 by coating grains with gum media (10 g gum powder (ElGomohoria Chemicals Co., Egypt): 500 ml water) carrying the bacterial strains (20 ml of one day LB media) on the same day of sowing. Liquid bacteria strains were applied to the inoculated grain plots (sprayed on soil 2.5 l/ha) three times after 23, 46 and 68 days of planting as described previously (Omar *et al*. 2000). The third plot was treated with FCM at a rate of 10 tons/fed 20 days during soil tillage before rice planting. FCM treatment and analysis were according to standard methods described by Brunner and Wasmer (1978) (**Table 3**).

Process of soil tillage

Lazar techniques were used and modified for leveling the soil surface followed by deep sub-soiling; plowing and establishing field drains at a distance of 10 m between any two drains, and in-depths of 90 cm at the beginning of each drain followed by the establishment of an irrigation canal in the middle part of the experimental pilot unit (Shaban 2005). Those pilot units were subjected to continuous and alternate leaching processes before rice planting.

Calcium super-phosphate (15.5% P_2O_5) was added at a rate of 30 kg P_2O_5/fed during soil preparation while potassium sulphate (48% K_2O) was added at a rate of 100 kg K_2O/fed in three doses after 21, 42 and 62 days of planting to conserve it from leaching.

Statistical analysis

A split-plot design with 3 replicates was applied in which the type of fertilization was the main plot and the other three rates of N were the sub main plot. Data were statistically analyzed according to Snedecore and Cochran (1980).

Plant material

Rice (*Oryza sativa*) var. 'Sakha 101' grains were obtained from the crop field of the Agricultural Research Institute (ARC), Egypt. The experiments were started for the 1st planting season, on the 5th of May, 2007. However, the second planting season began on the 3rd of May, 2008.

Soil analysis

The soil samples were collected from the soil surface (0– 30 cm). The soil was air–dried for 12 h in oven at 105°C, then passed through a 2-mm sieve to separate the coarse from fine sand, clay and silt each of which were individually separated and measured as shown in **Table 1**, according to Piper (1950). Calcium carbonate was determined using a calcimeter and calculated as $CaCO_3$%. Organic matter was assessed as described by Jackson (1973). Briefly, 1 g soil was added to 10 ml potassium dichromate (1N), 5 ml H_2SO_4, 10 ml phosphoric acid and 1 or 2 drops of diphenylamine then titrated by $Fe(NH_4)_2(SO_4)_2 \cdot 6H_2O$ (0.5 N). Total soluble salts were determined according to Jackson (1973). Briefly, a saturated soil paste (200 g soil with approximately 100 ml dd H_2O) was vacuum filtered and then the electrical conductivity (EC) was measured. The pH was measured using a pH meter in soil suspension (10 g soil: 25 ml dd H_2O) (Richards 1954). Soluble cations and anions were determined in a soil paste extract (5 ml with reagents depending on the desired elements) according to Page *el al.* (1982). Available N was measured (5 g soil dissolved in 40 ml KCL 2N) according to the modified Kjeldahal method (Black 1962). P was extracted by 0.5 N sodium bicarbonate ($NaHCO_3$) and determined calorimetrically according to Olsen's method (Jackson 1973). Available K was determined in 20 g soil dissolved in 40 ml ammonium biocarbonate ($(NH_4)_2HCO$) mixed with diethylene triamine pentaacetic acid (DTPA) solution by using flame photometry according to Soltanpour and Schwab (1977). Available micronutrients were extracted using ammonium bicarbonate (DTPA) solution and determined using Inductively Coup-

Table 1 Some physical and chemical properties of soil used before planting.

Depth	Particulars size distribution (%)				Texture classes	O.M (%)	$CaCO_3$ (%)
	Coarse sand	Fine sand	Silt	Clay			
0-30	2.5	38.9	16.6	42.0	Clay	0.41	7.9

Depth	pH (1:2.5)	EC (dS/m)	Cations (meq/l)				Anions (meq/l)			
			Ca^{+2}	Mg^{+2}	Na^{+}	K^{+}	CO^{--}_3	HCO^{-}_3	Cl^{-}	SO^{--}_4
0-30	8.45	23.5	17.3	21.7	196	0.37	nil	10.57	168	56.8

	Macro- and microelement content in soil used before planting					
Depth	Macro elements (mg/kg)			Micro elements (mg/kg)		
	N	P	K	Fe	Mn	Zn
0-30	44	4.5	185	10.65	7.89	0.37

Table 2 Chemical analysis of irrigation water from El-Salam Canal during rice planting two seasons.

Properties	Seasons	Time of water El-Salam Canal sampling			
	*period	May	June	July	September
pH (1:2.5)	1st	8.12	8.17	8.22	8.17
	2nd	8.07	8.11	8.18	8.13
EC (dS/m1)	1st	1.65	1.77	1.71	1.82
	2nd	1.53	1.69	1.59	1.78
NO_3 (mg)	1st	22.35	25.62	21.83	19.58
	2nd	20.01	27.87	23.51	22.71
NH_4 (mg)	1st	12.64	16.83	18.41	14.09
	2nd	15.31	17.43	19.46	19..16
P (mg)	1st	3.98	4.12	4.14	4.07
	2nd	4.10	4.23	4.28	4.16
K (mg)	1st	5.78	5.89	6.06	5.84
	2nd	5.99	6.05	6.15	6.03
Fe (mg)	1st	3.10	3.13	3.15	3.02
	2nd	3.22	3.24	3.18	3.20
Mn (mg)	1st	1.66	1.70	1.67	2.72
	2nd	1.68	1.84	1.80	1.77
Zn (mg)	1st	0.63	0.79	0.72	0.69
	2nd	0.75	0.84	1.00	0.98

led Plasma (ICP), visible recording spectrophotometer model 400 (Shimadzu, Kyoto, Japan), as described by Soltanpour and Schwab (1977). Soil analyses before rice planting are shown in **Table 1** and the mean values of water analysis during rice planting tested in two seasons, are show in **Table 2**.

Plant analysis

Rice was harvested in summer and grain was separated for plant analysis. Both straw and grains were air-dried for 10 days and their estimations were recorded as yield in ton/fed. One day before harvesting, 10 plants were collected manually in a random manner from different plots and treatments. Samples from each plot, divided into grains and straw, were subsequently air-dried at 70°C in an oven for 24 hrs and then weighed to determine the dry matter of grains and straw/plant. These plant parts were ground; subsequently, 0.5 g of each sample was digested using a 2 ml digestion mixture (2 H_2SO_4: 1 $HClO_4$) diluted in 100 ml dd H_2O (Soltanpoure 1985). The N, P, K, Fe, Mn, Zn, B and Pb contents were determined in the plant using above mentioned digest as described by Jackson (1973), Cottenie *et al.* (1982) and Page *et al*. (1982).

RESULTS AND DISCUSSION

Yield and yield components

Soil chemical properties and fertility conditions are reflected in a plant's growth, which in turn affect their straw and grain yield (Shaban 2005). In the current study, the direct effects of using different fertilizer sources, during two successive growth seasons, on rice yields were estimated (**Table 4, Fig. 1**). There were effects of three treatments (1, N-mineral fertilizer levels; 2, bio-fertilization with *A. brasilense* NO 40 salt-tolerant PGPR; 3, organic manure or FCM) on yield and yield attributes of rice cv. 'Sakha 10'). All of the three fertilizer sources, in both seasons, significantly increased straw and grain/plant, grain and straw yield/fed and the weight of 1000-grains. Using bio-fertilization and FCM increased rice yield, attributable to additional amounts of available N for biological N fixation by rhizosphere organisms. The observed data are in agreement with those reported by Zayed *et al.* (2005), who showed that different FYM levels and different modes of urea application had significant effects on rice (cv. 'Sakha 101') productivity in salt-affected soils. In the present investigation, application of bio-fertilizer or FCM in combination with mineral N-rates increased the dry mater yield. In addition, those treatments reduced soil salinity and sodicity. These increases in both rice straw and grain yields were noticed in all studied experimental pilot units. These increments seemed to be due to production of some material with organic manure and bio-fertilizer which may have activated microorganisms and thus improved soil fertility, as was also observed by Shaban and Helmy (2006) when they applied biofertilizer with different rates of urea to a wheat crop.

The relative increment in the percentage of applied urea levels at the rate of 25, 50, and 100 kg N/fed were 5.03–11.17% in the 1st season, and 12.44–21.76% in the 2nd season for straw yield, and 45.26–65.00% in 1st season, and 24.11–49.11% in the 2nd season for grain yield at 50 and 100 kg N/fed, respectively. In the 25 kg N/fed of the control treatment straw yield was 1.79 ton/fed in the 1st season and 1.93 ton/fed in the 2nd season; for grain yield these values were 0.95 and 1.12 ton/fed, respectively.

The corresponding values were 8.90% in the 1st and 9.48% in the 2nd seasons for straw; however, it was 12.12% in the 1st and 4.00% in the 2nd season for grain yield as affected by the combination between the highest dose of mineral and bio-fertilizers compared with 25 kg N/fed. On the other hand, the relative increases in straw and grains

Table 3 some chemical properties of the organic fertilizers used in the study.

Organic manure	pH 1:2.5	EC (dS/m)	C/N	N	P	K	Fe	Mn	Zn	Cu
					(%)			DTPA extractable (mg/kg)		
Chicken manure	7.27	6.34	24.89	1.77	0.85	1.96	34.0	72.0	41	3.8

Table 4 Rice straw and grain yields as effected with different fertilizer study.

Treatment	N- kg/fed	Weight (ton/fed)				Weight (g/plant)				Weight (1000 grains) (g)	
		Straw		Grain		Straw		Grain			
		1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
Mineral – N	25	1.79	1.93	0.95	1.12	32	33	15	19	21.59	23.21
	50	1.88	2.17	1.38	1.39	34	36	18	22	23.31	28.58
	100	1.99	2.35	1.57	1.67	40	41	21	24	28.28	32.41
	Mean	1.89	2.15	1.30	1.39	35	37	18	22	24.39	28.10
Bio-fertilizer	25	2.25	2.32	1.65	1.75	38	40	19	23	25.37	31.24
	50	2.77	2.87	1.74	1.79	42	45	23	26	30.16	34.85
	100	2.45	2.54	1.67	1.82	44	40	20	22	26.25	30.49
	Mean	2.49	2.58	1.69	1.78	41	42	21	24	27.26	32.19
Ch – manure	25	2.26	2.40	1.54	1.91	37	39	17	20	24.21	25.12
	50	2.87	2.88	1.61	1.97	41	42	22	23	29.42	35.68
	100	2.53	2.63	1.63	2.58	40	44	24	26	32.88	38.12
	Mean	2.55	2.64	1.60	2.15	39	42	21	23	28.84	33.17
LSD 5% Fert		0.26		0.18		6.76		1.55		2.00	
LSD 5% rateN		0.23		0.16		6.77		1.95		1.78	
LSD 5% season		0.55		0.28		5.52		4.69		3.04	

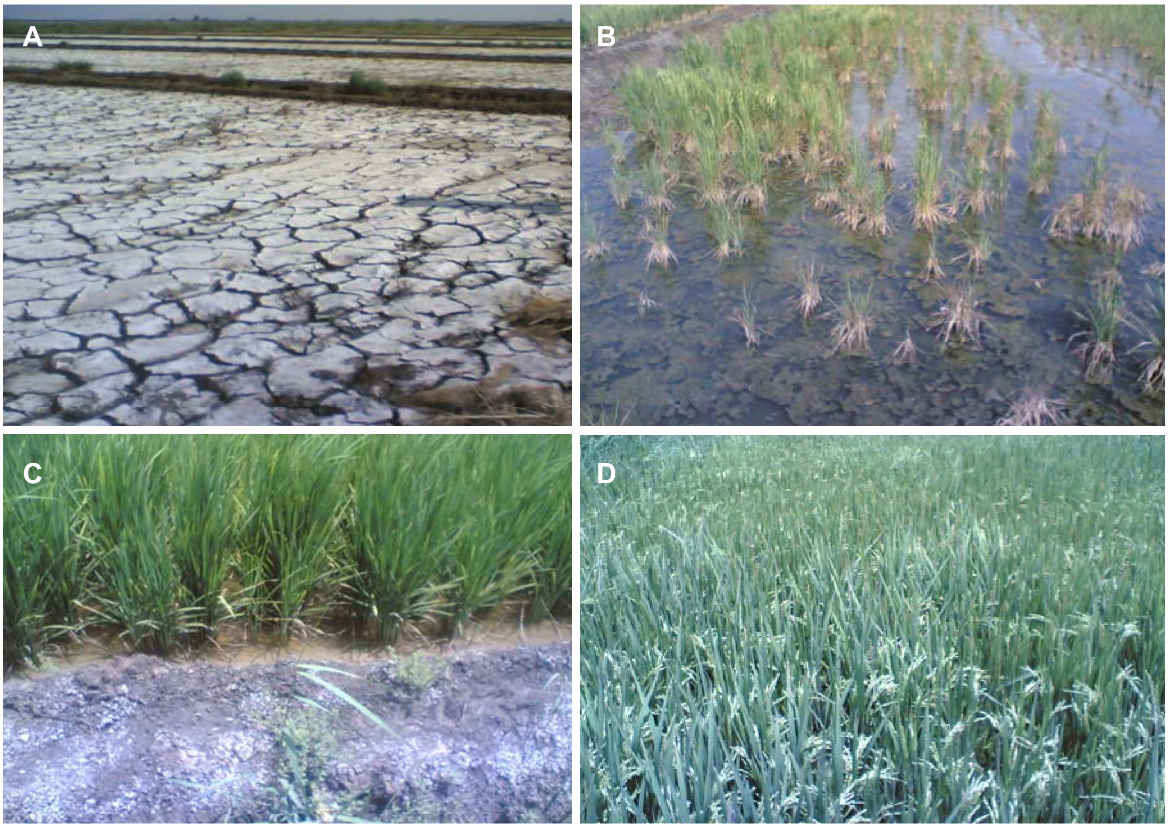

Fig. 1 Sequence of different treatments in the experiments. (**A**) Soil before tillage; (**B**) Soil irrigation after applying mineral N-fertilizer; (**C**) Plant growth in saline soil; (**D**) Growing plants after applying bio-fertilizers in combination N mineral fertilization.

yield (ton /fed) as affected by the application of chicken manure plus, the third levels of N-mineral, were 12.00% in the 1st and 9.58% in the 2nd season for straw, where the values of grain yield were 5.84% in the 1st and 14.1% in the 2nd had affected chicken manure + N rates of 100 kg N/fed than treatment chicken manure + 25 kg N/fed. These results may be attributed to the enhancing effect of mineral and organic fertilizers on increasing the availability of micro- and micronutrients in the experimental soil; consequently, its uptake by plants and its yield and productivity increased.

This data is in agreement with those reported in maize by Irshad *et al.* (2002) who found that the application of composted manure and urea fertilizer (N was applied at four levels as follows: urea, composted manure, ½urea + ½composted manure, and a control (no N fertilizer). Each of the three levels of applied N was at the rate of 200 kg/ha. A basal dose of P and K was also applied) enhanced maize growth and nutrient concentration and uptake compared with the non-treated control. Maize growth was better under area fertilizer than under composted manure (Irshad *at al.* 2002).

N, P and K concentration in rice crop

All treatments have significant effect on N, P and K concentrations in straw and grain of rice during both seasons (**Table** 5). These concentrations tend to be increased with additional rate of nitrogen plus chicken manure; however, it was decreased with the addition of bio-fertilizer. The resulted data also shows that the application of combined treatments (mineral -N+ bio-fertilizer + chicken manure fertilizer) resulted in significant effects on the concentration of N, P and K in grain and straw. The highest values of N, P and K concentration, for rice straw affected with chicken manure application, were 3.25, 0.46 and 2.14% or 1.52, 0.61 and 0.93% in both seasons, respectively. Data in **Table 5** also shows that N, P and K concentrations, in both straw and grains, were affected and could be arranged as follows:

Table 5 Macronutrients concentration in straw and grains of rice crop.

Treatment	N - kg/fed	N (%)				P (%)				K (%)			
		Straw		Grain		Straw		Grain		Straw		Grain	
		1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
Mineral – N	25	2.85	2.91	1.35	1.36	0.25	0.31	0.44	0.47	1.78	1.82	0.72	0.75
	50	2.93	2.96	1.39	1.42	0.27	0.33	0.47	0.49	1.82	1.83	0.76	0.78
	100	2.99	3.05	1.42	1.45	0.29	0.35	0.51	0.53	1.86	1.87	0.79	0.81
	Mean	2.92	2.97	1.39	1.41	0.27	0.33	0.47	0.50	1.82	1.84	0.76	0.78
Bio-fertilizer	25	3.12	3.15	1.37	1.39	0.31	0.36	0.48	0.50	1.84	1.86	0.75	0.79
	50	3.18	3.20	1.44	1.46	0.36	0.38	0.52	0.55	1.89	1.91	0.78	0.83
	100	3.16	3.19	1.48	1.49	0.37	0.39	0.55	0.58	1.92	1.93	0.81	0.86
	Mean	3.15	3.18	1.43	1.45	0.35	0.38	0.52	0.54	1.88	1.90	0.78	0.83
Ch – manure	25	3.14	3.16	1.40	1.43	0.38	0.41	0.43	0.53	1.90	1.94	0.77	0.84
	50	3.20	3.26	1.45	1.48	0.40	0.43	0.49	0.58	1.96	1.97	0.82	0.88
	100	3.23	3.25	1.49	1.52	0.43	0.46	0.58	0.61	2.11	2.14	0.84	0.93
	Mean	3.19	3.22	1.45	1.48	0.40	0.43	0.50	0.57	2..00	2.02	0.81	0.88
LSD 5% Fert			0.67		0.025		0.035		0.032		0.160		0.011
LSD 5% rateN			0.68		0.028		0.039		0.036		0.180		0.013
LSD 5% season			0.55		0.043		0.140		0.055		0.820		0.019

Table 6 Micronutrients concentration in straw and grains of rice crop.

Treatment	N - kg/fed	Fe (mg/kg)				Mn (mg/kg)				Zn (mg/kg)			
		Straw		Grain		Straw		Grain		Straw		Grain	
		1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
Mineral – N	25	148	150	122	124	66	67	47	51	42	44	57	61
	50	152	153	127	129	68	70	52	57	47	49	59	63
	100	155	157	130	134	72	74	55	59	52	53	61	65
	Mean	152	153	126	129	69	70	51	56	47	49	59	63
Bio-fertilizer	25	153	155	125	128	79	81	50	52	45	48	58	62
	50	156	158	129	132	82	83	54	58	55	59	62	64
	100	159	162	133	136	86	87	58	61	62	63	64	66
	Mean	156	158	138	132	82	84	54	57	54	57	61	64
Ch – manure	25	157	160	130	134	88	90	56	59	51	54	60	63
	50	160	163	134	137	90	94	58	61	59	64	65	68
	100	168	169	136	138	92	96	60	64	63	66	66	70
	Mean	162	164	133	136	90	93	58	61	58	61	64	67
LSD 5% Fert		3.56		1.52		3.24		4.17		6.80		4.59	
LSD 5% rateN		3.97		1.01		3.62		4.33		6.76		6.27	
LSD 5% season		3.04		Ns		5.52		Ns		5.52		Ns	

Chicken manure > bio-fertilizer > mineral-N for all experimental pilot units.

The relative increments of percentages for concentration means of N, P and K for bio-fertilizer and chicken manure in straw were 7.87–9.25% in the 1st season or 7.10–8.42% in the 2nd season. The increase of N in grain was 7.87–4.32% in the 1st season and 2.87–4.96% in the 2nd season. On the other hand, grain P concentration results were 29.63–48.15% in the 1st season and 15.16–30.30% in the 2nd season. In addition, P concentration was increased in straw by 10.64–6.38 in the 1st season and 18.00–14.00% in the 2nd season. However, K percentage in grain increased by 3.29–9.89% in the 1st season and by 3.26–9.78% in the 2nd season. In contrast, the increment was 2.63–6.57% in the 1st season, and 6.41–12.82% in the 2nd season when using N-mineral fertilizer (**Table 5**).

The obtained results are in agreement with those reported by Mahmoud *et al*. (2004) and El-Meneasy *et al*. (2005). In general, the increment of N, P and K concentration in rice straw and grain by soil treated with bio-fertilizer and chicken manure in combination with N–rates could be due to changes in soil chemical properties, microbial population, and biochemical soil enzymes activities in saline soil cultivation under semi-arid conditions (Haum *et al*. 2007).

In this respect, it was also reported that N, P and K uptake were higher in urea and urea+manure treatments as compared with manure and control treatment. The poor response of chicken manure may be due to its short-term application or impeded N mineralization under saline conditions (Irshad *et al*. 2002).

Trace element concentrations in straw and grain of rice plants

The concentrations of some micronutrients (Fe, Mn and Zn) in rice were affected by different fertilizer sources as presented in **Table 6**. Substantial increases in rice plants concentrations of Fe, Mn and Zn under application of the bio-fertilizer and chicken manure singularly or in combination with N-rates with more pronounced increase with residual effect of long term as shown in the 2nd season. These results are in agreement with those obtained by Ashmaye *et al.* (2008) who stated that the application of the organic farm yard manure and bio-fertilizer in combination with N-levels caused increases in the concentrations of Fe, Mn and Zn in straw and grains in agricultural land. The relative increases of the studied micronutrients (Fe, Mn and Zn) in rice (straw and grains) are mainly dependent on using different fertilization sources, as it could be arranged as follows: Compost > bio-fertilizer > mineral nitrogen.

Thus, it could be concluded, that the concentrations of micronutrients in rice plant, generally, reflect their availability in soil which are heavily dependent on the applied fertilization resources. These results are in agreement with those obtained by Ashmaye *et al*. (2008) who reported that application of bio-fertilizer or organic matter alone or combination with different rates of urea fertilizer on the concentration of some Fe, Mn, Zn and Cu in straw and grain maize caused an increases for straw and grain treated with bio-fertilizer + 85 kg N/fed and organic matter + 85 kg N/fed and Shaban *et al*. (2008) who found that applying of organic manures of rates 10-15 tons/fed and urea at 80 kg/fed caused an increase in the concentration of available of Fe, Mn, Zn and Cu in spinach levels.

Effect of different fertilization sources on available macronutrients in soil study

The recorded data showed that different fertilization resources, in the two successive seasons, affects the amounts of some available macronutrients, N, P and K (mg/kg) in studied soil (**Table 7**). Moreover, it was also shown that the soils treated with chicken manure and bio-fertilizer in combination with, mineral N- rates gave higher values of available N, P and K than those treated with mineral nitrogen (100 kg N/fed) alone. This may be attributed to chicken manure combination with N- rates, which is richer in organic materials as well as in N, P and K.

Likewise, the bio-fertilizer led to the increments in soil N, P and K available contents. These results indicate the important role of bio-fertilizers in improving soil nutrients status due to microorganism's activity in N fixation and by reduction of soil pH. Bio-fertilizers, especially those N-fixing bacteria, were suggested to reduce the amount of mineral fertilizer and produce clean and healthy crops. In conclusion, data showed that the applied mineral N-rates; chicken manure and bio-fertilization alone or in combination resulted in a significant increase effect on the available content of N, P and K. The obtained data are in agreement with those reported by Kavitha and Subramanian (2007) and Shaban and Omar (2006) who reported that applying biofertilizer resulted in decreasing soil pH and increased available N, P and K content.

Effect of different fertilization sources on available micronutrients in soil study

The results of the present investigation showed that variation in available microelement contents of soil, namely Fe, Mn and Zn, resulted from mineral-N, bio-fertilizer and chicken manure organic fertilization during both planting seasons (**Table 7**). This could be related to the residual effect of organic compounds in the chicken manure and bio-fertilizer.

In addition, the relative increases of those elements in the soil of the experimental pilot unit by adding chicken

Table 7 Available macro- and micronutrients in soil after rice harvest.

Treatment	N - kg/fed	N (mg/kg)		P (mg/kg)		K (mg/kg)		Fe (mg/kg)		Mn (mg/kg)		Zn (mg/kg)	
		1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
Mineral – N	25	58	63	6.24	6.52	215	227	13.21	13.48	8.10	8.24	0.41	0.47
	50	64	67	6.38	6.55	219	233	13.23	13.52	8.12	8.27	0.45	0.49
	100	66	71	6.43	6.59	224	237	13.25	13.55	8.14	8.28	0.47	0.53
	Mean	63	67	6.35	6.55	219	232	13.23	13.51	8.12	8.26	0.44	0.50
Bio-fertilizer	25	65	70	7.12	7.22	226	229	13.34	13.54	8.22	8.27	0.44	0.48
	50	68	72	7.15	7.31	228	238	13.42	13.59	8.26	8.34	0.46	0.54
	100	70	74	7.16	7.37	234	243	13.44	13.62	8.31	8.36	0.48	0.57
	Mean	68	72	7.14	7.30	229	237	13.40	13.58	8.26	8.32	0.46	0.53
Ch – manure	25	65	69	7.25	7.35	228	237	13.47	13.58	8.24	8.30	0.45	0.51
	50	68	73	7.34	7.42	235	244	13.53	13.65	8.27	8.38	0.49	0.58
	100	71	75	7.36	7.47	237	248	13.55	13.68	8.33	8.42	0.52	0.61
	Mean	68	72	7.32	7.41	233	243	13.52	13.64	8.28	8.37	0.49	0.57
LSD 5% Fert		3.24		0.67		0.84		0.32		0.49		0.36	
LSD 5% rateN		3.62		0.68		0.94		0.36		0.65		0.04	
LSD 5% season		5.52		0.55		1.43		0.55		0.38		0.03	

manure and bio-fertilizer in combination with, N-rates (25-50 and 100 kg N/fed) were significantly increased, as compared to the other experimental units which were treated with mineral N alone. This increase could be due to the accumulation of the suspended organic colloids which derived from the organic fertilizer. However, the variations in the contents of trace nutrients may not be due to different fertilization used only, but also by other causes, such as, continuous water irrigation with El-Salam canal (Nile water mixed with agriculture drainage water). The above mentioned results are in agreement with those obtained by Abou El-Roos *et al.* (1996) and Shaban (2005) who reported that application of biofertilizer resulted in decreasing soil pH and increased available content of Fe, Mn and Zn. In summary, all the different applied treatments showed significant increases in available Fe, Mn and Zn in soil.

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