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Role of Mineral and Bio-fertilizers on Some Soil Properties and Rice Productivity under Reclaimed Saline Soils

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Authors' contributions

This work was carried out in collaboration between all authors. Author MIM designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors MHMK and KAHS managed the analyses of the study. Author KAHS managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

A field experiment (randomized complete blocks with three replicates) was conducted during two successive summer seasons of 2016 and 2017 at Sahl El-Houssinia Agriculture Research Station in El-Shakia Governorate, Egypt. Its lies between 32˚00/00 to 32˚15/00/ N latitude and 30˚50 / 00// to 31˚15 00// E longitude. The combined effect of bio-fertilizers inoculated with *Rhizobium radiobacter* sp strain (salt tolerant PGPR); *Bacillus megatherium* (dissolving phosphate) and *Bacillus circulans* (enhancing potassium availability) and yeast strains (*Saccharomyces cerevisiae*) combined with different rates of N, P and K fertilizers (50, 75 and 100%) was evaluated on some soil properties, nutrient content in rice plants, and rice productivity in a reclaimed saline soil. From the crop field of the Agricultural Research Institute (ARC), Egypt, 101 grain kernels from rice (*Oryza sativa) var*. Sakha were selected.
The results indicated that soil pH and EC were decreased in soil treated with bio-fertilizers combined with different rates of mineral fertilizers in comparison with soil treated with yeast and

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control. Available N, P, K, Fe, Mn and Zn in the soil increased with the use of bio-fertilizers. Application of mineral fertilizers (N, P and K) alone or combined with bio-fertilizers (bacteria and yeast) resulted in increased yield grains and straw of rice plant. Macro- and micronutrients concentrations and uptake in grain and straw of rice plants increased in soil treated with bacteria + 75% N+P+K fertilizers compared with other treatments.

Keywords: Saline soil; rice crops; nutrients contents in soil and rice plant.

1. INTRODUCTION

Today the increasing food demand is one of the major issues of global concern for food security due to population rising and restricted cultivated lands because of increasing urbanization and industrialization. With the advent of green revolution in 1960, intensive agricultural practices that came into existence, including use of high-yielding, disease-resistant crop varieties, and constant input of agrochemicals such as chemical fertilizers, pesticides etc. Application of such chemicals adversely affects the dynamic equilibrium of soil and affects agro-biodiversity by destroying non-target useful soil flora and fauna [1] and [2].

The average nutrient content of rice grain is 80% starch, 7.5% protein, 0.5% ash and 12% water. The proportion of amylose and amylopectin in starch determines the cooking and eating qualities of the rice. Rice is a primary source of carbohydrate and the essential amino acids in sufficient amounts for good health [3].

Yeast *(Saccharomyces cerevisiae)* is rich in amino acid, proteins, carbohydrates, minerals, vitamins, hormones and other growth regulating substances [4]. Marzauk et al. [5] indicated that the foliar application of yeast extractin concentration 6 ml/L increased plant growth, expressed as plant length (cm), number of leaves and branches as well as fresh and dry weight of leaves, branches and whole plant in two seasons as compared to control.

Bio-fertilizers play a very significant role in improving soil fertility by fixing atmospheric nitrogen, solubilizing insoluble soil phosphates and producing plant growth substances in the soil [6]. The improvement of plants' growth in response to the foliar application of yeast extract may be attributed to its contents of different nutrients, i.e. (P, K, Mg, Ca, Fe, Ba, Mn and Zn), high percentage of proteins, high values of free amino acid and vitamins which may play an important role in improving growth and controlling the incidence of fungal diseases [7]. The soluble protein content increases as a result of yeast action. The yeast releases amino acids from the soluble protein [8].

This study aims to investigate the evaluation of applying bio-fertilizers and yeast combined with different rates of mineral fertilizers on some soil properties and rice productivity under saline soil conditions.

2. MATERIALS AND METHODS

2.1 Study Area

The study area is located at Sahl El-Houssinia Agriculture Research Station in El-Sharkia Governorate, Egypt, between 32˚00/00 to 32˚15/00/ N latitude and 30˚50/00// to 31˚15 00// E longitude. Soil salinity is attributed mainly to high evaporation under dry hot climate. El-salam canal (1:1 mixed of Nile and agricultural drainage water) is the main source of irrigation water.

Before the experiment, the following preparation works were carried out:

a) Levelling the soil surface using lazer technique;
b) Deep sub-soil plough;
c) Establishment of surface drains and irrigation canal networks;
d) Surface soil sampling for conducting some physical and chemical analysis performed according to Page et al. [9] and Cottenie [10] (Table 1).
e) Show some physical and chemical properties of the initial soil.

2.2 Experimental Work

The current experiment was conducted during two successive summer seasons (2016 and 2017) respectively, in saline clay soil.

Table 1. Physical and chemical properties in the soil studied before the rice was established

Coarse sand (%)	Fine sand (%)	Silt (%)	Clay (%)	Texture	O.M (%)	$CaCO_3$ (%)
4.57	33.95	15.58	45.90	Clay	0.58	9.33
F.C.	W.P.	A.W.	B.D (g/cm^3)		T.P (%)	
28.39	10.56	12.90	1.45		43.00	

Chemical properties in soil

pH (1:2:5)	EC (dS/m)	Cations (meq/l)				Anions (meq/l)		
		Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	HCO^{-}_{3}	Cl^{-}	SO^{2-}_{4}
8.12	9.90	12.50	20.31	65.40	0.79	7.49	48.38	43.13

Macronutrients (mg/kg)			Micronutrients (mg/kg)			
N	P	K	Fe	Mn	Zn	Cu
32.55	3.64	170	4.58	1.07	0.60	1.11

*CEC= 0.75*clay%+ 2.5*O.M%*

Table 2. Treatments applied

Treatment	Rate of N* kg/ ha	Rate of P_2O_5** kg/ ha	Rate of K_2O kg/ha
Mineral	0.0	0.0	0.0
	119	35.7	83.3
	178.5	59.5	130.9
	238	73.78	166.6
***Bacteria	0.0	0.0	0.0
	119	35.7	83.3
	178.5	59.5	130.9
	238	73.78	166.6
***Yeast	0.0	0.0	0.0
	119	35.7	83.3
	178.5	59.5	130.9
	238	73.78	166.64

**Urea 46% N is a source of N*

***Super phosphate 15.5% P_2O_5 is a source of P Potassium sulphate_(48% K_2O) source of K*

*****Bacteria and yeasts were obtained from microbiology Department, SWERI, Agric. RES. centre, Giza, Egypt.*

****** Kernels of rice cultivar Giza 104 were obtained from Crop Institute Agriculture Research Center, Giza, Egypt*

2.3 Experimental Design

The experiment was conducted in randomized complete blocks with three replicates. Two bio-fertilizers (i.e. yeast and bacteria) were randomly arranged as the main plot, where the rates of N, P and K were distributed randomly as sub-plot. The experimental unit area was 5 m long x 10 and m wide.This was divided into three treatments (mineral fertilizers, yeast and bacteria). Super phosphate rates were applied during soil tillage and plots were ploughed twice after super phosphate application.

Kernels were inoculated with *Rhizobium radiobacter* sp strain (salt tolerant PGPR) bio-fertilizer deposited in the Gen bank under the number of HQ395610 Egypt; *Bacillus megatherium* (dissolving phosphate) and *Bacillus circulans* (enhancing potassium availability) and yeast strains (*Saccharomyces cerevisiae*) by Bio-fertilizers Production Unit, Department of Microbiology, Soils, Water and Environment Research Institute, Agricultural Research Center, Giza, Egypt.

Rice (*Oryza sativa)* var. Sakha 101 grains were obtained from the crop field of the Agric. Res. Inst. (ARC), Egypt. Sowing of rice grains was carried out on 28 April (2016 and 2017). Untreated and treated seeds were applied separately. In the bacteria or yeast treatments, the rice kernels were inoculated at sowing. The coating processes were carried out using Arabic gum solution. More bio-fertilizers were added at three periods, at 30, 55 and 75 days after sowing in the form of liquid foliar application on plants at a rate of 47.6L/952Lwater /ha.

Nitrogen fertilizer was added in urea form (46% N) at three times, namely 21, 45 and 65 days after sowing. Potassium sulfate (48% K_2O) was applied as base fertilizer for all treatments at a rate of 119 kg K_2O /ha applied in two doses at 21 and 55 days after sowing.

All experimental plots were irrigated with El-Salam Canal (1:1) Nile water mixed with agricultural drainage water. To control soil salinity, water was applied immediately after sowing for 7 hours and then the excess water was drained. The same process was repeated on the second day. Irrigation water was applied every 12 days until the end of growing season. irrigated with El-Salam canal water (a mixture of Nile and agriculture drain waters. Rice was harvested on 5 September 2016 and 2017. At harvest time, the following parameters were recorded on a random sample of ten plants from each plot: seed yield (ton/ha), pod yield (ton/ha), the mass of 100 seeds (g).

Plant samples (oven-dried at 70C°) were digested using concentrated H_2SO_4/ $HClO_4$ mixture [11].

Photosynthetic chlorophyll (a+b) was estimated in fresh leaves as described by Witham et al [12]. Proline content was estimated according to Bates et al. [13].

The obtained data were statically analyzed using the COSTAT program and LSD test at probability levels of 5% calculated according to Gomez and Gomez [14].

3. RESULTS AND DISCUSSION

3.1 Soil pH

Soil pH is one of the most important parameters which reflect the overall changes in soil chemical properties. Data presented in Table 1 show the high pH value of 8.25 in the soil surface. The soil pH tended to increase slightly after the rice harvesting under all treatments. Soil pH is also known to be affected by bio-fertilizers. The soil pH of all experimental ranged was slightly to moderately alkaline conditions. The soil pH value ranged from 7.95 to 8.25 Table 3. Reduction in soil pH may be related to the residual organic matter after different biochemical and chemical changes. In addition, the activity of micro-organisms led to the production of organic acid that was released from the bio-fertilizers. These results are in agreement with a study by Shaban and Omar [15] and Hafez [16] who indicated that the reducing effect of biofertilizer combined with mineral nitrogen might be attributed to associated increase in activity of dehydrogenase enzyme as well as the release of carbon dioxide in the rhizosphere due to increase of the microorganisms. Shaban and Attia (2009) found that bacteria t fixing N_2, and dissolving P and available K led to a decrease in soil pH when added alone or in combination with chemical fertilizers.

3.2 Soil Salinity

Data in Table 3 reveal that the EC values ll treatments tended to decrease when soil was treated with mineral fertilizers combined with bio-fertilizers compared to soil treated with mineral fertilizers alone. The effect of all treatments on soil salinity was not statistically significant while the different rates of mineral fertilizers were significantly decreased with increasing rate of mineral fertilizers. The interaction between bio-fertilizers combined with mineral fertilizers was significant.

The corresponding relative decrease of mean values (EC dSm^{-1}) was 8.34% for soil treated with bio-fertilizers combined with different rates of mineral fertilizers and 0.16% for soil treated with yeast combined with mineral fertilizers rates compared with soil-accepted mineral fertilizers at different rates. These results confirmed the results reported by Vishal et al. [17] and Ali et al [18] who suggested that organic acids like indole acetic acid, gibberellic acid, and abscisic acid etc. are produced by the bacterial endophytes. These acids support plant growth by solubilizing minerals and by root growth promoting and lowering the EC in the rhizosphere. These organic acids can potentially provide a substantial modification of soil physical and chemical properties in the root environment.

It is necessary to mention the superiority of bacteria combined with different mineral fertilizers rates as compared to the other treatments is probably more related to the occurrence of active organic acids that are released from the activity of microorganisms. These bio-fertilizers provided a substantial modification of soil physical properties, especially soil structure as well as soil aggregation and drainable pores. Consequently, these favourable conditions can positively affect soil permeability and encourage the downward movement of leaching water.

3.3 Macronutrients Available in the Soil

Data presented in Table 3 show that the bacteria and yeast bio-fertilizations combined with mineral fertilizers at different rates increased the N, P and K availability in soil (this is not correct).

Moreover, the soil treated with bacteria combined with mineral N, P and K fertilizers at the high rates gave higher values of available N, P and K in soil than other treatments(This is not correct). However, the effect of different rates of mineral fertilizers on available N, P and K content in soil and bio-fertilizers were not statistically significant, while the interaction between mineral fertilizers and bio-fertilizers had a significant effect on soil available NT the relative increases of mean values were 4.91% for N; 6.43 for P and 3.95% respectively for K contents in the soil as affected by bacteria combined with different rates of mineral fertilizers compared to mineral fertilizers alone. Also, the relative increases of mean values N, P and K available in the soil as affected by yeast combined with different rates of mineral fertilizers were 1.44% for N; 2.95% for P and 0.92 for K respectively compared with mineral fertilizers alone. These results are in agreement with Abeer and Hanaa [19] who found that the bio-fertilizer inoculation generally increased the concentration of N, P and K in the soil when compared to control. Hafez [16] indicated that the application of bio-fertilizers on available contents of N, P and K in the soil after harvest did not show a significant effect. Rifat et al. [20] reported that PGPR as a bio-fertilizer helps in fixing N_2, solubilizing mineral phosphates and other nutrients as well as enhancing tolerance to stress.

3.4 Micronutrients Available Contents in Soil after Rice Harvest

The recorded data presented in Table 3 show that the different fertilization sources had a positive effect on micronutrients availability in soil (Fe, Mn and Zn, mg kg^{-1} soil). It was also shown that the soil treated with bacteria and yeast combined with mineral fertilizers rates gave higher increased values of available Fe, Mn and Zn than when treated with mineral fertilizers alone. The effect of bio-fertilizers combined with mineral fertilizers on Fe and Zn were not significant, while it was significant for Mn. Moreover, the application of mineral fertilizers at different rates to soil led to significant increases for Mn and Zn contents in soil. The interaction between bio-fertilizer and mineral fertilizers on available Mn and Zn contents in soil was significant, while the effect on Fe was not significant. These results suggest the important role of bio-fertilizers in improving soil nutrient availability status due to microorganism's activity in N fixation, P solubilization and K availability. These results are in agreement with those reported by Wu et al. [21] who found that the activity of bacteria *Azotobacter chroococcum*, *Bacillus megatherium* and *Bacillus mucilaginosus*, led to an increase in water dissolved organic carbon concentration and a decreased pH, which enhanced metal mobility and bio-availability. Shaban and Attia [22] found that the bio-fertilizers including *Azospirillum brasilense NO 40*, *Bacillus megatherium* and *Bacillus circularns* in combination with chemical fertilizers, may have a positive impact on bio-availability and mobility of micronutrients in the soil, depending on the chemical nature of metals.

3.5 Yield and Yield Components

The effect of mineral fertilizers and bio-fertilizers or yeast on yield and yield components i.e. plant height (cm), panicle length (cm), 1000 kernel mass (g), grain yield (ton/ha) and straw yield (ton/ha) were presented in Table 4. Results showed that applied of three treatments i.e. mineral fertilizers (N, P and K) alone or combined with bio-fertilizers (bacteria and yeast) to the soil cultivated with rice were not significant for yield and yield components of rice growth. The different rates of mineral fertilizers caused a significant increase for the plant height (cm), panicle length (cm), 1000 kernel mass (g), grain yield (ton/ha) and straw yield (ton/ha) with increasing rates without bacteria. Liang et al. [23] suggested that the mineral nutrient status of plants plays a crucial role in increasing plant resistance to environmental stresses including salinity. The effect of different applied mineral fertilizer rates either with or without yeast application gave marked increases in the plant height (cm), panicle length (cm), 1000 kernel mass (g), grain yield (ton/ha) and straw yield (ton/ha) with increasing rates, while the decrease of mineral fertilizers combined with bacteria led to an increase in the plant height (cm), panicle length (cm), 1000 kernel mass (g), grain yield (ton/ha) and straw yield (ton/ha). The relative increases of mean values were 6.18% for plant height (cm) 20.18% for panicle length (cm) 11.46% for 1000 kernel mass (g) 44 for grain yield ton/ha and 59.69 for straw yield ton/ha for soil treated with mineral fertilizers combined with bacteria compared to soil treated with mineral fertilizers alone. The relative increases of mean values were 4.63, 5.13, 4.87, 3.40 and 12.23% for the plant height (cm), panicle length (cm), 1000 kernel mass (g), grain yield (ton/ha) and straw yield (ton/ha) respectively, as affected by mineral fertilizers combined with yeast application compared to mineral fertilizers alone.

Shaban et al. [24] found that the increase of grain and straw rice yields to be due to the production of material with bio-fertilizers which may have activated microorganisms and improved soil fertility.

Generally, the improved rice growth in soil salinity may be due to the enhancing effect of bio-fertilizers (yeast and bacteria) on plants. Probably the applied yeast and bacteria produced cytokinins, which enhanced the accumulation of soluble metabolites, increasing the levels of endogenous hormones in treated plants, which could be by cell division and cell elongation. This in its turn, will, increase the metabolic process rate and levels of hormones (Indol acetic acid IAA and gibberellins GA3) in addition to the physiological roles of vitamins and amino acids in the bio-fertilizers strains.

3.6 Macro-Micronutrient Concentration and Uptake

Bio-fertilizers (PGPR) have the ability to increase the availability of nutrient concentration in the rhizosphere by fixing N; solubilizing phosphate and increasinge the availability of K. Data presented in Tables 5 and 6 show that the effect of mineral fertilizers alone or bacteria and yeast on N, P, K, Fe, Mn and Zn concentration in grains rice was not significant, while the application of different mineral fertilizer rates combined with bio-fertilizers caused significant increase, expect K concentration in grains. The interaction between bio-fertilizers and different rates of mineral fertilizers on N, P, Fe, Mn and Zn concentration in grains rice was significant while the effect on K was not significant. On the other hand, the increase in N, Fe and Zn uptake in rice was significant for soil treated with mineral nitrogen fertilizers or bacteria and yeast fertilizers while P, K and Mn were not influenced significantly. The uptake of N, P, K, Fe, Mn and Zn in rice was significant in soil treated with mineral fertilizers rates. The interaction between different mineral fertilizers rates and bio-fertilizers led to a significant increase of N, P, K, Fe, Mn and Zn uptake in rice. The application of bacteria combined with 75% N, P, K mineral fertilizers caused an increase in N, P, K, Fe, Mn and Zn concentration and uptake in rice plants compared to other treatments.

These results are in agreement with the results reported by Attia (2009) who suggested that the concentration of N, P, K, Fe, Mn and Zn in maize as affected by bio-fertilizers combined with chemical fertilizers.

These results are in agreement with the results reported by Attia 2009 who suggested that the concentration of N, P, K, Fe, Mn and Zn in maize as affected by bio-fertilizers combined with chemical fertilizers.

Mishra et al. [25] reported that the bio-fertilizer is a mixture of live or latent cells encouraging nitrogen fixing, phosphate solubilizing, or cellulolytic microorganisms used for applications to soil, seed, roots, or composting areas with the purpose of increasing the quantity of those mutualistic beneficial microorganisms and accelerating those microbial processes, which augment the availability of nutrients that can then be easily assimilated and absorbed by the plants.

3.7 Macro-Micronutrients Concentrations and Uptake in Straw Rice Plants

Data presented in Tables 6 and 7 show that the macro- micronutrients contents in straw rice plants under different bio-fertilizers and mineral fertilizers applied at different rates under soil salinity conditions. The data obtained for N, P, K, Fe, Mn and Zn concentrations and uptake were decreased with treated mineral fertilizers individually. All treatments for studied had no significant effect on N, P, K, Fe, Mn and Zn concentrations in straw while the Zn and Fe uptake had a significant effects of all treatments. The different rates of mineral fertilizers led to significant increases in N, P, K, Fe, Mn and Zn concentrations and uptake in the straw of rice plants. The interaction between mineral fertilizers and bio-fertilizers were Significant increases the uptake and concentration of the elements N, P, K, Fe, Mn and Zn. This is not undestandable The highest mean value of N, P, K, Fe, Mn and Zn concentrations and uptake in straw rice plants were in soil treated with bacteria combined with mineral fertilizers than other treatments. These results are in agreement with results reported by Haum et al. [26], who found that the increase of N, P and K concentrations in rice straw in soil treated with bio-fertilizer combined with mineral fertilizer at different rates could be due to changes in soil chemical properties, microbial population and biochemical soil enzymes' activities in saline soil cultivation. Ashmaye et al. [27] indicated that the use of bio fertilizers in combination with mineral fertilizer caused increases in the concentrations of Fe, Mn and Zn in straw.

Thus, it could be concluded that the concentration and uptake of macro-micronutrients in kernels and straw rice plants reflected the availability in soil and the applied fertilizers sources.

Table 3. Effect of different rates of mineral N, P and K fertilizers combined with bio-fertilizer on pH, EC and macro-micronutrients in the soil after rice harvested

Treatments	Rate of NPK kgha^{-1}	pH (1:2.5)	EC (dSm^{-1})	Macronutrients (mg kg^{-1})			Micronutrients (mg kg^{-1})		
				N	P	K	Fe	Mn	Zn
Mineral	0	8.05	6.89	38.99	3.51	180.00	5.90	1.33	0.79
	119	8.03	6.45	41.45	3.66	186.00	5.97	1.38	0.83
	178.5	8.01	5.80	42.30	3.80	195.00	6.05	1.45	0.86
	238	8.00	5.30	44.28	3.95	198.00	6.12	1.56	0.87
Mean		8.02	6.11	41.76	3.73	189.75	6.01	1.43	0.84
Bactria	0	8.03	6.40	40.55	3.75	187.00	5.93	1.40	0.84
	119	8.01	5.98	43.58	3.90	195.00	6.04	1.65	0.88
	178.5	7.98	5.27	44.23	4.05	202.00	6.10	1.70	0.97
	238	7.95	4.75	46.88	4.17	205.00	6.15	1.79	0.99
Mean		7.99	5.60	43.81	3.97	197.25	6.06	1.64	0.92
Yeast	0	8.04	6.73	40.00	3.65	185.00	5.91	1.38	0.82
	119	8.02	6.35	41.65	3.80	189.00	5.98	1.50	0.85
	178.5	8.00	5.75	42.90	3.93	194.00	6.06	1.63	0.88
	238	7.98	5.22	44.89	3.98	198.00	6.13	1.75	0.93
Mean		8.01	6.01	42.36	3.84	191.50	6.02	1.57	0.87
LSD. 5% treatment		**--**	**ns**	**ns**	**ns**	**ns**	**ns**	**0.021**	**ns**
LSD. 5%Rates		**--**	**0.51**	**ns**	**ns**	**ns**	**ns**	**0.024**	**0.016**
Interaction		**--**	**	*	**ns**	**ns**	**ns**	**	**

Table 4. Yield and yield components of rice as affected by bio-fertilizer and different fertilization under saline soil conditions

Treatments	Rate of NPK kgha^{-1}	Plant height (cm)	Panicle length (cm)	1000 kernel mass (g)	Grains yield mass (ton/ha)	Straw yield mass (ton/ha)
Mineral	0	54.22	12.85	21.95	1.81	2.13
	119	75.39	15.62	24.63	2.480	8.07
	178.5	80.45	16.32	27.95	5.90	10.20
	238	82.00	16.85	28.12	8.85	9.98
Mean		73.02	15.41	25.66	6.31	7.59
Bacteria	0	61.28	16.58	26.14	2.01	2.84
	119	80.49	17.66	28.69	7.49	9.18
	178.5	84.36	20.52	30.42	10.93	13.54
	238	84.00	19.32	29.14	9.44	12.46
Mean		77.53	18.52	28.60	7.47	9.50
Yeast	0	58.33	14.85	25.41	1.41	2.51
	119	79.85	15.99	26.95	6.28	8.71
	178.5	83.46	16.45	27.34	9.14	10.92
	238	83.95	17.52	27.94	9.23	11.93
Mean		76.40	16.20	26.91	6.52	8.52
LSD. 5% treatment		**ns**	**ns**	**ns**	**ns**	**ns**
LSD. 5% Rates		**3.522**	**4.09**	**3.45**	**1.29**	**1.12**
Interaction		***	***	**	**	**

Table 5. Effect of different rates of mineral N, P, K fertilizers combined with bio-fertilizer on the concentration of macro-micronutrients in grains of rice harvested

Treatments	Rate of NPK Kgha^{-1}	Macronutrients (%)			Micronutrients (%)		
		N	P	K	Fe	Mn	Zn
Mineral	119	1.20	0.38	1.95	85.42	65.98	18.94
	178.5	1.26	0.39	2.04	89.24	68.52	22.14
	238	1.34	0.45	2.08	93.40	72.16	25.63
	119	1.39	0.48	2.14	95.34	75.10	28.17
	Mean	1.30	0.43	2.05	90.85	70.44	23.72
Bacteria	0	1.48	0.45	2.04	88.65	69.24	20.14
	119	1.52	0.48	2.09	92.14	72.16	25.36
	178.5	1.63	0.58	2.17	99.13	79.25	32.46
	238	1.59	0.52	2.13	95.62	76.34	29.45
	Mean	1.56	0.51	2.11	93.89	74.25	26.85
Yeast	0	1.25	0.41	1.98	86.59	68.25	19.58
	119	1.30	0.46	2.04	92.14	70.14	24.34
	178.5	1.35	0.49	2.08	95.24	73.24	27.75
	238	1.45	0.51	2.15	96.24	77.36	30.94
	Mean	1.34	0.47	2.06	92.55	72.25	25.65
LSD. 5% treatment		**ns**	**ns**	**ns**	**ns**	**ns**	**ns**
LSD. 5% Rates		**0.056**	**0.022**	**ns**	**2.54**	**2.14**	**2.19**
Interaction		**	**	**ns**	**	**	**

***mean significant*

Table 6. Effect of different rates of mineral N P K fertilizers combined with bio-fertilizers on the uptake of macro-micronutrients in rice harvested

Treatments	Rate of NPK kgha^{-1}	Macronutrients (kgha^{-1})			Micronutrients (gha^{-1})		
		N	P	K	Fe	Mn	Zn
Mineral	0	21.66	6.90	35.22	154.30	188.45	34.22
	119	31.20	23.09	120.43	526.74	205.49	130.69
	178.5	74.26	39.03	180.64	811.37	230.12	222.65
	238	123.05	42.60	189.66	844.09	248.45	249.40
	Mean	83.85	27.92	131.45	584.12	218.13	159.25
Bacteria	0	29.75	9.04	41.17	178.5	243.90	40.55
	119	113.76	35.94	154.7	689.68	261.04	189.83
	178.5	178.02	63.31	237.05	1083.38	307.45	354.76
	238	150.18	49.03	201.35	903.47	261.04	278.27
	Mean	49.55	39.34	158.98	713.76	268.37	513.77
Yeast	0	17.61	5.71	27.85	121.99	203.04	27.58
	119	81.63	28.80	128.04	578.27	217.00	152.75
	178.5	123.28	44.74	190.16	870.41	235.31	253.61
	238	133.99	47.12	198.49	888.72	266.96	285.72
	Mean	89.13	31.59	136.14	614.85	230.57	179.93
LSD. 5% treatment		**7.80**	**ns**	**ns**	**9.71**	**ns**	**10.47**
LSD. 5% Rates		**8.99**	**7.57**	**9.88**	**11.21**	**9.85**	**12.14**
Interaction		**	**	**	**	**	**

Table 7. Effect of different rate of mineral N, P and K fertilizers combined with bio-fertilizer on macro-micronutrients in the straw of rice harvested

Treatments	Rate of NPK kgha^{-1}	Macronutrients (%)			Micronutrients (mg/kg)		
		N	P	K	Fe	Mn	Zn
Mineral	0	1.94	0.23	2.18	72.68	59.47	17.45
	119	1.98	0.27	2.22	77.52	61.30	20.41
	178.5	2.04	0.29	2.29	82.14	65.82	21.69
	238	2.09	0.32	2.35	85.36	69.52	22.74
	Mean	2.01	0.28	2.26	79.43	64.03	20.57
Bacteria	0	1.98	0.26	2.23	74.52	63.14	18.20
	119	2.16	0.29	2.28	79.32	69.52	21.35
	178.5	2.22	0.31	2.32	85.20	70.41	24.13
	238	2.28	0.35	2.38	89.14	71.00	25.69
	Mean	2.16	0.30	2.30	82.05	68.52	22.34
Yeast	0	1.97	0.24	2.20	72.96	61.38	18.00
	119	2.13	0.28	2.26	80.52	65.24	20.55
	178.5	2.18	0.30	2.28	81.00	69.22	20.95
	238	2.24	0.33	2.31	82.41	70.41	21.05
	Mean	2.13	0.29	2.26	79.22	66.56	20.14
LSD. 5% treatment		**ns**	**ns**	**ns**	**ns**	**ns**	**ns**
LSD. 5 %Rates		**0.07**	**0.023**	**0.031**	**1.73**	**2.88**	**1.64**
Interaction		**	**	***	***	***	**

Table 8. Effect of different rate of mineral N, P and K fertilizers combined with bio-fertilizer on macro-micronutrients uptake in the straw of rice harvested

Treatments	Rate of N PK Kgha^{-1}	Macronutrients (kgha^{-1})			Micronutrients (g/ha^{-1})		
		N	P	K	Fe	Mn	Zn
Mineral	0	41.17	4.99	46.41	154.65	126.54	37.13
	119	159.70	21.90	179.21	625.44	494.59	164.67
	178.5	208.01	29.51	233.48	837.69	671.26	221.20
	238	208.73	31.89	234.67	852.04	693.94	226.98
	Mean	154.41	22.09	173.45	617.46	496.59	162.51
Bacteria	0	56.168	7.38	63.31	211.58	179.29	51.67
	119	198.25	26.66	209.20	727.94	638	195.95
	178.5	300.59	41.89	314.16	1153.8	953.50	326.77
	238	284.17	43.55	296.55	111.06	884.96	319.63
	Mean	209.80	29.87	220.82	801.11	663.95	223.51
Yeast	0	49.50	5.95	55.22	183.38	154.27	45.24
	119	185.64	24.28	196.83	701.39	568.30	178.99
	178.5	238.24	32.84	249.19	884.86	756.17	228.86
	238	267.27	39.27	275.60	983.04	839.88	251.09
	Mean	185.16	25.59	194.21	688.18	579.65	176.05
LSD. 5% treatment		**ns**	**ns**	**ns**	**10.42**	**ns**	**3.26**
LSD. 5 %Rates		**7.43**	**3.33**	**76.54**	**12.04**	**64.52**	**3.76**
Interaction		***	***	**	**	**	**

Pictures. 1- Soil treated with mineral fertilizers – 2- Yeast combined with mineral fertilizers – 3- Bacteria combined with mineral fertilizers

4. CONCLUSIONS

Chemical and microbial fertilizers have its advantages and disadvantages in terms of nutrient supply, soil quality and crop growth. Biological fertilization with N_2 fixing bacteria, phosphorus solubilizing bacteria and potassium dissolving bacteria are of great importance in increasing crop production and saving mineral fertilizers. Moreover, inoculation of plants grown in salt-affected soils with salt-tolerant microorganisms offered them tolerance against salinity, thereby increasing their production. It can be concluded that bio-fertilization by *Rhizobium radiobacter* sp strain, *Bacillus megatherium* as (dissolving phosphate bacteria) and *Bacillus circulans* inoculants could be applied to rice as a supplement to inorganic NPK-fertilizer. A considerable increase was observed when plants were treated with bio fertilizers + 75% NPK-recommended by the Ministry of Agriculture. It could be recommended that salt tolerant plant growth promoting rhizobacteria (PGPR) should be used to face the problem of salinity or excessive NPK-mineral use for the rice plants.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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