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NITROGEN EFFECIENCY IN BARELY UNDER SALINE-SODIC CONDITIONDS AS AFFECTED BY UREA, COMPOST AND BIOFERTILIZER (*Rhizobium radiobacter* sp.)

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ABSTRACT

Effects of application of different rates of urea, biofertilizer, (*Rhizobium radiobacter* sp.) as salt tolerant PGPR strain and compost on barley (*Hordeum valgare L*. cv. Giza 126) were studied on a saline-sodic sandy loam soil at Gelbana village, Northern Sinai Governorate, Egypt during the two successive winter seasons of 2011/2012 and 2012/2013. The studied treatments were No, control (non fertilized), N1, mineral-N (119 kg N ha^{-1}), N2, mineral-N (179 kg N ha^{-1}), equivalent 0 , 50 and 75% from recommended rate for barley, biofertilizer (Bio), biofertilizer (Bio) + N1, biofertilizer (Bio)+ N2, compost, compost + N1 and compost + N2. The results could be summarized as follow: available N, P, K, Fe, Mn and Zn concentrations were significantly increased due to the above mentioned treatments. On the other hand, the electrical conductivity (EC dSm^{-1}) and soil pH values decreased due to these treatments. The applied urea, compost and biofertilizer as well as their combinations significantly, increased straw and grain yields as well as N, P, K, Fe, Mn and Zn contents in straw and grains, grain weight $spike^{-1}$ and 1000-grain weight in the two growing seasons, except grains $spike^{-1}$ which did not reach the level of significantly in the first season. The highest values of nitrogen use efficiency (NUE), nitrogen agronomic efficiency (NAE) and apparent nitrogen recovery (ANR) were obtained due to the treatment Biofertilizer + N1 (119 kg N ha^{-1}). The higher rate of N fertilization *i.e.,*179 kg N ha^{-1} combined with compost was of superior effect on improving soil chemical properties and increasing barley production, protein content and nutrient uptake as compared to the other treatments. This was found to be true for straw and grains. Thus, it is suggested to use a combination of organic and inorganic fertilizers to achieve the highest yield without negative effect on grain quality.
Keywords: Saline-sodic soil, urea, biofertilizer, compost and barley.

INTRODUCTION

Solving the problem of shortage in food production to face the demand of fast growing population is a national goal for the Egyptian Government. Therefore, increasing the productivity of crops, such as cereals especially wheat and barley became a necessity to minimize the gap between our total production and consumption. Many researchers paid a great attention to increase the productivity of barley per unit of cultivated area through mineral fertilization. Such a fertilization practice although increases grain yield, yet this occurs at the expense of both soil health and environment. It is now unanimously agreed that decreasing fertilizer use efficiency (FUE) and declining soil organic matter (SOM) levels are serious threats to sustainability. The combined use of organic manures and inorganic fertilizers influences the physical, chemical and biological properties of the soil and plays an important role in energy flow and nutrient cycling. It does not only sustain higher levels of productivity, but also improves soil health and enhances nutrient use efficiency (Palm *et al.,* 2001). If soil biodiversity is the guardian of soil fertility and the health of the soil and crops, then frequent additions of fresh organic matter are the guardians of soil biodiversity (Krupenikov *et al.,* 2011). Many of the characteristics of highly productive soils relate to the organic fraction of the soil, especially as continued crop production potential has a direct relationship with its organic matter content (Mann *et al.,* 2002).

The adoption of management practices such as crop residue treatment, the use of catch crops, or the appropriate timing and amount of manure application determines the degree to which yields and nutrient losses are affected (Doltra *et al.,* 2011). Residue harvest removes more nutrients from the agro-ecosystem than grain harvest alone (Andrews, 2006). After a long-term experiment, Kas *et al.* (2010) concluded that the incorporation of cereal straw as the only source of organic fertilization sustained wheat and barley yields near the production level of the system. Montemurro *et al.* (2006) indicated that the partial substitution of mineral N with organic N did not reduce yields and that N utilization and mixed fertilization resulted in a good balance between productive parameters, N utilization efficiency indices and soil N deficit, while also involving lower pollution risks. The combined application of chemical fertilizer and maize straw with a wide C/N ratio is an important way of reducing the superfluous accumulation of N fertilizer (Lu *et al.,* 2010).

Soil salinity is one of the important factors affecting growth and yield of most crops. Many workers reported that application of organic manure and bio-fertilizer can alleviate the adverse effects of soil salinity on both soil and the grown plants. In this concern, Poraas *et al.* (2008) stated that maize grain yield, 100 grain weight and stover yield which grown on saline soil (EC dSm^{-1} in soil paste, 10.7) were significantly increased due to organic and bio treatments. Omran *et al.* (2009) reported that the interaction effect between FYM with 50% of the recommended dose of N and bio-fertilizer inoculation induced significant increase in growth parameters, seed quality and seed chemical compositions of flax seeds grown on sandy soil. Berhanu *et al.* (2013) found that organic fertilizer sources (*i.e,* plant residues and FYM) greatly enhanced the grain yield and yield components of wheat grown on brown forest soil.

The present work aims at identifying the effective role of applied organic compost and bio-inoculation with *Rhiobium radiobacter* sp strain (salt tolerant PGPR) applied solely or in combination with chemical-N fertilizer (urea) on maximizing the productivity of barley plants grown under saline-sodic soil condition. Evaluating the optimal use of nitrogen fertilizer when combined with the abovementioned treatments on barley yield and its quality as well as its contents of some nutrients beside of the implications of the used treatments on some soil properties were also taken into consideration in this study.

MATERIALS AND METHODS

A filed experiment was carried out on a saline-sodic sandy loam soil at Gelbana village, North Sinai Governorate, Egypt during the two successive winter seasons of 2011/2012 and 2012/2013, using a randomized complete block design with three replicates. The purpose of this experiment to evaluate the effect of biofertilizer (*Rhizobium radiobacter* strain, salt tolerant PGPR), urea (460 g N kg^{-1}) and organic fertilizer (compost) on grain quality, productivity and contents of some macro (N, P and K) and micro (Fe, Mn and Zn) nutrients of barley plants. Also, soil properties after harvest were taken into consideration. A representative soil sample of the field was taken from 0 – 30 cm layer and used for determining some physical and chemical properties of studied soil whose results are presented in Table 1.

The soil experimental filed was pre-treated by applying the gypsum requirements then ploughing soil to a depth of 30 cm. Therefore, continuous leaching process was carried out through adding water to soil basins until it reaches a height of 15 cm above the soil surface. Such height of water was kept constant for 3 days. Two weeks after the leaching process lazar technique was used for leveling the soil surface followed by deep sub-soiling, plowing and establishing field drains at a depth of 90-cm at the beginning of each drain followed by establishment of an irrigation canal in the middle part of the experimental area. The soil was irrigated from El-Salam Canal (a mixture of Nile water and agricultural drainage water), (Table 2).

Organic compost was prepared using two tons of air-dried straw residues (rice straw, maize stover and faba bean straw) and its chemical composition is shown in Table 3.

Barley seeds (*Hordeum valgare* cv. Giza 126) were inoculated with biofertilizer which was prepared from *Rhiobium radiobacter* sp strain (salt tolerant plant growth promoting rhizobacteria, PGPR) isolated from the rhizosphere soil of Sahl El-Tina location and deposited in Gene bank under number of HQ395610 Egypt by Bio-fertilizer Production Unit, Department of Microbiology, Soils, Water and Enviro. Res. Inst., Agric. Res. Center, Giza, Egypt. *Rhizobia* inoculant was applied at a rate of 100g of the inoculant for 15 kg seeds wetted with 300 ml of adhesive. The moist seeds were thoroughly mixed with the inoculants in the shade, sown immediately and covered with soil in order to minimize *Rhizobia* exposure to the sun. Seeds of barley were sown, 20^{th} and 25^{th} of October 2011/2012 and 2012/2013, respectively. The inoculation of the *Rhizobia* strain was added 3 times at 21, 45 and 65 days after planting at rate of 12 L of the inoculant suspension / 950 L water ha^{-1}.

Table 1. Physical and chemical properties of the investigated soil

Propertie	Value	Properties	Value
Particle size distribution [%]:		– **Soluble ions (mmolc L^{-1})**	
– **Clay**	16.76	▪ **Na^+**	117
– **Silt**	10.24	▪ **K^+**	0.80
– **Fine sand**	68.31	▪ **Ca^{++}**	12.8
– **Coarse sand**	4.69	▪ **Mg^{++}**	22.2
– **Textural class**	**Sandy loam**	▪ **Cl^-**	103
– **EC (dSm^{-1}) in soil paste**	15.3	▪ **HCO_3^-**	10.6
– **pH [Soil suspension 1:2.5]**	8.12	▪ **$SO_4^=$**	39.2
▪ **Organic matter (g kg^{-1})**	4.81	▪ **$CaCO_3$ (g kg^{-1})**	85.7
▪ **SAR**	28.0	▪ **ESP**	28.6

Available macro and micronutrients (mg kg^{-1} soil)

N	P	K	Fe	Mn	Zn	Cu
30.0	3.25	195	5.96	2.26	0.83	0.02

Critical levels of nutrients in soil after Page *et al.,* (1982)

Limits	N	P	K	Fe	Mn	Zn
Low	< 40.0	< 5.0	< 85.0	< 4.0	< 2.0	< 1.0
Medium	40 -80	5 -10	85 - 170	4 - 6	2 - 5	1 - 2
High	> 80.0	> 10.0	> 170	> 6.0	> 5.0	> 2.0

Table 2. Chemical properties of the irrigation water in the two successive years of study.

Properties	Season		
	2011/2012	2012/2013	Average
pH	7.89	7.93	---
EC (dSm^{-1})	1.46	1.32	1.39
	Macronutrient (mg kg^{-1})		
N – NH_4^+	7.99	6.55	7.27
N – NO_3^-	7.32	7.68	7.50
P	2.08	2.14	2.11
K	9.02	9.08	9.05
	Micronutrient (mg kg^{-1})		
Fe	0.97	0.86	0.92
Mn	1.32	1.35	1.34
Zn	0.72	0.78	0.75

Table 3. Chemical properties of the compost used in the study.

Property	pH (1:2.5)	EC dSm^{-1} (1:10)	O.C	C/N ratio	Total macronutrients (g kg^{-1})			Total micronutrients (mg kg^{-1})		
					N	P	K	Fe	Mn	Zn
Compost	7.95	4.60	35.7	23.6	15.1	6.61	18.6	699	431	286

The treatments were arranged in a randomized complete block design with three replicates. The plot area was 40m^2 (4 m width and 10 m length). Soil was amended with compost 20 days before sowing at a rate of 6 Mega gram (Mg) ha^{-1} and ordinary superphosphate (67.6 g P kg^{-1}) at a rate of 31 kg P ha^{-1} during seed bed preparation. Also, all treatments received potassium fertilizer 60 kg K ha^{-1} as potassium sulphate (400 g K kg^{-1}) in two equal doses at 21 and 42 days after planting. All normal agricultural practices recommended for the region were applied. Nitrogen fertilizer was applied as urea, 460 g N kg^{-1} at three rates 0, 119 and 179 kg N ha^{-1} equivalent 0 , 50 and 75% from recommended rate for barley in three equal doses; started before planting, then 30 and 50 days after planting. The experiment treatments were as follow:

1. **1-** N0, control (non-treated)
2. **2-** N1, mineral-N (119 kg N ha^{-1})
3. **3-** N2, mineral-N (179 kg N ha^{-1})
4. **4-** biofertilizer, (Bio), by inoculation with *Rhizobium radiobacter* strain (PGPR) as a salt tolerant rhizobacteria.
5. **5-** Bio + N1
6. **6-** Bio + N2
7. **7-** compost (6 Mega gram, Mg ha^{-1}), Mega gram = 10^6 gram = Metric ton
8. **8-** compost + N1
9. **9-** compost + N2

Harvest was done on, 27th of April and, 2nd of May 2011/2012 and 2012/2013, respectively.

Dry matter and grain yield

At harvest, ten plants were taken randomly from each plot and tagged for yield assessment. Grain weight $spike^{-1}$ and 1000-grain weight were measured. Total proline content was determined according to **Bates *et al.* (1973).** In addition, plants in an area of 2 m^2 of each plot were harvested, air dried, then straw yield, grain yield, biological yield were estimated. Representative ten plants were taken and the following parameters were calculated:

- Grain protein contents by multiplying grain N% by 5.83 **(Baker, 1979).**
- Grain protein yield in kg ha^{-1}{protein content g kg^{-1} x grain yield Mg ha^{-1}}
- Harvest Index (HI): (grain yield / biological yield) x100
- Yield efficiency: (grain yield / straw yield) x 100.
- Apparent N recovery (ANR) by the equation described by Echeverria and Videla (1998), *i.e.,* ANR = [N uptake (fertilized plot) – N uptake (zero plot) / N fertilizer rate] X 100.
- Nitrogen agronomic efficiency (NAE) for N according to Craswell and Godwin (1984): [grain yield (fertilized plot) - grain yield (zero plot)] / N fertilizer; yield and N fertilizer in kg ha^{-1}.
- Nitrogen use efficiency (NUE) is the N applied to produce yield and is defined here as the amount of grain yield per unit of applied N (kg of grain yield kg^{-1} of N applied) as described by Angas *et al*. (2006).

Macro and micronutrients content of seeds and pod samples were determined in aliquots of digested solutions resulting from the digestion of grains and pod samples by a mixture of H_2SO_4 and $HClO_4$ acids after drying in an oven at 70º C as described by Ryan *et al*. (1996).

Soil characteristics

After harvest, representative soil samples of the field were taken (0 – 30 cm layer) from each plot. Samples were analyzed for EC (in soil paste extract), pH (in 1: 2.5 soil: water suspension) according to **Page *et al.* (1982).** Available nitrogen was extracted by KCl 2N extract and determined by steam - distillation procedure using MgO- Devarda alloy according to Bremner and Keeney method's described by Black *et al.* (1982). Available phosphorus was extracted using 0. 5 N Na HCO_3 solution at pH 8.5 and determined colorimetrically according to Watanabe and Olsen (1965). Available potassium was extracted using 1N ammonium acetate at pH 7.0 and determined photometrically according to Jackson (1958). Available iron, manganese and zinc were extracted by DTPA and measured using atomic absorption spectrophotometer as described by Soltanpour, (1985).

Statistical analysis

Data of the two seasons were subjected to statistical analysis of variance (ANOVA), and the least significant differences (L.S.D) at 5% level according to Snedecor and Cochran, (1971).

RESULTS AND DISCUSSION

Effect of treatments on some soil chemical properties after barley harvest

Soil pH

Data in Table 4 show the effect of mineral, bio. and organic-N fertilization on some chemical properties of the soil at the end of the experiment. The values of pH were slightly decreased as affected by all the studied treatments for the two seasons. These results are in agreement with those of Siam *et al.* (2013) who reported that the decrease in pH was marked particularly when N and compost fertilization were combined. The highest decrease in pH value was achieved by treating the soil by compost + N2. Such decreases in soil pH might be attributed to the effect of microorganisms on decomposing organic matter releasing organic acids and producing several phytohormones such as indole acetic acid and cytokinins. These results are similar to those obtained by Ashmaye *et al.* (2008) and Abdel-Fattah (2012).

Table 4. Effect of mineral N, biofertilizer and compost on soil properties during 2010/2011 and 2011/2012 seasons.

Treatment	pH	EC	cations mmol$_c$ L^{-1}				anions mmol$_c$ L^{-1}				SAR	ESP
	[1:2.5]	dSm^{-1}	Ca^{++}	Mg^{++}	Na^{+}	K^{+}	Cl^{-}	$CO_3^{=}$	HCO_3^{-}	$SO_4^{=}$		
						2011-2012						
Control	8.10	13.5	10.5	21.9	102	0.78	90.1	nil	8.26	42.3	25.4	36.6
N1 (119 kg N ha^{-1})	8.08	12.7	13.7	18.1	85.6	0.79	78.2	nil	7.21	33.0	21.4	30.7
N2 (179 kg N ha^{-1})	8.07	12.6	14.3	17.0	94.2	0.82	88.3	nil	6.22	32.2	23.8	34.2
Bio	8.04	10.3	12.0	17.5	82.2	0.83	75.2	nil	7.83	29.7	21.4	30.6
Bio + N1	8.01	10.5	14.3	16.2	72.0	0.93	63.1	nil	6.10	34.3	18.4	26.2
Bio + N2	8.05	11.0	15.6	16.2	70.0	0.92	62.0	nil	5.69	35.1	17.6	24.9
Compost	8.02	10.8	13.5	16.9	79.4	0.89	70.5	nil	6.49	34.2	20.4	29.0
Compost + N1	8.03	11.1	12.4	16.9	83.8	0.86	77.4	nil	6.33	30.6	21.9	31.4
Compost + N2	8.00	11.4	15.8	16.0	74.7	0.96	60.6	nil	5.23	36.9	18.7	26.6
Grand Mean	8.05	11.6	13.6	17.4	82.7	0.86	73.9	nil	6.60	34.3	21.0	30.0
						2012-2013						
Control	8.06	13.3	14.5	19.7	98.3	0.82	82.4	nil	8.22	43.1	23.8	34.1
N1 (119 kg N ha^{-1})	8.02	10.7	15.8	17.3	80.8	0.84	74.3	nil	7.17	39.5	19.9	28.3
N2 (179 kg N ha^{-1})	8.02	11.5	15.8	17.1	73.1	0.85	66.1	nil	7.08	33.8	18.0	25.6
Bio	8.02	9.07	14.7	20.7	69.6	0.86	60.5	nil	6.35	33.5	16.6	23.4
Bio + N1	7.97	9.20	15.2	18.0	53.9	0.97	48.3	nil	5.42	37.3	12.6	17.5
Bio + N2	8.00	10.6	15.4	17.2	58.5	0.93	49.4	nil	5.43	37.6	14.9	20.3
Compost	8.00	9.31	17.7	18.2	56.6	0.94	52.1	nil	5.89	35.5	13.4	18.6
Compost + N1	8.01	9.34	15.0	17.3	59.9	0.85	51.2	nil	6.28	35.8	14.9	20.9
Compost + N2	7.95	9.39	17.8	17.0	50.7	0.95	42.0	nil	5.10	36.8	12.7	17.7
Grand Mean	8.01	10.3	15.8	18.1	66.8	0.89	58.5	nil	6.33	37.0	16.3	22.9

Total soluble salts

Data presented in Table 4 show that soluble salts decreased when the compost or bio-fertilizers were applied alone or in combination with N-fertilizer. This would improve soil conditions for plant growth. Improvement in porosity and aggregation may have occurred due to the applied compost and biofertilizer and hence enhanced the leaching of salts (Zaka *et al.,* 2005). The reclamation pre-treatments executed before carrying out the experiment enhanced the positive effect of bio and organic fertilization. Organic acids must have provided a substantial modification of soil physical properties, especially soil structure as well as soil aggregation and drainable pores. Consequently, these favorable conditions would positively affect soil permeability and encourage downward movement of water carrying Na-salts out of the soil. These results are in agreement with those of Bassiouny and Shaban (2010) and Rashed *et al.* (2011).

The lowest EC values (10.3 and 9.07 dSm^{-1}) were recorded with the treatment Bio + N1 at the first and second seasons, respectively. The used treatments could be arrange according to their effects on reducing EC of soil in the following descending order: Biofertilizer treatment when added solely or in combination with N1 and N2 followed by compost treatment when added solely or in combination with N1 and N2 and then mineral-N fertilization at the rates N1 and N2. This trend was found true for the two seasons. These results are in agreement with those obtained by Nasef *et al.* (2009) who found that beside of the improvement in soil aggregation caused by compost, its decomposition when combined with bio-fertilizers released acids therefore; such conditions facilitated leaching of soluble salts and decreased soil salinity.

Soluble ions

Data presented in Table 4 indicate that Ca^{++} and K^{+} increased while Na^{+} and Mg^{++} decreased. The treatment (compost + N2) seemed to be generally of the most superior effect on Ca^{++} and K^{+}.

Soluble anions *i.e.,*Cl^{-}, HCO_3^{-} and SO_4^{--} decreased due to the bio, organic and mineral-N fertilization in soil after harvest for the two growing seasons 2011/2012 and 2012/2013. No free carbonates were detected in soil extracts. Bicarbonates which ranged from 8.26–5.23 $mmol_c$ L^{-1} for 2011/2012 season and 8.22–5.10 $mmol_c$ L^{-1} for 2012/2013 season were generally of the highest concentrations. Lowest value of Cl^{-} and HCO_3^{-} (60.6 and 5.23 $mmol_c$ L^{-1}, respectively) at 2011/2012 season and (42.0 $mmol_c$ L^{-1} and 5.10 $mmol_c$ L^{-1}, respectively) at 2012/2013 season were obtained under (compost + N2), while for SO_4^{--} the treatment of biofertilization gave the lowest values (29.7 and 33.5 at 2011/2012 season and 2012/2013 season, respectively).

Soil sodicity

Soil sodicity in terms of exchangeable sodium percentage (ESP) of the soil as well as sodium adsorption ratio (SAR) of the soil paste extract, decreased considerably as affected by the fertilizer treatments (Table 4). Generally, all treatments resulted in a sharp decrease in SAR and ESP values. The SAR decreased from 25.4 for control to 17.6 for soil treated with Bio+N2, thus exhibiting a decrease of 30.7% in 2011/2012 season. The SAR decreased from 23.8 (control) to 12.6 due to the treatment Bio +N1 corresponding to a decrease performance of 47.1% in 2012/2013 season. The ESP followed a trend similar to that of SAR which; the ESP values showed a decrease ranged between 32.0 to 48.7% due to the treatment (Bio + N2) in 2011/2012 and (Bio + N1) in 2012/2013 seasons, respectively.

Available macronutrients (N, P and K)

Data presented in Table 5, show the available N, P and K (mg kg^{-1}) as affected by the used treatments and their combinations on the studied soil. Data revealed that available N, P and K increased as affected by the treatments of mineral, organic and bio and their combinations. Available N ranged between 33.1 to 56.1 mg kg^{-1} for 2011/2012 season and 37.2 to 63.1 mg kg^{-1} for 2012/2013 season. Available P ranged between 3.58 to 4.33 mg kg^{-1} for 2011/2012 season and 3.64 to 4.83 mg kg^{-1} for 2012/2013 season. Available K ranged between 198 to 229 mg kg^{-1} in 2011/2012 season and 201 to 236 mg kg^{-1} in 2012/2013 season. The soil treated with compost + N2 gave the highest values of available N, P and K. The positive effect of organic N- source is partially due to a slow release of N from manure, as suggested by Bhandari *et al.* (2002).

Table 5. Available macro and micronutrients in soil after harvest during 2010/2011 and 2011/2012 seasons.

Treatment	Available macronutrients (mg kg^{-1})			Available micronutrients (mg kg^{-1})		
	N	P	K	Fe	Mn	Zn
				2011-2012		
Control	33.1	3.58	198	6.53	2.58	0.96
N1 (119 kg N ha^{-1})	44.2	3.72	193	6.76	2.66	0.98
N2 (179 kg N ha^{-1})	47.2	3.80	198	6.83	2.72	1.00
Bio	38.1	3.64	201	6.59	2.61	0.98
Bio + N1	48.2	4.22	215	7.12	2.89	1.07
Bio + N2	50.1	4.26	219	7.16	2.96	1.08
Compost	39.2	4.18	205	7.09	2.84	1.03
Compost + N1	52.1	3.77	222	7.63	2.65	0.98
Compost + N2	56.1	4.33	229	7.23	3.01	1.12
Grand Mean	45.4	3.94	209	6.99	2.77	1.02
$LSD_{0.05}$	3.62	0.34	2.03	0.12	0.18	NS
				2012-2013		
Control	37.2	3.64	201	5.63	2.65	1.02
N1 (119 kg N ha^{-1})	46.2	3.78	204	6.74	2.77	1.06
N2 (179 kg N ha^{-1})	53.4	3.89	207	6.79	2.82	1.09
Bio	41.2	3.76	208	5.66	2.71	1.04
Bio + N1	54.2	4.29	225	7.04	3.06	1.14
Bio + N2	59.1	4.76	232	7.08	3.12	1.15
Compost	43.3	4.25	214	7.81	3.02	1.10
Compost + N1	57.0	3.80	229	5.71	3.07	1.06
Compost + N2	63.1	4.83	236	7.12	3.16	1.18
Grand Mean	50.5	4.11	217	6.62	2.93	1.09
$LSD_{0.05}$	3.21	0.50	3.72	1.01	NS	NS

The P and K fractions added through organic manures upon its decomposition with time may account for the increases in both P and K. (Yadvinder *et al.,* 2004). Also the production of organic and inorganic acids during the degradation of such organic materials (as well as humates) as a result of the microorganisms activities must have contributed to a decrease in soil pH which would reduce K fixation and produce more chelating ions, leading to an increase in available forms of elements in the rhizosphere zone. These results are in agreement with those obtained by Ewees and Abdel Hafeez (2010). The corresponding relative increases were 69% and 70% in 2011/2012 and 2012/2013 seasons for available N, 20.9% and 32.7% in 2011/2012 and 2012/2013 seasons for available P and 15.7% and 17.4% in 2011/2012 and 2012/2013 seasons for available K. This was found to be obvious due true due to the treatment compost + N2.

Available micronutrients (Fe, Mn and Zn)

The concentrations of Fe and Mn in soil at the end of the experiment significantly increased due to application of compost, urea and biofertilizer in comparison with the untreated control treatment except for Mn in 2011/2012 season. Zn also increased due to the different treatments; however, the increases occurred were insignificant. This fact hold true for the two seasons under study. This may be due to the vital role of compost which contains microorganisms that make these nutrients more available in the soil. In addition, compost may play a vital role for increasing nutrients availability through the processes of chelating, biochemical processes and production of several organic acids during decomposition of compost as reported by Hammad and Abdel Ati (1998). Also, bacteria cause some micronutritive elements such as Fe, Mn and Zn to release in available forms in soil through break down of organic materials in the soil (Bhande *et al.,* 1997). The highest available Fe values (7.63 and 7.91 mg kg^{-1}) were obtained under the treatments of compost + N1 in 2011/2012 season and compost in 2012/2013 season, respectively. The highest available Mn and Zn contents in soil were 3.01 and 1.12 mg kg^{-1}soil in 2011/2012 season and 3.16 and 1.18 mg kg^{-1}soil in 2011/2012 season, respectively and were obtained due to the treatment of compost + N2.

Effect of treatments on growth parameters and yield of barley:

Growth parameters

Some growth parameters of barley plants are shown in Table 6. Application of urea, compost and biofertilizers solely or in combinations with urea significantly, increased grains weight *per* spike and 1000-grains weight of barley as compared to the untreated (control). This was found true for both the growing seasons 2011/2012 and 2012/2013, except for grain weight *per* spike in 2011/2012 season. The highest grain weight *per* spike and 1000-grains weight were recorded in the plants treated with compost + N2 which caused increases of about 31.8% and 77.7% in 2011/2012 season and 30.7% and 71.2% in 2012/2013 season, respectively. Application of N1 (119 kg N ha^{-1}) and N2 (179 kg N ha^{-1}) increased grain weight *per* spike by 10.9% and 17.3% in 2011/2012 and 12.3% and 16.7% in 2012/2013, respectively and increased 1000-grain weight by 22.0% and 35.8% in 2011/2012 and 18.6% and 30.7% in 2012/2013, respectively. This shows the positive effect of urea which would enhance the decomposers of the organic matter thereby releases the nutrients in available form. Previous studies justified the positive effects of nitrogen application (Abedi *et al.,* 2010 and Daneshmand *et al.,* 2012) and biofertilizer inoculation (Kandil *et al.,* 2011).

Table 6. Effect of urea, biofertilizer and compost on yield and yield components of barley during 2010/2011 and 2011/2012 seasons.

Treatments	Grain weight spike^{-1} (g)	1000-grain weight (g)	Yield (Mg ha^{-1})			Yield efficiency (%)	Harvest index (HI) %
			Straw	Grain	Biological		
	First Season [2011-2012]						
Control	1.10	28.2	0.874	0.355	1.23	40.6	28.9
N1 (119kg N ha^{-1})	1.22	34.4	1.86	1.19	3.05	64.0	39.0
N2 (179kg N ha^{-1})	1.29	38.3	2.25	1.64	3.89	72.9	42.2
Bio	1.15	35.5	0.960	0.702	1.66	73.1	42.3
Bio + N1	1.30	41.3	2.52	2.29	4.81	90.9	47.6
Bio + N2	1.38	48.1	2.81	2.59	5.40	92.2	48.0
Compost	1.20	40.5	1.38	0.73	2.11	52.9	34.6
Compost + N1	1.36	46.2	2.72	2.52	5.24	92.7	48.1
Compost + N2	1.45	50.1	2.95	2.67	5.62	90.5	47.5
Grand Mean	1.27	40.3	2.04	1.63	3.67	74.4	42.0
LSD $_{0.05}$	NS	3.341	0.173	0.320	3.691		
	Second Season [2012-2013]						
Control	1.14	32.3	0.886	0.388	1.27	43.8	30.6
N1 (119kg N ha^{-1})	1.28	38.3	1.96	1.25	3.21	63.8	38.9
N2 (179kg N ha^{-1})	1.33	42.2	2.22	1.46	3.67	65.8	39.8
Bio	1.22	35.2	0.993	0.733	1.73	73.8	42.4
Bio + N1	1.36	44.4	2.58	2.35	4.93	91.1	47.7
Bio + N2	1.42	52.2	2.85	2.69	5.53	94.4	48.6
Compost	1.26	42.2	1.01	0.75	1.76	74.3	42.6
Compost + N1	1.43	51.4	2.61	2.36	4.97	90.4	47.5
Compost + N2	1.49	55.3	2.87	2.72	5.60	94.8	48.6
Grand Mean	1.33	43.7	2.00	1.63	3.63	76.9	43.0
LSD $_{0.05}$	0.085	4.413	0.195	0.403	3.726		

Straw and grains yields

As shown in Table 6, N application, biofertilizer and compost as well as their combinations significantly, increased straw and grain yields of barley plants. The treatments followed the following descending order according to their effects on straw and grain yields: compost + N2 > Bio + N2 > compost + N1 > Bio + N1 > N2 > N1 > compost > Bio > control. This trend was found to be true for both the two growing seasons. The organic manure treated soil plots became more enriched in the released nutrient, especially the micronutrients, which directly or indirectly in valve in formation of starch, protein and other biological components through their roles in the respiratory and photosynthesis mechanisms as well as in the activity of various enzymes. In addition, the organic manure, leads to improve soil physicochemical, hydrological and biological characteristics, which facilitate nutrients uptake by barley, and hence increases barley straw and grain yields (Hegazi, 2004). Application of biofertilizer is suggested as a sustainable way for increasing crop yields due to the plant growth promoting substances produced by the biofertilizer (Joshi *et al.,* 2012), in addition to the reasonable quantity of atmospheric nitrogen fixed by *Rhizobium radiobacter* (Namvar *et al.,* 2012). Therefore, the general physiological status of the plants as indicated by the dry weight always exhibit positive response to use of biofertilizer. Piccinin *et al.,* (2013) showed that the grain yield of wheat improved when wheat plants were grown with a combination of chemical N and biofertilizer inoculation. These results are in agreement with those obtained by Berhanu *et al.* (2013) and Namvar and Teymur (2013).

The highest straw and grain yields of 2011/2012 season (2.95 and 2.67 Mg ha^{-1}) and of 2012/2013 season (2.87 and 2.72 Mg ha^{-1}), respectively were obtained due to the addition of compost + N2 treatment which resulted in relative increments of 179% and 652% in 2011/2012 season as well as 224% and 601% at 2012/2013, respectively.

Grain yield efficiency and harvest index

Values of yield efficiency as affected by mineral, bio and organic-N whether applied solely or in combinations are shown in Table 6. Grain yield efficiency, which is the ratio of grain yield to straw yield at maturity varied between 40.6% - 90.5% in the growing season of 2011/2012 and 43.8% - 94.8% in 2012/2013 growing season. The plants treated with compost + N1 gave the highest yield efficiency followed by biofertilizer + N2 treatment. The values were 92.7% and 92.2% for the season of 2011/2012 giving increases of 128% and 127%, respectively while the values were 94.8% and 94.4% observed under the treatments of compost + N2 and biofertilizer + N2 for the season of 2012/2013 giving increases of 116% and 115%, respectively.

Harvest index of barley increased due to the treatments urea, bio and compost solely or in combination with N-fertilization. Harvest index of plants treated with compost + N1 in season 2011/2012 was the highest giving increase of 66.4% as compared to the control. The effects of compost + N2 and biofertilizer +N2 treatments were equal and gave almost the same highest value (48.6%) in the growing season of 2012/2013. The favorable effect of mineral N- fertilization is due to N being essential for plant growth. Therefore, the increase in N-fertilization rate would increase metabolic processes and physiological activities rate, and thus, increased yield with good quality of grains would occur (Russel, 1973).

Total proline content

Data presented in Table 7, show the effect of nitrogen fertilization, biofertilization and compost on the total proline content in dry weight of grains. The plants received fertilizers showed significant decreases compared to the control (without fertilizers) which gave the highest proline contents 16.0 and 16.6 g kg^{-1} dry leaves in 2011/2012 and 2012/2013 seasons, respectively. These treatments can be arranged due to their effects on proline content in the following order: control > N2 > N1 > compost + N2 > compost + N1 > biofertilizer + N2 > biofertilizer + N1 > compost > biofertilizer. This trend was found true for 2011/2012 and 2012/2013 seasons. Nour El-Din and Salama (2006) reported that proline accumulation is a common metabolic response of higher plants to salinity stress. Also, compost treatments decreased the proline accumulation in wheat plants grown in saline soil. These results agree with those obtained by Amirjani (2011) and Siam *et al.* (2013).

The biofertilizer inoculation with *Rhizobium radiobacter* sp. treatment decreased proline content by 23.8% and 29.5% at 2011/2012 and 2012/2013 seasons, respectively compared to the control.

Grain protein content and protein yield

It can be seen from results presented in Table 7 that the grain protein content and grain protein yield of barley significantly increased as affected by the treatments of urea, biofertilizer and compost and their combinations. Mabrouk (2002) found that bio-mineral and organic-mineral fertilization treatments were more effective in increasing protein content of peanut plants as compared with the individual mineral fertilization. The favorable effect of mineral N-fertilization is attributed to its role as one of the most important constituents of all proteins and nucleic acids, and hence protoplasm and chlorophyll (Wortman *et al.,* 2011). As the level of N- supply increases, the extra protein produced allows the plant leaves to grow larger and consequently photosynthesis increases; therefore, the increase in N-fertilization level led to an increase in metabolic processes and physiological activities necessary for more plant organs formation, more dry matter accumulation and enhancing the grain hilling rate, which finally increase the amount of protein in grain. These results are in accordance with those reported by Abbas *et al.* (2011) and Joshi *et al.* (2012). The highest values of protein content (128 and 132 g kg^{-1}) were obtained due to the treatment compost + N2 in 2011/2012 and 2012/2013 seasons representing increase percentage of 94.2% and 90.8%, respectively.

Table 7. Effect of urea, biofertilizer and compost on concentration proline content, protein content and protein yield as well as N content and uptake by barley during 2010/2011 and 2011/2012 seasons.

Treatment	Proline (g kg^{-1}) dry weight	Protein (g kg^{-1})	Protein yield (kg ha^{-1})	N content (g kg^{-1})		N uptake (kg ha^{-1})	
				Straw	Grain	Straw	Grain
			2011/2012				
Control	16.0	65.9	23.4	7.97	11.3	6.96	4.61
N1 (119kg N ha^{-1})	15.3	79.9	95.1	8.58	13.7	16.0	16.1
N2 (179kg N ha^{-1})	15.4	85.7	141	9.68	14.7	21.8	24.0
Bio	11.2	79.3	55.7	8.24	13.6	7.91	9.62
Bio + N1	12.8	120	275	9.91	20.5	25.0	46.9
Bio + N2	13.9	125	324	10.1	21.5	28.5	55.6
Compost	12.2	88.0	64.2	8.54	15.1	11.8	11.0
Compost + N1	14.6	124	313	10.2	21.2	27.8	53.5
Compost + N2	14.9	128	342	10.8	22.0	31.9	58.6
Grand Mean	14.0	101	182	9.34	17.3	19.7	31.1
$LSD_{0.05}$	0.141	0.875	0.768	0.074	0.152	6.916	12.53
			2012/2013				
Control	16.6	69.2	26.8	8.24	11.9	7.30	5.01
N1 (119kg N ha^{-1})	15.9	82.8	104	8.86	14.2	17.4	17.7
N2 (179kg N ha^{-1})	16.0	89.2	130	9.83	15.3	21.8	22.3
Bio	11.7	80.8	59.2	8.64	13.9	8.58	10.4
Bio + N1	12.8	125	294	10.3	21.5	26.6	50.5
Bio + N2	14.5	126	339	11.1	21.6	31.5	58.0
Compost	12.3	88.2	66.2	9.17	15.1	9.24	10.6
Compost + N1	15.3	131	309	10.7	22.5	27.8	53.1
Compost + N2	15.5	132	359	11.3	22.6	32.3	61.6
Grand Mean	14.5	103	187	9.78	17.7	20.3	32.1
$LSD_{0.05}$	0.170	1.322	0.987	NS	0.281	6.928	17.80

Regarding the grain protein yield, results followed a trend similar to that of protein content and followed the sequence: compost + N2 > Bio + N2 > compost + N1 > Bio + N1 > N2 > N1> compost > Bio. This promoting effect could be attributed to the integrated effect of highly humified organic materials plus bio effect of nitrogen fixing bacteria on increasing the available nutrients and supporting them as a storehouse for plant growth against the adverse conditions e.g. high salinity and sodicity and accordingly maximizing the biological yield and grain quality of barley (Ewees and Abdel Hafeez, 2010). The highest values of protein content (342 and 359 kg ha^{-1}) were obtained due to the same treatment which resulted in the highest protein content in the two growing seasons, respectively.

Macronutrient content

Data in Tables 7 and 8 show that N, P and K uptake increased significantly due to addition of urea, bio and organic-N sources and their combinations. Also, the treatment consisting of compost + N2 was superior for increasing the uptake of N, P and K as compared to the other treatments. This promoting effect could be related to the N supplementary effect of N_2 fixing bacteria (used as bio N -fertilizer) to plants due to their ability to fix free molecular atmospheric nitrogen as well as the role of these bacteria in improving the availability of soil elements (Table 5) through secreting chelating substances (such as organic acids) which are important for solubilizing sparingly soluble inorganic compounds to more available forms for plants uptake (Kandil *et al.,* 2011 and Daneshmand *et al.,* 2012). On the other hand, the positive effect of organic manures might reflect the different characteristics of the added organic manures (their chemical composition and nutritional status). The organic manures might create favorable soil physical and chemical conditions, which affect the solubility and availability of nutrients and thus uptake of nutritional elements. Moreover, the released N is known to be an essential nutrient for plant growth and development involved in vital plant functions such as photosynthesis, DNA synthesis, protein formation and respiration (Diacono *et al.,* 2013). These results coincide with the results of Abbas *et al.* (2011) and Namvar and Teymur (2013).

The individual effect of urea, compost and biofertilizer treatments showed a descending increase in the order: (N2 > N1 > compost > biofertilizer) for N, P and K uptake by straw and grains during the growing season 2011/2012 and the same trend was found true at 2012/2013 season except for K uptake by straw which followed the order: (N2 > N1 > biofertilizer > compost).

Table 8. Uptake of P and K as well as Fe, Mn and Zn by barley as affected by bio, mineral and organic-N fertilization during 2011/2012 and 2012/2013 seasons.

Treatment	Macronutrient uptake (kg ha^{-1})				Micronutrient uptake (g ha^{-1})					
	P		K		Fe		Mn		Zn	
	Straw	Grains	Straw	Grains	Straw	Grains	Straw	Grains	Straw	Grains
					2011/2012					
Control	1.95	1.19	23.4	4.98	46.2	27.7	27.3	15.6	12.6	7.32
N1(119kg N ha^{-1})	4.64	4.09	51.2	17.1	121	103	68.7	58.2	35.2	35.2
N2(179kg N ha^{-1})	6.38	5.90	65.2	24.1	161	154	95.5	85.9	48.2	51.3
Bio	2.29	2.90	26.1	11.2	52.5	58.5	32.7	35.0	15.2	14.5
Bio + N1	7.11	10.2	77.2	37.1	178	213	104	112	55.9	84.9
Bio + N2	8.55c	12.3	86.0	44.0	221	268	131	144	77.3	93.6
Compost	4.41	3.15	37.9	11.9	80.3	61.3	49.7	38.5	26.4	18.5
Compost + N1	9.28	13.0	83.9	46.2	208	248	120	142	69.5	94.2
Compost + N2	11.0	15.2	91.6	50.4	243	291	151	161	89.4	105
Grand Mean	**6.18**	**7.55**	**60.3**	**27.4**	**146**	**158**	**86.7**	**88.0**	**47.7**	**56.1**
LSD 0.05	**1.835**	**3.513**	**24.27**	**13.02**	**42.38**	**72.37**	**25.57**	**44.65**	**17.31**	**28.18**
					2012/2013					
Control	2.21	1.33	23.9	5.53	47.1	30.9	29.3	18.2	13.5	8.37
N1(119kg N ha^{-1})	6.14	5.12	56.0	18.5	135	112	80.6	67.9	42.1	40.6
N2(179kg N ha^{-1})	7.34	5.93	64.6	22.0	165	138	97.8	79.8	51.5	51.0
Bio	2.77	3.30	28.3	11.8	59.3	61.3	36.1	38.4	18.2	18.6
Bio + N1	8.10	10.8	81.6	39.6	189	233	115	132	63.0	81.2
Bio + N2	10.0	14.1	89.0	46.2	235	285	143	156	86.4	103
Compost	2.94	3.68	27.9	12.6	62.6	65.0	35.6	42.8	20.1	22.9
Compost + N1	8.97	12.8	82.0	43.5	207	249	126	142	71.5	86.3
Compost + N2	10.7	15.6	91.8	53.2	250	306	161	175	95.8	115
Grand Mean	**6.57**	**8.07**	**60.6**	**28.1**	**150**	**165**	**91.6**	**94.5**	**51.3**	**58.6**
LSD 0.05	**2.693**	**4.918**	**26.63**	**10.15**	**41.81**	**77.13**	**29.44**	**42.69**	**18.37**	**27.45**

The effect of compost and biofertilization in combinations with urea, on increasing N, P and K uptake followed the order: (compost + N2 > biofertilizer + N2 > compost + N1 > biofertilizer + N1) for N uptake by straw and grains as well as K uptake by straw during the two growing seasons as well as P and K uptake by grains at the second season 2012/2013. However, the followed sequence: compost + N2 > compost + N1 > biofertilizer + N2 > biofertilizer + N1 characterized P and K uptake by grain at the first season and P uptake by straw at the second season.

The highest values of N, P and K uptake during the two growing seasons were achieved due to application of compost + N2.

Micronutrient contents

Values of Fe, Mn and Zn uptake by barely plants as affected by application of urea, compost and biofertilization solely or in combinations were shown in Table 8. The uptake of Fe, Mn and Zn followed a pattern similar to that shown by the macronutrient where they increased significantly by the addition of the aforementioned fertilization treatments during the two growing seasons. Compost + N2 treatment was most effective on uptake of Fe, Mn and Zn as compared to the other treatments. This trend was found true for the two growing seasons 2011/2012 and 2012/2013.The percentages response of Fe, Mn and Zn uptake by barley straw over the control were 426, 453 and 610% in 2011/2012 and 431, 449 and 610% in 2012/2013, respectively corresponding to 950, 932 and 1334%, respectively by barley grains in the first growing season and 890, 862 and 1274% in the second growing season, respectively. These findings are in agreement with those reported by Ashmaye *et al.* (2008) and Nasef *et al*. (2009) who reported that the application of compost and bio-fertilizer combined with mineral N fertilizer caused pronounced increases in soil available micronutrients contents (Fe, Mn , Zn and Cu) during two season under rice cropping. These increases may be attributed to the role of organic sources in improving these micronutrients availability which was likely attributed to several reasons: *i*) Releasing of these nutrients through microbial decomposition of organic matter ; *ii*) Enhancing the chelation of metal ions by fulvic acid, organic legends and / or other organic function groups which may promote the mobility of metal from solid to liquid phase in the soil environment; *iii*) Lowering the redox statues of iron and manganese, leading to reduction of higher Fe^{3+} & Mn^{4+} to Fe^{2+} and Mn^{2+} and / or transformation of insoluble chelated forms into more soluble ions.

Effect of the treatments on N utilization efficiencies

The efficiency of applied N is considered important criterion beside the N-requirements to obtain maximum economic yield. Accordingly, the efficiencies of the applied nitrogen for the different bio and organic treatments were calculated and the results were shown in Table 9.

Nitrogen use efficiency (NUE) kg kg^{-1}

The values of nitrogen use efficiency show that the inoculation with *Rhizobium radiobacter* sp. increased NUE than the other treatments. On the other hand, application of compost decreased NUE obviously, and this may be because the nitrogen in the organic compost was not readily available for plant and, therefore the total N applied by fertilizer plus compost content (denominator) was much lower than the actual values. These results are in line with those obtained by Abbas *et al.* (2011) who found that the inoculation with *B*. *japonicum* increased NUE and nitrogen uptake efficiency compared with the uninoculated treatments. Also, the values of NUE markedly decreased as the nitrogen addition rate increased. Values of NUE ranged from 9.17 – 19.2 at 2011/2012 season and 8.16 – 19.7 at the second season 2012/2013. The highest NUE value 19.7 kgkg^{-1} was obtained at the second growing season when plants urea treated with *Rhizobium radiobacter* plus the low rate of urea N1 (119 kg N ha^{-1}) which increased the efficiency use of urea fertilizer by 87.6% compared with the treatment received urea (119 kg N ha^{-1}) only.

Nitrogen agronomic efficiency (NAE) kg kg^{-1}

The NAE parameter (the plants ability to increase the yield in response to N fertilization levels) kg grain / kg N applied followed the same trend shown for the NUE and apparent nitrogen recovery (ANR) hence, the increase of N rate decreased the NAE values. The above three traits which behaved similarly, showed that plants absorb more N when it is of low level in the soil. As the level of N increased the relative absorption of N went on decrease. The highest NAE values (13.3 and 13.6 kg kg^{-1} at 2011/2012 and 2012/2013 seasons, respectively) were obtained due to the treatment Bio + urea N1 (119 kg N ha^{-1}) which resulted in 90.5 % and 88.4 increase percentages in the first and second growing seasons, respectively compared with the treatment received urea (119 kg N ha^{-1}).

Apparent nitrogen recovery (ANR)

The ANR parameter, which indicates the ability to increase N uptake in response to N applied and the proportions of fertilizer N recovered by the plants, was greatest when 119 kg N ha^{-1} was added in combination with bio inoculation of *Rhizobium radiobacter* compared to the other treatments and gave 31.3% and 33.7% recovery in the two growing seasons 2011/2012 and 2012/2013, respectively. This shows that the application of the low rate of nitrogen caused an enhancement of plant growth, causing the roots to explore a greater soil volume and absorb more N from the soil. The lower N recovery occurred at theN2 (179 kg N ha^{-1}) rate indicates the considerable expansion of the root system in the rhizosphere and more N must have been released from the indigenous N in soil for plant uptake. The lower N recovery in compost treatment was due to lower uptake of N by grains compared to the other treatments.

Table 9. NUE, NAE (kg kg^{-1} N) and ANR (%) of barley as influenced by urea, compost and biofertilization during 2011/2012 and 2012/2013 seasons.

Season / Treatment	Control	N1 (119 kg N ha^{-1})	N2 (179 kg N ha^{-1})	Bio	Bio + N1	Bio + N2	Compost	Compost + N1	Compost + N2
Nitrogen use efficiency, NUE (kg kg^{-1} N)									
2011/2012	0.00	9.96	9.17	0.00	19.2	14.5	8.08	12.1	9.93
2012/2013	0.00	10.5	8.16	0.00	19.7	15.0	8.34	11.3	10.1
Nitrogen agronomic efficiency, NAE (kg kg^{-1} N)									
2011/2012	0.00	6.98	7.19	0.00	13.3	10.5	4.13	8.59	7.23
2012/2013	0.00	7.22	5.99	0.00	13.6	10.9	4.03	7.72	7.35
Apparent nitrogen recovery, ANR (%)									
2011/2012	0.00	9.66	10.8	0.00	31.3	25.7	7.10	20.3	17.7
2012/2013	0.00	10.7	9.66	0.00	33.7	26.5	6.21	20.3	18.9

The combined use of organic and inorganic nutrient sources may have contributed to better synchrony of nutrient availability to the crop, which was reflected in higher grain yield and biomass production. Also, the combined application of organic sources and fertilizer may provide more favorable conditions for plant growth. The use of organic sources provides not only nutrients in available forms but also organic matter, which is as an ecological method of sustaining soil productivity. Thus, it is suggested to use a combination of bio, organic and inorganic fertilizer to achieve the highest yield and best grain quality and ensure at the same time environmental conservation.

CONCLUSION

It could be concluded that application of bifertilizers and compost is very important due to their effect on improving soil physical, chemical and biological properties, besides compost represents a storehouse for all essential macro and micronutrients. The applied organic manure led to improve barley grain quality. Also, from the economical point of view, the use of organic manure decreases the needed amounts of chemical fertilizers produces higher yield and better quality of barley grains with a relatively lower coast. Finally, under the current experimental conditions, it could be concluded that this work hand granted evidence to the effective role of applied compost manure at the rate of 6 Mg ha^{-1} in combination with urea at the rate of 179 kg N ha^{-1} to achieve the greatest growth parameters, yield and quality of barley plants grown under salinity and sodicity stresses.

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كفاءة التسميد النيتروجيني للشعير في الأراضي الملحية الصودية تحت تأثير التسميد باليوريا و الكمبوست والتلقيح الحيوي بالريزوبيوم (*Rhizobium radiobacter* sp.)

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تم دراسة كفاءة التسميد النيتروجيني (اليوريا) في الأرض الملحية في وجود الكمبوست المنتج من مخلفات نباتية و التسميد الحيوي بالريزوبيم راديوباكتر (PGPR) المعزولة من أرض ملحية بقرية جلبانه رقم (٤) ، محافظة شمال سيناء - جمهورية مصر العربية وذلك منفردين أو بالتداخل مع اليوريا خلال موسم الشتاء لعامين متتالين هما ٢٠١٢/٢٠١١ و ٢٠١٣/٢٠١٢ على نبات الشعير صنف جيزة ١٢٦ و تأثير ذلك علي انتاجية الشعير وجودة الحبوب و أمتصاصه لبعض العناصر الكبري و الصغري وتحسين بعض صفات التربة وقد تم اضافة اليوريا بمعدلات ٠ ، ١١٩ و ١٧٩ كجم نتروجين للهكتار بما يعادل ٠ ، ٥٠ و ٧٥ % من الجرعة السمادية الموصي بها والكمبوست أضيف بمعدل ٦ ميجاجرام للهكتار. وقد أظهرت النتائج أن هناك إنخفاضاً في درجة الملوحة في منطقة أنتشار الجذور بمعدل ١٥.٦% للموسم الأول ٢٠١٢/٢٠١١ و بمعدل ٢٩.٤ % للموسم الثاني ٢٠١٣/٢٠١٢م كما إنخفض رقم الحموضة بالتربة pH نتيجة للأضافات تحت الدراسة مقارنة بمعاملة المقارنة. وقد أوضحت النتائج زيادة جميع صفات النمو (وزن الحبوب بالسنبلة و ووزن الألف حبة) كذلك محصول الحبوب و القش خلال موسمي النمو تحت الدراسة نتيجة لإضافة المعاملات المستخدمة. بالنسبة للعناصر الكبري و الصغري الممتصة بواسطة القش و الحبوب وكذلك محتوي الروتين بالحبوب قد إزدادت معنويا وكانت أعلي القيم المتحصل عليها نتيجة للمعاملة (ن٢ بمعدل ١٧٩ كجم ن للهكتار + الكمبوست).بالنسبة لمحتوي البرولين لوحظ إنخفاضة نتيجة للمعاملات تحت الدراسة وكان اقل إنخفاض خلال موسمي الدراسة نتيجة لمعاملة التسميد الحيوي بالريزوبيوم يلية معاملة الكمبوست كنتيجة لخفض تأثير الملوحة بالتربة والتي ينخفض معها تراكم البرولين. أعلي كفاءة محصولية ودليل حصاد تم التحصل عليهما خلال الموسم الأول نتيجة إضافة (ن١ بمعدل ١١٩ كجم ن للهكتار + الكمبوست) بينما كانت نتيجة معاملة (ن٢ بمعدل ١٧٩ كجم ن للهكتار) خلال الموسم الثاني ٢٠١٣/٢٠١٢. أعلي القيم لكفاءات التسميد النيتروجيني المعدني (كفاءة أستخدام النيتروجين NUE وكفاءة النيتروجين المحصولية NAE والكمية المستعادة من النيتروجين ANR) قد تحصل عليها من أستخدام المعدل المنخفض من اليوريا (ن١ بمعدل ١١٩ كجم ن للهكتار + التسميد الحيوي) وهو ما يوضح دور التسميد الحيوي في خفض الكمية المستخدمة من التسميد النيتروجيني المعدني دون خفض الإنتاجية من الشعير معنويا.

بصفة عامة فان إضافة الكمبوست أو البكتريا المثبتة للأزوت الجوي (PGPR) + المعدل المنخفض من النيتروجين المعدني (اليوريا) ٥٠% أو ٧٥ % من الجرعة الموصي بها أعطت أعلي إنتاجية وكفاءة لمحصول الشعير وأعلي محتوي بروتين وكذلك رفع خصوبة التربة من خلال تحسين الصفات الطبيعية والكيماوية و الحيوية بها.

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