J.Soil Sci. and Agric. Eng., Mansoura Univ., Vol. 6 (11): 1281 - 1303, 2015

Alleviation of some problems in newly reclaimed salt affected soil at north sinai by using bio-conditioner to maize production

Kadria M. EL Azab
Soils, Water and Environment Res. Inst., Agric. Res. Center, Giza, Egypt

ABSTRACT

A field experiment was performed in a newly reclaimed salt affected soils area of Gelbana village No 7, Sahl El-Tina, North Sinai Governorate, Egypt, during the summer season of 2013, to assess the effectiveness of cyanobacteria as a biological soil conditioner combined with different nitrogen forms and rates to improve and enhance maize production under saline soil. Three N-mineral forms namely N1: urea (46% N), N2: ammonium nitrate (33.5%N) or N3: ammonium sulfate (20.6%N), were added at a rate of 100% or 75% from the recommended dose (RD) (120 kg N/fed) as soil application in presence or absence of cyanobacteria. Maize (*Zea mays* L., Th. 321 cv.) as a moderately salt-sensitive plant was used as an indicator to identify the response to applied treatments in a split - split plot design.

Results revealed that cyanobacteria application recorded significant increases of plant growth, biological yield and yield components of maize. Under the experiment condition, the results clearly indicated that the applied ammonium sulfate was more effective compared to the other used forms on above mention traits. Moreover, the highest value of N use efficiency (NUE) (79.8%) was recorded in the presence of cyanobacteria combined with ammonium sulfate at a rate of 75 % RD. These results were explained that cyanobacteria could supplement up to 20% of RD of mineral nitrogen fertilizer for maize cultivation in saline soils, this percentage was different from one N form to another. Thus, cyanobacteria currently seem to be offering a potentially environmental friendly alternative to the use of mineral fertilizers, and they succeeded to minimize the amount of applied mineral fertilizer and reduce the production costs and environmental pollution. Furthermore, cyanobacteria application practices as a bio-fertilizer and a soil bio-conditioner alleviated of salt hazards, which improved and enhanced some soil properties reflected positively on maize yield production.

Keywords: Saline sandy loam soil, Cyanobacteria, N-forms, rates and maize

INTRODUCTION

In arid and semi-arid climates, increasing salinity is considered the most threat for agriculture and the major limiting factor in reducing plant productivity and a contributor to land degradation; therefore, it is necessary to know how to obtain sufficient control over the phenomenon. Low rainfall and high potential evapotranspiration in these regions promote the upward movement of salts in the soil solution, which adversely affects soil physical, chemical, and biological properties; (Rengasamy, 2006). Exploiting saline soils in growing crops, especially cereal crops, can be shared in solving the problem of food production shortage, to face the demand of fast growing population; (Ghoulam et al., 2002).

Nitrogen is usually the most growth limiting plant nutrient in soils. Many investigations on salinity-nitrogen issue were focused either on nitrogen influence on plant *i.e.,* Ozer et al., 2004 and Svoboda and Haberle, 2006 or on salinity as limiting plant growth factor; (Burger and Celkova, 2003).Most salinity and nitrogen interaction studies have been conducted on saline soils that were deficient in nitrogen; (Svoboda and Haberle, 2006) or on salinity as limiting plant growth factor, where the form in which N is supplied is important. (Orak and Ates, 2005 and Supanjani and Lee, 2006). Also some of saline soils have low organic matter and nitrogen (N) concentration (Asmalodhi et al., 2009). Therefore, application of N fertilizers improved growth and yield of maize, wheat grown on saline soils (Soliman et al., 1994).

Studies on the effects of salinity and nitrogen (N) fertilization on ionic balance, (Moshe et al., 1997) found that salinity increased the concentration of total inorganic cations (C) and anions (A) in plants specifically sodium (Na) and chloride (Cl) . When plants were supplied with nitrate (NO_3), salinity increased the concentrations of NO_3 in plants. Increasing salinity and N concentration in the growth medium differs the balance between C and A. The effect of different N sources on C/A balance followed the order: NH_4NO_3 > NO_3 > ammonium (NH_4). The base of organic anions and inorganic ions with salinity contributed closely to the osmotic potential of plant shoot and roots . A high and positive linear dependency was found between N_{org} and C/A in plants grown at high and low salinity levels and different N sources, pointing out the close relationship between N_{org} and organic anions on metabolism under these conditions. The amount of biomass produced was correlated positively with organic anion concentration in plants exposed to different salinity levels.

Choudhury and Kennedy, 2004, and Rai, 2006 reported that the intensive use of expensive mineral fertilizers (*i.e.* nitrogen) in recent years which results in environmental pollution problems has focused the attention of researches on the possibility of using biofertilizers as an alternative or complementary for mineral fertilizers.

Cyanobacteria (Blue-Green Algae) is one of the major natural components, beneficial and ecological, commonly known as biofertilizers, which have several advantages over chemical fertilizers; (Board, 2004). They currently seem to be offering a potentially environmental friendly alternative to the use of mineral fertilizers, succeeded to minimize their applied amount and reduce the production costs and environmental pollution ; (El-khawaga et al., 2003; Choudhury and Kennedy, 2004 and Rai, 2006). Cyanobacteria that dominate a wide range of diverse environments are characterized by their tolerance to various stresses such as high temperatures, desiccation, pH, high salinity, light intensity, low water potential, deserts and nutrients (Whitton, 2000). Cyanobacteria can supplement the nitrogen requirement of plant and replacing about 30-50% of plant requirement of mineral nitrogen as a cheap source of N, which does not cause pollution because they are capable of fixing atmospheric nitrogen and convert it into an available form of ammonia required for the plant growth; (Osman et al., 2010).

These studies have shown that soil conditioners when applied to coarse textured stabilize soil aggregation, increase water holding capacity, suppress water evaporation from soil, and control soil erosion. ; (Choudhary et al*.,*1998). In recent years, much consideration were sent towards the possibility of using the biological conditioners to reduce the resultant pollution to soil and plants together in addition to their ability to improve both soil and plant properties; (Banerjee & Kumar, 1992 and Silke et. al,. 2007). Several studies have reported that application of cyanobacteria as a biological a soil conditioner added to soil improved the soil's qualities, especially its ability to provide nutrition for plants and the plant growth by enhancing the soil structure such as aggregation status of soil, pH, electric conductivity, exchangeable sodium, and increased considerably the hydraulic conductivity; (Song et al. 2005; Maqubela et al., 2009; Saadatnia and Riahi, 2009).

There is no sufficient information exactly about the recommended of rate and N forms supply to saline soil. So, this current work aims to study the influence of bioconditioner (cyanobacteria) in maximizing Nitrogen Use Efficiency (NUE) of added N forms to saline soil, detect the best combination with cyanobacteria and N forms to improve both saline soil properties and plant production and also to minimize the amount of applied mineral fertilizer and reduce the production costs.

MATERIALS AND METHODS

A field experiment was conducted on a sandy loam soil at Sahl El-Tina, Gelbana village No 7, North Sinai Governorate, Egypt, during the growing summer season of 2013. The studied treatments were designed to identify the appropriate of bio fertilizer as dry application (1kg/fed), N forms, N rates and their interactions on growth, yield and yield components of maize (*Zea mays* L., Th. 321 cv.) under conditions of agricultural technique (Raised beds) on saline soil according to Amer et al., (2011), each plot contained 3 raised beds. Thus, the area of each plot was 3.5x $3m^2$. Some physical and chemical properties of the experimental soil (upper15 cm layer) are presented in Table 1 and analysed according to Page et al., (1982).The experiment soil was irrigated from El-Salam canal (Nile water + drainage water, 1:1). The chemical properties of irrigation water are shown in Table 2.

Table 1. Some physical and chemical properties of the experimental soil before sowing.

Particle Size distribution (%)				**Texture**	**O.M (%)**	**$CaCO_3$ (%)**	**Available Macro-nutrients ($mg.kg^{-1}$Soil)**		
C.Sand	**F.Sand**	**Silt**	**Clay**	**Sandy Loam**			**N**	**P**	**K**
15.8	55.2	17.9	11.1		0.88	7.7	40.1	5.8	185
SP	**pH (1:2.5)**	**EC ($dS.m^{-1}$)**	**Soluble Ions ($meq.L^{-1}$)**						
			Cations				**Anions**		
			Na^+	**K^+**	**Ca^{++}**	**Mg^{++}**	**$HCO_3^=$**	**Cl^-**	**$SO_4^=$**
37	8.2	11.2	49.47	4.34	33.25	24.6	2.56	61.53	47.58

Table 2. Some chemical characteristics of El-Salam canal irrigation water.

pH	EC ($dS.m^{-1}$)	Soluble Ions (mmol. L^{-1})								SAR
		Na^+	K^+	Ca^{++}	Mg^{++}	$CO_3^{=}$	HO_3^-	Cl^-	$SO_4^{=}$	
8.04	1.66	8.16	0.41	3.07	4.29	----	3.83	6.74	5.73	4.25

Maize grains soaked by 2% urea solution for about 18h before planting (15 May 2013) for obviation salt damage and drought stress injury according to EL Azab,et al., (2011). The experiment field was immediately flood irrigated after planting, occasional large irrigation for immerge the bed, each irrigation may be required for leaching of salts. Managing irrigation schedules (amounts and timing) according to calculation of crop water requirements and soil leaching requirement, irrigation was done every 8 days till crop maturity.

All other agronomic operations were kept normal uniform for all treatments. Where, the experiment soil plots were received local manufacture compost at a rate of 15 m^3. fed^{-1}, (It was prepared from the farm residues and its analysis is shown in Table (3), and 200 kg fed^{-1} super phosphate (15.5% P_2O_5) was added 10 days before planting , then cyanobacteria was mixed with quantity of soil and prod casted on specific plots from experiment soil before sowing plant and 1.0% of potassium sulfate (48% K_2SO_4) was added in two foliar sprayed as described by Zameer khan, et al., (2006) and El Azab, et al., (2011) after 25 and 50 days of sowing plants. The used mineral fertilizer (urea 46% N, ammonium nitrate, 33.5% N or ammonium sulfate 20.6% N) was applied in one of (100% and 75% from the recommended dose RD, 120 kg. N fed^{-1}) on two equal doses after 25 and 50 days sowing.

Table 3. Chemical analysis of the used compost.

pH (1:2.5)	EC ($dS.m^{-1}$)	C/N	Macro-nutrients (%)			Micro-nutrients ($mg.kg^{-1}$)	
			N	P	K	Fe	Zn
7.5	5.8	23.1	1.7	0.66	2.1	23.5	20.1

The design of the experiment area was laid out in a split-split-plot design with three replicates. The main plots were bio-fertilizer; (with or without cyanobacteria), sub plots were three N forms and the sub- sub plots were N rates. It was included 12 treatments with three replicates. The experiment comprises the following:

Bio-fertilizer (conditioner): I without Cyanobacteria and II with Cyanobacteria.

N forms: (N.1): urea - $(NH_2)_2\ CO$ (46% N), (N.2): ammonium nitrate - $(NH_4)_2\ NO_3$ (33.5%N) and (N.3): ammonium sulfate - $(NH_4)_2\ SO_4$ (20.6 %N).

N rates (From the RD): (A) 100% and (B) 75%.

Plant samples: At harvest time (10 September), samples of 6 plants were taken randomly from each experimental plot to measure; plant height (cm), first ear height (cm), stem diameter (cm), ear length (cm), ear diameter (cm), 100- grain weight (g), grain yield (kg fed^{-1}), and stover yield (kg fed^{-1}). Also, the samples of maize grains, stover were collected from every plot, oven dried at 70°C, crushed and wet digested using mixture of H_2SO_4 + $HClO_4$

acids to determine nutrient contents, after Ryan et al., (1996). Nitrogen, P and K content in the digests stover and grains were determined according to the methods described by Cottenie, et al., (1982) and Page et al., (1982).

Soil Samples: wet samples of the root zone (0-25 cm) were taken and prepared for chemical analysis; pH in 1-2.5 soil -water suspension, EC and soluble cations and anions were determined in soil paste extract according to Black et al., (1982). Available N was determined using K_2SO_4 (1%) according to the method described by Jackson,(1973)and measured according to the modified Kjeldahal method. Available phosphorus was extracted using the method described by Soltanpour, (1985) and determined spectro-photo-metrically as mentioned by Watanabe and Olsen, (1965). Available potassium was extracted using the method described by Soltanpour, (1985) and determined using flame-photometric method after APHA, (1992).

Nitrogen Use Efficiency (NUE) the term used to indicate the ratio between the amount of fertilizer N removed from the field by the crop and the amount of fertilizer N applied was calculated in the formula:

$$\mathbf{NUE} = \frac{\mathbf{N\ removal\ with\ harvest}}{\mathbf{mineral\ N\ input}}\ \boldsymbol{x}\ \mathbf{100}$$

That NUE was classified to 4 levels by, Johnston and Poulton, (2009) and Brentrup and Palliere, (2010) as the following:

1) **Soil mining (> 100%):** N removal exceeds N input = declining soil fertility and yield = unsustainable.
2) **Risk of soil mining (90 - 100%):** additional N requirement for plant is not met by N input.
3) **Balanced in-and outputs (60 - 90%):** N fertilizer input meets total crop demand.
4) **Risk of high N loses (< 60%):** N fertilizer input exceeds total crop demand = increased risk of leaching.

Statistical analyses: The obtained data were subjected to statistical analysis of variance (ANOVA) by using Minitab computer program and least significant difference (L.S.D) were calculated at level of 5%, Barbara and Brain, (1994).

RESULTS AND DISCUSSION

Availability of NPK in soil:

Regarding to mean values for available N in soil presented in Table 4 it was noticed significant difference among treatments of each individual factor recording superiority of bio conditioners application to non-application, the rate corresponding 100% RD to 75% and urea > ammonium sulphate > ammonium nitrate with significant difference within them. The double and triple interactions were generally insignificant among them with exception of the rate corresponding 75% RD with bio conditioners which was superior significantly to that without bio conditioners with about 21%.This may be due to the sufficient soil nitrogen in the initial soil and that added in compost application. Thus where there is shortage in N, the bio conditioners can give good results.

4-

On the other hand, it was noticed that mean values of available P in soil at harvesting did not significantly change with different N forms and rates addition but decreased with presence of bio conditioners (Cyanobacteria) due to increasing the consummation of biomass growth (plant and cyanobacteria), generally, all obtained available P data were high compared with the initial value of experiment soil before plant sowing.

In contrast, the mean values of available K in soil were increased significantly in presences of bio conditioners (cyanobacteria) with different N forms addition, reaching maximum values with ammonium sulfate followed urea and ammonium nitrate compared with the initial values in soil. With different N rates it was noticed that soil available K took the same trend of available N at used 100% RD while N forms follows the descending order; urea > ammonium sulfate > ammonium nitrate as individually treatment or combined with bio conditioners, this may be due to diminution effect of cyanobacteria at the high N rate. In contrast, the N forms were followed other descending order at addition of 75% RD namely ; ammonium sulfate > ammonium nitrate> urea, the maximum value were obtained on presence of cyanobacteria although the individually effect to N rats (r), the double interactions (b*f, b*r) and triple interactions effect (b*f*r) were generally insignificant, but these results recorded that role of cyanobacteria increased at decreasing N rate supply particularly with ammonium sulfate which obtained the highest value (224.0 mg.kg^{-1}) compared with ammonium nitrate (193.2 mg. kg^{-1}) and urea (185.8 mg.kg^{-1})

Results clearly indicated that cyanobacteria might be used effectively for improving soil fertility of saline soil by increasing the soil availability of N. Results suggested that 1/4 of the RD of nitrogen mineral fertilizer could be saved by using cyanobacteria. These data are in agreement with Osman et al., (2010) who reported that cyanobacteria can supplement the nitrogen requirement of plant and replacing about 30-50% of plant requirement of mineral nitrogen because they are capable of fixing atmospheric nitrogen and convert it into an available form of ammonia required for the plant growth. El-khawaga et al., (2003) showed that the application of bio fertilizer succeeded to minimize the amount of applied chemical fertilizer and reduce the production costs and environmental pollution.

Maize growth parameters, yield and yield components:

Tables 5a and b revealed the effect of the studied factors on growth parameter, yield components and grains quality. Application of bio conditioner was of significant progress on all parameters studied with exception of crude protein and harvest index. These increases were attributed to enhancing the availability of nutrients in soil (soil fertility) according to Song et al., (2005) who decided that cyanobacteria play an important role in maintenance and build-up of soil fertility, consequently increase plant growth and yield as a natural bio fertilizer which improves soil chemical and physical properties. In general, the obtained increases in biological yield with addition of bio conditioner were higher than those did not receive it. These increases were 6.4 and 5.7% for stover and grain yields, respectively. Reducing nitrogen application rate 25% of the recommended dose was significantly beneficial in increasing plant height, stem, ear diameters and wt. 100 kernels It was statistically as the same as 100% RD for other parameters. Comparing of mineral N forms appeared significant increases in plant and 1st ear heights, ear diameter, grain and stover yield and wt. 100 kernels, where ammonium sulphate was superior to urea in all cases and as the same as ammonium nitrate in plant and 1st ear height and ear diameter. Ammonium sulphate was significantly effective on grains and stover yield which appeared the maximum values followed by urea then ammonium nitrate. In other parameters, all the used N forms were of insignificant differences.

Due to the double interactions, the interaction of bio conditioner and mineral N forms (b*f) was of the following descending order; bio +AS > bio +U > bio +AN > without bio+ AS > without bio +AN >without bio +U in plant height with significant difference between treatments of mineral N forms combined with bio conditioner compared without it, while the more height of plant was with thus above first treatment. Also, these interactions revealed significant increases in 1st ear height, crude protein in grains and wt.100 kernels but did not the same order. In other parameters, all these double interactions were of insignificant differences. In spite of these data which were significant differences or insignificant, ammonium sulphate used with bio conditioner gave the best values for most parameters studied particularly with plant height, grains yield and harvest index. As soon as, the interaction of bio conditioner and mineral N rates (b*r) appeared insignificantly effective on all parameters studied except wt. 100 kernels, the data obtained for these interactions on parameters studied were increased in presence bio conditioner compared without it. On the other hand, the interaction of mineral N forms and rates (f*r) showed insignificantly effective in plant and 1st ear height, stem diameter, yield component and harvest index, also significantly effective in ear length and diameter and grains quality.

5-a

The triple interaction of the all studied factors (Table 5b) showed insignificant differences in most parameters studied with exception of plant height, ear length and wt. 100 kernels where some treatments were of significant differences over others irregularly. That data led to a conclusion that using bio conditioner unified the activities of each mineral N forms and rats to give an opened chance to use any form or rate of mineral N especially when the purpose of maize planting was to produce high grain and stover yields in good harvest index containing high crude protein percentage. So, it could be recommended that 75% RD of any forms of mineral N was the best treatment with bio conditioner (cyanobacteria). This evidence was clearly appeared in growth criteria of maize represented in Tables (5a and b) and Figure (1) which illustrated that conclusion .Those data were in accordance with Nanjappan-Karthikeyan et al., (2007) who noted that the cyanobacteria applied with 75% from mineral N gave statistically equivalent results as compared to application of full dose of chemical fertilizers in terms of wheat grain yields. This was also confirmed by Amer et al., (2011) who reported that addition N at recommended rate (120 kg. fed^{-1}) for maize production was not acceptable to their studied saline soil, which its use efficiency was decreased.

5-

Also figure (1) showed different increases for grain and stover yield due to application of different N forms which it follows the descending order; ammonium sulfate > ammonium nitrate > urea as inorganic N forms which it increased up to 8.3, 5.2 and 3.4 % respectively in presence of bio conditioner (cyanobacteria) compared without it.

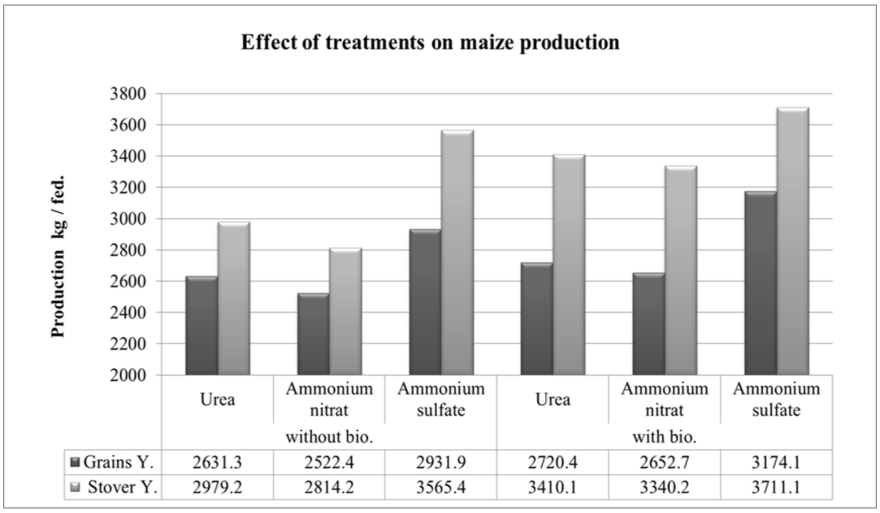

Figure 1. Effect of addition N forms in presence or absence cyanobacteria on maize production (kg. fed^{-1}).

Contents and uptake of N, P and K in maize plant:

The data presented in Table 6a and b showed insignificant effect due to applied mineral N forms either individually or combined with bio conditioner on N content in grains and stover at harvest. In contrast, the high rate of mineral N addition appeared significant increases for N, P and K particularly in grains and K content in stover. On the other hand, neither the double interaction of bio conditioner and mineral N forms (b*f)or bio conditioner and mineral N rats (b*r) appeared any significantly differences to N, P and K contents in grains or N content in stover. These interactions revealed significantly affectation to P and K in stover. The interaction of mineral N forms and rats showed significantly differences on N, P and K content in grains and P and K in stover. The triple interaction of the all studied factors (Table 6b) showed insignificant differences of N, P and K content in grains with exception in cases of stover, where P and K content were of significant differences. In general, the N values measured in grain or stover did not affected by the studied treatments, although its positive effect on growth parameters.

Table 6 a. Nutrient contents in maize as affected by different treatments under study. (Individual factors and their double interactions).

Treatments			Grains			Stover		
			N%	P%	K%	N%	P%	K%
Cyanobacteria (b)	without bio.		1.29	0.36	0.95	0.84	0.20	1.24
	with bio.		1.30	0.37	1.02	0.86	0.18	1.21
	LSD at 0.05 level (b)		ns	ns	0.037	ns	0.003	ns
N - Forms (f)	Urea (U)		1.29	0.35	1.03	0.85	0.19	1.13
	Ammonium Nitrate (A.N)		1.30	0.34	0.94	0.84	0.17	1.33
	Ammonium Sulfate (A.S)		1.29	0.39	1.00	0.87	0.21	1.22
	LSD at 0.05 level (f)		ns	0.013	0.046	ns	0.004	0.031
N - Rates (r)	100% N-RD		1.32	0.38	1.04	0.86	0.19	1.25
	75% N-RD		1.27	0.35	0.93	0.84	0.19	1.01
	LSD at 0.05 level (r)		0.019	0.011	0.037	ns	ns	0.026
Bio * Forms -N	without bio.	U	1.26	0.34	0.97	0.84	0.19	1.16
		A.N	1.29	0.33	0.91	0.83	0.16	1.38
		A.S	1.30	0.39	0.98	0.86	0.24	1.17
	with bio.	U	1.32	0.36	1.08	0.85	0.19	1.10
		A.N	1.30	0.35	0.96	0.85	0.19	1.28
		A.S	1.29	0.39	1.02	0.88	0.18	1.26
	LSD at 0.05 level (b*f)		0.033	ns	ns	ns	0.005	0.044
Bio * Rates - N	without bio.	100%	1.31	0.37	0.99	0.85	0.19	1.30
		75%	1.26	0.34	0.91	0.83	0.20	1.18
	with bio.	100%	1.32	0.38	1.09	0.86	0.19	1.20
		75%	1.28	0.35	0.95	0.86	0.18	1.22
	LSD at 0.05 level (b*r)		ns	ns	ns	ns	0.004	0.036
Forms -N * Rates -N	U	100%	1.33	0.36	1.11	0.85	0.21	1.12
		75%	1.25	0.34	0.94	0.84	0.16	1.15
	A.N	100%	1.32	0.35	0.95	0.84	0.16	1.38
		75%	1.27	0.34	0.92	0.83	0.19	1.27
	A.S	100%	1.30	0.42	1.06	0.88	0.20	1.25
		75%	1.29	0.36	0.93	0.86	0.22	1.18
	LSD at 0.05 level (f *r)		0.033	0.019	0.064	ns	0.005	0.044

Table 6 b. Effects of applied treatments on the content of N, P and K (%) in maize. (Factor triple interactions.)

Treatments			Grains			Stover		
Cyanobacteria (b)	N-miniral Forms (f)	N- Rates (% N-RD) (r)	N%	P%	K%	N%	P%	K%
without cyanobac.	Urea (U)	100%	1.14	0.36	1.03	0.85	0.22	1.14
		75%	1.21	0.33	0.91	0.83	0.16	1.18
	Ammonium Nitrate (A.N)	100%	1.32	0.34	0.90	0.84	0.14	1.43
		75%	1.26	0.33	0.93	0.82	0.18	1.33
	Ammonium sulfate (A.S)	100%	1.30	0.43	1.05	0.88	0.22	1.32
		75%	1.31	0.36	0.90	0.85	0.26	1.03
with cyanobac.	Urea (U)	100%	1.34	0.37	1.19	0.86	0.21	1.09
		75%	1.29	0.34	0.98	0.85	0.16	1.12
	Ammonium Nitrate (A.N)	100%	1.33	0.36	1.01	0.85	0.18	1.33
		75%	1.28	0.35	0.92	0.84	0.20	1.22
	Ammonium sulfate (A.S)	100%	1.30	0.41	1.08	0.89	0.17	1.19
		75%	1.27	0.36	0.97	0.87	0.19	1.33
LSD at 0.05 level (b *f *r)			ns	ns	ns	ns	0.007	0.063

Data in Ttables 7a and b showed a clear response to studied treatments on the quantity of macronutrients which were removed to maize plant. These increases were attributed to enhancing the availability of nutrients in soil (soil fertility) consequently increasing plant growth and yield. These notes were in agreement with those obtained by Song et al. (2005). The obtained increases in quantity of macronutrients (N, P and K) with addition of bio conditioner were higher than those obtained without it, these increases were (13.9, 6.9%), (2.6, 8.4%) and (10.2, 13.3%) for stover and grain yields respectively. Also, it is noticed that these increases differed with addition different N forms. They were (5.8, 6.8%), (21.4, 6.2%) and (16.9, 7.5%) for N uptake by stover and grain at addition ammonium sulfate, ammonium nitrate and urea respectively as. In spite of increasing the percentage for quantity of macronutrients removed by maize plant as consequence to addition the low rate of N combined with cyanobacteria compared with the high one. The quantities removed from macronutrients by maize plants at high rate addition (100% RD) were usually higher than those removed at addition of 75% RD. This notice may be attributed to decreasing the activity of bio conditioner (cyanobacteria) with addition the high dose of mineral N forms to experiment soil.

Table 7 a. Nutrients uptake (kg. fed^{-1}) by stover and grain of maize at harvesting as affected by different treatments (Individual factors and their double interaction).

Treatments			Grains			Stover		
			N - Uptake	P - Uptake	K - Uptake	N - Uptake	P - Uptake	K - Uptake
Cyanobacteria (b)	without bio.		34.67	9.64	25.72	26.37	6.26	38.40
	with bio.		37.04	10.45	29.13	30.03	6.43	42.31
	LSD at 0.05 level (b)		0.33	0.38	1.44	1.79	ns	1.90
N - Forms (f)	Urea (U)		34.50	9.35	27.46	27.05	6.02	36.13
	Ammonium Nitrate (A.N)		33.59	8.89	24.30	25.78	5.38	40.68
	Ammonium Sulfate (A.S)		39.47	11.89	30.52	31.77	7.65	44.26
	LSD at 0.05 level (f)		2.05	0.47	1.77	2.19	0.40	2.32
N - Rates (r)	100% N-RD		36.97	10.63	29.32	28.99	6.44	41.94
	75% N-RD		34.73	9.46	25.53	27.41	6.26	38.77
	LSD at 0.05 level (r)		0.33	0.38	1.44	ns	ns	1.90
Bio * Forms -N	without bio.	U	33.25	9.03	25.51	24.95	5.70	34.63
		A.N	32.58	8.38	23.04	23.29	4.44	38.79
		A.S	38.16	11.52	28.61	30.87	8.66	41.80
	with bio.	U	35.75	9.68	29.41	29.16	6.34	37.63
		A.N	34.59	9.40	25.56	28.27	6.31	42.57
		A.S	40.78	12.27	32.43	32.67	6.64	46.73
	LSD at 0.05 level (b*f)		ns	ns	ns	ns	0.57	ns
Bio * Rates- N	without bio.	100%	36.16	10.37	27.44	27.21	6.25	41.21
		75%	33.17	8.92	24.00	25.53	6.28	35.60
	with bio.	100%	37.79	10.89	31.21	30.77	6.63	42.68
		75%	36.30	10.01	27.05	29.30	6.23	41.94
	LSD at 0.05 level (b*r)		ns	ns	ns	ns	ns	2.68
Forms -N * Rates –N	U	100%	36.18	9.91	30.23	27.89	6.94	36.49
		75%	32.82	8.79	24.70	26.21	5.09	35.77
	A.N	100%	34.51	9.02	24.85	26.44	5.05	43.06
		75%	32.66	8.76	23.74	25.12	5.70	38.30
	A.S	100%	40.23	12.96	32.89	32.64	7.32	46.28
		75%	38.72	10.83	28.15	30.90	7.98	42.25
	LSD at 0.05 level (f *r)		ns	0.66	2.50	ns	0.57	ns

Table 7 b. Effects of applied treatments on the uptake of N, P and K (kg. fed^{-1}) stover and grain of maize at harvesting (Factor triple interactions).

Treatments			Grains			Stover		
Cyanobacteria (b)	N-miniral Forms (f)	N- Rates (% N-RD) (r)	N - Uptake	P - Uptake	K - Uptake	N - Uptake	P - Uptake	K - Uptake
without cyanobac.	Urea (U)	100%	35.75	9.67	27.96	25.93	6.62	34.97
		75%	30.75	8.39	23.07	23.96	4.77	34.28
	Ammonium Nitrate (A.N)	100%	33.79	8.56	22.88	23.96	4.01	40.96
		75%	31.38	8.19	23.21	22.62	4.87	36.62
	Ammonium sulfate (A.S)	100%	38.94	12.87	31.47	31.74	8.11	47.68
		75%	37.39	10.17	25.74	29.99	9.20	35.91
with cyanobac.	Urea (U)	100%	36.61	10.15	32.49	29.85	7.26	38.00
		75%	34.90	9.20	26.33	28.46	5.41	37.26
	Ammonium Nitrate (A.N)	100%	35.23	9.48	26.83	28.92	6.10	45.16
		75%	33.95	9.33	24.28	27.61	6.53	39.98
	Ammonium sulfate (A.S)	100%	41.51	13.04	34.31	33.53	6.53	44.88
		75%	40.05	11.49	30.55	31.81	6.76	48.58
LSD at 0.05 level (b *f *r)			ns	ns	ns	ns	ns	4.65

Mineral N fertilizer use efficiency (NUE):

The mean values of N removed by plant at maturity (kg. fed.$^{-1}$) are presented in Table 8 Treatments showed increasing in removal N with increasing N addition rate to100% RD compared with 75% RD. It is noteworthy to mention that increasing the quantity N removed differed from one N forms to another, which this augmentation was appeared clearly in descending order; ammonium sulfate > urea > ammonium nitrate. On the other hand, the percentage of NUE was increased with addition of bio conditioner (cyanobacteria) to such saline soil compared to those without addition of it. This increase was negligible particularly with application of the highest rate for all N forms which decreased the positive effect for bio conditioner (cyanobacteria) at that high N rate. So, there were increased risks of high N losses which the percentage of NUE was less than 60%.These results were in agreement with those obtained by Amer, et al., (2011). In contrast, decreasing the N rate addition up to (90 kg. fed.$^{-1}$) leads to increases the percentage of NUE, these increasing were appeared clearly by addition of ammonium sulfate (74.9%) followed by urea (60.8%) and ammonium nitrate (60.0%) in absence bio conditioner (cyanobacteria), these percentages values were increased up to 79.8, 70.4 and 68.4% in presence of cyanobacteria combined with above N forms respectively.

Table 8. Stimulation of NUE for mineral N application (rates and forms) combined with bio conditioner (cyanobacteria) to saline soil.

Treatments			N removal with harvest kg. fed. $^{-1}$ (output)		Total N removal kg. fed. $^{-1}$ (output)	N mineral application rates Kg. fed. $^{-1}$ (input)	N use efficiency (NUE) %
Cyanobacteria (b)	N-miniral Forms (f)	N- Rates (% N-RD) (r)	Stover	Grains			
without cyanobac.	Urea (U)	100%	25.9	35.7	61.7	120.0	51.4
		75%	24.0	30.7	54.7	90.0	60.8
		mean	24.9	33.2	58.2	105.0	56.1
	Ammonium Nitrate (A.N)	100%	24.0	33.8	57.8	120.0	48.1
		75%	22.6	31.4	54.0	90.0	60.0
		mean	23.3	32.6	55.9	105.0	54.1
	Ammonium sulfate (A.S)	100%	31.7	38.9	70.7	120.0	58.9
		75%	30.0	37.4	67.4	90.0	74.9
		mean	30.9	38.2	69.0	105.0	66.9
mean			26.4	34.7	61.0	105.0	59.0
with cyanobac.	Urea (U)	100%	29.8	36.6	66.5	120.0	55.4
		75%	28.5	34.9	63.4	90.0	70.4
		mean	29.2	35.8	64.9	105.0	62.9
	Ammonium Nitrate (A.N)	100%	28.9	35.2	64.2	120.0	53.5
		75%	27.6	33.9	61.6	90.0	68.4
		mean	28.3	34.6	62.9	105.0	60.9
	Ammonium sulfate (A.S)	100%	33.5	41.5	75.0	120.0	62.5
		75%	31.8	40.0	71.9	90.0	79.8
		mean	32.7	40.8	73.5	105.0	71.2
mean			30.0	37.0	67.1	105.0	65.0

These results indicated that addition of bio conditioner (cyanobacteria) to saline soil combined with 90 kg N. fed.$^{-1}$ from any one of N forms studied increases the percentage of NUE up to balance (60 - 90%) and the best values were found with ammonium sulfate addition. These findings are in accordance with Prasanna et al., (2008) who found that N-use efficiency was enhanced by inoculation with cyanobacteria but with urea fertilizer at 36 or 72kg N ha^{-1} rather than 108 kg N ha^{-1} without inoculation.

Economic evaluation of the experimental treatments:

An economic evaluation should be done for assigning the best experimental treatment, which achieved the highest financial gain (£e.fed.$^{-1}$). It would be carried out through the calculating the differences between costs of production (£e.fed.$^{-1}$) and income profits (£e.fed.$^{-1}$) to obtain the net gain or return (£e.fed.$^{-1}$) of different treatments. It is important to notice that, all costs of production differ only in the prices of buy inorganic N forms fertilizers as well as the costs of bio conditioner (cyanobacteria) needed to one feddan as dry application ; 1kg/fed (50 £e. Kg.$^{-1}$ fed.$^{-1}$), and the costs of all field practices was in the year 2013, (2500 £e. Kg.$^{-1}$ fed.$^{-1}$). In addition, all costs of production and profits of incomes were mathematically converted to be per fed. On the other hand, costs of production and profits of incomes were calculated according to the actual prices during time of experiment proceeding. Both of Prices of fertilizers (£e. Kg^{-1}) and amounts of the used fertilizers (Kg. fed.$^{-1}$) for all N forms, were used to calculate the costs of fertilizers (£e.fed^{-1}).

In general, data in Table 9 declared that the highest values for net gains (£e.fed.$^{-1}$) were obtained by addition of ammonium sulfate compared to the other N forms. Although increasing the net gains at addition the high rate of different N forms (120 kg. fed.$^{-1}$) without cyanobacteria , it is not recommended because of the much loss by leaching or volatilization that cause soil and water pollution, guiding by NUE which was less than 60 %. Cyanobacteria addition with the lowest rate (90 kg. fed.$^{-1}$) appeared clearly increases in net gains (£e.fed.$^{-1}$) up to 16.8, 12.9 and 12.0% compared to its absence at use of ammonium sulfate, ammonium nitrate and urea; respectively. Thus, cyanobacteria application was preferable as a cheap source of N does not cause pollution and minimize the applied amount of mineral fertilizer.

9-

CONCLUSION

Cyanobacteria have several advantages over mineral fertilizers. They are non-polluting, cheap source of N, tolerate high salinity and utilize renewable resources. They were recommended to be used as bio fertilizers or bio conditioner to alternative or complementary for mineral fertilizers, replacing about 20% of plant requirement of mineral nitrogen. So, they were used to alleviation the problems of salt stress and deficient in N. In addition, they improved saline soil fertility and plant production, recording the highest significant increases in maize yield components. Thus, they had ability to increase NUE at lowest rate of N forms particularly ammonium sulfate.

Acknowledgments

The author wish to express their appreciations to the Director of "Soils, Water & Environment Research Institute" as well as Chairman of "Soils Improvement & Land Conservation Department" for providing facilities, supporting and valuable help in accomplishing this study. Thanks also extended to Prof. Dr. Mahmoud Saied for his helpful guidance.

REFERENCES

Amer, A. kh.; El azab k. M.; Mansour S. F. and Ahmed M. M. M.(2011). Management of salinity problems at sahlEltina- North Sinai.j.Soil Sci. and Agric. Eng., Mansora Univ., vol. 2 (11): 1099 – 1114

APHA, American Public Health Association (1992). "Standard Methods Examination of Wastewater", 17th ed. American Public Health Association, Washington D.C., p. 116.

Asmalodhi, M. A., Azam, F. and Sajjad, M.H. (2009).Changes in mineral and mineralizable N of soil incubated at varying salinity, moisture, and temperature regimes. Pakistan Journal of Botany 41, 967–980.

Banerjee, M. and Kumar, H. (1992).Nitrogen fixation by Aulosirafertilissima in rice fields.Nautralia, Sao Paulo, 17: 51-58.

Barbara, F.R. and Brain L.J. (1994). ''Minitab Hand book''.Duxbury press. An Imprint of Wad Sworth Publish. Comp. Belonont California, U.S.A.

Black, C.A.; Evans, D.D.; Ensminger L.E.; White J.L. and Clark F.E. (1984). "Methods of Soil Analysis" .Am. Soc. of Agron.Inc. publisher Madison, Wisconsin, USA.

Board N. (2004). The Complete Technology Book on Biofertilizer and Organic Farming, New Delhi.

Brentrup F. and Palliere C. (2010). Nitrogen use efficiency as an agroenvironmental indicator OECD workshop “Agri-environmental indicators: lessons learned and future directions”, 23-26 March 2010, Leysin, Switzerland.

Burger, F. and Celkova A. (2003) Salinity and sodicity hazard in water flow processes in the soil. Plant Soil Environ., 49: 314–320.

Choudhary, M.I.; Al-Omran, A.M. and Shalaby, A.A. (1998) Physical properties of sandy soil affected by soil conditioner under wetting and drying cycles. Agricultural Sciences, 3 (2):69-74.

Choudhury, A.T.M. and Kennedy, I.R. (2004).Prospects and potentials for systems of biological nitrogen fixation in sustainable rice production.Biol.Fertile. Soils, 39: 219-227.

Cottenie, A.; Verloo M.; KikensL.; Velghe G. and Camerlynck R.(1982). Analytics Problems and Methods in Chemical Plant and Soil Analysis.Handbook, Ed. A. Cottenie, Gent, Belgium.

El-Azab Kadria M.; Amer A. Kh; HegabI. A. E. and Abou El-DefanT. A. (2011). Compacting the negative effect of soil salinity stress at Sahl El-Tina area on maize growth and productivity using some fertilization manipulations. Fayoum J. Agric. Res. & Dev.,25: (1):107-123.

El-khawaga, A.A.H.; El-Nagar, M., Assey; A.A.A. and Metwally, S.A. (2003). Influence of Rhizobia inoculation and nitrogen, phosphorus, bio-chemical fertilization regimes on growth and nodulation of two faba bean cultivable . Agronomy Dept. Fac. Agric., Zagazig Univ., 30(3): 651-675

Ghoulam, C.; Foursyand A. and Fares, A. (2002). Effects of salt stress on growth, inorganic ions and proline accumulation in relation to osmotic adjustment in five sugar beet cultivars. Environmental and Experimental Botany, 47(1):39-50.

Jackson, M.L. (1973). "Soil Chemical Analysis." 2nd Ed. Prentice Hall of India Private and L. T. D. , New Delhi, India.

Johnston, A.E. and Poulton, P.R. (2009). “Nitrogen in Agriculture: An Overview and Definitions of Nitrogen Use Efficiency”, Proceedings International Fertiliser Society 651, York, UK.

Maqubela MP, Mnkeni PNS, Issa MO, Pardo MT, D’Acqui LP (2009).Nostoccyanobacterial inoculation in South African agricultural soils enhances soil structure, fertility and maize growth. Plant Soil, 315: 79-92.

Moshe, S.; Amos, D.;Tal K. and Herman L.,(1997).Ionic balance, biomass production, and organic nitrogen as affected by salinity and nitrogen source in annual ryegrass. Journal of Plant Nutrition V(20), Issue 10.

Nanjappan-Karthikeyan; Radha-Prasanna; Lata-Nain; Kaushik, B.D. (2007).Evaluating the potential of plant growth promoting cyanobacteria as inoculants for wheat.European-Journal-of-Soil-Biology. 43(1): 23-30.

Orak, A. and AtesE. (2005).Resistance to salinity stress and available water levels at the seedling stage of the common vetch (Vicia sativa L.). Plant Soil Environ., 51: 51–56.

Osman, MEH.; El-Sheekh, MM.; El-Naggar AH. and Gheda, SF. (2010).Effect of two species of cyanobacteria as biofertilizers on some metabolic activities, growth, and yield of pea plant.BiolFertil Soils. 46: 861-875.

Ozer, H.; Polat,T. and Ozturk, E. (2004). Response of irrigated sunflower (Helianthus annuus L.) hybrids to nitrogen fertilization: growth, yield and yield components. Plant Soil Environ., 50: 205–211.

Page, A. L.; Miller, R. H. and Keeney D.R.(1982)."Methods of Soil Analysis". II. Chemical and Microbiological Properties 2nd Ed. Madison, Wisconsin, U.S.A.

Prasanna, R.; Jaiswal, P.; Singh, Y.V. and Singh, P.K. (2008). Influence of biofertilizers and organic amendments on nitrogenase activity and phototrophic biomass of soil under wheat. ActaAgronomicaHungarica. 56(2): 149-159.

Rai, M.K. (2006). "Handbook of Microbial Biofertilizers". Haworth Press, New York.

Rengasamy P., (2006). World salinization with emphasis on Australia. Journal of Experimental Botany 57, 1017–1023. doi:10.1093/jxb/erj108

Ryan, J.; Garabet S.; HarmsenK. and Rashid A. (1996) A Soil and Plant Analysis Manual Adapted for the West Asia and North Africa Region. ICARDA, Aleppo, Syria, 140 pp.

Saadatnia, H. and Riahi, H., (2009). Cyanobacteria from paddy fields in Iran as biofertilizer in rice plants. Plant Soil Environ., 55(5): 207-212

Silke, R.; Vigdis, T.; Frida, L. D.; Lise, and Jörg, R., (2007). Nitrogen availability decreases prokaryotic diversity in sandy soils. BiolFertil Soils, 43:449–459.

Soliman, M.S.; Shalabi H.G. and. Campbell W.F., (1994). Interaction of salinity, nitrogen and phosphorous fertilization on wheat. J. Plant Nutr., 17: 1163–1173.

Soltanpour, N. (1985). Use of ammonium bicarbonate- DTPA soil test to evaluate elemental availability and oxicity. Soil Sci. Plant Anal., 16: 3, 323- 338.

Song T., Martensson L., Eriksson T., Zheng W. and Rasmussen U. (2005) Biodiversity and seasonal variation of the cyanobacterial assemblage in a rice paddy field in Fujian, China. The Federation of European Materials Societies Microbiology Ecology, *54*: 131–140.

Supanjani, E. and Lee K.D. (2006). Hot pepper response to interactive effects of salinity and boron. Plant Soil Environ., 52: 227–233.

Svoboda, P. and Haberle, J. (2006). The effect of nitrogen fertilization on root distribution of winter wheat. Plant Soil Environ., 52: 308–313.

Watanabe, F.S. and Olsen, S.R. (1965) Test of an ascorbic acid method for determine phosphorus in water and NaHCO3 extract from soil. Soil Sci. Soc. Am Proc. 29: 677-678.

Whitton, B.A. (2000) Soils and rice-fields. PP. 233-255 in B.A. Whitton and M. Potts (eds.) TheEcology of Cyanobacteria: Their Diversity in Time and Space. Kluwer Academic, Netherlands.

Zameer khan, M.; Muhammad, S.; Naeem m. A.; akhtar E. and Khalid M. (2006). Response of some wheat (triticumaestivum l.) Varieties to foliar application of N&K Under rainfed conditions. Pak. J. Bot., 38:4,1027-1034.

تخفيف بعض مشاكل الأراضى المتأثرة بالأملاح والمستصلحة حديثا بشمال سيناء بإستخدام محسن حيوى لإنتاج الذرة الشامية

قدرية مصطفي العزب
معهد بحوث الأراضى والمياه والبيئة - مركز البحوث الزراعية - جيزة - مصر

أقيمت تجربة حقلية فى الأراضى المتأثرة بالأملاح و المستصلحة حديثا بقرية جلبانة رقم ٧ بسهل الطينة– محافظة شمال سيناء – جمهورية مصر العربية فى الموسم الصيفى لعام ٢٠١٣ و ذلك لتحديد قدرة الثيانوبكتريا كمحسن حيوى للأرض مصحوبة بصور و معدلات مختلفة من النيتروجين المعدنى على تحسين وزيادة إنتاجية محصول الذره فى الأراضى الملحية. أضيفت إحدى صورالنيتروجين المعدنى وهى ن١ (يوريا ٤٦% ن)، ن٢ (نترات الأمونيوم ٣٣.٥% ن) او ن٣ (كبريتات الأمونيوم ٢٠.٦% ن) لنبات الذره كإضافة أرضية وذلك بمعدل ١٠٠ % او٧٥% من الموصى به (١٢٠ كجم نيتروجين/ فدان) وذلك فى وجود وعدم وجود الثيانوبكتريا. استخدم صنف الذره (٣٢١ هجين) وهو من النباتات متوسطة التحمل للملوحة للتعرف على مدى الإستجابة للمعاملات المطبقة فى تصميم قطع منشقة مرتين.

اوضحت النتائج أن إضافة الثيانوبكتريا سجلت زيادة معنوية لنمو النبات والمحصول الحيوى ومكونات المحصول لنبات الذرة بالمقارنة بعدم إضافتها تحت ظروف التجربة. كما أشارت النتائج بوضوح أن إضافة صورة بريتات الأمونيوم كمصدر معدنى للتسميد الأزوتى كان أكثر إيجابية من الصور الأخرى المستخدمة تحت نفس ظروف التجربة المقامة. علاوة على ذلك سجلت أعلى قيمة لكفاءة إسخدام النيتروجين (٧٩.٨%) عند إستخدام صورة كبريتات الأمونيوم (ن ٣) بمعدل ٧٥% من الجرعة السمادية الموصى بها من التسميد الأزوتى لنبات الذرة فى وجود الثيانوبكتريا. هذه النتائج تفسر قدرة الثيانوبكتريا على تعويض نبات الذرة النامى فى الأراضى الملحية بما يصل الى ٢٠ % او اكثر من إحتياجاته من التسميد الأزوتى المعدنى الموصى بها وأن هذه النسبة تختلف من صورة نيتروجين لأخرى .

وعليه تبدو الثيانوبكتريا فى الوقت الحاضر كصديق للبيئة من المحتمل أن تكون بديلا لإستخدام الأسمده المعدنيه فقد نجحت فى تقليل الكميات المضافة من الأسمده المعدنية وأيضا فى تقليل تكلفة الإنتاج وتلوث البيئة وعلاوة على ذلك فإن إستعمال الثيانوبكتريا فى التربة كمخصب حيوى أو محسن حيوى قد خفف من مخاطر الملوحة على نمو النبات حيث تحسنت بعض خواص التربه والتى انعكست إيجابيا على إنتاج محصول الذرة.

Table 5 a. Growth parameters and yield components of maize as affected by different treatments under study. (Individual factors and their double interaction.)

Treatments			Growth Parameters (cm)					Yields (kg.fed^{-1})		Grain Quality		Harvest Index %
			Plant height	1st ear height	Stem diameter	Ear length	Ear diameter	Grains	Stover	Crude protein (%)	Wt . 100 Kernels (g)	
Cyanobacteria (b)	without bio.		211.0	95.6	2.75	22.5	4.85	2695.2	3119.6	7.87	33.81	46.4
	with bio.		255.1	121.5	2.93	23.5	5.03	2849.0	3320.5	8.13	38.27	46.2
	LSD at 0.05 level (b)		6.4	5.3	0.15	0.9	0.08	130.3	165.0	ns	0.22	ns
N – Forms (f)	Urea (U)		222.6	98.3	2.84	22.3	4.78	2675.9	3194.7	7.80	33.20	45.6
	Ammonium Nitrate (A.N)		235.5	113.8	2.77	23.3	5.00	2587.5	3077.2	8.13	36.98	45.8
	Ammonium Sulfate (A.S)		241.1	113.5	2.91	23.5	5.05	3053.0	3388.2	8.08	37.94	47.5
	LSD at 0.05 level (f)		7.8	6.5	ns	ns	0.10	159.5	202.1	ns	0.27	ns
N – Rates (r)	100% N-RD		226.5	108.7	2.69	23.2	4.89	2810.2	3201.2	8.05	34.83	46.8
	75% N-RD		239.6	108.5	3.00	22.8	4.99	2734.0	3238.9	7.95	37.25	45.8
	LSD at 0.05 level (r)		6.4	ns	0.15	ns	0.08	ns	ns	ns	0.22	ns
Bio*Forms – N	without bio.	U	188.4	77.6	2.70	21.3	4.68	2631.3	2979.2	7.35	30.21	46.9
		A.N	221.1	100.6	2.66	23.0	4.83	2522.4	2814.2	8.10	35.11	47.3
		A.S	223.6	108.6	2.89	23.2	5.05	2932.0	3565.4	8.15	36.12	45.1
	with bio.	U	256.8	119.0	2.98	23.2	4.88	2720.4	3410.2	8.25	36.19	44.4
		A.N	249.9	127.0	2.87	23.6	5.16	2652.7	3340.2	8.15	38.86	44.3
		A.S	258.7	118.5	2.93	23.7	5.05	3174.1	3211.1	8.00	39.75	50.0
	LSD at 0.05 level (b*f)		11.0	9.1	ns	ns	0.14	ns	ns	0.20	0.38	ns
Bio*Rates-N	without bio.	100%	205.3	96.5	2.62	22.7	4.79	2758.4	3183.2	8.20	32.33	46.5
		75%	216.8	94.8	2.89	22.4	4.92	2632.0	3056.0	7.87	35.29	46.4
	with bio.	100%	247.8	120.8	2.78	23.8	4.99	2861.9	3552.5	8.26	37.31	47.1
		75%	262.4	122.2	3.12	23.2	5.08	2836.1	3421.8	8.00	39.22	45.3
	LSD at 0.05 level (b*r)		ns	ns	ns	ns	ns	ns	ns	ns	0.31	ns
Forms-N* Rates -N	U	100%	213.6	99.9	2.70	23.5	4.88	2729.7	3272.2	8.29	34.26	45.5
		75%	231.5	96.8	2.98	21.0	4.68	2622.0	3117.1	7.82	32.14	45.7
	A.N	100%	233.0	110.5	2.59	22.8	4.88	2605.4	3130.9	8.27	33.34	45.5
		75%	238.0	117.1	2.94	23.8	5.11	2569.6	3023.4	7.94	40.62	46.0
	A.S	100%	232.9	115.6	2.79	23.3	4.92	3095.4	3700.4	8.13	36.87	49.4
		75%	249.4	111.5	3.08	23.6	5.21	3010.6	3576.1	8.04	39.00	45.7
	LSD at 0.05 level (f*r)		ns	ns	ns	1.5	0.14	ns	ns	0.20	0.38	ns

Table 4. Effect of applied treatments on available N, P and K (mg. kg^{-1}) in experimental soil (0-30 cm) at harvest.

Item studient	Treatments	without bio. (cyanobacteria)			with bio. (cyanobacteria)			mean of 100 %	mean of 75 %	mean of N forms	LSD at 0.05 level
	Inorganic N formes (F)	Rate of inorganic N formes (R)									
		100%	75%	mean	100%	75%	mean				
N	Urea (U)	96.2	70.2	83.2	95.6	81.7	88.7	95.9	76.0	85.9	(b : 2.501) (f: 3.063) (r : 2.501) (b*f : ns) (b*r : 3.537) (f*r : ns) (b*f*r : ns)
	Ammonium Nitrate (A.N)	78.0	54.3	66.2	78.0	65.4	71.7	78.0	59.9	68.9	
	Ammonium sulfate (A.S)	80.6	57.6	69.1	86.1	71.8	79.0	83.4	64.7	74.0	
	mean	84.9	60.7	72.8	86.6	73.0	79.8	85.7	66.8	76.3	
P	Urea (U)	7.5	7.4	7.5	6.8	6.6	6.7	7.2	7.0	7.1	(b : 0.281) (f: ns) (r : ns) (b*f : ns) (b*r : ns) (f*r : ns) (b*f*r : ns)
	Ammonium Nitrate (A.N)	7.0	6.9	7.0	7.3	6.7	7.0	7.2	6.8	7.0	
	Ammonium sulfate (A.S)	7.4	7.0	7.2	6.8	7.0	6.9	7.1	7.0	7.1	
	mean	7.2	7.0	7.1	7.1	6.9	7.0	7.1	6.9	7.0	
K	Urea (U)	211.8	182.0	196.9	215.5	185.8	200.7	213.7	183.9	198.8	(b : 3.089) (f: 3.783) (r : ns) (b*f : ns) (b*r : ns) (f*r : 5.350) (b*f*r : ns)
	Ammonium Nitrate (A.N)	182.0	185.5	183.8	184.2	193.2	188.7	183.1	189.4	186.2	
	Ammonium sulfate (A.S)	205.8	219.8	212.8	206.3	224.0	215.2	206.1	221.9	214.0	
	mean	193.9	202.7	198.3	195.3	208.6	201.9	194.6	205.6	200.1	

bio. : (b), Form : (f), Rate : (r)

Table 9. Economic evaluation of the experiment treatments (£e.fed.$^{-1}$).

Treatments		Rates (kg.fed.$^{-1}$)	Price	bio conditioner	F.Prac*	Total	Grains Y. (kg. fed.$^{-1}$)	Stover Y. (kg. fed.$^{-1}$)	Total	Net Gains (£e.fed.$^{-1}$)
		Costs of production (£e.fed.$^{-1}$)					Incomes Profits (£e.fed.$^{-1}$)			
without cyanobac.	Urea (U)	120	480	0	2500 (* F.Prac: Field Practices)	2980.0	5435.2	306.3	5741.5	2761.5
		90	360	0		2860.0	5090.0	289.5	5379.5	2519.5
	Ammonium Nitrat (A.N)	120	360	0		2860.0	5109.2	286.5	5395.7	2535.7
		90	270	0		2770.0	4980.2	276.3	5256.5	2486.5
	Ammonium sulfate (A.S)	120	300	0		2800.0	6006.2	362.2	6368.4	3568.4
		90	225	0		2725.0	5721.6	350.9	6072.5	3347.5
with cyanobac.	Urea (U)	120	480	50		3030.0	5483.6	348.1	5831.7	2801.7
		90	360	50		2910.0	5398.0	333.9	5731.9	2821.9
	Ammonium Nitrat (A.N)	120	360	50		2910.0	5312.6	339.7	5652.3	2742.3
		90	270	50		2820.0	5298.0	328.4	5626.4	2806.4
	Ammonium sulfate (A.S)	120	300	50		2850.0	6375.6	277.9	6653.5	3803.5
		90	225	50		2775.0	6320.6	364.3	6684.9	3909.9

Table 5 b. Effects of applied treatments on growth parameters and yield components of maize. (factor triple interactions).

Treatments			Growth Parameters (cm)					Yields (kg.fed^{-1})		Grain Quality		Harvest Index %
Cyanobacteria (b)	N-miniral Forms (f)	N- Rates (% N-RD) (r)	Plant height	1st ear height	Stem diameter	Ear length	Ear diameter	Grains	Stover	Crude protein (%)	Wt . 100 Kernels (g)	
without cyanobac.	Urea (U)	100%	188.8	83.0	2.66	23.6	4.76	2717.6	3063.1	7.10	31.77	47.0
		75%	188.0	72.3	2.74	19.1	4.60	2545.0	2895.3	7.60	28.65	46.8
	Ammonium Nitrate (A.N)	100%	205.0	93.8	2.43	21.5	4.70	2554.6	2865.0	8.30	30.37	47.1
		75%	237.3	107.5	2.90	24.5	4.96	2490.1	2763.3	7.90	39.84	47.4
	Ammonium sulfate (A.S)	100%	222.0	112.7	2.76	22.9	4.91	3003.1	3621.5	8.10	34.86	45.3
		75%	225.3	104.5	3.02	23.6	5.19	2860.8	3509.3	8.20	37.38	44.9
with cyanobac.	Urea (U)	100%	238.5	116.8	2.74	23.5	5.00	2741.8	3481.3	8.40	36.75	44.1
		75%	275.0	121.3	3.22	23.0	4.75	2699.0	3339.0	8.10	35.64	44.7
	Ammonium Nitrate (A.N)	100%	261.0	127.3	2.76	24.1	5.05	2656.3	3396.8	8.30	36.31	43.9
		75%	238.8	126.8	2.98	23.1	5.27	2649.0	3283.5	8.00	41.41	44.7
	Ammonium sulfate (A.S)	100%	243.8	118.5	2.76	23.8	4.91	3187.8	2779.3	8.10	38.90	53.4
		75%	273.5	118.5	3.10	23.6	5.19	3160.3	3642.8	7.90	40.60	46.5
LSD at 0.05 level (b *f *r)			15.6	ns	ns	2.1	ns	ns	ns	ns	0.54	ns