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Effect of Bio Fertilizer, Nitrogen and Sulfur Levels on Maize Production in Saline Soil of North Delta of Egypt

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ABSTRACT

Two field experiments were carried out at El-Serw agricultural Research Station, Governorate of Damietta through growing summer seasons of 2014 and 2015. The aim of the investigation is to study the effects of N bio fertilization (*cyanobacteria*, *Azotbacter*, Phosphorine and without inoculation), mineral sulfur applications (0, 15 and 30 kg S fed^{-1}) and mineral nitrogen fertilization (0, 60 and 120 kg fed^{-1}) on growth of the maize crop. Results showed that *Cyanobacteria* inoculation + 30 kg S fed^{-1} + 120 kg N fed-^{1} gave the highest maize plant height, dry weight, 100 grains weight of maize and maize grain and stover yield. Moreover, results indicated that the element N at a rate of 120 kg fed^{-1} with 30 kg S fed^{-1} with phosphorin, azotobacter and *Cyanobacteria* inoculation can increase the maize grain yield by 21.52, 22.95 and 24.45%, respectively and the maize stover yield by 21.01, 23.25 and 24.68%, respectively in first season but the increasing in the second season was as follows: 21.49, 22.95 and 24.42%, respectively for maize grain yield and 21.03, 23.25 and 24.67%, respectively for maize stover yield.

Keywords: maize, bio fertilization, nitrogen, sulfur, mineral.

INTRODUCTION

Maize (*Zea mays*, L.) ranks the third in the world production of cereals following wheat and rice. It is a staple food for humans and used as feed for livestock and a principal raw material for many industrial products. All parts of the crop can be used for food and non-food products. In industrialized countries, maize is largely used as livestock feed and as a raw material for industrial products.

Bio fertilizers have great potential to improve the nutrition of plants by replacing synthetic fertilizers for ecofriendly agriculture. Bio fertilizers contain plant growth promoting rhizobacteria (PGPR) such as, *Azotobacter*, *Azospirillum* and phosphorus solubilizing bacteria (PSB) such as, *Pseudomonas sp*. and *Bacillus sp.* having the ability of atmospheric nitrogen fixing and solubilizing the soil phosphorus. Thus, they perfect the nitrogen and phosphorus requirement of cereals and also improve the fertility of soil. So the utilization of nitrogen fixing and phosphorus solubilizing bacteria as bio-fertilization have gigantic potential for using the atmospheric nitrogen and making use of fixed phosphorus present in the soil in crop production without causing any harmful effects on aerial and soil environment (Yasin *et al.*, 2012).

In soils in temperate zones, the *Cyanobacteria* can fixation rates between 13 and 38 kg N ha^{-1} y^{-1} have been recorded (Witty *et al.*, 1979). A range of diazotrophic plant growth-promoting rhizobacteria participate in interactions with C3 and C4 crop plants (e.g. rice, wheat, maize, sugarcane and cotton), significantly increasing their vegetative growth and grain yield, (Kennedy, *et al.*, 2004). *Gholami*, *et al.*, (2012) reported that plant growth promoting rhizobacteria (PGPR) plays an important role in plant health and soil fertility. The experiment was conducted as a factorial experiment with *Azotobacter* the results indicated that growth promotion by PGPR appears from early stages of growth, 45 days after inoculation (DAI). *Zahir*, *et al.*, (2005) revealed that application of L-tryptophan (L-TRP) or *Azotobacter* inoculation alone significantly affected the maize crop; however, their combined application produced more pronounced effects as compared with their separate application. Combined application of 10^{-4} M L^{-1}TRP and *Azotobacter* significantly increased total nitrogen uptake (40%) compared with an untreated and un-inoculated controL.

Zulpa, *et al.*, (2008) indicated that when they studied the effect of cyanbacterial products of *Tolypothrix tenuis* and *Nostoc muscorum* on the activity of microbiological and the nutrient content of the soil underlying the remains of maize and on the degradation of remains. They indicated that the biomass and extracellular products of both strains raised up the soil microbial activity such as total N (10%: 12%) and available P (22%: 32%) and decreased the maize remains dry weight and C content therefore C:N ratio was closer to soil normal value.

Ghazal, *et al.*, (2013) reported that the use of *Cyanobacteria* inoculation (dry and spray) along with 286 kg N ha^{-1} gave significantly maize grain yield that was not significantly different from that recorded by the use of 357 Kg N ha^{-1} alone (full recommended N dose). Also, the use of either *Cyanobacteria* or humic acid increased the soil biological activity of the plants rhizosphere.

In recent years sulfur shortage has become an increasing problem for agriculture, resulting in low yields and quality parameters. Fertilization of sulfur has become an issue due to reduced industrial emissions of sulfur to the atmosphere and the consequent decreased deposition of S onto agricultural land in many areas of the world (McGrath *et al.*, 1996). Hawkesford, (2000) reported that nutrition of sulfur plays an important role in the growth and development of high plants, and sulfur limitation results in decreased crops yield and quality parameters. Adequate sulfur nutrition is also required for plant health and resistance to pathogens (Rausch and Wachter, 2005).

Application of sulfur at 45 kg S ha^{-1} significantly increased the yield attributes, number of cobs plant^{-1}, length of cob, number of grains/cob, and 1000-grain weight of maize over its lower levels of sulfur (Maurya *et al.*, 2005).

Plants show a dramatic response to nitrogen amendments, since nitrogen is a major building block of amino acids and proteins. Plants contain 2 to 5 percent of N by dry weight and nitrogen is taken up both as nitrate and ammonium, and both are metabolized, although more nitrate is taken up at a low soil pH and ammonium is taken up at neutral pH values (Wilkinson, 2000).

Nofal and Hinar, (2003) found that maize needs high levels of N-mineral application, reached 300kg urea fed^{-1} in normal soils. Nassr *et al.*, (2015) showed that Maize grain yield, 100 grains weight, ear diameter and plant height increased with increasing rate of N-fertilization. The values of maize grain yield were 25.71, 27.66 and 29.68 ardab fed^{-1} in the first season and 26.23, 28.62 and 30.72 ardab fed^{-1} in the second season for 90, 120 and 150 kg N fed^{-1}, respectively. The corresponding values of protein percentage were 6.01, 11.68 and 15. 55 % in the first season and 5.94, 11.54 and 15.52 % in the second season, respectively. Data showed that V2 resulted in a significant increase in the grain yield, 100 grain weight and Plant height of the maize crop.

The aim of this investigation was carried out to study the effect of Bio fertilization and mineral nitrogen and sulfur fertilization on growth, yield and nutrients uptake of maize.

MATERIALS AND METHDOS

Experimental Site:

Two field trials were carried out at El-Serw agricultural research station, Governorate of Damietta. Split split plot design with four replications was conducted to study the effect of applying different bio fertilizer inoculations (*Cyanobacteria*, *Azotobacter*, *Phosphorine* and without inoculation), mineral sulfur fertilizer levels (0, 15 and 30 kg fed^{-1} as mineral sulfure 80% S) and mineral nitrogen fertilization (0, 60 and 120 kg fed^{-1} as Urea 46.5% N) on maize (*Zea mays* L.) seeds, variety single cross 30K8, growth and nutrients uptake. Maize seeds were sown on May 15th in 2014 & May 12th in 2015 and harvesting was done on 5th October 2014 & 3rd October 2015.

The blue-green algae (*cyanobacteria*) was provided from the soil Microbiology Department at Soil, Water and Environmental Institute, ARC, Giza. Algalization treatment was inoculated 5 days after planting using dry mixed culture (2 kg ha^{-1}) containing *Anabaena Oryza*, *Nostoc muscrum* and *Tolypothrix tenuis*, (El-Kholy, 1997). An N_2-fixing bacteria (*Azotobacter*) and phosphorin (commercial names in Egypt) were provided from the Soil, Water and Environmental Institute, ARC, Giza. Maize grains were inoculated with Azotobacter and Phosphorin at planting where the adhesive glue material was added to 500 ml mild hot water, splashed on grains and then bacterial were added, well mixed with grains and air dried for adhesion.

Soil Analysis:

Soil samples were taken from the experimental field before conducting from soil layer (0-30 and 30-60 cm depth), then air-dried and ground to pass through 2 mm sieve. Soil physical and chemical properties were shown in Tables 1-2. Particle size distribution of the composite sample was determined according to the international method (*Piper*, 1950). Soluble cations, anions and total soluble salts were estimated in the (1:5) soil water extract, while the organic matter was determined by using Walkley & Black method, but available potassium was extracted by ammonium acetate ($C_2H_3O_2NH_4$) and then measured by a flame photometer as described by *Jackson*, (1967). Soluble SO_4^{-2} was taken the difference between the summation of soluble cations and anions. pH values were measured in the soil-water suspensions (1:2.5) according to *Jackson*, (1973). Available nitrogen was determined in the soil extracted using Potassium Sulfate (K_2SO_4) and determined by using macro Kjell-dhal according to *Hesse*, (1971). Available phosphorus was extracted by sodium bicarbonate ($NaHCO_3$) and then determined colorimetrically according to *Olsen*, and *Dean*, (1965).

Table 1. Physical and chemical properties of the soil samples which were taken from the experimental field before corn cultivation in 2014 growing season.

Depth, cm	Particle size distribution: Coarse sand %	Fine sand %	Silt %	Clay %	Texture	O. M. g kg^{-1}	C.E.C cmol$_c$ kg^{-1}	pH in the soil-water suspensions (1:2.5)	EC, dS m^{-1} in the soil extract (1:5)
0-30	1.45	10.34	22.28	65.93	Clayey	8.9	44.3	8.2	4.6
30-60	2.10	15.20	25.25	57.45	Clayey	6.5	40.5	8.1	4.7

Depth, cm	Soluble cations and anions in the soil extract (1:5), cmol$_c$ kg^{-1} — Cations: Ca^{++}	Mg^{++}	Na^{+}	K^{+}	Anions: $CO3^{=}$	HCO_3^{-}	Cl^{-}	$SO4^{=}$	N Extraction by	P Extraction by mg kg^{-1}	K Extraction by $C_2H_3O_2N$
0-30	3.12	2.79	11.40	0.28	n.d.	1.70	12.21	3.68	33	7.94	479
30-60	2.49	3.13	13.72	0.29	n.d.	1.65	13.62	4.36	30	6.17	463

Table 2. Physical and chemical properties of the soil samples which were taken from the experimental field before corn cultivation in 2015 growing season.

Depth, cm	Particle size distribution: Coarse sand %	Fine sand %	Silt %	Clay %	Texture	O. M. g kg^{-1}	C.E.C cmol$_c$ kg^{-1}	pH in the soil-water suspensions (1:2.5)	EC, dS m^{-1} in the soil extract (1:5)
0-30	1.09	11.23	21.67	66.01	Clayey	7.5	44.1	8.0	4.4
30-60	1.97	16.03	24.64	57.63	Clayey	5.2	39.7	7.9	4.5

Depth, cm	Soluble cations and anions in the soil extract (1:5), cmol$_c$ kg^{-1} — Cations: Ca^{++}	Mg^{++}	Na^{+}	K^{+}	Anions: $CO3^{=}$	HCO^{3-}	Cl^{-}	$SO4^{=}$	N Extraction by	P Extraction by mg kg^{-1}	K Extraction by $C_2H_3O_2N$
0-30	2.95	2.81	11.21	0.27	n.d.	1.59	12.02	3.63	31	8.01	483
30-60	2.24	3.21	12.99	0.29	n.d.	1.51	13.43	3.79	28	6.21	471

n.d. = not detected.

Growth and yield parameters

At harvesting stage plant height and dry weight of maize plant were measured. 100-grains weight, grain yield (ton fed^{-1}) and maize stover yield was determined at harvesting stage.

Statistical Analysis:

Data were collected to statistical analysis according to Snedecor and Cochran (1967). Mean values were compared at the levels of significance at 5% and 1% by using the Least Significance Difference (LSD) test. (CoHort Software, 2008) was used to statistical analysis for data.

RESULTS AND DISCUSSION

Plant height & Dry weight

According to the data contained in the Table 3, maize plant height & dry weight was significantly affected by bio fertilization treatment at harvesting stage, whereas maize plant height & dry weight were increased with following order: without inoculation, phpsphorin, *Azotobacter* and cyanobacteria inoculation, respectively during 2014 and 2015 seasons. These results are due to Bio-fertilization inoculations have a tendency to fix atmospheric nitrogen and the production of certain metabolites including auxin, cytokinin, gibberellins, vitamin B complex, hydrogen cyanide (HCN), phytohormones and production of certain unstable substances and growth hormones having great potential increasing the growth such as plant height and dray matter. On the contrary, maize plant height & dry weight were significantly increased with mineral sulfur application at harvesting stage in 2014 & 2015 seasons. The order of sulfur fertilization rates for their influences on maize plant height & dry weight were as follows: 30 kg S fed^{-1} > 15 kg S fed^{-1} > 0 kg S fed^{-1}. These results could be attributed that an important role of sulfur element in the growth and development of higher plants, and sulfur limitation results in decreased yields and quality parameters of crops (Hawkesford, 2000). In 2014 & 2015 seasons, mineral nitrogen fertilization were influencing factors in the significant increase which was noticed in maize plant height & dry weight after both sowing growth period and harvesting stage. Data in Table 3 also expounds that the order of nitrogen fertilization levels for their influences on maize plant height & dry weight were as follows: 120 kg N fed^{-1}, 60 kg N fed^{-1} and 0 kg N fed^{-1}, respectively. Increasing in maize plant height & dry weight could be attributed to nitrogen role in cell elongation.

Data in Table 3 explicates the interaction between bio fertilization treatment and mineral nitrogen fertilization effect. In 2014 and 2015 seasons, the effect of that interaction was significant on maize plant height and dray weight at harvesting stage. The highest values of maize plant height & dry weight were obtained when *cyanobacteria* inoculation with 120 kg N fed^{-1} treatment was used. The lowest results were obtained by non-inoculation with 0 kg N fed^{-1} treatments. Data in Table 3 clarify the consequence of different nitrogen fertilization levels and mineral sulfur treatments interaction. Maize plant height was significantly increased at harvesting stage in 2014 and 2015 seasons, but maize dry weight was significantly increased in 2015 season and it was non-significantly increased in 2014 season. Using of 120 kg N fed^{-1} with 30 kg S fed^{-1} treatments gave the highest result at harvesting stage. The lowest results were obtained by using 0 kg N fed^{-1} with 0 kg S fed^{-1} treatments in both seasons. Data in Table 3 shows the effect of mineral sulfur fertilization and bio fertilization treatments interaction on maize plant height and dry weight at harvest stage. Consequently, maize plant height and dray weight was a non-significantly increased at harvesting stage in 2014 season, but in 2015 season this effect was a significantly at 5% level for plant height and it was a significantly for dry weight at harvesting stage. The highest results were obtained by 30 kg S fed^{-1} with cyanobacteria inoculation. Data in Table 3 expounds the outcome of bio fertilization inoculation, mineral sulfur fertilization and nitrogen fertilization interaction. Maize plant height & dry weight were non-significantly affected by the outcome of these interactions harvesting stage in 2014 & 2015 seasons. The highest results were obtained with (Cyanobacteria inoculation + 30 kg S fed^{-1} + 120 kg N fed^{-1}).

100-grain weight:

Data in Table 4 indicates that there was a significant decrease in maize100-grain weight by the cause of bio fertilization treatments in both seasons 2014-2015. Data in Table also shows that the order of bio fertilization inoculations for their influences on maize highest 100-grain weight was as follows: *cyanobacteria* > *Azotobacter* > Phosphorine inoculation. In addition, data in Table 4 showed that there was a significant increase in maize 100-grain weight caused by mineral sulfur fertilization in both 2014 and 2015 seasons. The highest 100-grain weight was obtained with 30 kg S fed^{-1} following by 15 kg S fed^{-1}. This increase is due to effect of nitrogen from any source on grains filling which reflected on their weights. Moreover, data in Table 4 indicated that mineral nitrogen fertilization affected on maize 100-grain weight significantly in both 2014 and 2015 seasons. The highest results were obtained by 120 kg N fed^{-1} followed by 60 kg N fed^{-1}. Data in Table 4 shows the influence of bio fertilizers inoculations and mineral nitrogen fertilization interaction. In 2014 and 2015 seasons, the interaction affected significantly on maize 100-grain weight. The highest values of 100-grain weight were obtained when cyanobacteria inoculation with 120 kg N fed^{-1} treatment was used. The lowest results were obtained by non-bio fertilizer inoculation with 0 g N fed^{-1}. Data in Table 4 shows the effect of sulfur fertilization levels and mineral nitrogen fertilization treatments interaction. The effect of this interaction on maize 100-grain weight was a significant in (2014 & 2015) seasons. Using of 30 kg S fed^{-1} with 120 kg N fed^{-1} treatment gave the highest result. Data in Table 4 shows the effect of bio fertilizer inoculations and sulfur fertilization levels interaction. The effect of this interaction on maize 100-grain weight was a significant in (2014&2015) seasons. Using of cyanobacteria inoculation with 30 kg S fed^{-1} treatment gave the highest result. Data in Table 4 shows the effect of bio fertilizer inoculations, mineral sulfur fertilizations and mineral nitrogen fertilization interaction. The effect of this interaction was significant effect at 5% level in 2014 season and it was no significant effect in 2015 season. The highest results were obtained with (cyanobacteria inoculation + 30 kg S fed^{-1} + 120 kg N fed^{-1}), (cyanobacteria inoculation + 15 kg S fed^{-1} + 120 kg N fed^{-1}). The lowest values were obtained with (non-inoculation + 0 kg S fed^{-1} + 0 kg N fed^{-1}) in both 2014&2015 seasons.

Table 3: Effect of interactions among (Bio × M. sulfur × M. Nitrogen) on plant height and dry weight in 2014-2015 seasons.

Treatment		2014						2015					
		Plant heigh(cm) at harvest stage			Dry weight (gm) at harvest stage			Plant heigh(cm) at harvest stage			Dry weight (gm) at harvest stage		
		N_0	N_{60}	N_{120}	N_0	N_{60}	N_{120}	N_0	N_{60}	N_{120}	N_0	N_{60}	N_{120}
	S_0	146.205	217.507	241.557	251.60	291.28	402.10	147.295	219.129	243.358	236.39	284.12	404.30
I_0	S_{15}	153.786	228.437	254.793	234.64	282.01	410.15	154.625	229.683	256.183	252.98	292.87	413.20
	S_{30}	165.699	236.088	264.720	263.17	305.60	429.27	167.050	238.014	266.879	265.32	308.09	432.77
	S_0	164.651	275.216	288.432	280.18	423.23	570.39	165.220	276.167	289.429	281.14	424.69	573.62
I_1	S_{15}	173.188	289.046	304.236	300.43	437.14	581.80	174.168	290.681	305.957	302.13	439.61	583.81
	S_{30}	186.604	298.727	316.090	314.24	458.62	608.93	188.369	301.551	319.078	317.21	462.96	614.68
	S_0	161.422	264.631	280.031	272.02	395.54	538.10	163.110	267.397	282.959	274.86	399.67	539.37
I_2	S_{15}	169.792	277.929	295.375	291.68	408.54	548.87	170.192	278.583	296.071	292.36	409.50	554.61
	S_{30}	182.945	287.237	306.883	305.08	428.62	574.46	184.765	290.094	309.935	308.12	432.88	580.17
	S_0	158.257	254.452	271.875	264.09	369.66	507.65	158.725	255.205	272.678	264.87	370.75	509.84
I_3	S_{15}	166.463	267.239	286.772	283.18	381.81	517.80	167.183	268.395	288.012	284.41	383.47	519.33
	S_{30}	179.358	276.190	297.945	296.20	400.58	541.94	179.994	277.169	299.001	297.25	402.00	543.86
F. Test			ns			ns			ns			ns	
LSD 5%			---			---			---			---	
LSD 1%			---			---			---			---	
F. Test	I		**			**			**			**	
	S		**			**			**			**	
	N		**			**			**			**	
	N×I		**			**			**			**	
	N×S		**			ns			**			**	
	S×I		ns			ns			*			**	

. Significant at 1% leveL**

I_0= Without Bio fertilization.
I_1= *Cyanobacteria Inoculation*.
I_2= Azotobacter Inoculation.
I_3= Phosphorin Inoculation.

S_0 = 0 kg S fed^{-1}.
S_{15} =15 kg S fed^{-1}.
S_{30} =30 kg S fed^{-1}.

N_0 = 0 kg N fed^{-1}.
N_{60} = 60 kg N fed^{-1}.
N_{120} = 120 kg N fed^{-1}.

Grain and Stover yield:

According to the data contained in Table 4 shows that maize grain and stover yield were significantly affected by bio fertilization inoculation. It was noticed that grain and stover yield increased drastically with following order: non inoculation, Phosphorin, *Azotobacter* and *cyanobacteria* inoculation, respectively in both seasons 2014-2015. Increasing in maize grain and stover yield could be attributed to phosphorus solubilizing microorganisms have a great tendency to enhance the provision of soluble phosphate and increase the growth and development of crop plants by enhancing biological nitrogen fixation. *Azotobacter* could increase maize yield by stimulating processes such as seed germination, resistance of seedlings to stress conditions, nitrogen fixation and production of phytohormones (Ponmurugan and Gopi, 2006 and Timea *et al.*, 2012). In addition, maize grain and stover yield were significantly increased with mineral sulfur application in 2014 and 2015 seasons. In other word, Data in Table 4 also explicates that the order of sulfur fertilization application for their influences on maize grain yield was as follows: 30 kg S fed^{-1} > 15 kg S fed^{-1} > 0 kg S fed^{-1}. During 2014 and 2015 seasons, a significant increase was noticed on maize grain and stover yield due to mineral nitrogen fertilizer. Data in Table 4 also shows that the order of nitrogen fertilization levels for their influences on maize grain and stover yield was as follows: 120 kg N fed^{-1}, 60 kg N fed^{-1} and 0 kg N fed^{-1}. Data in Table 4 shows the influence of bio fertilizers inoculations and mineral nitrogen fertilization interaction. In 2014 and 2015 seasons, the interaction affected significantly on maize grain yield in 2014 season and it was also significantly on maize grain and stover yield in 2015 season but maize stover yield in 2014 season this effect was significantly at 5% only. The highest values of maize grain and stover yield were obtained when cyanobacteria inoculation with 120 kg N fed^{-1} treatment was used. The lowest results were obtained by non-bio fertilizer inoculation with 0 kg N fed^{-1}. Data in Table 4 shows the effect of sulfur fertilization levels and mineral nitrogen fertilization treatments interaction. The effect of this interaction on maize grain and stover yield was a significant in (2014 & 2015) seasons. Using of 30 kg S fed^{-1} with 120 kg N fed^{-1} treatment gave the highest result. Data in Table 4 shows the effect of bio fertilizer inoculations and sulfur fertilization levels interaction. The effect of this interaction on maize grain and stover yield was a significant in (2014&2015) seasons. Using of cyanobacteria inoculation with 30 kg S fed-1 treatment gave the highest result. Data in Table 4 shows the effect of bio fertilizer inoculations, mineral sulfur fertilizations and mineral nitrogen fertilization interaction. The effect of this interaction was significant effect at 5% level on maize grain yield in 2015 season and it was no significant effect on maize grain and stover yield in 2014 season and it was no significantly on maize stover yield in 2015 season. The highest results were obtained with (cyanobacteria inoculation + 30 kg S fed^{-1} + 120 kg N fed^{-1}), (*Azotobacter* inoculation + 30 kg S fed^{-1} + 120 kg N fed^{-1}). The lowest values were obtained with (non-inoculation + 0 kg S fed^{-1} + 0 kg N fed^{-1}) in both 2014 and 2015 seasons.

Table 4: Effect of interactions among (Bio × M. sulfur × M. Nitrogen) on 100 grain weight, grain yield and stover yield in 2014-2015 seasons.

Treatment		2014 100 grain weight (gm)			2014 Grain yield(ton fed^{-1})			2014 stover yield(ton fed^{-1})			2015 100 grain weight (gm)			2015 Grain yield (ton fed^{-1})			2015 stover yield(ton fed^{-1})		
		N_0	N_{60}	N_{120}	N_0	N_{60}	N_{120}	N_0	N_{60}	N_{120}	N_0	N_{60}	N_{120}	N_0	N_{60}	N_{120}	N_0	N_{60}	N_{120}
	S_0	5.36	18.95	31.01	0.743	1.769	3.137	1.051	2.535	4.471	5.40	19.09	31.24	0.748	1.782	3.161	1.059	2.554	4.504
I_0	S_{15}	6.45	21.5	32.75	0.805	1.931	3.409	1.140	2.768	4.857	6.49	21.62	32.93	0.810	1.941	3.427	1.146	2.783	4.884
	S_{30}	7.94	23.18	35.17	0.919	2.100	3.634	1.301	3.011	5.179	8.00	23.37	35.46	0.927	2.117	3.664	1.311	3.035	5.221
	S_0	9.5	37.41	71.72	0.775	1.855	3.330	1.096	2.659	4.746	9.53	37.54	71.97	0.777	1.862	3.342	1.100	2.669	4.762
I_1	S_{15}	11.43	42.44	75.75	0.845	2.038	3.640	1.195	2.921	5.187	11.50	42.68	76.18	0.850	2.049	3.66	1.202	2.937	5.216
	S_{30}	14.06	45.76	81.36	0.970	2.229	3.904	1.373	3.196	5.563	14.20	46.19	82.13	0.979	2.250	3.941	1.386	3.226	5.615
	S_0	8.63	33.4	62.36	0.769	1.840	3.297	1.089	2.638	4.699	8.72	33.75	63.01	0.777	1.860	3.332	1.100	2.666	4.748
I_2	S_{15}	10.4	37.89	65.87	0.838	2.019	3.600	1.186	2.895	5.130	10.42	37.98	66.02	0.840	2.024	3.609	1.189	2.902	5.143
	S_{30}	12.78	40.86	70.75	0.961	2.207	3.857	1.360	3.164	5.497	12.91	41.26	71.45	0.971	2.229	3.896	1.374	3.196	5.551
	S_0	7.85	29.82	54.23	0.764	1.826	3.265	1.081	2.617	4.652	7.87	29.91	54.39	0.766	1.831	3.274	1.084	2.625	4.666
I_3	S_{15}	9.45	33.83	57.28	0.831	2.001	3.561	1.177	2.869	5.075	9.49	33.98	57.52	0.835	2.010	3.577	1.182	2.881	5.097
	S_{30}	11.62	36.48	61.52	0.953	2.185	3.812	1.348	3.133	5.432	11.66	36.61	61.74	0.956	2.193	3.825	1.353	3.144	5.451
F. Test			*			ns			ns			ns			*			ns	
LSD 5%			0.930			---			---			---			0.026			---	
LSD 1%			---			---			---			---			---			---	
F. Test	I		**			**			**			**			**			**	
	S		**			**			**			**			**			**	
	N		**			**			**			**			**			**	
	N×I		**			**			*			**			**			**	
	N×S		**			**			**			**			**			**	
	S×I		**			*			ns			**			**			ns	

. Significant at 1% leveL**
I_0= Without Bio fertilization.
I_1= *Cyanobacteria Inoculation*.
I_2= Azotobacter Inoculation.
I_3= Phosphorin Inoculation.
S_0 = 0 kg S fed^{-1}.
S_{15} =15 kg S fed^{-1}.
S_{30} =30 kg S fed^{-1}.
N_0 = 0 kg N fed^{-1}.
N_{60} = 60 kg N fed^{-1}.
N_{120} = 120 kg N fed^{-1}.

CONCLUSION

It could be concluded that under saline soil condition in North Delta region, applying bio-fertilization (*Cyanobacteria, Azotobacter* and Phosphorin) and mineral sulfur fertilization at 30 kg S fed^{-1} is very important to obtain permanent productivity of maize plant.

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تأثير التسميد الحيوى والتسميد المعدنى الكبريتى والنيتروجينى على انتاجية الذرة الشامية فى الأراضى المتأثرة بالأملاح فى شمال الدلتا فى مصر.

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أجريت تجربتان حقليتان في محطة البحوث الزراعية بالسرر بمحافظة دمياط خلال الموسمين الصيفيين لعامي2014 و 2015 لدراسة تأثير التسميد الحيوي (لقاح السيانوباكتيرا, الأزوتوباكتر, الفوسفورين وبدون تلقيح) والتسميد المعدنى الكبريتى (0, 15, 30 كجم كبريت معدنى فدان$^{-1}$) والتسميد المعدنى النيتروجينى (0, 60 و 120 كجم نيتروجين معدنى فدان$^{-1}$) على نمو ومحصول الذرة الشامية تحت الظروف الملحية. أوضحت النتائج أن معاملة (الطحالب الخضراء المزرقة مع 30 كجم كبريت فدان$^{-1}$ مع 120 كجم نيتروجين فدان$^{-1}$) أعطت أعلى النتائج من طول نبات الذرة وكذلك الوزن الجاف ووزن الـ100 حبة وكذلك محصول الذرة من الحبوب والحطب. كذلك دلت النتائج أن استخدام التسميد المعدنى النيتروجينى عند معدل 120 كجم نيتروجين فدان$^{-1}$ مع 30 كجم كبريت فدان$^{-1}$ مع لقاح الفوسفورين, الأزوتوباكتر و الطحالب الخضراء المزرقة يمكن ان تزيد محصول حبوب الذرة بـ 21.52, 22.95 و 24.45% على التوالى ومحصول الحطب بـ21.01, 23.25 و 24.68% على التوالى فى موسم 2014, ولكن هذه الزيادة فى موسم 2015 كانت كالآتى: 21.49, 22.95 و 24.42% على التوالى لمحصول الحبوب و 21.03, 23.25 و 24.67% لمحصول الحطب.