RESPONSE OF MAIZE GRAIN YIELD TO A PARTIAL SUBSTITUTION OF N-MINERAL BY APPLYING ORGANIC MANURE, BIO-INOCULATION AND ELEMENTAL SULPHUR AS AN ALTERNATIVE STRATEGY TO AVOID THE POSSIBLE CHEMICAL POLLUTION

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A field experiment was conducted on a slightly saline and alkaline sandy loam soil located at a newly reclaimed area of the eastern desert zone of El Fayoum district, El Fayoum Governorate during the growing summer season of 2010. This study aimed at evaluating the effect a partial substitution of 25 % of recommended N-mineral dose by applying organic manure (composted cattle wastes), elemental sulphur and grain bio-inoculation with *Azuspirillum barastlense* strain on maize grain yield and its quality as related to the achieved amelioration of some soil properties. So, this scientific study represents a new strategy for understanding the best usage of local soil amendments (*i.e.,* organic manure and elemental sulphur) and N-bio-sources, whether be under demand for agricultural utilization. In addition, it is considered a huge challenge and technical solution for alleviating the possible adverse fears of human health through environmental risks as a result of excessive use of the nitrogenous fertilizers as well as to support the newly technique of “bio-organic agriculture”. To achieve this target, inoculated grain of three selected maize varieties (*i.e.,* single cross 10, single cross 129 and three cross 324 hybrids) were sown under the aforementioned soil conditions and applied treatments as solely or combined ones. However, the N-mineral fertilizer, organic manure, elemental sulphur and grain bio-inoculation with salt tolerant PGPR strains N-fixer bacteria were applied at the rates of 75 % of N-recommended dose (NRD) in form of urea (46 % N), 25 m^3 fed^{-1}, 250 kg S fed^{-1}, and 300 g of bacterial culture/40 kg maize grain, respectively, comparing with the control treatment of 100 % NRD.

According to the obtained results of field work and physio-chemical characteristics, the experimental soil could be classified at a family level of "Typic Torriorthents, loamy skeletal, mixed, hyperthermic". Also, soil texture, $CaCO_3$, gypsum and salinity/alkalinity represent the main limitations for soil productivity, with an intensity degree of moderate (65 %), for soil texture and slight (> 90 %) for the other ones. The suitability classes for irrigated agriculture land in both current and potential conditions could be belong a moderately suitable class (S2), with suitability index rating ranged 50.02-55.57 %, respectively. The obtained results showed also that the studied plant parameters of maize varieties under investigation such as germination rate, shoot and radical lengths as well as vegetative growth characters (*i.e.* , plant height, leaf area, height of ear from ground surface and nutrients uptake by maize leaves), ear characters (*i.e.* , length, diameter, No. of rows and No. of grain row^{-1}), biological yield (*i.e.* , grain and straw yields fed^{-1}) grain quality (*i.e.,* weight of 100 grain, crude protein, oil, carbohydrate, ECg and nutrient contents) were recorded the greatest values at the two combined treatments of (75 % N-RD + 25 m^3 fed^{-1} organic manure + 250 kg fed^{-1} elemental sulphur) and (75 % N-RD + 20 m^3 fed^{-1} organic manure + 250 kg fed^{-1} elemental sulphur + bio-inoculation), with a superiority for the later and insignificant difference between them. These beneficial effects are more attributed to the achieved soil amelioration in the values of ECe, pH, ESP and biological N-fixation as well as released nutrients from either native source or applied organic manure, which are supported the aforementioned maize parameters.

So that, it could be recommended that organic manure, elemental sulphur and salt tolerant PGPR strains of N_2-fixer bacteria should be used to face a great problem of either soil salinity or excessive N-mineral use for the tested maize varieties. Hence, applying such treatments leading to alleviate the hazardous effect of grain chemical pollution and the environmental risks, which negatively effect on the human health. In addition, such favourable conditions should be enhance continuous bio-fixed nitrogen slow release along the growth stages of maize plants, and in turn to minimize its possible N-losses by either leaching process or volatilization and rationalize use of N-mineral fertilizers, which represents surplus point for sustainable agriculture system. This approach represents a new strategy in agriculture field that

has a long-term positive agronomic value and an effective practice of nutrient management, and in turn affects the country's economy and its development. That is true, since it is not considered only an ideal solution to meet the excessive nitrogenous fertilizers demand, but also reduce the potential hazardous contamination of both surface and natural underground waters.

Key words: Maize, saline soil, N-mineral, organic manure, elemental sulphur and salt tolerant PGPR strains bio-fertilizer.

Introduction

Since few years, World face a great problem either in the human health or in the environmental pollution. This problem is more related to the excessive use mineral or chemical fertilizers, especially those of nitrogenous ones, to maximize crop yields. Interest in the N-excessive use, it could be partially attributed to the advent of high yielding crop cultivars under assured perennial irrigation. Most of N-mineral fertilizer is a potential by NO_3^- losses in groundwater, which negatively affected human and animal health **(Sarhan *et al.,* 2002)**. In this concern, **Akalan (1983)** pointed out that addition of organic manure is one of fundamental processes to minimize the nutrients losses from soil by means leaching and denitrification as well as to improve the physico-chemical, nutritional and biological properties the treated soil. So, sustainable farming by using such organic manure in agriculture is considered to be a strategy to preserve the environment and prevent chemical pollution.

Today, there is a renewed interest in organic recycling to improve soil fertility and its productivity. Moreover, the periodical application of the natural organic wastes to soils has gained momentum in the recent past and called "organic agriculture, clean agriculture and bio-agriculture". The integrated use of the natural organic manures and mineral fertilizers is considered the best option not only for reducing the previous enormous consumption of chemical fertilizers, but also maintain soil fertility status and help to sustain crop productivity, as well as, to increase fertilizer use efficiency in the soil. Such New Agricultural Strategy alleviates the hazardous effects on the grown plants not only in agriculture fields, but also human health through toxic elements persist in the ecosystem heaving accumulated in different tropic levels of the food chain as well as the dynamic equilibrium of the biosphere **(Singh *et al*., 1999; Bhatia *et al*., 2001 and Palm *et al.,* 2001)**.

The beneficial effects of organic materials on crop yield and its components suggested by many investigators such as **Salib (2002)** who pointed out that the beneficial effect of soil treated with organic amendments was closely extended to the grown plants. The positive effect depends mainly on the C/N ratio, which plays an important role for the degree or rate of decaying. In addition, crop yield and its components responded markedly to different organic amendments used either individually or together. These beneficial effects are cleared through enhancing the chelating agent by active organic acids for micronutrients and their easily uptake by plants. **Ali (2004) and Mohammed (2004)** reported that the conjunctive use of N fertilizers and local manure organic material in the newly cultivated desert soils had favorable higher influence on either wheat or maize productivity than the recommended dose of NPK fertilizers alone. This may be due to these applied organic materials augmented soil organic matter content that increases available essential plant nutrients in the soil. Besides, such organic manure encourages the biological uptake of the released nutrients by plant roots as well as already their benefits extend to a long-term, and then positively reflected on maize grain yield and its contents of nutrients and protein.

Germanous plants such as maize are a major crop for food production, since various diazotrophic bacteria have been found in association with them; however, they are possible candidates for beneficial interactions with agriculturally important crops. **Ramadan *et al.* (2007)** stated that *P. polymyxa* was active producers of indole acetic acid and gibberellins which produced as high as 167.0 and 584 mg/L. Another effect includes an increase in mobilization of insoluble nutrients followed by enhancement of uptake by the plants **(Lifshutz *et al*., 1987)**. 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 be alleviated the adverseable effects of soil salinity on both soil and the grown plants. In this concern, **El Fayoumy and Ramadan (2002)** studied the effect of N-mineral and bio-fertilization on soil salinity and salts distribution, and they found that such fertilizers resulted in reducing the harmful effect of soil salinity. Also, **Shaban and Omer (2006)** reported that N_2-fixer strains in combination with 150 kg urea fed^{-1} showed an effective role for PGPR on maize yield under saline condition. In addition, adding organic manure as a soil amendment was more benefit for soil fertility status, due to it attains more pronounced contents of macro- (N, P and K) and micronutrients (Fe, Mn, Zn and Cu), which was consequently reflected on plant growth and yield **(Ismaiel, 2002 and Mahdy, 2003)**. So that N_2-fixer strains as a plant growth promoting rhizobacteria (PGPR) were recommended by **Noel *et al.* (1996)**. This is due to such strains can actively colonize plant roots and improved its growth and yield by direct or indirect mechanisms. Moreover, bio-fertilizers, particularly N-fixing bacteria, were suggested to reduce the used N-mineral fertilizer quantities and produce clean and healthy crops **(Mantripukhri, 2006)**.

Maize is one of the important cereal crops in Egypt needs high rates of N-mineral application, reached 300 kg urea fed^{-1} in normal soils **(Nofal and Hinar, 2003)**. These large quantities of N-mineral fertilizer, especially in the salt affected soils, cause chemical environmental pollution through drainage water or other N-contaminated water **(Mantripukhri, 2006)**. **Abbas *et al.* (2006)** bio-fertilization through seed or grain inoculation Azotobacter or Azospirillum as well as applying organic manure could minimize the dose of N-mineral required to be applied, which is a profitable from the economical point of view, and effective in reducing chemical pollution of soil with N. **George (2008)** added that, if large quantities of low N-organic matter are incorporated into soil, then legumes fix N more effectively and increase their total dry matter production. As for the beneficial role of sulphur for plant, **Lal *et al.* (1995)** pointed out that sulphur is an integral part of acylcoenzyme A that helps synthesis of more fatty acid. Also, **Ceccotti (1996)** reported that sulphur plays an important role in the primary and secondary plant metabolism as a component of protein, glucosinolates and other compounds that related to several parameters determining the nutritive quality of crops.

Therefore, the present work aimed at identifying the effective role of applied organic manure, elemental sulphur and grain bio-inoculation with *Azuspirillum barastlense* strain (salt tolerant PGPR strains N_2-fixer bacteria) as solely or combined treatments on minimizing the tolerance of maize plants grown under a slightly soil salinity condition. Evaluating the effect of a partial substitution of 25 % of recommended N-mineral by application these treatments on maize grain yield and its quality as related to the achieved amelioration of some soil properties was also taken into consideration in this study.

Materials and Methods

To achieve the aforementioned target, a field experiment was conducted on a slightly saline and alkaline sandy loam soil developed on a newly reclaimed area at the eastern desert zone of El Fayoum district, El Fayoum Governorate during the growing summer season of 2010. The tested treatments were applied on three maize varieties of single cross 10, 129 and three cross 324 hybrids) as solely or combined ones. The N-mineral fertilizer, organic manure and elemental sulphur were applied the rates of 75 % of N-recommended dose in form of urea (46 % N), 25 m^3 fed^{-1} and 250 kg fed^{-1}, respectively. *Azuspirillum barastlense* bacterium was provided by Bio-fertilizer Production Unit, Department of Microbiology, Soils, Water and Environment Research Institute, Agric. Res. Center, Giza. The bacterium was own on maximum density (10^9 cells mL^{-1}) in Difico nutrient broth medium **(Difico Manual, 1984)** for 24 hrs. Grain inoculation was performed by dipping the grains in the bacterial culture at a rate of 300 g of bacterial culture/40 kg maize grain, however, each grain received about 10^6 cells mL^{-1} using Arabic Gum as adhesive agent.

The grains were left for drying overnight before sowing. Some physical and chemical properties of the experimental soil, which were determined according to the described standard methods after **Black *et al.* (1965), Page *et al.* (1982) and Klut (1986)**, are presented in Table (1).

Table (1): Some physical, chemical and fertility characteristics of the studied soil.

Soil characteristics	Value	Soil characteristics.	Value
Particle size distribution %		ESP	15.60
Coarse sand	20.7	ECe in dS m^{-1} (*Soil paste extract*):	7.35
Fine sand	46.0	*Soluble ions in soil paste extract(m molc L^{-1}):*	
Silt	15.9	Ca^{++}	9.45
Clay	17.4	Mg^{++}	16.54
Soil texture class	Sandy loam	Na^{+}	47.85
$CaCO_3$ %	7.47	K^{+}	0.57
Gypsum %	0.65	CO_3^{--} HCO_3^{-}	0.00 4.75
Organic matter %	0.38	Cl^{-}	41.40
pH (1:2.5 soil water suspension)	8.47	SO_4^{--}	28.26

Available macro and micronutrients (mg/kg soil)						
N	P	K	Fe	Mn	Zn	Cu
21.75	4.53	148.60	3.72	1.04	0.65	0.43

Critical levels of nutrients after Lindsay and Norvell (1978) and Page et al. (1982)							
Limits	N	P	K	Fe	Mn	Zn	Cu
Low	< 40.0	< 5.0	< 85.0	< 4.0	< 2.0	< 1.0	< 0.5
Medium	40.0-80.0	5.0-10.0	85.0-170.0	4.0-6.0	2.0-5.0	1.0-2.0	0.5-1.0
High	> 80.0	> 10.0	> 170	> 6.0	> 5.0	> 2.0	> 1.0

The experimental soil is also irrigated with a saline water (a mixture of the fresh Nile water and agricultural drainage one) derived from one of Bahr Wahby branches, which could be classified as a second class (C2S2), denoting increase problems for soil salinity (C2) and sodicity (S2) are expected. The chemical characteristics of irrigation water were carried out according to the described methods and suitability criteria for irrigation after **Page *et al.* (1982) and Ayers and Westcot (1985)**, respectively, as shown in Table (2).

Table (2): Chemical characteristics of the used irrigation water.

pH	ECiw (dS/m)	Soluble cations (m molc L^{-1})				Soluble anions (m molc L^{-1})				SAR
		Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	CO_3^{2-}	HCO_3^{-}	Cl^{-}	SO_4^{2-}	
7.78	1.42	3.05	1.10	9.85	0.45	0.00	5.20	6.30	2.95	6.84

The experimental soil plots were arranged in a combined split plots design with three replicates. The area of each soil plot was 10.5 m^2 (3.0 m width x 3.5 m length). Soil plots were ploughed twice in two ways after received superphosphate fertilizer (15 % P_2O_5) at a rate of 200 kg fed^{-1}. Also, potassium sulphate (48 % K_2O) was added at a rate of 100 kg fed^{-1} in two equal doses, *i.e.*, after 15 and 40 days from planting.

The applied treatments were as follows:

a. Control, where the recommended dose of N-mineral (N-RD, 120 kg N fed^{-1}) was applied in the form of urea (46 % N).
b. Organic manure (OM) at a rate of 25 m^3 fed^{-1} + 75 % of N-RD.
c. Bio-fertilizer (BF, grain inoculation with *Azospirillum barastlense* No. 40 as a salt tolerant PGPR strain N_2-fixer bacteria) + 75 % of N-RD.
d. Elemental sulpher (ES) at a rate 250 kg fed^{-1} + 75 % of N-RD.
e. OM + BF + 75 % of N-RD.
f. OM + ES + 75 % of N-RD.
g. BF + ES + 75 % of N-RD.
h. OM + BF + ES + 75 % of N-RD.

N-mineral fertilizer was added in two equal doses, *i.e.,* after 15 and 40 days from planting. Bio-fertilizer used as maize grain inoculated with *Azospirillum barastlense* No. 40 (salt tolerant PGPR strains of N_2-fixer bacteria). Organic manure and elemental sulphur were applied during soil preparation for cultivation. Data illustrated in Table (3) showed the chemical characteristics of applied organic manure (cattle wastes).

Table (3): Chemical characteristics of the used organic manure (composted cattle wastes).

Properties	Value	Properties	Value
pH (1:10 water suspension)	7.15	Potassium %	2.35
Organic matter %	34.72	*Available micronutrients (mg kg^{-1}):*	
Organic carbon %	20.19	Fe	79.63
Total nitrogen %	1.34	Mn	36.42
C/N	15.07	Zn	24.83
Phosphorus %	0.52	Cu	9.75

Maize varieties of single cross 10, 129 and three cross 324 hybrids were sown on 5th of May for the growing summer season of 2010. Germination rate was conducted, where normal seedling counted after 8 days according to international rules after **I.S.T.A. (1993)** and expressed as germination percentages. Seedling vigor assessed by measuring shoot and radical lengths.

Vegetative growth and ear characters:

Maize plants were harvested after 120 days from planting to determine some growth characters, *i.e.*, plant height (cm), leaf area (cm^2, using planymeter), Nos. of ear plant^{-1}, ear height from ground surface (cm), ear diameter (cm^2, using planymeter), Nos. of rows ear^{-1}, Nos. of grain row^{-1} and weight of grain ear^{-1} (g).

Grain characters:

Maize grains were collected from each plot after harvesting and subjected to determine 100 grain weight (g) and grain yield (ton fed^{-1}). Representative samples of maize grains were dried at 70 ^oC, ground in a Willy Mill and digested with H_2SO_4 - H_2O_2 according to **Parkinson and Allen (1975)** to determine N, P, K **(Chapman and Pratt, 1961)**, Fe, Mn, Zn and Cu **(Hesse, 1971)**. Total carbohydrate and oil contents of maize grain were determined according to **A.O.A.C. (2000)**. Crud protein in maize grains was calculated by multiplying total N-content by 6.25 **(Deyoe and Shellenberger, 1965)**. Also, electrical conductivity (ECg) of grain leachiest was determined according to the method described by **A.O.S.A. (1983)**, however, 50 grain of each subplot were weighted and placed into flask with 250 ml of distilled water and held at 25 °C for 25 h, then the electrical conductivity in µs cm^{-1} was measured using the conductivity meter. The ECg for one gram of grain was calculated as follows:

$$ECg\ (\mu s\ cm^{-1})\ \text{for each flask/weight of grain sample (g)} = \mu s\ cm^{-1}\ g^{-1}$$

Soil characters:

Topsoil samples (0-50 cm) were collected from all the experimental plots at a maximum growth stage, air-dried, crushed and sieved through a 2 mm sieve and analyzed for soil ECe, pH, ESP and available nutrient contents according to the aforementioned methods used for analytical data of the initial soil. The data obtained of the tested plant characters were subjected to the statistical analysis according to **Snedecor and Cochran (1980)** to define the least significant difference test (L.S.D. at p=0.05 level), which was used to verify the differences between the tested treatments.

Results and Discussion

I. A general view on the experimental soil:

The experimental sandy loam soil represents some newly reclaimed areas of the scattered Private Farms at the eastern desert rim of El Fayoum district that are mainly encompassing the fluvio-aeolian plain of sandy loam in texture. It is developed under climatic conditions of long hot rainless summer and short mild winter, with scarce amounts of rainfall. Data illustrated in Table (1) indicate that the ECe value was 7.35 dS m^{-1} as well as ESP value was 15.60 %, hence the studied soil were surveyed as either slight saline or slight sodic one. Such results are emphasized by the progressive increments of soluble Na^{+}, which surpassed the soluble (Ca^{2+}+Mg^{2+}) contents that reflected the signs of unfavourable soil aggregation, with weak granular as a structure type. In addition, the field work showed that the studied soil profile at the experimental field was characterized by a moderate effective soil depth of 90-100 cm due to the occurrence of water table. The later condition is confirmed by few mottling phenomena in the subsoil of profile layers, which reflected the signs of imperfect soil aeration.

The analytical data in Table (1) reveal that the studied sandy loam soil attains a relatively moderate $CaCO_3$ content. In addition, the prevailing hot and arid climatic may be ascribed to the low accumulated plant residues (low organic matter content) and soil pH tended to be the alkaline side. As for soil fertility status, the studied soil was mostly suffering from macro and micronutrients deficient, due to the skeletal nature of such desert sandy loam soil that is poorer in nutrient-bearing minerals, as shown in Table (1). According to the critical levels of the studied available nutrients after **Lindsay and Norvell (1978) and Page *et al.* (1982),** the experimental soil is suffering from plant nutrients deficiency, as shown from data illustrated in Table (1). Thus, supplying essential elements for these nutrients is undoubtedly of great importance, especially for the micronutrient deficient.

II. Soil taxonomy and evaluation in the current and potential conditions:

According to the obtained results of field work and physio-chemical characteristics as well as based on the outlines of classification system **(USDA, 2006)**, the experimental soil could be classified at a family level of "Typic Torriorthents, loamy skeletal, mixed, hyperthermic. Also, a parametric system of soil evaluation, undertaken by **Sys and Verheye (1978)**, was applied to define the limitations for soil productivity, their intensity degrees and suitability classes for irrigated agriculture land, as shown in Table (4).

Table (4): Soil limitations and rating indices for evaluating the studied soil.

Suitability condition	Topography (t)	Wetness (w)	S: Soil texture (s_1)	S: Soil depth (s_2)	S: $CaCO_3$ (s_3)	S: Gypsum (s_4)	Soil salinity/ Alkalinity (n)	Rating (Ci)	Suitability class	Suitability subclass
Current	100	100	65	100	95	90	90	50.02	S3	S3s_1
Potential	100	100	65	100	95	90	100	55.57	S3	S3s_1

The obtained data show that soil texture (s_1), $CaCO_3$ (s_3), gypsum (s_4) and salinity/alkalinity represent the main limitations for soil productivity, with an intensity degree of moderate (65 %), for soil texture and slight (> 90 %) for the other ones. Also, the suitability classes in the current and potential cases of the studied soil could be categorized as a moderately suitable for irrigated agriculture land (S2), with suitability index rating (Ci) ranged 50.02-55.57 %.

III. Response of some soil properties and available nutrient contents to the applied treatments:

Data in Table (5) showed an obvious clear response for some soil properties (*i.e.,* pH, ECe and ESP) and available nutrient contents to the applied treatments, particularly the triple combined ones. Generally, the beneficial effect of the applied treatments, especially those included organic manures, on an increment of available nutrient contents in the soil may be attributed to their slow release during the decomposition and mineralization processes as well as minimizing their possible lose by leaching throughout the studied relatively coarse texture soil **(Mohammed, 2004)**. Moreover, the integrated role of applied organic manure plus bio-fertilizer was more pronounced for nutrients availability in the soil, may be the released active organic acids during microbial activity that enhancing the solubilization of nutrient from the native and added sources.

Table (5): Effect of applied treatments on some soil properties and available nutrients status.

Soil properties & nutrients status	Maize varieties (V)	Applied treatments (T)							
		Control* (100% N-RD)	OM +75% N-RD	BF +75% N-RD	ES +75% N-RD	OM+BF +75% N-RD	OM+ES +75% N-RD	BF+ES +75% N-RD	OM+BF+ ES+75% N-RD
Soil properties									
pH	S.C.10	8.40	7.95	8.23	7.71	7.84	7.53	7.65	7.47
	S.C.129	8.46	8.00	8.28	7.75	7.88	7.57	7.69	7.51
	Th.C.324	8.44	7.98	8.26	7.73	7.86	7.55	7.67	7.48
ECe ($dS\ m^{-1}$)	S.C.10	7.20	6.80	7.00	6.55	6.65	6.38	6.48	6.32
	S.C.129	7.29	6.90	7.20	6.75	6.85	6.67	6.77	6.60
	Th.C.324	7.26	6.85	7.15	6.70	6.80	6.52	6.62	6.46
ESP	S.C.10	13.74	12.00	12.60	11.85	11.95	11.10	11.70	10.45
	S.C.129	13.52	11.98	12.36	11.21	11.80	11.05	11.52	10.20
	Th.C.324	13.36	11.76	12.15	11.10	11.50	11.25	11.42	10.85
Available macro and micronutrients ($mg\ kg^{-1}$)									
N	S.C.10	62.50	65.74	54.50	47.25	72.50	68.05	61.15	78.54
	S.C.129	61.94	63.92	52.46	45.38	70.04	65.80	60.47	75.15
	Th.C.324	60.80	62.40	49.34	42.50	69.75	64.97	59.70	64.40
P	S.C.10	4.55	6.15	5.25	5.90	6.90	7.05	6.00	7.54
	S.C.129	4.50	6.02	5.10	5.73	6.64	6.75	5.85	7.15
	Th.C.324	4.47	5.95	5.05	5.65	6.25	6.40	5.74	6.98
K	S.C.10	159.54	197.42	175.50	184.74	209.85	214.15	190.35	220.50
	S.C.129	157.85	195.65	174.15	183.70	208.69	212.95	189.25	219.40
	Th.C.324	158.42	196.10	175.30	185.30	210.45	214.75	190.90	221.12
Fe	S.C.10	3.80	5.85	5.09	5.65	6.50	6.65	5.75	7.05
	S.C.129	3.75	5.75	5.00	5.55	6.40	6.54	5.65	6.95
	Th.C.324	3.78	5.80	5.05	5.60	6.45	6.57	5.70	7.00
Mn	S.C.10	0.91	1.23	1.05	1.18	1.40	1.45	1.25	1.60
	S.C.129	0.89	1.20	1.02	1.15	1.35	1.40	1.20	1.50
	Th.C.324	0.93	1.25	1.07	1.20	1.40	1.43	1.22	1.55
Zn	S.C.10	0.64	1.07	0.95	1.05	1.20	1.25	1.10	1.35
	S.C.129	0.62	1.03	0.91	1.00	1.15	1.17	1.02	1.25
	Th.C.324	0.65	1.08	0.95	1.05	1.19	1.22	1.07	1.30
Cu	S.C.10	0.40	0.85	0.77	0.83	0.94	0.95	0.85	1.00
	S.C.129	0.43	0.90	0.80	0.87	0.97	0.98	0.88	1.05
	Th.C.324	0.42	0.88	0.79	0.85	0.95	0.97	0.87	1.02

Statistical analysis (L.S.D. at 0.05)			
Soil properties	Treatment (T)	Varieties (V)	T x V
pH	0.02	0.03	0.02
ECe	0.02	0.04	0.3
ESP	1.11	0.95	0.99
N	2.91	3.11	4.31
P	0.57	0.71	0.93
K	1.24	2.25	3.98
Fe	0.12	0.57	0.77
Mn	0.03	0.13	0.21
Zn	n.s.	n.s.	0.05
Cu	n.s.	n.s.	0.08

*100% of recommended N-mineral dose (N-RD), OM=Organic manure, BF=Bio-fertilizer, ES=Elemental sulphur
S.C. 10=Single cross and Th.C.=Three cross hybrids

Also, the effective role of organic manure plus sulphur was commonly achieved by lowering soil pH, and in turn encouraging the availability of plant essential nutrients, especially phosphorus and micronutrients that forming organo-metalic compounds of chelated micronutrients. The later represent the next superior available forms, this is due to a higher portion of these compounds still in maintained active ones for extended period. The superiority of combined effects of applied organic manure, bio-fertilizer and elemental sulphur treatments for the noticeable reduction in the values of soil pH, ECe and ESP vs a pronounced increase in soil available nutrient contents and biological conditions that enhancing nutrients uptake by plants could be interpreted as follows:

i. Organic compost decomposition tends to accelerate in the presence of microbial media of bio-fertilizer, and in turn produces active organic and inorganic acids that led to decrease soil pH as well as they have used to chelate metals (Fe, Mn, Zn and Cu). These chelated metal cations are not sensitive to the restriction or the adverseable effects of alkaline side, consequently they are found as strategic storehouse in organo-metalic compounds that are more suitable for uptake by plant roots.
ii. Elemental sulphur can be oxidized by many soil micro-organisms and forming sulphuric acid, consequently it reacts with soil $CaCO_3$ resulting in $CaSO_4$. The latter can be ionized to Ca^{2+} and SO_4^{2-}, then Ca^{2+} can be improved soil aggregation and permeability and SO_4^{2-} reduced soil pH. These results are in agreement with those obtained by **Awadalla *et al.* (2003)**.
iii. The released soluble Ca^{2+} partial substitution by exchangeable Na and leads to coagulate Na-separated clay particles due to the replacement of sodium by calcium leading to reduce ESP value and forming small clay domains. Such clay domains are coated with the released active organic acids, and then forming coarse sizes of water stable aggregates isolated or separated by conductive coarse pores that are accelerating leaching of a pronounced content of soluble salts and reducing the ECe value.
iv. The effective role of microbial activity to reduce soil salinity stress, particularly in a combination with either organic or sulphur sources, could be interpreted according to many opinions outlined by **El-Fayoumy and Radwan (2002), Bacilio *et al.* (2003), Shaban and Omar (2006) and Ashmaye *et al.* (2008)** who reported that many strains produce several phytohormones (*i.e.,* indole acetic acid and cytokinins) and organic acids. Such products reduce the deleterious effect of Na-salts, and then simultaneously improving soil structure, *i.e.,* increasing aggregate stability and drainable pores. Consequently, these created conductive pores enhancing the leaching process of soluble salts through irrigation fractions.

IV: Plant parameters as affected by ameliorating soil properties:

a. Vigor testing and vegetative growth characters:

Data in Tables (6 and 7) indicate that the achieved favourable soil conditions due to the applied treatments, particularly the triple combined ones, were positively reflected on the studied values of vigor testing (*i.e.,* germination rate, shoot and radical lengths) and vegetative growth characters (*i.e.,* plant height, leaf area and ear height from ground surface) and nutrient contents in maize leaves) as compared to the solely ones.

Table (6): Effect of applied treatments on germination rate, shoot and radical lengths of maize.

Vigor test	Maize varieties (V)	Applied treatments (T)							
		Control* (100% N-RD)	OM +75% N-RD	BF +75% N-RD	ES +75% N-RD	OM+BF +75% N-RD	OM+ES +75% N-RD	BF+ES +75% N-RD	OM+BF+ ES+75% N-RD
Germination rate %	S.C.10	83.64	82.57	80.25	78.05	94.98	90.12	87.32	95.42
	S.C.129	81.20	80.74	78.34	75.93	93.02	89.74	86.02	93.50
	Th.C.324	78.15	76.89	75.60	73.75	90.46	86.95	84.65	90.97
Shoot length (cm)	S.C.10	16.75	16.40	15.85	14.52	22.76	20.14	18.08	23.10
	S.C.129	16.00	15.79	15.21	13.67	22.00	19.35	17.73	22.96
	Th.C.324	14.32	14.01	13.64	12.75	19.87	17.20	15.65	20.34
Radical length (cm)	S.C.10	8.75	8.40	8.15	7.84	14.05	13.10	10.92	14.12
	S.C.129	8.24	8.00	7.92	7.70	13.42	12.85	10.50	13.84
	Th.C.324	7.82	7.53	7.35	6.95	12.00	11.03	9.38	12.35

Statistical analysis (L.S.D. at 0.05)			
Vigor test	Treatment (T)	Varieties (V)	T x V
Germination rate %	1.72	2.20	3.91
Shoot length (cm)	0.73	1.01	1.95
Radical length (cm)	0.51	0.95	2.75

*100% of recommended N-mineral dose (N-RD), OM=Organic manure, BF=Bio-fertilizer, ES=Elemental sulphur
S.C. 10=Single cross and Th.C.=Three cross hybrids

So, it could be arranged the applied treatments according to their favourable conditions as shown in the following an ascending order, as follows: (OM + BF + ES +

75% N-RD) ≥ (OM + BF + 75% N-RD) > (OM + ES + 75% N-RD) > (BF + ES + 75% N-RD) > (100% N-RD) ≥ (OM + 100% N-RD) > (BF + 75% N-RD) > (ES + 75% N-RD). Also, it is noteworthy to mention that the applied combined treatments of (OM+BF+ES+75%N-RD) and (OM+BF+75%N-RD) were achieved the greatest values with insignificant difference. On the other hand, the lowest value was associated with the treatment of (ES+75%N-RD), which was usefulness than the treatments of (100%N-RD) ≥ (OM+100%N-RD) > (BF+75%N-RD). With respect to the positive response of the tested maize varieties to the applied treatments, the obtained data reveal that single cross 10 hybrids surpassed the other two ones, *i.e.*, single cross 129 followed by three cross 324 hybrids. Such slightly variations detected among the tested three maize varieties could be attributed to their different genetic constitutions.

Table (7): Effect of applied treatments on some growth characters of maize plants.

Growth character	Maize varieties (V)	Applied treatments (T)							
		Control* (100% N-RD)	OM +75% N-RD	BF +75% N-RD	ES +75% N-RD	OM+BF +75% N-RD	OM+ES +75% N-RD	BF+ES +75% N-RD	OM+BF+ ES+75% N-RD
Plant height (cm)	S.C.10	201.5	198.9	193.4	188.0	227.8	216.0	209.3	229.7
	S.C.129	204.6	201.8	196.2	190.8	232.3	220.4	213.6	234.4
	Th.C.324	205.1	202.5	196.8	191.4	233.0	221.2	214.2	235.9
Leaf area (cm^2)	S.C.10	315.7	311.7	302.9	294.5	358.4	340.0	329.4	360.0
	S.C.129	368.4	363.6	353.7	344.0	418.1	396.7	384.5	421.6
	Th.C.324	376.8	371.4	360.5	350.7	426.7	404.8	392.7	428.2
Ear height from ground surface (cm)	S.C.10	83.2	82.3	79.8	77.6	94.5	89.6	86.8	95.0
	S.C.129	95.5	94.2	91.6	89.1	108.2	102.7	99.5	109.7
	Th.C.324	98.3	97.0	94.3	91.7	111.6	105.9	102.9	113.5

Statistical analysis (L.S.D. at 0.05)			
Growth character	Treatment (T)	Varieties (V)	T x V
Leaf area (cm^2)	0.95	9.20	2.20
Plant height (cm)	11.50	5.10	15.70
Ear height from ground	3.40	3.20	1.70

*100% of recommended N-mineral dose (N-RD), OM=Organic manure, BF=Bio-fertilizer, ES=Elemental sulphur S.C. 10=Single cross and Th.C.=Three cross hybrids

It is noteworthy to mention that grain inoculation with strains N_2-fixer bacteria in combination with organic manure gave significant increases in the vigor test parameters as compared to N-mineral fertilizer (urea) when solely added. That was true, since the combination between bio-fertilizer and organic manure enhancing and sustaining the increase in the values of germination rate, shoot and radical lengths. Moreover, such combination is more attributed to enrich in both organic and mineral substances essential to plant growth, stimulating and activating the bio-chemical processes in plant organs, *i.e.,* respiration, photosynthesis, chlorophyll content, vital enzymes and hormonal stimulating, which increasing photosynthetic activity. Such favourable condition of soil fertility was reflected on vegetative growth characters of the grown maize plants, mainly owing to the applied organic and bio-fertilizers are not only improving soil fertility but also assisting maize plants to tolerant soil salinity and sodicity. In addition, combining both fertilizers with elemental sulphur and N-mineral led to a markedly increase in growth characters, this is due to their outcomes are essentially for creation of protoplasm, and hence producing new cells and new leaves of maize plants that lead to a larger leaf area available for photosynthesis and increase dry matter accumulation.

In this connection, **Atta-Allah (1998)** reported that application of bio-fertilizer treatments significantly increased plant height, leaf area, ear height from ground surface, ear length and diameter. Also, **Griesh *et al.* (2001)** found that application of 80 kg N/fed in combination with bio-fertilizer gave the highest means for all plant characters of three local maize varieties, except of number of rows/ear that shows insignificant affect by the applied treatments, due to it is rarely influenced by cultural practices as compared with other character. In addition, **Bakry *et al.* (2005)** reported that applying the bacterial fertilizer to the experimental soil influenced the most test characters in the direction of improving growth, photosynthesis and dry matter accumulation of the plant. Also, the increase in plant synthetic pigments as a result of bacterial inoculation may be attributed to increases in fixed nitrogen in plants via an increase of N_2-ase enzyme activity of bacteria, where nitrogen is a major component of chlorophyll.

b. Plant nutrient contents as affected by ameliorating soil properties:

The data of of macro- and micro-nutrients (N, P, K, Fe, Mn, Zn and Cu) uptake by maize plants at vegetative growth stage are presented in Table (8). The obtained results exhibited pronounced increases due to the applied combined treatments that are contain organic manure as compared to the control treatment (100 % N-RD). On the other hand, the applied solely and some combined treatments were usefulness for the released available nutrients, and in turn their contents in plant tissues. Such surpassed effect of organic manure in the combined treatments is more associated with to the relatively high contents of both essential macro- and micro-nutrients (N, P, K, Fe, Mn, Zn and Cu), the released active organic acids that enhancing more released micronutrients or their solubilization from both native or added sources as well the favourable biological conditions that are keeping them in as a storehouse of organo-metalic forms for extended period and their mobility for uptake by plant roots.

Table (8): Effect of applied treatments on nutrient contents in maize leaves after 75 days from planting.

Nutrient	Maize varieties (V)	Applied treatments (T)							
		Control* (100% N-RD)	OM +75% N-RD	BF +75% N-RD	ES +75% N-RD	OM+BF +75% N-RD	OM+ES +75% N-RD	BF+ES +75% N-RD	OM+BF+ ES+75% N-RD
Macronutrients %									
N	S.C.10	4.25	4.10	3.94	3.52	4.25	4.03	3.90	4.46
	S.C.129	3.78	3.64	3.55	3.28	4.00	3.79	3.65	4.10
	Th.C.324	4.10	3.98	3.70	3.35	4.08	3.87	3.75	4.30
P	S.C.10	0.37	0.34	0.31	0.29	0.35	0.33	0.32	0.39
	S.C.129	0.32	0.29	0.26	0.25	0.30	0.28	0.27	0.33
	Th.C.324	0.35	0.32	0.29	0.27	0.33	0.31	0.30	0.37
K	S.C.10	3.07	2.85	2.74	2.60	3.16	3.00	2.85	3.35
	S.C.129	2.88	2.71	2.62	2.49	3.05	2.89	2.80	3.25
	Th.C.324	2.95	2.75	2.70	2.55	3.10	2.95	2.84	3.30
Micronutrients (mg kg^{-1} dry weight)									
Fe	S.C.10	184.20	178.64	173.56	166.67	202.85	192.60	186.59	205.90
	S.C.129	167.96	164.85	160.30	153.90	187.27	177.73	172.20	189.75
	Th.C.324	179.55	176.59	172.05	165.15	200.79	190.52	184.60	203.84
Mn	S.C.10	86.25	84.05	81.17	77.75	94.61	89.75	86.96	95.67
	S.C.129	77.40	75.40	72.82	70.05	85.18	80.80	78.30	87.50
	Th.C.324	84.63	82.91	80.66	76.95	93.70	88.90	86.15	94.82
Zn	S.C.10	35.24	33.50	32.58	31.20	37.96	36.05	34.90	39.25
	S.C.129	32.00	30.84	29.30	27.84	33.85	32.10	31.00	35.05
	Th.C.324	33.05	32.70	31.15	29.76	36.21	34.35	33.30	38.74
Cu	S.C.10	14.10	13.60	13.00	12.45	15.15	14.35	13.90	16.89
	S.C.129	12.15	11.75	11.23	10.78	13.22	12.55	12.15	14.73
	Th.C.324	13.94	13.20	12.78	12.27	14.93	14.10	13.65	15.94

Statistical analysis (L.S.D. at 0.05)			
Nutrient	Treatment (T)	Varieties (V)	T x V
N	0.71	0.30	0.54
P	0.03	0.05	0.07
K	0.51	0.42	0.37
Fe	12.51	10.91	3.78
Mn	2.13	1.95	2.99
Zn	0.34	0.17	0.78
Cu	1.00	0.51	0.75

*100% of recommended N-mineral dose (N-RD), OM=Organic manure, BF=Bio-fertilizer, ES=Elemental sulphur
S.C. 10=Single cross and Th.C.=Three cross hybrids

In general, the favourable effect of the combined treatments attained organic manure or elemental sulphur was commonly achieved due to lowering soil pH that improving nutrients availability, mobility, reliability and ability to uptake by plant roots. Also, the superiority of applied treatments attained organic manure plus bio-fertilizer was more attributed to their enrichment in the organic substances that ameliorate soil-moisture regime and the biological soil condition, which have ability to reserve the released nutrients as a storehouse in available forms to uptake by plant roots. Also, it had a great extent favourable effect on the mobilization of the released nutrients as compared to the NPK treatment alone. This beneficial effect could be explained by many aspects, *i.e.*, increasing the released either macro- or micro-nutrient contents through the decomposition of the applied manures, reduction of nutrient fixation and forming the stable complexes of micronutrients-humic substances supplied from such manures and keeping them in available forms for extended period **(Shanmugam and Veeraputhran, 2001)**. Moreover, the organic mater treated soils are characterized by nutrients slow release during organic material decomposition and mineralization processes as well as minimizing their possible lose by leaching process through such a relatively coarse textured soil.

So, the combined treatment of (OM + BF + ES + 75% N-RD) exhibited a superior effect due to improving soil physico-chemical properties by using the triple soil amendments, *i.e.,* organic manure, bio-fertilizer and elemental sulphur that positively affect the nutrients availability as well as maintaining a suitable soil moisture regime, which showed a pronounced positive effect on the biological activity in soil. Also, such favourable effect extends to reduce soil pH, mainly due to the integrated action of the released active organic acids and S-transformation to H_2SO_4, respectively, besides the possible released phosphate ions by sulfate ions **(El Tapey and Hassan, 2002)**. It is noteworthy to mention that the nutrient contents in plant tissues were, in general, extending parallel close to the corresponding available nutrient contents in the studied soil, as shown in Tables (5 and 8).

The slightly variations detected for nutrients uptake by the tested three maize varieties could be attributed to their different genetic constitutions **(Mahgoub and El-Sayed, 2001)**. This may be due to differing rates of absorption, translocation and utilization between the tested varieties.

c. Ear characters, grain and straw yields of maize as affected by soil amelioration:

The beneficial effects of the applied treatments were greatly supported by the values of ear characters (*i.e.,* length, diameter, Nos. of rows and grain row^{-1}), as shown in Table (9), which can be explained on the basis that the organic manure treated soil plots became enriched in the released nutrient contents, especially those of micronutrients, which are involved directly or indirectly 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 **(Nassar *et al*., 2002)**. In addition, the aforementioned results came to a conclusion that the applied treatments, especially those included organic manure, led to improve soil physico-chemical, hydrological and biological characteristic, and then its fertility status. Such positively effects are reflected on soil productivity and returned on increasing the biological nutrients uptake by maize, and then increasing maize grain yield and its quality (Tables, 10, 11 and 12).

Also, the applied organic manure is enrichments in both organic and mineral substances essential to plant growth and activating the bio-chemical processes in plants, *i.e.*, respiration, photosynthesis and chlorophyll content, which increased the grain quality and quantity **(Hegazi, 2004)**. However, the obtained data showed that addition of the triple materials, *i.e.,* organic manure, elemental sulphur and bio-fertilizer to the studied soil, which is characterized by relatively coarse texture and suffering from either salinity or sodicity, increased the biological yield of maize (*i.e.,* grain and straw yields). It is noteworthy to mention that these increases were attributed to a long-term positive agronomic value due to a higher portion of the released nutrients and to improve soil characteristics as well as its capacity to gradually liberate available plant nutrients that are still in maintained active forms for uptake by plant roots. That mean an integrated supply of nutrients through organic and inorganic sources could be an effective practice of nutrient management by reducing N-inorganic rate or nutrient losses. These results are in agreement with those obtained by many investigators on different field crops, such as **Soliman (1980)** for Zn, **Baza *et al.* (1989)** for Fe and **Basyouny (2005)** for Mn and Cu. In general, the optimum grain and straw yields of maize were extending parallel close to the corresponding available nutrient contents in the soil, as shown in Tables (5 and 10).

Table (9): Effect of applied treatments on ear characters of maize.

Ear character	Maize varieties (V)	Applied treatments (T)							
		Control* (100% N-RD)	OM +75% N-RD	BF +75% N-RD	ES +75% N-RD	OM+BF +75% N-RD	OM+ES +75% N-RD	BF+ES +75% N-RD	OM+BF+ ES+75% N-RD
Ear length (cm)	S.C.10	21.45	20.70	19.85	17.60	21.35	20.10	19.15	23.30
	S.C.129	20.23	19.55	18.70	16.59	20.57	19.53	18.67	21.98
	Th.C.324	19.57	18.90	18.15	16.00	19.48	18.29	17.55	20.69
Ear Diameter (cm^2)	S.C.10	31.75	30.69	29.50	26.15	31.75	29.90	28.85	33.45
	S.C.129	30.94	29.85	28.70	25.40	30.85	29.00	27.76	32.70
	Th.C.324	30.41	29.30	28.20	25.00	30.40	28.65	27.54	31.89
No. of rows ear^1	S.C.10	13.25	12.78	12.30	10.90	13.25	12.45	11.90	14.65
	S.C.129	13.07	12.60	12.00	10.65	12.95	12.19	11.70	13.95
	Th.C.324	12.78	12.25	11.75	10.40	12.60	11.85	11.40	13.36
Nos. of grains row^1	S.C.10	41.50	40.05	38.45	34.10	41.47	39.00	37.35	42.75
	S.C.129	37.84	36.50	35.00	31.25	37.95	35.76	34.20	39.15
	Th.C.324	36.65	35.64	34.25	30.35	36.75	34.60	33.12	37.97
Weight of grains ear^1 (g)	S.C.10	159.74	155.10	148.54	131.70	160.00	151.88	146.13	171.40
	S.C.129	145.45	140.40	134.75	119.65	145.30	136.93	132.05	152.95
	Th.C.324	143.90	139.80	133.98	118.75	145.29	136.75	131.60	151.60

Statistical analysis (L.S.D. at 0.05)

Ear character	Treatment (T)	Varieties (V)	T x V
Ear length (cm)	1.31	1.77	2.11
Ear Diameter (cm^2)	0.82	0.95	0.91
Nos. of rows ear^1	0.13	0.87	0.57
Nos. of grains row^1	2.11	5.71	1.77
Weight of grains ear^1 (g)	3.40	3.20	2.24

*100% of recommended N-mineral dose (N-RD), OM=Organic manure, BF=Bio-fertilizer, ES=Elemental sulphur
S.C. 10=Single cross and Th.C.=Three cross hybrids

Table (10): Effect of applied treatments on weight of 100 grain, grain and straw yields.

Grain and straw characters	Maize varieties (V)	Applied treatments (T)							
		Control* (100% N-RD)	OM +75% N-RD	BF +75% N-RD	ES +75% N-RD	OM+BF +75% N-RD	OM+ES +75% N-RD	BF+ES +75% N-RD	OM+BF+ ES+75% N-RD
Weight of 100 grain (g)	S.C.10	28.54	27.60	26.45	23.55	28.74	27.05	25.70	31.25
	S.C.129	27.65	26.71	25.64	22.75	27.60	26.00	24.84	30.32
	Th.C.324	27.23	26.47	25.40	22.60	27.45	25.85	24.65	30.04
Grain yield (kg fed^{-1})	S.C.10	2376.25	2298.50	2200.10	1949.96	2365.50	2225.00	2120.80	2585.40
	S.C.129	2109.70	2040.70	1955.90	1735.20	2105.90	1980.60	1879.76	2290.10
	Th.C.324	2035.93	1969.35	1887.50	1675.54	2035.64	1918.49	1825.94	2220.65
Straw yield (kg fed^{-1})	S.C.10	4158.30	4022.30	3856.15	3420.25	4150.58	3905.95	3720.35	4525.58
	S.C.129	3947.50	3818.75	3660.95	3250.65	3945.35	3715.55	3540.68	4310.00
	Th.C.324	4079.84	3945.45	3782.50	3355.70	4071.72	3835.30	3655.00	4450.75

Statistical analysis (L.S.D. at 0.05)

Grain & straw characters	Treatment (T)	Varieties (V)	T x V
Weight of 100 grain (g)	0.77	0.82	0.81
Grain yield (ton fed^{-1})	73.22	87.12	97.83
Straw yield (ton fed^{-1})	44.71	51.71	64.22

*100% of recommended N-mineral dose (N-RD), OM=Organic manure, BF=Bio-fertilizer, ES=Elemental sulphur
S.C. 10=Single cross and Th.C.=Three cross hybrids

Thus, the positive roles of both combined treatments (OM + BF + 75% N-RD) and (OM + BF+ ES+75% N-RD) are more attributed to improve the efficiency of either nutrients released or uptake and enhancing dry matter yield, and in turn the grain quality of maize. These results are also in the line with those obtained by **Aly (2003)** who stated that some bacteria such as *Azotobacter chroococcum* and *Paenibacillus polymyxa* are capable to produce some hormones which induces the proliferation roots and root hair that increase nutrient absorbing surfaces as well as produce organic acids, which solublize inorganic and organic forms of mineral elements, and consequently increase stems and leaves then the straw and grain yields.

Table (11): Effect of applied treatments on maize grain contents of macro- and micro-nutrients.

Grain content of nutrients	Maize varieties (V)	Applied treatments (T)							
		Control* (100% N-RD)	OM +75% N-RD	BF +75% N-RD	ES +75% N-RD	OM+BF +75% N-RD	OM+ES +75% N-RD	BF+ES +75% N-RD	OM+BF+ ES+75% N-RD
Macronutrients %									
N	S.C.10	1.52	1.47	1.41	1.33	1.69	1.63	1.58	1.75
	S.C.129	1.48	1.42	1.36	1.30	1.64	1.58	1.53	1.70
	Th.C.324	1.40	1.39	1.34	1.27	1.60	1.54	1.50	1.65
P	S.C.10	0.39	0.36	0.32	0.29	0.46	0.44	0.41	0.49
	S.C.129	0.36	0.35	0.32	0.28	0.44	0.42	0.39	0.47
	Th.C.324	0.34	0.32	0.30	0.25	0.41	0.38	0.36	0.43
K	S.C.10	2.15	2.05	1.92	1.84	2.39	2.30	2.22	2.47
	S.C.129	1.97	1.89	1.80	1.71	2.20	2.14	2.05	2.28
	Th.C.324	1.78	1.71	165	1.59	1.98	1.92	1.85	2.06
Micronutrients (mg kg^{-1})									
Fe	S.C.10	70.85	67.02	63.90	59.57	81.95	78.40	74.04	84.76
	S.C.129	69.20	65.95	61.79	57.97	79.24	75.73	73.15	82.92
	Th.C.324	65.47	61.48	57.82	53.65	75.80	72.92	68.70	79.85
Mn	S.C.10	57.55	55.10	53.64	51.20	62.05	60.47	58.82	64.12
	S.C.129	55.09	53.35	51.57	49.84	61.73	59.60	56.98	63.94
	Th.C.324	52.40	50.74	48.65	45.92	57.15	55.98	54.30	59.63
Zn	S.C.10	38.36	36.60	35.08	34.25	44.64	42.75	39.85	46.18
	S.C.129	37.90	36.15	34.73	32.94	43.20	41.65	39.76	44.79
	Th.C.324	34.76	32.89	31.30	29.80	38.04	36.95	35.49	39.30
Cu	S.C.10	10.54	10.02	9.41	8.92	12.47	11.83	11.15	13.08
	S.C.129	9.72	8.97	8.35	7.70	11.59	10.77	10.23	12.14
	Th.C.324	8.35	7.90	7.28	6.94	9.80	9.34	8.87	10.25

Statistical analysis (L.S.D. at 0.05)			
Grain content of nutrients	Treatment (T)	Varieties (V)	T x V
N	n.s.	n.s.	0.13
P	0.05	n.s.	0.17
K	0.11	n.s.	0.23
Fe	1.29	0.51	2.12
Mn	2.43	1.23	1.81
Zn	1.89	1.99	3.42
Cu	0.93	0.43	1.13

*100% of recommended N-mineral dose (N-RD), OM=Organic manure, BF=Bio-fertilizer, ES=Elemental sulphur
S.C. 10=Single cross and Th.C.=Three cross hybrids

The significantly response of nutrients contents in maize grain to bio-inoculation, soil application of organic manure and elemental sulphur may be due to increased root growth and utilization of N released from bio-fixation along the different growth stages enable the grown plants to absorb more nutrients. These findings are in agreement with those reported by **Kloepper (2003**) who pointed out that phytohormones producer bacteria causes pronounced increases for plant root elongation by then uptake of more nutrients via the root system, and hence utilization of N as a result of bio-inoculation. This is mainly due to the applied inoculants of bacteria play a dual role by fixation of atmospheric N and producing antimicrobial agents against deleterious rhizosphere bacteria. Also, **Lifshitz *et al*. (1987)** reported that bio-inoculation effect includes an increase in immobilization of insoluble nutrients followed by enhancement of uptake by the plants. These results are also in a line of those obtained by **Massoud *et al*. (2004)** who repoted that inoculation with N_2-fixer bacteria increased uptake of N, P, K, Fe, Zn, and Mn by plants.

Table (12): Effect of applied treatments on grain contents of carbohydrate, protein, oil and ECg of maize.

Grain content of	Maize varieties (V)	Applied treatments (T) Control* (100% N-RD)	OM +75% N-RD	BF +75% N-RD	ES +75% N-RD	OM+BF +75% N-RD	OM+ES +75% N-RD	BF+ES +75% N-RD	OM+BF+ES+75% N-RD
Carbohydrate %	S.C.10	70.46	70.12	69.85	69.45	71.40	71.05	70.70	71.85
	S.C.129	69.58	69.25	69.00	68.65	70.54	70.20	69.85	70.72
	Th.C.324	68.65	68.47	68.25	67.80	69.72	69.40	68.97	70.08
Protein %	S.C.10	9.50	9.16	8.82	8.32	10.59	10.17	9.85	10.94
	S.C.129	9.25	8.90	8.51	8.13	10.00	9.87	9.54	10.60
	Th.C.324	8.75	8.55	8.35	7.95	10.05	9.65	9.40	10.35
Oil %	S.C.10	2.30	2.24	2.19	2.14	2.56	2.47	2.38	2.69
	S.C.129	2.21	2.18	2.14	2.10	2.50	2.40	2.32	2.62
	Th.C.324	2.17	2.15	2.10	2.05	2.46	2.35	2.28	2.59
ECg ($\mu s\ cm^{-1}\ g^{-1}$)	S.C.10	5.05	3.30	3.05	3.59	3.49	3.94	3.75	4.32
	S.C.129	5.17	3.37	3.23	3.64	3.55	4.07	3.80	4.40
	Th.C.324	5.36	3.54	3.42	3.85	3.73	4.25	4.04	4.71

Statistical analysis (L.S.D. at 0.05)

Grain content of	Treatment (T)	Varieties (V)	T x V
Carbohydrate %	0.95	0.51	1.11
Protein %	0.24	0.11	0.32
Oil %	n.s.	n.s.	0.05
ECg ($\mu s\ cm^{-1}\ g^{-1}$)	n.s.	n.s.	n.s.

*100% of recommended N-mineral dose (N-RD), OM=Organic manure, BF=Bio-fertilizer, ES=Elemental sulphur
S.C. 10=Single cross and Th.C.=Three cross hybrids

Concerning the influence of applied treatments on maize grain contents of carbohydrates, protein, oil, ECg and nutrients uptake, data in Tables (11 and 12) showed a markedly positive and significant effects were achieved due to applying both combined treatments of (OM + BF + 75% N-RD) and (OM + BF + ES +75% N-RD). Such a superior effect was achieved upon the significance the L.S.D. values at 0.05 as well as it is more attributed with the integrated effect of highly humified organic materials plus bio-oxidation of elemental sulphur, besides *Azospirillum barastlense* No. 40 (salt tolerant PGPR strains of N_2-fixer bacteria). This integrated effect support the available nutrients as a storehouse for plant growth against the adverseable conditions as well as maximizing the biological yield and grain quality. These beneficial effects were varied among the tested three maize varieties, may be attributed to their different genetic constitutions.

Also, the obtained results indicate that ECg showed the greatest value was occurred in case of the solely treatment of 100 % N-RD, while the lowest one was associated with the treatment of (BF+75 % N-RD) followed by (OM + 100 % N-RD) > (OM + BF + 75 % N-RD) > (ES + 75 % N-RD) > (BF + ES + 75 % N-RD) > (OM + ES + 75 % N-RD) > (OM + BF + ES + 75 % N-RD). That was true, sine the incubation of maize grains in N-mineral (urea) or elemental sulphur media increased the electrical conductivity of grain leachiest (ECg) as compared to those treated with either bio-fertilizer (strains N_2-fixer bacteria) or organic manure. That means such applied N-S-mineral fertilizers resulted in an increase for the chemical constituents in maize grains, however, the reverse was true for bio-fertilizer and organic manure. This emphasizes that the usage of the later ones leads to alleviate the hazardous effects of mineral fertilizers, particularly those of nitrogenous chemical pollution in the human health. The statistical data of L.S.D at 0.05 indicate that the results of germination rate, shoot and radical lengths as well as ECg were significantly affected by the applied treatments.

Generally, it could be concluded that the increases in the studied maize parameters were extending parallel close to the corresponding soil amelioration process and increment of the available nutrients in the soil. With respect to the positive response of the tested maize varieties to the applied treatments, the obtained data showed that single cross 10 hybrid surpassed the other two ones (*i.e.,* single cross 129 followed by three cross 324 hybrids). Also, the slightly variations detected among the tested three maize varieties could be attributed to their different genetic constitutions. This may be due to differing rates of absorption, translocation and utilization between the tested varieties. In addition, these magnitude responses could be depend on the nature of applied soil amendments, *i.e.,* elemental sulphur and organic manure as well as bio-fertilizer used and the concerned attributable, where the check soil plots with 75 % N-RD + such applied materials exhibited a relative high values for maize parameters.

It is noteworthy to mention that data obtained are of the importance in such studied saline-alkaline sandy loam soil, owing to the effective role of the used organic manure, elemental sulphur bio-fertilizer, which was not only exerted a positive effect on soil fertility status, but also on the different soil properties. Such amelioration in physical, chemical and biological was reflected positively on the maize yields of grain and straw as well as chemical constituents of grain (grain quality). Also, the applied organic manure had a long-term positive agronomic value due to its capacity to gradually liberate available plant nutrients and to improve soil characteristics. The integrated supply of nutrients through organic and inorganic sources could be an effective practice of nutrient management by reducing N-inorganic rate or nutrient losses. The latter's could also be interpreted the reason of 25 % partial substitution of N-mineral dose by organic manure, elemental sulphur bio-fertilizer superiority as compared to the recommended doses of nitrogen as mineral fertilizes. Moreover, this approach is not only assist a suitable income farmers due to increasing plant production wit less N-mineral fertilizer, but also reduce the potential hazardous contamination of both surface and underground waters.

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