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EVALUATION OF BIO- AND CHEMICAL FERTILIZERS APPLIED TO CORN GROWN ON A SALINE SANDY SOIL

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ABSTRACT: ***Two field experiments were conducted during two successive summer seasons; 2007 and 2008, to evaluate the individual and the combined effect of three bio-fertilizers namely Azospirillum brasilense NO 40 (Salt Tolerant PGPR), Bacillus megatherium (dissolving phosphate) and Bacillus circulans (enhancing potassium availability). Chemical fertilizers were applied solely or in combination of the studied bio-fertilizer at the rate of 75, 150 and 300 kg/fed urea (46%N); 50, 100 and 200 kg/fed calcium super phosphate (15.5%P_2O_5) and 25, 50 and 100 kg/fed potassium sulphate (48 %K_2O). The effect of the aforementioned treatments on some chemical properties of soil, yield and yield component of maize (Zea mays L) cultivar Triple hybrid 310 productivity) grown on a private farm, having saline sandy soil at Sahl El-Tina, North Sina Governorate. The obtained results indicated that the increase of yield and yield components ton /fed, 100 grain (g) and weight of grains /ear (g). The concentration of N, P, and K values in maize grain and straw were increased with elevating the levels of chemical fertilizer or bio-fertilizer combined with chemical fertilizers. Application of bio-fertilizer in combination with chemical fertilizer gave the highest Fe, Mn, Zn and Cu contents in maize grain and straw. Application of all treatments had an effective and significantly increased protein and oil content. Augmenting levels of chemical fertilizers added whether alone or in combination of bio-fertilizer, markedly increased the available N, P , K , Fe and Cu in soil, while, Increases in available Mn and Zn in soil were not significant. Soil pH and EC values were lowered in all studied treatments. However, usage of chemical fertilizers in combination with bio-fertilizer had noticeable effect.***

Key Words*: Bio-fertilizers, mineral fertilizer Soil salinity, Zea maize productivity.*

INTRODUCTION

Soil salinization is one of the major causes of declining agricultural productivity in many arid and semiarid regions of the world. Excessive salt concentrations in soils, in most cases, cannot be reduced with time by routine irrigation and crop management practices, Qadir *et al*. (2001).

Microorganisms play a substantial role in chemical and biological transformations in soil and maintain soil fertility. The major biological elements, carbon, nitrogen, oxygen and sulphur are subjected to comparable cyclic processes. Nevertheless, on top of them is the nitrogen cycle, from both ecological and economic viewpoints (Idriss 2004). Hedge *et al*. (1999)

indicated that bio-fertilizers play an important role in enhancing crop productivity through nitrogen fixation, phosphate solubilization, plant hormones production, ammonia excretion, siderophore formation besides controlling of various plant diseases. El- Sawah (2000) noticed that, there is a significant increase in N, P and K content of maize plant when grains were inoculated with *Asospirillum brasilense and Bacillus megatherium* with a low dose of mineral nitrogen fertilizers were applied. Shaban and Omar (2006) indicated that EC decreased with bio-fertilizer due to many *Azospirillum strains* which produce several phytohormones such as indole acetic acid and cytokines. They studied the effect of adding different mineral nitrogen fertilizer with bio-fertilizer on dehydrogenase activity and production of micro moles of H_2 in the rhizosphere of maize root media. They found that bio-fertilizer had a positive effect on increasing the hydrogen moles and led to soil pH decreased. Omar *et al*. (1993) suggested that bio-fertilizers promote plant growth and had an effect to reduce the salinity stress. (Hanan *et al*. 2008) reported that the increase of N level up to 140kg N/fed significantly increased plant height, fresh and dry weight, weight of leaf ear, ear weight, 100 grain weight, yield and N, P, K uptake of maize plant. Nasf *et al*. (2004) reported that the application of N at different levels and bio-fertilization led to an increase in total porosity, available nutrients in soil and plant and improved soil aggregation and probably salt soil moving with irrigation water. Mustafa *et al*. (2006) found that bacteria fixed N_2, dissolved P and significantly increased growth of barley seedlings. Available phosphate in soil was significantly increased by seed inoculation with *Bacillus megatherium.*

Corn *(Zea mays L.)* is an important crop and one of two sources for cereal flour used in Egypt for making bread .The average area of corn in1999 was 1.648 million feddans which produced 5.438 million tons (ACSRT, 1999). El-Bana and Gomaa (2000) found a significant increase in grain yield as results of increasing levels of nitrogen from 100 to 120 kg N/fed. Mohamed *et al*. (2001) revealed that using *Azospirllium brasileinse* or commercial bio-fertilizer of cereals with half N rate (144 kg N /ha) resulted in a significant increase in maize yield (straw and grains). Salama (2006) found that application of bio-fertilizer significantly increased the N, P and K content in grain and straw in wheat plant as compared with uninoculated treatment (control).

This investigation aims to study the effect of different individual and combined application of some bio- and mineral fertilizers on the growth and yield of corn plants under saline sandy soil. Also, the effect of used fertilizers on some soil properties and content of available nutrients, some yield parameters, plant content of macro and micronutrients and grain content of protein and oil was studied.

MATERIALS AND METHODS

A field experiment was carried out on sandy saline soil of Galbana village at Sahl El-Tina in the east Suez Canal, of North Sinai Governorate, Egypt during two successive seasons 2007 and 2008 to study the effect of application of mineral fertilizer (N, P and K) and Bio-fertilizer on maize growth, yield and quality of *(Zea mays L*) cultivar Triple hybrid 310.Some physical and chemical properties of the studied soil before planting are shown in Table (1). The experiment was carried out in randomized complete blocks design with 3 replicates. The treatment comprised: (1)usage of mineral fertilizer alone where urea fertilizer (46 %N), super phosphate (15.5% P_2O_5) and potassium sulphate (48 % K_2O) were added to experimental plots at the rates of 75, 150 and 300 kg/fed urea; 50, 100 and 200 kg/fed calcium super- phosphate and 25, 50 and 100 kg/fed potassium sulphate, respectively.(2) mineral fertilizers in combination with bio-fertilizer obtained from Department Microbiology in Soil, Water and Environment Research Inst. Agric. Res. Center, Giza, Egypt. These bio-fertilizer were *Azospirillum brasilense NO 40* (Salt Tolerant PGPR)*, Bacillus megatherium* for dissolving phosphate and *Bacellus circulans* for potassium availability .Chemical fertilizer combination with bio-fertilizer were added at the rate of 75, 150 and 225 kg/fed urea, 50, 100 and 150 kg/ fed calcium super phosphate and 25, 50 and 75 kg/fed potassium sulphate, respectively.(3)sole application of bio-fertilizers. The phosphate fertilizer was added during soil preparation, but urea and potassium sulphate were added after 3, 5 and 6 weeks after planting. The rate of mineral fertilizers was applied solely recommended by Egyptian Ministry of Agriculture bulletin (2006). While bio-fertilization, *Azospirillum brasilense NO 40* (Salt Tolerant PGPR) was applied as coating for grains using the gum media, on the same day of sowing as described by (Omar *et al*. 2000). Bio-fertilizer was applied to soil using a liquid bacteria strain, three times after 30, 45 and 65 days of planting.

Maize grains (*Zea mays L*) cultivar Triple hybrid 310 supplied by Maize Department Filed Crop Res Inst. ARC, were sown on the 5th of May 2007, and same 2008. Crop maturity was occurred on the 27th September 2007 and 2008. Maize ears were collected on the 20th October of each plot counted and weighed. At harvesting stage grains and cobs were weighed, 100 grain weight was recorded. Suitable portion of the plant materials were oven dried 75 ^{0}C, thereafter chemically analyzed to determine their contents of macro-micronutrients according to Chapman and Pratt (1961).

Surface soil samples (0 – 30 cm) were collected from the used soil, air – dried, ground, good mixed, sieved through a 2m m sieve and analyzed for some chemical properties and also its content of some macro-and micronutrients according to the international Pipette method was used to determine the particle size distribution as described by Piper (1950). Soluble cations and anions, pH, organic matter, calcium carbonate, electrical

conductivity and available N, P and K, Fe, Mn, Zn and Cu were determined as described by Black (1965), Soltanpour (1985) and Jackson (1967).

The oven dried plant part samples were ground, 0.5 g of each sample was digested using $H_2SO^-_4$, $HClO_4$ mixture according to the methods described by Chapman and Pratt (1961).The plant content of N, P, K, Fe, Mn, Zn and Cu was determined in plant digestion using the methods described by Jackson (1967), Cottenie *et al*. (1982) and Black (1965) .

Data were statistically analyzed according to Snedecor and Cochran (1979). Oil seed content was determined using Soxhlet method (AOAC, 1990). Protein percentage was calculated by multiplying the nitrogen percentage by the factor 6.25 (Hymowitz *et al*., 1972).

Table (1): Physical and chemical properties of the studied soil

Location	Course sand (%)	Fine sand (%)	Silt (%)	Clay (%)	Texture	O.M (%)	$CaCO_3$ (%)
Galbana village	2.84	61.71	12.85	22.60	Sandy clay loam	0.63	10.23

Location	pH (1:2:5)	EC (dS/m)	Cations (meq/l)				Anions (meq/l)		
			Ca^{++}	Mg^{++}	Na^+	K^+	HCO^-_3	Cl^-	SO^{--}_4
Galbana village	8.28	8.73	7.21	12.58	66.86	0.65	9.57	49.63	28.10

Location	Macronutrients ($mgkg^{-1}$)			Micronutrients ($mgkg^{-1}$)			
	N	P	K	Fe	Mn	Zn	Cu
Galbana village	49	4.69	188	3.94	2.73	1.22	0.072

RESULTS AND DISCUSSION

Effect of bio- and mineral fertilizer on soil pH and EC in the studied saline soil:

Data in Table (2) show that the pH and EC_e values of the studied soil were more affected at the combined treatment of different levels of (N, P and K mineral and bio-fertilizers) compared to the other treatments. The decrease of soil pH was noticed in soil treated with bio-fertilizer in combination with mineral N, P and K fertilizer at the rate of 225 kg urea, 150 super phosphate and 75 kg potassium sulphate in both season as compared with those treated with chemical fertilizers alone. Dissolved nitrogen fertilizers are therefore additive to the total salt in solution. In fact certain forms of nitrogen such as NH_4 and NO3 tend to reduce soil pH. The bacteria that fixed N_2, dissolved P and available K led to a decrease in soil pH when added alone and in combination with chemical fertilizers. The obtained data may be explained on the base of some products of added mineral fertilizers transformation in the soil have a acidic effect. Also, most of actives products of the used bio-fertilizer characterized by acidic effects where these products

mainly are Weakley acidic compound .These results are agreement with those found by Shaban and Omar (2006) and Nader *et al*. (2008).

Data present in Table (2) show that the obtained values of ECe were decreased with the increase mineral fertilizer in combination with bio-fertilizer as compared with chemical fertilizers alone in both seasons' .The treatments exhibited the same trend for the ECe values throughout soil surface layer, as shown in all experiments. These results could be related to the influence of bio-fertilizer on total porosity, and improving soil aggregation and possible moving salt soil under irrigation water. These results are in agreements with those found by Nasf *et al*. (2004). The corresponding relative decreases in soil ECe values were 23.14, 24.63 and 25.66 % in 1st and 38.48, 40.32 and 40.66 % in 2nd season as affected with different rates of mineral fertilizer alone as compared with soil initial. Concerning the relative decreases in soil ECe as affected with different rates of mineral fertilizer in combination with bio-fertilizer they were 35.85, 39.17 and 40.21 in 1st and 47.54, 49.25 and 51.89 % in 2nd season, while the percentage values of decrease in soil ECe as affected with bio-fertilizer alone were 27.62 in 1st and 41.58 % in 2nd season as compared with the ECe initial soil. These results are in agreement with those found by El-Fayoumy and Ramdan (2002); Nasef *et al*. (2004) and Shaban and Omar (2006).

Available Macronutrients content in the studied soil after maize harvest :

Data presented in Table (2) show that the soil content of available N, P and K (mg/kg) values of studied soil were grater affected at the combined treatment of the tested bio-fertilizer and inorganic fertilizers of NPK , than with each one when applied alone. Concerning the higher soil available N, P and K obtained from soil treated with Bio-fertilizer in combination with chemical fertilizer they were significant as compared with chemical and bio-fertilizer when applied alone. These results are in similar to those found by Abeer and Hanaa (2008) who found that the bio-fertilizer inoculation generally increased the concentration of N, P and K in soil as compared to control. Available N, P and K were significantly increased in soils treated with Bio-fertilizer in combination with chemical fertilizers, as compared to soils treated with chemical and bio-fertilizers alone. These results are in agreement with those found by Mustafa *et al*. (2006) who found that available phosphate in soil was significantly increased by seed inoculation of *Bacillus megatherium* .Shaban and Omar (2006) reported that soil available N increased as the levels of mineral N increased especially with bio-fertilization*(Azospirillum brasilense NO 40*).

Table 2

Available micronutrients content in soil after crop production:

Data in Table (2) show the content of available Fe, Mn, Zn and Cu (mg/kg) were insignificantly increase as affected by all treatments. Bio-fertilizers including *Azospirillum brasilense NO 40*, Bacillus *megatherium* and *Bacillus circularns* in combination with chemical fertilizers, may have positive impact on bio-availability and mobility of micronutrients in soil, depending on the chemical nature of metals. These results agreement by Wu *et al* (2006) who found that, the activity of bacteria *Azotobacter chroococcum*, *Bacillus megatherium* and *Bacillus mucilaginosus*, led to an increase of water dissolved organic carbon concentration and a decreased pH value, which enhanced metal mobility and bio-availability.

Effect of bio-and mineral fertilizers on the content of macronutrients in Straw and grains of Zea maize.

Data in Table (3) show that the applied rates of mineral fertilizers either alone or in combination with bio-fertilizer led to increase of N, P and K contents in maize plants , but it was noticeable in case of the combined treatment. These increases were more clear with high application rates of added mineral fertilizers, also, these increases were more clear with combination treatments compared with mineral fertilizers alone .This may be explained as the application of bio-fertilizers could make such nutrients more available for plants. These results coincide with those found by Abeer and Hanaa (2008) who revealed that the bio-fertilizer inoculation generally increased the concentration of N, P and K in wheat plant as compared to control.

The data obtained of N, P and K concentration in maize plant (straw and Grains) show relative increases with decreasing soil salinity. The recorded data aforementioned show a negative relationship between soil salinity and plant content of N, P and K. This result is in harmony with those obtained by Mostafa (1995) and Shaban and Healmy (2006). The N, P and K concentration in maize straw ranged between 1.83 to 2.16 %, 0.28 to 0.48 % and 2.25 to 2.96 % , While the N , P and K contents in grain value ranged were 1.20 to 1.48, 0.40 to 0.66% and 0.94 to 1.14% during the two seasons respectively. However the inoculation with *Azospirillum brasilense NO 40*, Bacillus *megatherium* and Bacillus *circularn*s fertilizers in combination with NPK chemical fertilizer significantly surpassed the single alone. These results are in agreement with those found by El- Sawah (2000) and Cabrera (2006) who reported that the application of bio-fertilizers enabled plants to extract a higher amounts of N ,P, K, Ca^{+2} and Mg^{+2} and increased yield.

Table 3

Effect of bio- and mineral fertilizers on grain content of oil and protein.

Data in Table (3) show that the application of bio-fertilizers in combination with chemical fertilizers, significantly increased oil and protein (%) concentration. The oil content in grain maize plant increased with the increasing levels of mineral fertilizers in combination with bio-fertilizers as compared with mineral fertilizers when applied alone. Generally all treatments significantly increased oil and protein contents. Nevertheless, the highest content of oil and protein in the grain were recorded as 225, 150, 75 kg of N, P and K fertilizers were added, respectively, in combination with the tested bio-fertilizer.

Effect of Bio- and mineral fertilizers on the content of micronutrients in straw and grain.

Data presented in Table (4) show that , Fe, Mn, Zn and Cu concentration (mg/kg) in straw and grain maize plant in both seasons were increased by inoculation with bio-fertilizers in combination with chemical fertilizers as compared with bio-fertilizer or mineral fertilizers added alone. On the other hand, results showed that the Fe, Mn, Zn and Cu solubility tented to increase with increasing the rates of chemical fertilizers . In generally, pronounced responses were obtained in the concentration of Fe, Mn, Zn and Cu when added bio-fertilizer was in combination with chemical fertilizers. This may be due to improved physical and chemical properties of the soil, and increased the available nutrients to plant. These results are in similar to those found by Nasef *et al*. (2004) and Samia *et al*. (2008).

Effect of Bio- and mineral fertilizers on yield and yield components:

Data in Table (5) show that the treatments of bio-fertilizer in combination with chemical fertilizers gave a significantly increase of straw and grains yield as compared with non- treated in both seasons. Moreover, combined bio-fertilizer and chemical fertilizers treatment gave the best results as compared with the other treatments in both seasons. Generally, the results revealed that, bio-fertilization caused a significant increase in straw and grains yield. The highest values were 149 (g) for weight grains of ear, 2.175 ton /fed of straw yield, 1.246 ton /fed of grain and 37.22 (g) weight of 100grains.These values were obtained in the case of addition of bio-fertilizer in combination with chemical fertilizer namely (225kg/fed urea, 150 kg fed super phosphate and 75 kg/fed potassium sulphate fertilizers).

This result is in harmony with those obtained by Abeer and Hanaa (2008) and Shaban and Omar (2006).

Table 4

Table 5

The bio-fertilizers may play an important role in enhancing crop productivity through nitrogen fixation, phosphate solubilization, plant hormone productivity, ammonia excretion, siderophore formation and to control various plant diseases (Hedge *et al*. 1999). Moreover, Mustafa *et al*. (2006) and Shaban and Omar (2006) stated that tested bacterial strains have a potential on plant growth activity of maize.

CONCLUSION

The results revealed that lower rate of applied mineral fertilizers could be used for boos times the yield of maize and its yield components wherever bio-fertilizers were implicated.

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تقييم التسميد الحيوي والتسميد المعدني المضاف لمحصول الذرة الشامية النامي في الأراضى الرملية الملحية

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الملخص العربي

أجريت تجربتان حقليتان في موسمين صيفين متتالين ٢٠٠٧ /٢٠٠٨ لدراسة تقيم ثلاث لقاحات مثبتة للنتروجين (مقاومة للملوحة وتحتوى على مجوعة منظمات نمو الاسبيريليم) والبكتريا المذيبة للفوسفور (البسلس ميجاثيريم) والبكتريا الميسرة للبوتاسيوم (البسلس ثيركيلانس) وأيضا تقييم استخدام الأسمدة المعدنية حيث أضيفت سواء بمفردها أو مع اللقاحات تحت الدراسة واشتملت على اليوريا كمصدر للنتروجين(٤٦% ن) بمعدلات ٧٥ و١٥٠ و٣٠٠ كجم / فدان والسوبر فوسفات كمصدر للفوسفور (١٥.٥ % فو٢ أ٥) كمصدر للفوسفور بمعدلات ٥٠ و١٠٠ و٢٠٠ كجم / فدان وسلفات البوتاسيوم (٤٨ % بو٢ أ) كمصدر للبوتاسيوم بمعدلات ٢٥ و٥٠ و١٠٠ كجم / فدان وتم دراسة الصفات الكيمائية للتربة وإنتاجية محصول الذرة هجين٣١٠ تحت ظروف الاراضى الرملية الملحية حيث أجريت هذه الدراسة في مزرعة خاصة بمنطقة سهل الطينة.

<u>وكانت النتائج كالتالي</u>:

- **تشير النتائج أن إضافة الاسمده المعدنية مع الاسمده الحيوية أدت إلى زيادة في إنتاج محصول الذرة من الحبوب بالطن وكذلك المكونات المحصولية وزيادة ١٠٠ حبه بالجرام ووزن الحبوب للكوز الواحد بالجرام .**
- **إضافة الأسمدة المعدنية منفردة أو بمعدلات مختلفة وأيضا بمصاحبة الاسمده الحيوية أدت إلى زيادة في تركيز العناصر الكبرى (نيتروجين – فوسفور والبوتاسيوم) بينما في حالة العناصر الصغرى (حديد – منجنيز – زنك والنحاس) لوحظ هذا التأثير في حالة المعاملة الاسمدة المعدنية بمصاحبة التسميد الحيوي وذلك في القش والحبوب لنبات الذرة.**

- إضافة المعاملات السابقة أدت إلى زيادة نسبة الزيت والبروتين في حبوب الذرة لوحظ أن إضافة الاسمده المعدنية + الأسمدة الحيوية أدت إلى زيادة العناصر الميسرة للتربة (نيتروجين– الفسفور – البوتاسيوم والحديد والنحاس)
- وجد أن إضافة الأسمدة المعدنية والحيوية ليس لها تأثير معنوي على مدى تيسر عناصر الزنك والمنجنيز في التربة
- وجد أن هناك نقص في رقم الحموضة للتربة ونسبة ملوحة التربة نتيجة للمعاملات المستخدمة
- وعموما فان استخدام تسميد المعدني بمصاحبة التسميد الحيوي كان له تأثير أكثر وضوحا

Table (2) pH, EC and Macro-Micronutrients contents in soil after maize harvest in seasons 2007 and 2008

treatments	Chemical fertilizer (kg/fed)			pH (1:2.5)	EC (dSm^{-1})	Macronutrients ($mgkg^{-1}$)			Micronutrients ($mgkg^{-1}$)			
	Urea	Super phosphate	Potassium sulphate			N	P	K	Fe	Mn	Zn	Cu
Mineral fertilizer	75	50	25	8.23	6.71	59	6.82	194	6.29	3.69	1.36	0.087
	150	100	50	8.19	6.58	64	6.88	199	6.36	3.74	1.43	0.093
	300	200	100	8.18	6.49	67	6.93	204	6.39	3.79	1.49	0.096
Bio-fertilizer	75	50	25	8.21	5.60	61	6.90	205	6.45	3.77	1.44	0.095
	150	100	50	8.16	5.31	66	7.12	209	6.51	3.84	1.57	0.098
	225	150	75	8.12	5.22	69	7.19	211	6.58	3.88	1.63	0.100
Bio-fertilizer	0	0	0	8.18	6.35	64	6.62	198	6.36	3.75	1.47	0.0.93
2008												
Mineral fertilizer	75	50	25	8.19	5.37	62	7.24	201	6.38	3.75	1.42	0.095
	150	100	50	8.16	5.21	67	7.37	209	6.43	3.78	1.46	0.099
	300	200	100	8.14	5.18	72	7.42	213	6.45	3.83	1.52	0.102
Bio-fertilizer	75	50	25	8.13	4.58	71	7.35	215	6.52	3.84	1.49	0.097
	150	100	50	8.10	4.43	77	7.56	219	6.59	3.92	1.63	0.105
	225	150	75	8.06	4.20	80	7.62	226	6.64	3.96	1.69	0.109
Bio-fertilizer	0	0	0	8.15	5.10	70	6.74	205	6.39	3.78	1.52	0.098
LSD % 0.0 5 fertilizer				ns	0.18	0.63	0.86	ns	ns	ns	ns	ns
LSD% 0.05 seasons				ns	0.10	0.34	0.46	ns	ns	ns	ns	ns

Table (3): Macronutrients concentration in straw and grains of maize in seasons 2007 and 2008

treatments	Chemical fertilizer (kg/fed)			N (%)		P (%)		K (%)		Protein (%)	Oil (%)
	Urea	Super phosphate	Potassium sulphate	Straw	Grain	Straw	Grain	Straw	Grain		
Mineral fertilizer	75	50	25	1.83	1.20	0.28	0.40	2.25	0.94	7.50	5.39
	150	100	50	1.96	1.32	0.32	0.49	2.36	0.99	8.25	5.46
	300	200	100	2.04	1.36	0.36	0.53	2.42	1.04	8.50	5.50
Bio-fertilizer	75	50	25	1.99	1.28	0.34	0.46	2.65	0.98	8.00	6.44
	150	100	50	2.06	1.39	0.39	0.56	2.88	1.05	8.70	6.55
	225	150	75	2.13	1.43	0.42	0.62	2.93	1.09	8.94	6.59
Bio-fertilizer	0	0	0	1.85	1.26	0.30	0.44	2.32	0.97	7.87	6.42
2008											
Mineral fertilizer	75	50	25	1.86	1.25	0.31	0.45	2.31	1.02	7.81	6.49
	150	100	50	1.99	1.34	0.36	0.53	2.43	1.05	8.37	6.57
	300	200	100	2.08	1.39	0.40	0.57	2.50	1.08	8.69	6.62
Bio-fertilizer	75	50	25	2.03	1.33	0.37	0.48	2.66	1.03	8.31	7.53
	150	100	50	2.12	1.42	0.44	0.59	2.91	1.10	8.87	7.66
	225	150	75	2.16	1.48	0.48	0.66	2.96	1.14	9.25	7.69
Bio-fertilizer	0	0	0	1.90	1.31	0.35	0.53	2.36	1.03	8.19	6.51
LSD % 5 fertilizer				0.37	ns	ns	ns	0.180	0.04	0.18	0.45
LSD% 5 seasons				0.20	1.48	ns	ns	0.079	0.02	0.09	0.24

Table (4): Micronutrients concentration in straw and grains of maize in two seasons

treatments	Chemical fertilizer (kg/fed)			Fe (mgkg^{-1})		Mn (mgkg^{-1})		Zn (mgkg^{-1})		Cu (mgkg^{-1})	
	Urea	Super phosphate	Potassium sulphate	Straw	Grain	Straw	Grain	Straw	Grain	Straw	Grain
Mineral fertilizer	75	50	25	120	38	75	11.89	29	40.25	4.32	1.05
	150	100	50	128	46	79	12.14	34	40.67	4.36	1.09
	300	200	100	132	52	84	12.29	38	40.77	4.40	1.12
Bio-fertilizer	75	50	25	126	42	77	12.34	33	41.35	5.12	1.08
	150	100	50	139	54	82	13.10	39	41.46	5.18	1.14
	225	150	75	142	56	87	13.18	41	41.52	5.27	1.16
Bio-fertilizer	0	0	0	126	40	76	11.93	32	40.32	4.40	1.07
2008											
Mineral fertilizer	75	50	25	125	41	78	11.92	33	40.31	4.34	1.09
	150	100	50	133	49	82	12.18	38	40.72	4.39	1.13
	300	200	100	139	56	89	12.34	41	40.80	4.45	1.15
Bio-fertilizer	75	50	25	133	48	84	12.39	38	41.42	5.19	1.19
	150	100	50	144	59	87	13.15	45	41.54	5.23	1.23
	225	150	75	149	61	89	13.21	48	41.58	5.30	1.27
Bio-fertilizer	0	0	0	130	43	80	12.09	39	40.36	4.37	1.12
LSD % 5 fertilizer				ns	ns	ns	3.01	ns	0.018	1.36	ns
LSD% 5 seasons				ns	ns	ns	1.61	ns	0.009	ns	ns

Table (5): yield and yield components in two seasons

Treatments	Chemical fertilizer (kg/fed)			Weight grain of ear (g)	Weight straw yield (ton /fed)	Weight grain yield (ton /fed)	Weight 100grain (g)
	Urea	Super phosphate	Potassium sulphate				
Mineral fertilizer	75	50	25	119	1.765	0.986	28.37
	150	100	50	125	1.941	1.183	32.10
	300	200	100	134	2.056	1.196	33.12
Bio-fertilizer	75	50	25	128	1.954	1.094	29.35
	150	100	50	136	2.146	1.210	33.18
	225	150	75	143	2.168	1.337	34.21
Bio-fertilizer	0	0	0	122	1.772	1.077	30.96
2008							
Mineral fertilizer	75	50	25	127	1.773	1.023	30.24
	150	100	50	136	1.948	1.196	36.10
	300	200	100	139	1.124	1.204	38.09
Bio-fertilizer	75	50	25	135	1.964	1.142	31.41
	150	100	50	145	2.152	1.254	35.41
	225	150	75	149	2.175	1.246	37.22
Bio-fertilizer	0	0	0	130	1.780	1.120	32.14
LSD % 5 fertilizer				ns	0.18	0.32	ns
LSD% 5 seasons				ns	0.097	0.17	ns