J. Soil Sci. and Agric. Eng., Mansoura Univ., Vol. 6 (12): 1421 – 1440 ,2015

MANAGING NITROGEN REQUIREMENTS FOR MAIZE CROP GROWN ON SANDY SOIL USING FOLIAR APPLICATION OF NITROGEN AND ZINC WITH BIO-FERTILIZATION.

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ABSTRACT

The integration among nitrogen mineral fertilization, foliar application of micronutrients and inoculation with bio-fertilizers become necessary to save mineral nitrogen fertilizers and increase the productivity of maize yield and its quality. As for, a field experiment was carried out during the two successive summer growing seasons 2013 and 2014 in sandy soil at El-Sharawy village in EL-Bostan area – Noubaria Region, Elbeheira governorate (Latitude 30° 43' 22.01" N, Longitude 30° 16' 44.50" E), to study the response of maize (*Zea maize L.*) yield and its components to mineral nitrogen fertilization rates as soil and foliar application and zinc-EDTA foliar application with bio-fertilizer. Treatments were carried out as split split plot design with three replicates; the main plots were bio-fertilizer without (Bio$_0$) and with (Bio$_1$); the split plots were two levels of Zn-EDTA foliar application, Zn$_0$ (without foliar) and Zn$_1$ (with foliar 0.06 % Zn-EDTA), and the sub split plots were five rates of nitrogen fertilizer (N1: 100 % of recommended N (RN) fertilizer as soil application; N2:75 % RN + 1% N foliar at two times, N3: 75 % RN + 1% N foliar at three times, N4: 50 % RN + 1% N foliar at two times and N5: 50 % RN + 1% N foliar at three times).

The most important results could be summarized as follows:

- Application of N-fertilization rates, foliar Zn-EDTA and inoculation with bio-fertilizer have a significant effects on all studied parameters such as plant height, ear weight/plant, grain and stalks yields, 100-grain weight, percentage of carbohydrate, oil and protein, concentrations and uptake of N, P, K and Zn by maize grain. Where, grain yield increased by 12.81% with bio-fertilizer inoculation and by 7.13% with Foliar Zn-EDTA.
- The interaction between zinc and bio-fertilizer significantly increased plant height, ear weight/plant, 100-grain weight, concentrations and uptake of phosphorus and zinc, also the interactions between N-rates and bio-fertilizer have significant effects on 100-grain weight, grain yield, concentrations and uptake of phosphorus and zinc. Moreover, the interaction between N-rates and foliar Zn-EDTA has significant effect on maize grain yield.
- Also, the interaction among N-rates, Zn and bio-fertilizer have significant effect on ear weight/plant, stalks yield, 100-grain weight, oil %, concentrations and uptake of N, K and Zn by grain. Whereas, the superiority was for interaction N3*Zn$_1$*Bio$_1$ that achieve the highest relative increase % for ear weight, grain and stalks yields, carbohydrate %, oil % and protein % (13.03, 27.82, 18.53, 4.14, 16.10 and 11.16 %, respectively).

Keywords: Nitrogen, zinc, foliar application, bio-fertilization, maize and sandy soils.

INTRODUCTION

Maize is one of the most important cereals that grown in Egypt. It is used as human food and animal feed. In Egypt, there is a gap between production and consumption, which return to many reasons such as (decreased maize growing area, soil fertility, shortage in mineral nitrogen fertilizers and low fertilizers use efficiency), so the efforts have been devoted to increase the productivity of maize per unit area by increasing fertilizers efficiency using different macro, micronutrients and bio-fertilizers through different management methods.

Recently, Egypt faces a great problem either in the excessive use of mineral fertilizers, especially nitrogen fertilizers, as it is one of the most frequently limiting factors in crop production. Nitrogen is a major nutrient-element and it is needed in large amount to increase growth and yield of maize. Many of researchers studied the responses of maize to nitrogen fertilization. Darwish (2003) reported that maize yield and its components i.e. ear weight, ear grains weight, 100-grain weight, ear yield t fed^{-1}, grain yield t fed^{-1} and stalks yield t fed^{-1}, as well as N, P and K concentrations and its uptake were significantly increased by applying increasing rates of N-fertilizer up to 120 kg N fed^{-1}. Also, Ewais et al., (2009) found that maize yield, 100-grain weight, oil % and carbohydrate %, and nitrogen, phosphorus and potassium uptake were significantly increased with increasing nitrogen level up to 120 kg N fed^{-1} as 50% N-mineral + 50% N-organic form. In field studies in sandy soil, El-Atawy and Eid (2010) showed that maize grain yield were increased significantly with increasing nitrogen rate up to 150 kg N fed^{-1}, also Hokam et al., (2011) indicated that maize vegetative growth and crop growth parameters were increased with increasing nitrogen level up to 160 kg N fed^{-1}. Moreover, El-Agrodi et al., (2011) revealed that splitting nitrogen fertilizer added at 120 kg N fed^{-1} in four doses 40, 20, 20 and 20% applied after 14, 28, 48 and 56 days from sowing gave the highest maize grain yield, its components and its uptake of N, P and K in sandy clay loam soil. Nemati and Sharifi (2012) reported that the highest maize grain yield (7928.6 kg ha^{-1}), 1000-grain weight (174.6g) and plant height (185 cm) were recorded at 225 kg N ha^{-1} application at three doses (1/3 in planting + 1/3 at 8-10 leaf stage + 1/3 in teaseling initiation), in silty loam soil.

Application of fertilizers as foliar spray plays important role in increasing fertilizers use efficiency and treat the nutrients deficiency. Foliar fertilization is a quick and efficient method of supplying nutrients in particular microelements; also it can also be used to satisfy acute needs of macro elements. Moreover, some of soil fertilization problems can only be solved by foliar application (Alexander, 1986). Also, foliar nutrients application under drought conditions may be able to exclude or include a water deficit or nutrient deficiency effect under short-term drought (Ling and Silberbush, 2002). Whereas, foliar fertilization with nitrogen, phosphorus, and potassium can be supplemented with soil applied fertilizers but cannot replace soil fertilization in the case of maize. El-Dissoky (2013) showed that wheat fertilization as soil application at rate 50 % of recommended doses of NPK fertilizers with foliar application of 1%N + 1%P + 1%K at two times recorded high yield of wheat without insignificant differences with 100 % recommended soil application.

Zn deficiency is one of the commonest micronutrient deficiencies and it is becoming increasingly significant in crop production. The susceptibility of crop plant to Zn deficiency varies depending on species and even cultivars.

Corn plants are high nutrient demanding crop but sensitive to Zn deficiency in soil (Mengle and Kirkby, 1982). Ismail et al., (1999) reported that both grain and stalks yield, total N and Zn-uptake as well as protein content in maize grain was significantly affected by nitrogen levels and zinc addition. Moreover, Osman et al., (2001) reported that dry weight of plant, weight of 100 grain, grain yield, nutrient uptake of Zn and Fe and nitrogen use efficiency were significantly affected by the interaction between nitrogen and micronutrients. In field experiment, Abd El-Kader et al., (2007) found that the highest maize grain yield, oil %, carbohydrate %, ear weight, 100-grain weight and stalks yield were obtained when the plants received 98.8 kg N as anhydrous ammonia+ 45 kg P_2O_5 fed^{-1} combined with zinc foliar application twice at 45 and 65 days after sowing as 0.06 % Zn-EDTA. Also, Zein et al., (2009) showed that maize grain yield and its components and N, P, K and Zn uptake were significantly affected by Zn soil treatments and Zn foliar application at 500 ppm with or without 2% urea, whereas he recommended using Zn foliar application combined with 2% urea. Moreover, El-Azab (2015) showed that foliar application of 1, 1.5 and 2 % Zn combination with NPK fertilizer significantly improved plant height, 1000-grain weight, grain yield, harvest index and N, P, K and Zn uptake compared to the treatment fertilized only with NPK, whereas the optimal rate ranged from 1- 1.5 kg Zn ha^{-1}.

The use of bio-fertilizers in agriculture under Egyptian conditions, still limited to minimize the high doses of chemical fertilizers as well as to lower the agricultural production costs. Although, several investigators have used bio-fertilizers from bacterial origin successfully for reducing doses mineral nitrogen fertilization. The exudates of bacterial strains act as plant growth promoters and apparently stimulate growth mainly throughout modifying root development, which improve macronutrients, micronutrients and water uptake (El Komy et al., 1998). Salem (2000) showed that the highest grain yield of maize has been obtained under sub optimal N-bio-mineral fertilizer. Also, El-Akabawy et al., (2001) reported that, the highest grain yield was obtained by using microbein with 90 kg N fed^{-1}, thus bio-fertilization use seems to save and compensate more than 30 kg N fed^{-1}. Accordingly, Zarabi et al., (2011) proved that different bio-fertilizers can positively affect on the growth increase of maize plant and phosphorus absorption. Eleiwa et al., (2012) illustrated that the use of *Azospirillum, Azotobacter* or *Bacillus*, in combination with foliar application of micronutrients mixture (200, 300 and 200 mg L^{-1} of Mn, Fe and Zn, respectively) can lead to higher wheat yield, growth parameters and nutrients content of wheat plants in sandy soil. Mosaad et al., (2013) showed that application of organic fertilizer with a mixture of bio-fertilizers, *Cyanobacteria*, *Azotobacer* and *Azospirillum* inoculations + 90 kg N fed^{-1} gave the highest wheat grain and straw yields and N-uptake.

Most of the newly reclaimed lands, especially sandy soils are more poor in its fertility than any either soil and need to more fertilization and great management. So, this work aim to evaluate the integrated effect between N fertilization rates (soil and foliar), Zn foliar and bio-fertilizer on maize productivity grown on sandy soil, moreover, investigating use these bio-fertilizer in combinations with foliar fertilization as a technique to reduce the mineral nitrogen fertilizers dose in order to reduce the production cost and minimize environmental pollution.

MATERIALS AND METHODS

A field experiment was carried out during the two successive growing summer seasons of 2013 and 2014 in sandy soil at El-Sharawy village in EL-Bostan area-Noubaria Region, Elbeheira governorate (Latitude 30° 43' 22.01" N, Longitude 30° 16' 44.50" E), to study the response of maize crop (*Zea maize L.*) cultivar, three way cross 325, to mineral nitrogen fertilization rates as soil and foliar application, zinc foliar application with bio-fertilizer (microbein). Soil sample of field experiment was analyzed before sowing of two seasons according to Hesse (1971), as shown in Table 1 (Average of the two seasons):

Table 1: Some physical and chemical properties of experiment soil before sowing.

Mean of two season	Particle size distribution					OM %	$CaCO_3$ %	PH	EC dSm^{-1}
	Coarse sand %	Fine sand %	Silt %	Clay %	Texture class				
Values	52.2	39.3	5.4	3.1	Sand	0.16	3.5	8.1	0.41

Mean of two season	Cations and anions in the soil baste extract, (meq/100 g soil)								available nutrients ($mg\ kg^{-1}$)			
	Cations				Anions				N	P	K	Zn
	Ca^{++}	Mg^{++}	Na^{+}	K^{+}	CO_3^{--}	HCO_3^{-}	Cl^{-}	SO_4^{--}				
Values	1.61	1.28	1.02	0.18	--	1.53	1.92	0.64	15	6.5	85	0.7

Treatments were conducted as split split plot design with three replicates. The main plots were bio-fertilizer (Bio_0: without inoculation and Bio_1: with inoculation). The sub plots were two levels of Zn-EDTA foliar application (Zn_0: without foliar and Zn_1: with foliar 0.06 % Zn-EDTA). The sub-split plots were assigned for five rates of nitrogen fertilization as soil and foliar application as follows:

N1: 100 % of recommended N (RN) fertilizer as soil application (control).
N2: 75 % of RN as soil application+ 1% N foliar at 2 times.
N3: 75 % of RN as soil application + 1% N foliar at 3 times.
N4: 50 % of RN as soil application + 1% N foliar at 2 times.
N5: 50 % of RN as soil application + 1% N foliar at 3 times.

The experimental plot area was $10.5m^2$ (5 lines x 0.60m width x 3.5m length). Maize seeds were inoculated by coating with bio-fertilizer (commercial bio-fertilizer produced by General Organization for Agricultural Equalization Fund, Ministry of Agric., and Land Rec., Egypt). The bio-fertilizer contains a mixture of multi strains of nitrogen fixation bacteria *(Azotobacter spp.* and *Azospirillum spp.,)* and phosphorus dissolving bacteria *(Bacillus megatherium, Bacillus polymyxa* and *Peseudomonas spp).*

Maize seeds were sown in May 11th 2013 and harvested in September 10th 2013 in 1st season and sown in May 15th 2014 and harvested in September 14th 2014 in 2nd season. Phosphorous fertilizer as calcium super phosphate (15% P_2O_5) was added with soil preparation at rate of 200 kg fed^{-1} fertilizer (30 kg P_2O_5 fed^{-1}). Potassium fertilizer was applied at rate of 24 kg K_2O fed^{-1} (50 kg potassium sulphate 48% K_2O) after thinning. Nitrogen fertilizer was applied as ammonium sulphate (20.5 % N) at rate of 140 kg N fed^{-1} (683 kg fertilizer, the full recommended N fertilizer at newly soils). Each N-rate was added at eight equal doses, weekly after emergence. Nitrogen foliar application was carried out using solution of urea (400L fed^{-1} per foliar time) at concentration 1% N (w/v) at two or three times (after 25, 40 and 60 days from planting). Zinc was added as foliar application of 0.06 % Zn-EDTA (15% Zn) at rate 400 L water fed^{-1} for each foliar time, at 40 and 60 days from planting. Also, all recommended field practices for maize crop were carried out for the two experiments. The Field experiment irrigation was drip irrigation system (irrigation laterals were 16 mm in diameter and 30 meter length had in line emitters (drippers) spaced 0.3m apart with 3.6 L h^{-1} flow rate at pressure of 100 kpa).

At harvesting time, plants for each experimental plot were harvested and yield parameters were recorded; Plant height (cm), ear weight (g $plant^{-1}$), grain yield (kg fed^{-1}), 100-grain weight (g) and dry weight of stalks yield (kg fed^{-1}). Samples of grains were taken randomly from each plot for chemical analysis; nitrogen, phosphorus, potassium and zinc concentrations according to Piper (1950), carbohydrate % and oil % in grains were determined according to A.O.A.C. (1990). Protein content was calculated by multiplying the nitrogen percentages by the factor 6.25.

The statistical analysis was done according to the method of Gomez and Gomez (1984) and treatment means values were compared against least significant differences test (L.S.D.) at 5% level.

RESULTS AND DISCUSSION

1-Maize yield and its components:

Data in Table 2 and Fig. 1 show the influence of nitrogen, zinc and bio-fertilizer and their interactions effect on maize plants height, weight of ear per plant, grain and stalks yields.

Data reveal that application of N-rates with or without N foliar have a significant effect on plants height, weight of ear per plant, grain yield and stalks yield, whereas the differences between N1 and N-rates (N2, N4 and N5) were significant, but the differences between N1 and N3 were insignificant. These results clear that application of 75% of recommended N fertilizer with foliar N at 1% three times (N3) recorded the highest values of grain yield (3838 kg fed^{-1}) and stalks yield (2173 kg fed^{-1}). These results may be related to that splitting N recommended dose at 75% as a soil application with foliar 1% N application at three times decreased the amount of N-fertilizer losses by leaching and volatilization and increased the efficiency of N-fertilizer that applied. These results agree with that obtained by Hokam et al., (2011), El-Agrodi et al., (2011) and El-Dissoky (2013).

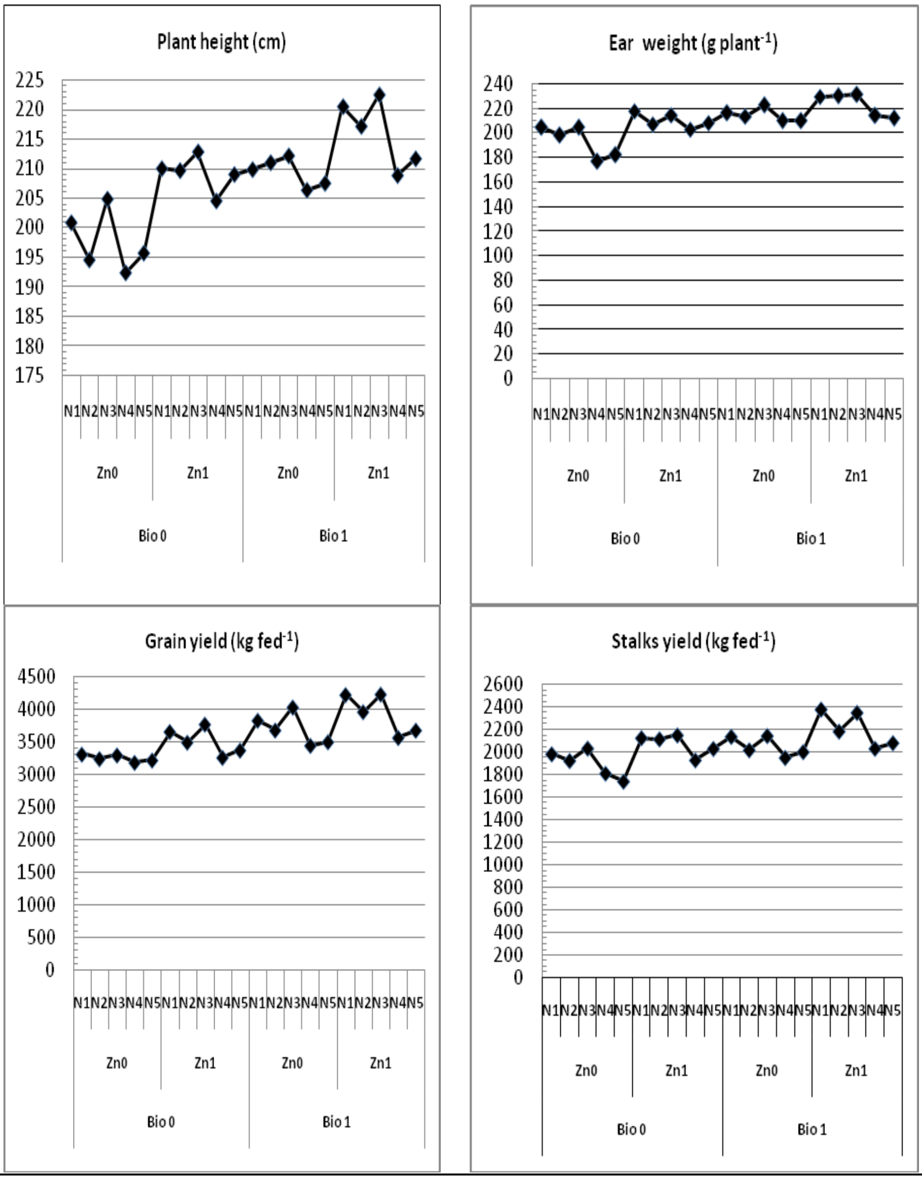
Foliar application of Zn-EDTA significantly increased plant height, ear weight/plant, grain yield and stalks yield, whereas maize grain yield was increased by 7.13%. These responses may be attributed to low soil available Zn before sowing (as shown in Table 1) that reflected on responsibility of maize plants to Zn foliar application, and also related to the vital role of Zn in plant for building up vegetative growth as well as suggested its roles in activation of many enzymatic reactions probable connection of auxin and its close involvement in nitrogen metabolism (Mengle and Kirkby, 1982). These results are in accordance with Abd El-Kader et al., (2007), Zein et al., (2009) and El-Azab (2015).

Also, inoculation maize seeds before sowing with bio-fertilizer significantly increased plant height, weight of ear per plant, grain yield and stalks yield. Inoculation maize seeds by bio-fertilizer increased grain yield by 12.81% and stalks yield by 7.25%. This could be attributed to the beneficial effect of bacteria on nutrients availability, vital enzymes, and growth promoting substances which may be produced by some bacteria such auxin, gibberelic acid, indole-3-acetic acid and cytokine, that promote plant growth (Salem 2000 and Eleiwa et al., 2012).

Concerning the effect of interactions among nitrogen, zinc and bio-fertilizer, results reveal that the interaction between zinc and bio-fertilizer (Zn*Bio) significantly increased plant height and weight of ear per plant, but the increases in grain and stalks yields were insignificant. The interaction between N-rates and bio-fertilizer has insignificant effect on plant height, weight of ear per plant and stalks yield, but have significant effect on grain yield. Also, the interaction between N-rates and Zn-EDTA foliar application have significant effect on maize grain yield and insignificant effect on stalks yield, plant height and weight of ear per plant. The increase in grains and stalks by N or Zn may be due to that rate of N and Zn could be suitable for the enhancement of photosynthesis and the accumulation of metabolites in maize organs. Regarding the effect of interaction among N-rates, zinc and bio-fertilizer (N*Zn*Bio), results shown by Fig. 1 reveal that this interaction have significant effect on weight of ear per plant and stalks yield, and insignificant effect on grain yield and plant height. It is obvious from the results that effect of interactions $N1*Zn_1*Bio_1$ and $N3*Zn_1*Bio_1$ were more effective on increasing plant height, weight of ear per plant, grain yield and stalks yield, whereas the superiority was for interaction $N3*Zn_1*Bio_1$. These results may be due to the effect of integration among splitting of soil nitrogen fertilizer application at 75% and 1% N foliar spray with Zn-EDTA foliar spray, in addition to the effect of bio-fertilizer on soil and consequently on plant. In general, it could be concluded that the effective action of nitrogen fertilizer may be improved by combination with bio-fertilization or with spraying N and Zn for higher maize grain yield. These results are in agreement with those obtained by El-Akabawy et al., (2001), Abd El-Kader et al., (2007) and Eleiwa etal.,(2012).

Table 2: Influence of nitrogen, zinc and bio-fertilization and its interactions on maize yield and its components (Average of the two growing seasons).

Treatments			Plant height (cm)	Ear weight (g plant^{-1})	Grain yield (kg fed^{-1})	Stalks yield (kg fed^{-1})
Bio-fertilization						
Bio_0			203	202	3386	1987
Bio_1			213	219	3820	2131
LSD at 5%			1.94	0.94	134.9	38.4
Zn-foliar						
Zn_0			204	204	3479	1978
Zn_1			213	217	3727	2141
LSD at 5%			0.65	3.22	86.4	41.1
N-rates						
N1			210	217	3761	2160
N2			208	212	3599	2064
N3			213	218	3838	2173
N4			203	201	3369	1934
N5			206	203	3447	1967
LSD at 5%			2.53	3.85	87.0	60.4
Interaction effects						
Interaction Zn*Bio	Bio_0	Zn_0	198	193	3255	1901
		Zn_1	209	210	3516	2073
	Bio_1	Zn_0	209	214	3703	2054
		Zn_1	216	223	3938	2209
LSD at 5%			0.67	3.35	ns	ns
Interaction N*Bio	Bio_0	N1	205	211	3489	2057
		N2	202	203	3372	2023
		N3	209	210	3539	2095
		N4	198	190	3227	1873
		N5	202	195	3300	1888
	Bio_1	N1	215	223	4033	2262
		N2	214	222	3826	2105
		N3	217	227	4138	2251
		N4	208	212	3510	1994
		N5	210	211	3594	2045
LSD at 5%			*ns*	*ns*	*123.3*	*ns*
Interaction N*Zn	Zn_0	N1	205	211	3575	2063
		N2	203	206	3466	1974
		N3	209	214	3670	2093
		N4	199	194	3319	1884
		N5	202	196	3365	1874
	Zn_1	N1	215	224	3946	2256
		N2	213	219	3733	2153
		N3	218	223	4007	2254
		N4	207	209	3418	1983
		N5	210	210	3529	2059
LSD at 5%			ns	ns	123.3	ns



Bio_0: without bio-fertilizer, Bio_1: with bio-fertilizer; Zn_0: without Zn foliar, Zn_1: with Zn foliar N1: 100% RN; N2: 75% RN+ 1% N foliar 2 times; N3: 75% RN+ 1% N foliar 3 times; N4: 50% RN+ 1% N foliar 2 times and N5: 50% RN+ 1% N foliar 3 times.

Fig. 1: Influence of interaction among nitrogen, zinc and bio-fertilization (N*Zn*Bio) on maize plant height, ear weight, grain and stalks yield (Average of the two growing seasons).

2- Maize grain quality:

Presented data in Table 3 and Fig. 2 show the effect of N-rates, zinc, bio-fertilizer and their interactions on maize grain quality (100-grain weight, carbohydrate %, oil % and protein %).

Data in Table 2 illustrate that application of N-rates significantly increased all of 100-grain weight, carbohydrate %, oil % and protein % up to rate N3, whereas the differences between N1 and N3 were insignificant for 100-grain weight and protein%, and significant for carbohydrate % and oil %. These results are in accordance with that obtained by Ewais et al., (2009), El-Atawy and Eid (2010) and Hokam et al., (2011).

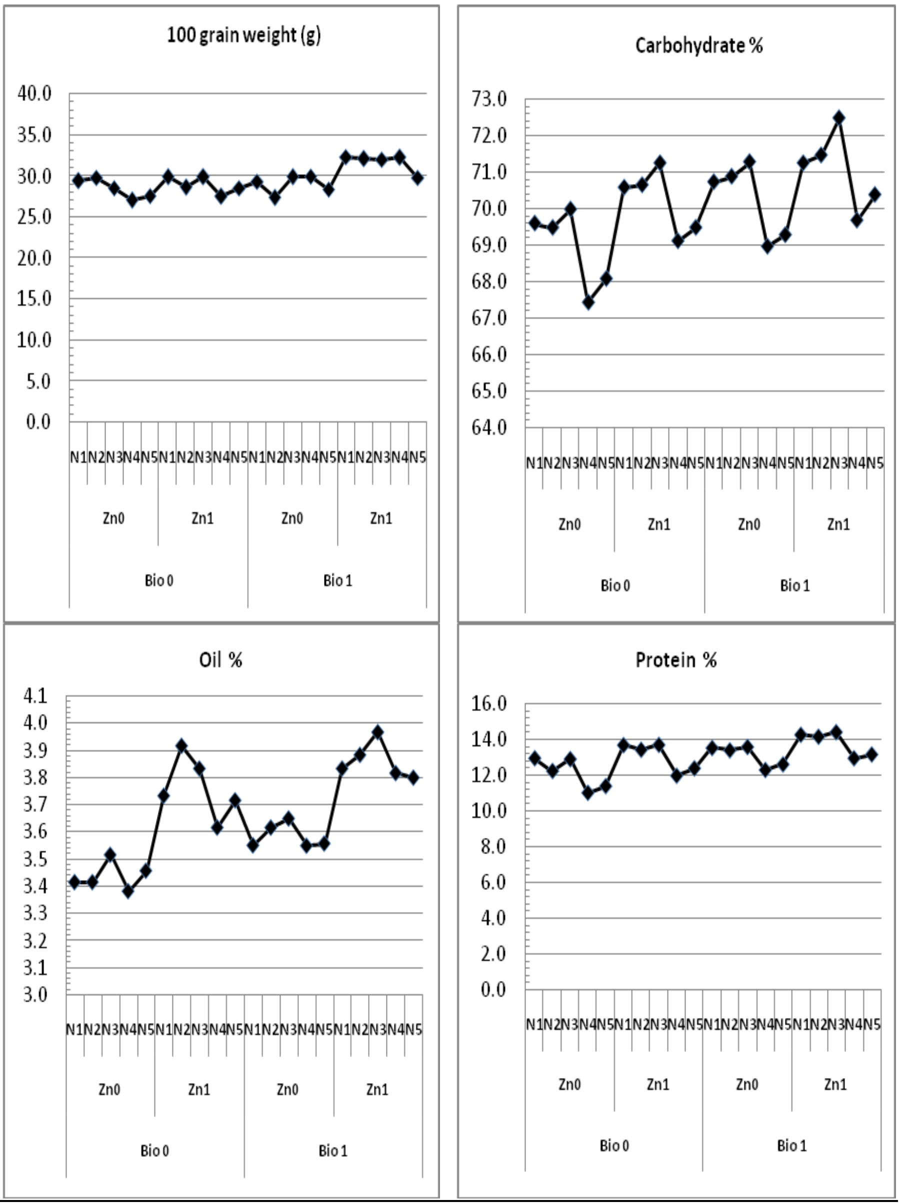
As for the effect of Zn-EDTA foliar application on maize grain quality, results reveal that all of 100-grain weight, carbohydrate %, oil % and protein % significantly increased with Zn foliar application. The 100-grain weight was increased by 5.53%. These effect may be attributed to role of Zn in plant, that plays an important role as a metal component of enzymes, as a functional, structural or regulator co-factor for a large number of enzymes, in carbohydrate metabolism, protein synthesis and particularly the buildup of the amino acid tryptophan, as well as a precursor for the synthesis of IAA (Marschner, 1986). Concerning the effect of zinc on protein content, Roy et al., (1981) gave an explanation for this effect, that zinc is recognized as an essential component of a number of dehydrogenises, proteinases and peptidases. Moreover, they added that associated with the role of zinc in protein synthesis, its apparent role in the activity of tryptophan synthesis, which consider one of the amino acids. These results agree with those obtained by Osman et al., (2001) and Abd El-Kader et al., (2007).

Application of bio-fertilizer significantly increased weight of 100-grain, carbohydrate %, oil % and protein %. The weight of 100-grain increased by 5.82%, this effect return to positive effect of bio-fertilizer on nitrogen fixation and release of phosphorus that reflected on the amount of nitrogen and phosphorus uptake and plants growth, yield and its components (El-akabawy et al., 2001 and Zarabi et al., 2011).

Concerning the effect of interactions among N, Zn and bio-fertilizer, results reveal that interaction Zn*Bio have a significant effect on 100-grain weight and insignificant effect on carbohydrate %, oil % and protein %. The interaction between N-rates and bio-fertilizer (N*Bio) significantly increased 100-grain weight and protein %, while insignificantly increased carbohydrate % and oil %. Also, the effect of interaction between N and Zn (N*Zn) have insignificant effect on 100-grain weight, carbohydrate % and protein %, but affected significantly on oil %. As shown in Fig 2 the interactions among N-rates, Zn and bio-fertilizer (N*Zn*Bio) increased 100-grain weight and oil % significantly, but have insignificant effect on carbohydrate %, and protein %. These increases were more obvious under the interactions $N1*Zn_1*Bio_1$, $N2*Zn_1*Bio_1$ and $N3*Zn_1*Bio_1$ comparing with others. These results positively response to application of nitrogen fertilizer, zinc foliar and bio-fertilizer may be attributed to integration effect among application of N-rates and foliar application of Zn and bio-fertilizer inoculation.

Table 3: Influence of nitrogen, zinc and bio-fertilization and its interactions on quality of maize grain yield (Average of the two growing seasons).

Treatments			100-Grain weight (g)	Carbohydrate %	Oil %	Protein %
Bio-fertilization						
Bio_0			28.70	69.57	3.60	12.58
Bio_1			30.37	70.64	3.72	13.45
LSD at 5%			0.20	0.55	0.04	0.19
Zn-foliar						
Zn_0			28.74	69.57	3.51	12.61
Zn_1			30.33	70.64	3.81	13.42
LSD at 5%			0.26	0.26	0.03	0.22
N-rates						
N1			30.25	70.54	3.63	13.62
N2			29.50	70.62	3.71	13.32
N3			30.11	71.25	3.74	13.66
N4			29.22	68.80	3.59	12.08
N5			28.59	69.31	3.63	12.41
LSD at 5%			0.54	0.37	0.04	0.19
Interaction effects						
Interaction Zn*Bio	Bio_0	Zn_0	28.48	68.92	3.44	12.12
		Zn_1	28.92	70.22	3.76	13.05
	Bio_1	Zn_0	29.00	70.23	3.59	13.10
		Zn_1	31.74	71.05	3.86	13.80
LSD at 5%			0.27	ns	ns	ns
Interaction N*Bio	Bio_0	N1	29.68	70.09	3.58	13.33
		N2	29.23	70.07	3.67	12.85
		N3	29.23	70.62	3.68	13.31
		N4	27.30	68.28	3.50	11.52
		N5	28.07	68.78	3.59	11.91
	Bio_1	N1	30.83	70.99	3.69	13.91
		N2	29.78	71.18	3.75	13.79
		N3	30.98	71.88	3.81	14.01
		N4	31.14	69.33	3.68	12.64
		N5	29.11	69.83	3.68	12.90
LSD at 5%			0.77	ns	ns	0.28
Interaction N*Zn	Zn_0	N1	29.37	70.17	3.48	13.26
		N2	28.59	70.18	3.52	12.83
		N3	29.23	70.63	3.58	13.26
		N4	28.52	68.20	3.47	11.68
		N5	27.98	68.68	3.51	12.02
	Zn_1	N1	31.14	70.92	3.78	13.98
		N2	30.41	71.06	3.90	13.80
		N3	30.98	71.87	3.90	14.06
		N4	29.93	69.40	3.72	12.48
		N5	29.19	69.93	3.76	12.79
LSD at 5%			ns	ns	0.055	ns



Bio_0: without bio-fertilizer, Bio_1: with bio-fertilizer; Zn_0: without Zn foliar, Zn_1: with Zn foliar N1: 100% RN; N2: 75% RN+ 1% N foliar 2 times; N3: 75% RN+ 1% N foliar 3 times; N4: 50% RN+ 1% N foliar 2 times and N5: 50% RN+ 1% N foliar 3 times.

Fig. 2: Influence of interaction among nitrogen, zinc and bio-fertilization (N*Zn*Bio) on 100-grain weight, carbohydrate %, oil % and protein % (Average of the two growing seasons).

All of these fertilizers play important roles for maize yield that grown in sandy soils, which are poor in its fertility. These results have clearly the great important role of balanced nutrition with macro and micronutrients for obtaining higher grain yield productivity. These results agree with those of Eleiwa *et al.,* (2012) and El-Azab (2015).

3- Concentration and uptake of N, P, K and Zn in grain:

Data in Table 4 and Figs. 3 and 4 shows the effect of application N-rates as soil and foliar, Zn-EDTA, bio-fertilizer and their interactions on concentrations of N, P, K and Zn and its uptake of maize grain yield.

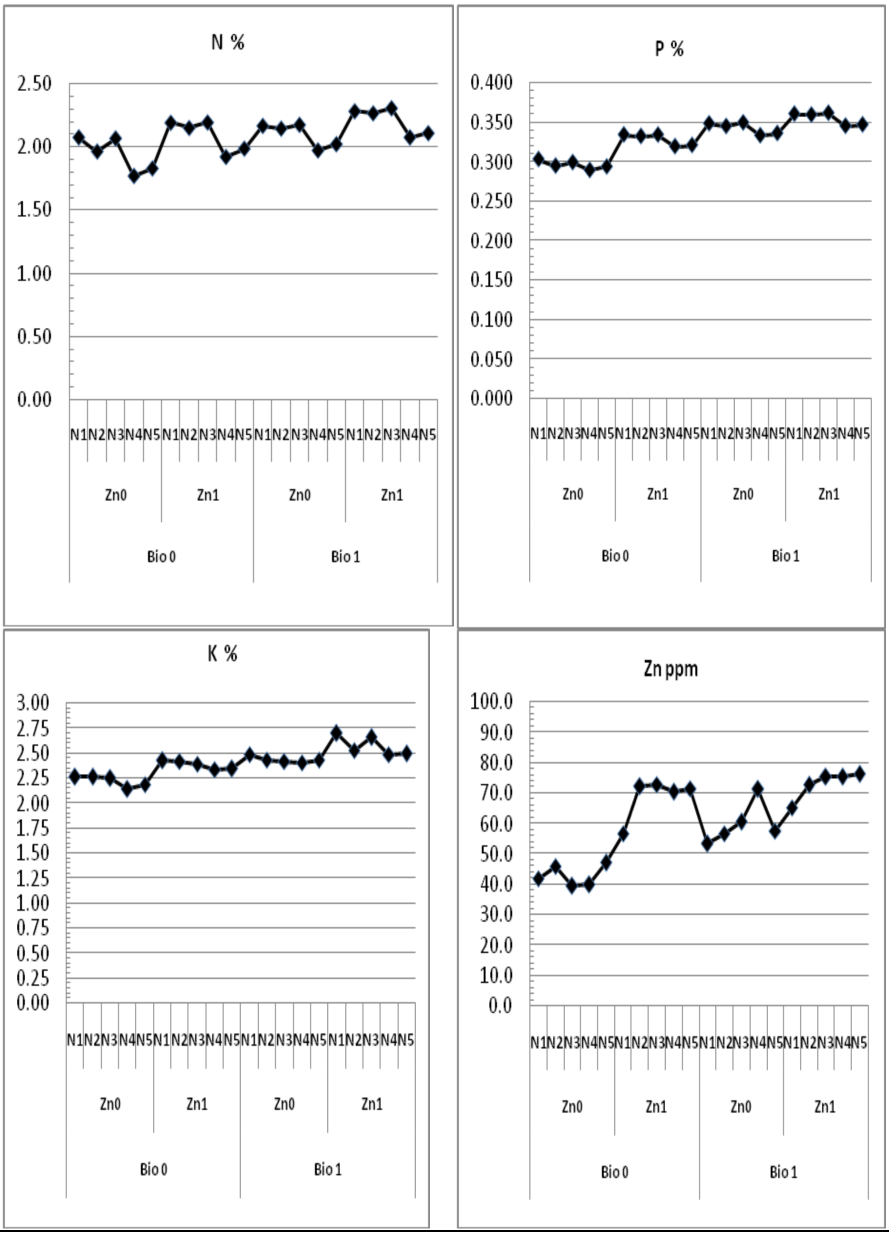
As shown in Table 4, application of N-rates with N foliar significantly affected on concentrations of N, P, K and Zn in grains and its uptake. The differences between N3 and N1 were insignificant, but the differences between N1 and N2, N4 and N5 were significant. This effect of N-rate N3 may be return that addition of 75% of recommended N with three foliar times of 1% N gave to plants more chances to uptake higher amount of N application than with application of all recommended doses as a soil application (N1) in sandy soils. This reflected on the amount of N that may be lost, and consequently reflected on the amount of N uptake by plants and consequently on phosphorus, potassium and zinc concentrations and uptake. These results are in accordance with those of Darwish (2003), Ewais et al., (2009), El-Atawy and Eid (2010) and El-Agrodi *et al.,* (2011).

Concerning the effect of foliar Zn-EDTA, results show that all of N, P, K and Zn concentration and its uptake by maize grain yield significantly increased with Zn-EDTA foliar. This increase at N, P, K and Zn in concentration and its uptake may be attributed to the low level of available Zn in soil, and also attributed role of zinc in plant. Whereas maize plants is considered sensitive to Zn deficiency in soil and high nutrient demanding crop (Mengle and Kirkby, 1982). Also, the increments in these values were due to that application of the Zn can exert an influence on electron transfer reactions including those in the Kreps cycle and subsequently on energy production in the plant. Other general types of reactions are affected by Zn enzymatic roles include protein synthesis. These results are agreed with Osman *et al.,* (2001) and El-Azab (2015).

Also, application of bio-fertilizer significantly increased concentrations and uptake of N, P, K and Zn in grain yield. This effect may be attributed to increasing the accounts of useful microorganisms which are low in sandy soils, such as *Azotobacter spp., Azospirllum spp., Bacillus megatherium, Bacillus polymyxa* and *Pseudomonas spp*, which plays important role in N-fixation, as well as production of physiologically active compounds to stimulate root growth and the availability of nutrient elements from soil which subsequently improved the nutritional status of whole plant tissues then the synthesis assimilation and translocation to the grains (Zarabi et al., 2011 and Eleiwa *et al.,* 2012).

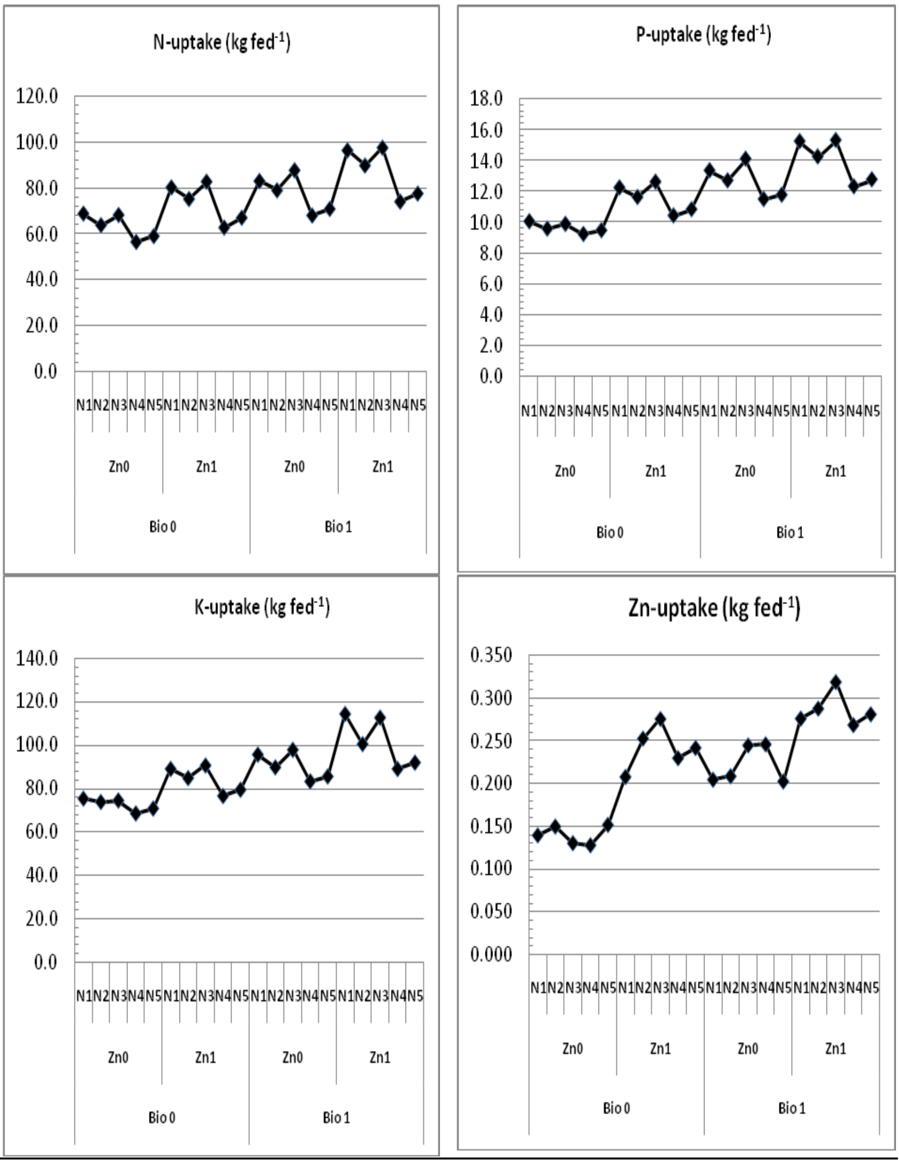
Table 4: Influence of nitrogen, zinc and bio-fertilization and their interactions on concentrations and uptake of N, P, K and Zn in maize grain (Average of the two growing seasons).

Treatments			N (%)	N-uptake (kg fed^{-1})	P (%)	P-uptake (kg fed^{-1})	K (%)	K-uptake (kg fed^{-1})	Zn (ppm)	Zn-uptake (kg fed^{-1})
Bio-fertilization										
Bio_0			2.01	68.4	0.313	10.6	2.31	78.2	56	0.191
Bio_1			2.15	82.5	0.349	13.3	2.51	96.0	66	0.254
LSD at 5%			0.03	3.12	0.003	0.42	0.04	3.62	3.8	0.007
Zn-foliar										
Zn_0			2.02	70.5	0.320	11.2	2.33	81.4	51	0.180
Zn_1			2.15	80.4	0.342	12.8	2.48	92.8	71	0.264
LSD at 5%			0.04	2.32	0.003	0.27	0.03	1.92	4.1	0.015
N-rates										
N1			2.18	82.2	0.337	12.7	2.47	93.5	54	0.207
N2			2.13	77.0	0.333	12.1	2.41	87.1	62	0.225
N3			2.19	84.2	0.337	13.0	2.43	93.8	62	0.242
N4			1.93	65.3	0.322	10.9	2.35	79.2	64	0.218
N5			1.99	68.6	0.325	11.2	2.37	81.8	63	0.219
LSD at 5%			0.03	2.18	0.004	0.34	0.03	2.15	2.5	0.011
Interaction effects										
Interaction Zn*Bio	Bio_0	Zn_0	1.94	63.2	0.297	9.67	2.22	72.4	43	0.140
		Zn_1	2.09	73.6	0.329	11.6	2.39	84.0	69	0.242
	Bio_1	Zn_0	2.10	77.7	0.343	12.7	2.44	90.3	60	0.221
		Zn_1	2.21	87.2	0.355	14.0	2.58	101.6	73	0.287
LSD at 5%			ns	ns	0.003	0.28	ns	ns	4.28	0.016
Interaction N*Bio	Bio_0	N1	2.13	74.6	0.319	11.2	2.35	82.1	49	0.173
		N2	2.06	69.5	0.314	10.6	2.35	79.2	59	0.201
		N3	2.13	75.5	0.317	11.3	2.32	82.4	56	0.203
		N4	1.84	59.5	0.305	9.86	2.24	72.4	55	0.179
		N5	1.91	62.9	0.308	10.2	2.27	75.0	59	0.197
	Bio_1	N1	2.23	89.8	0.355	14.3	2.60	104.9	59	0.240
		N2	2.21	84.5	0.353	13.5	2.48	95.1	65	0.248
		N3	2.24	92.8	0.356	14.7	2.54	105.2	68	0.282
		N4	2.02	71.0	0.340	11.9	2.45	86.1	73	0.257
		N5	2.06	74.2	0.342	12.3	2.47	88.7	67	0.242
LSD at 5%			0.04	3.10	ns	0.48	0.04	3.05	3.6	0.015
Interaction N*Zn	Zn_0	N1	2.12	75.9	0.326	11.7	2.38	85.4	48	0.172
		N2	2.05	71.4	0.321	11.2	2.35	81.7	51	0.179
		N3	2.12	78.0	0.325	12.0	2.34	86.1	50	0.187
		N4	1.87	62.1	0.312	10.4	2.28	75.8	56	0.187
		N5	1.92	64.9	0.316	10.6	2.31	78.1	52	0.177
	Zn_1	N1	2.24	88.4	0.348	13.8	2.57	101.6	61	0.242
		N2	2.21	82.6	0.346	13.0	2.48	92.6	73	0.270
		N3	2.25	90.3	0.348	13.9	2.53	101.6	74	0.298
		N4	2.00	68.4	0.333	11.4	2.42	82.7	73	0.249
		N5	2.05	72.3	0.335	11.8	2.42	85.6	74	0.262
LSD at 5%			ns	3.10	ns	0.48	0.04	3.05	3.6	0.015



Bio_0: without bio-fertilizer, Bio_1: with bio-fertilizer; Zn_0: without Zn foliar, Zn_1: with Zn foliar N1: 100% RN; N2: 75% RN+ 1% N foliar 2 times; N3: 75% RN+ 1% N foliar 3 times; N4: 50% RN+ 1% N foliar 2 times and N5: 50% RN+ 1% N foliar 3 times.

Fig. 3: Influence of interaction among nitrogen, zinc and bio-fertilization (N*Zn*Bio) on concentrations of N, P, K and Zn in maize grain (Average of the two growing seasons).



Bio_0: without bio-fertilizer, Bio_1: with bio-fertilizer; Zn_0: without Zn foliar, Zn_1: with Zn foliar N1: 100% RN; N2: 75% RN+ 1% N foliar 2 times; N3: 75% RN+ 1% N foliar 3 times; N4: 50% RN+ 1% N foliar 2 times and N5: 50% RN+ 1% N foliar 3 times.

Fig. 4: Influence of interaction among nitrogen, zinc and bio-fertilization (N*Zn*Bio) on uptake of N, P, K and Zn by maize grain (Average of the two growing seasons).

Regarding the effect of interactions, results at Figs. 3 and 4 reveal that interaction between Zn foliar application and bio-fertilizer (Zn*Bio) have a significant effect on phosphorus and zinc concentration and uptake. Whereas the interaction between N-rates and bio-fertilizer (N*Bio) significantly affected N, K and Zn concentration and its uptake by grain yield. Interaction between N-rates and foliar Zn-EDTA (N*Zn) have a significant effect on K and Zn concentration and its uptake. As for interaction among N-rates, Zn foliar and bio-fertilizer, results in Figs. 3 and 4 show that all of N, P, K and Zn concentration and its uptake by grain yield significantly affected by interaction (N*Zn*Bio), while the differences between values of interactions ($N1*Zn_1*Bio_1$), ($N2*Zn_1*Bio_1$) and ($N3*Zn_1*Bio_1$) were insignificant.

Finally, from the previous results, it can be concluded that integration among application of N-rates as a soil and foliar application in two or three times with foliar application of Zn-EDTA in two times in addition to inoculation maize seeds before sowing by bio-fertilizer have a positive effect on all parameters under investigation, especially weight of ear per plant, 100-grain weight, grain yield, stalks yield, carbohydrate %, oil % and protein %, and all of N, P, K and Zn uptake. Also, from comparison study by relative increase % (RI %) between the mean values of weight of ear per plant, 100-grain weight, grain yield, stalks yield, carbohydrate %, oil % and protein % as shown in Tables 5a and 5b as influenced by interaction of nitrogen, zinc and bio-fertilization (N*Zn*Bio). It is obvious from the two tables that all of interactions $N1*Zn_1*Bio_1$, $N2*Zn_1*Bio_1$ and $N3*Zn_1*Bio_1$ were more effective in increasing these parameters, whereas, the RI % of grain yields were 27.58, 19.68 and 27.68 %, and for stalks yields were 20.00, 10.17 and 18.83%, respectively.

Table 5a: Comparison study by relative increase % (RI %) on maize yield and its components as influenced by interaction among nitrogen, zinc and bio-fertilization (N*Zn*Bio).

Interaction	Ear weight (g plant^{-1})	Relative increase (%)	100-grain weight (g)	Relative increase (%)	Grain yield (kg fed^{-1})	Relative increase (%)	Stalks yield (kg fed^{-1})	Relative increase (%)
$N*Zn_0*Bio_0$ (control)	205	0.00	29.42	0.00	3315	0.00	1986	0.00
$N1*Zn_1*Bio_1$	230	12.21	32.35	9.97	4229	27.58	2383	20.00
$N2*Zn_1*Bio_1$	230	12.38	32.15	9.29	3968	19.68	2188	10.17
$N3*Zn_1*Bio_1$	231	13.03	32.07	9.01	4238	27.82	2354	18.53
$N4*Zn_1*Bio_1$	214	4.56	32.28	9.75	3571	7.70	2035	2.49
$N5*Zn_1*Bio_1$	212	3.42	29.85	1.47	3683	11.09	2085	4.99

Table 5b: Comparison study by relative increase % (RI %) on maize grain yield quality as influenced by interaction among nitrogen, zinc and bio-fertilization (N*Zn*Bio).

Interaction	Carbohydrate %	Relative increase (%)	Oil %	Relative increase (%)	Protein %	Relative increase (%)
$N*Zn_0*Bio_0$ (control)	69.60	0.00	3.42	0.00	12.97	0.00
$N1*Zn_1*Bio_1$	71.25	2.37	3.83	12.20	14.27	10.04
$N2*Zn_1*Bio_1$	71.47	2.68	3.88	13.66	14.17	9.24
$N3*Zn_1*Bio_1$	72.48	4.14	3.97	16.10	14.42	11.16
$N4*Zn_1*Bio_1$	69.68	0.12	3.82	11.71	12.97	0.00
$N5*Zn_1*Bio_1$	70.38	1.13	3.80	11.22	13.18	1.61

These effects may be attributed to facts, 1) that sandy soils are poor in its fertility and so it needs more fertilizer with integrated management; 2) Zn application is necessary in fertilization practices especially in newly land and sandy soils and 3) inoculation of bio-fertilizer is important to increase nitrogen fertilizer supply. Where, N-rate (N3) was more superior, because it saved about 112.2 kg nitrogen fertilizer fed^{-1} (23 kg N fed^{-1}) comparing with application of all recommended N-fertilizer (683 kg ammonium sulphate fed^{-1}) as soil application (N1). From the previous results, it is interesting to mention that bio-fertilizer inoculation is important economically for reducing the rate of nitrogen fertilizer and also for reducing environmental pollution.

CONCLUSION

So, this study can be recommended by maize crop fertilization in sandy soils with N-fertilization at 105 kg N Fed^{-1} (512.2 Kg ammonium sulphate fed^{-1}) with foliar application of 1% N (21.74 g urea L^{-1}) at three times after 25, 40 and 60 days from planting with foliar application of 0.06 % Zn-EDTA at two times after 40 and 60 days from planting, with inoculation seeds before sowing by bio-fertilizer with addition the constant recommended doses of phosphorus and potassium to achieve the highest maize grain yield under the same conditions.

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إدارة الاحتياجات النتروجينية لمحصول الذرة الشامية النامي في الأرض الرملية بالإضافة الورقية للنتروجين والزنك مع التسميد الحيوي.

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أصبح التكامل بين التسميد النتروجيني المعدني والإضافة الورقية للعناصر الغذائية الصغرى والتلقيح بالأسمدة الحيوية أمراً ضرورياً لترشيد استخدام الأسمدة النتروجينية المعدنية وزيادة إنتاجية محصول الذرة الشامية وجودته، ولذلك أجريت تجربة حقلية خلال موسمي النمو الصيفيين لعام ٢٠١٣ و ٢٠١٤ بقرية الشعراوي بمنطقة البستان –النوبارية - محافظة البحيرة – مصر(الواقعة بين خط عرض ٣٠° - ٤٣´ - ٢٢.٠١" شمالاً وخط طول ٣٠° -١٣´ -٤٤.٥٠" شرقاً) لدراسة استجابة محصول الذرة الشامية ومكوناته (صنف هجين ثلاثي ٣٢٥ أصفر) في الأراضي الرملية وذلك لإضافة خمسة معدلات مختلفة من السماد النتروجيني المعدني (ن١: ١٠٠% أرضى ؛ ن٢: ٧٥% أرضى + رش ١% ن مرتين ؛ ن٣: ٧٥% أرضى + رش ١% ن ثلاث مرات ؛ ن٤: ٥٠% أرضى +رش ١% ن مرتين ؛ ن٥: ٥٠% أرضى + رش ١% ن ثلاث مرات) ومعاملات الرش بالزنك المخلبي (بدون رش ، مع رش عند تركيز ٠.٠٦%) والتسميد الحيوي (بدون تلقيح، ومع تلقيح بالسماد الحيوي). نفذت التجربة كقطع منشقة مرتين حيث تمثل التسميد الحيوي في القطع الرئيسية والرش بالزنك في القطع الشقية ومعدلات التسميد النتروجيني في القطع تحت الشقية.

وكانت أهم النتائج المتحصل عليها كما يلي:

- إضافة معدلات التسميد النتروجيني و الرش الورقي بالزنك المخلبي والتلقيح بالمخصب الحيوي أثر معنويا على كل من القياسات المدروسة مثل ارتفاع النبات ووزن الكوز للنبات ، محصولي الحبوب والحطب ، وزن المائة حبه ، نسب كل من الكربوهيدرات ، الزيت والبروتين وتركيز كلا من النتروجين والفوسفور والبوتاسيوم والزنك والممتص منهم بواسطة الحبوب، حيث زاد محصول الحبوب بنسبة ١٢.٨١% مع التلقيح بالسماد الحيوي وبنسبة ٧.١٣ % مع الرش الورقي بالزنك المخلبي.
- زاد كل من ارتفاع النبات ووزن الكوز للنبات وتركيز كل من الفوسفور والزنك والممتص منهم بواسطة الحبوب في حالة التفاعل بين الرش بالزنك والتسميد الحيوي، كذلك أثر التفاعل بين معدلات النتروجين والتسميد الحيوي معنويا على محصول الحبوب ووزن المائة حبه وتركيز كل من الفوسفور والزنك والممتص منهم بواسطة الحبوب، علاوة علي ذلك أثر التفاعل بين معدلات النتروجين والرش بالزنك معنويا علي محصول الحبوب.
- كان للتفاعل الثلاثي بين معدلات التسميد النتروجيني والرش بالزنك والتسميد الحيوي تأثيراً معنويا علي كلا من متوسط وزن الكوز للنبات ومحصولي الحبوب والحطب ومحتوي الزيت وتركيز كلا من النتروجين والبوتاسيوم والزنك والممتص منهم بواسطة الحبوب، حيث كان التفوق للتفاعل الثلاثي بين معدل النتروجين ن٣ (٧٥% أرضي + الرش ب ١% ن ثلاث مرات) والرش بالزنك المخلبي عند تركيز ٠.٠٦% والتلقيح بالمخصب الحيوي حيث حقق أعلي نسبة زيادة لكل من وزن الكوز ومحصولي الحبوب والحطب ونسب كل من الكربوهيدرات والزيت والبروتين (١٣.٠٣ ، ٢٧.٨٢ ، ١٨.٥٣ ، ٤.١٤ ، ١٦.١٠ ، ١١.١٦ % على التوالي) .