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Response of Maize Yield to Nitrogen Fertilization and Foliar Spray by Some Microelements

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ABSTRACT

Two field experiments were conducted on the Agricultural Research and Experiment Center, Faculty of Agriculture Moshtohor, Benha University, Toukh Directorate, Kalubia Governorate, Egypt,during the two successive summer seasons of 2014 and 2015 tostudy the effect of four nitrogen fertilizer treatments, i.e. 40, 70, 100 and 130 kg N/fed. and foliar spray by five micronutrient treatments, i.e. Non-fertilized, Zn, Mn, Fe and Zn + Mn + Feon the growth traits, yield, its component and some chemical properties of maize(white single cross hybrid 2031). The experimental design was split plot design in four replications. The obvious results of this investigation can be summarized as follows: All traits of maize under study (plant height, No. of green leaves/plant and leaf area index at 100 days from planting, No. of ears/fed., ear length, ear weight, weight of kernels/ear, 100-kernel weight, kernels shelling %, biological yield/fed., grain yield/fed., stover yield/fed., harvest index %, kernels nitrogen uptake/fed., kernels protein yield/fed., leaf and kernel nitrogen contents, zinc, manganese and iron contents of maize leaves in the two seasons.) showed significantly increased by increasing nitrogen fertilizer rates, except, mid tasseling and silking dates significantly decreased with increasing nitrogenrates in the both seasons. Application of 130 kg N /fed significantly gave the maximum values of above traits. Results revealed that micronutrient foliar spray using Zn + Mn + Fe treatment was the most effective treatment forprevious growth, yield and its components traits of maize in the two seasons. Meanwhile, maize plants which foliar spray by singly Zn, Mn and Fe treatments significantly gave the highest values of leaf zinc content, leaf manganese content and leaf iron content, respectively in 2014 and 2015 seasons. The interaction between nitrogen fertilizer by 130 kg N/fed.and foliar spray by mixed Zn + Mn + Fe treatment significantly gave the greatest values ofmaize traits, i.e. plant height, No. of green leaves/plant and leaf area index at 100 days from planting, No. of kernels/ear, ear weight, weight of kernels/ear, biological yield/fed., grain yield/fed, kernels nitrogen uptake/fed.and kernels protein yield/fed.in the both seasons. It could be summarized that fertilization of maize field by 130 kg N/fed.and foliar spray by mixed of Zn + Mn + Fe to maximized grain yield/feddan.

INTRODUCTION

Maize (*Zea mays*, L.) is one of the most important cereal crops in the world and ranks the third of the most important cereal crops in the world which surpassed by wheat and rice. In Egypt, maize is essential for livestocks and human consumption as an available source of carbohydrate, oil and slightly for protein. The growing area of maize in Egypt during 2013 year is about 2,142,857 feddan with a total grain yield of 6,500,000 ton and average grain yield production per feddan was about 3,033 kg(Min. Agric. Statistic Year Book, 2013). The total production supplies 80 % of the require consumption with a reduction gap of 20 % which has to be filled via importation.

Increasing maize production during the last period became one of the most important goals of the Egyptian government to satisfy human and animal demands.Determination the required rate of nitrogen fertilization of maize is of the main important practices of great contribution for the highest production of better quality, as well as nitrogen is a key element for corn productivity as well as in many other field cereal crops.Several investigations reported that increasing nitrogen fertilization rates caused significant increase in growth, yield, its components and chemical properties traits of maize.El-Gizawy 2000; El-Gizawy 2005;Mehasen and Saeed 2006; El-Gedwy 2007; Alizadeh 2010; Attia*et al*., 2011; El-Gharieb*et* al., 2011;Shafea and Saffari 2011; Siam *et al*., 2012; Verma*et al*., 2012; Raskar*et al*., 2013; Manasek*et al*., 2013 and Azeem*et al*., 2015showed that significantly increases in plant height, No. of green leaves/plant, leaf area index, No. of ears/fed., ear length, ear weight, weight of kernels/ear, 100-kernel weight, kernels shelling %, biological yield/fed., grain yield/fed., stover yield/fed., harvest index %, kernels nitrogen uptake/fed., kernels protein yield/fed., leaf and kernel nitrogen contents, zinc, manganese and iron contents of maize leaves with increasing nitrogen fertilization rates. On the other hand No. of days to 50 % tasseling and silking weresignificantly decreased

Several investigators reported positive response of maize plants to micronutrient foliar spaying(El-Gizawy 2000; El-Akabawy*et al.,* 2001; El–Gizawy 2005; Attia*et al*., 2011; Shafea and Saffari 2011; Salem and El-Gizawy 2012; Siam *et al*., 2012 andRaskar*et al*., 2013). Micronutrients are required in small amounts and they affect directly or indirectly photosynthesis, vital processes in plants such as respiration, protein synthesis and reproduction phase (Marschner, 1995). El-Akabawy*et al.*, 2001stated that the beneficial effects of micronutrients application were recorded by many workers on soils of Egypt.

Zinc plays an important role as a metal component of enzymes (superoxide dismutase, carbonic anhydrase and RNA polymerase) or as a functional, structural, or regulator cofactor of a large number of enzymes. Manganese has an essential role in amino acid synthesis by activating a number of enzymes particularly decarboxylases and dehydrogenases of the tricarboxylic acid cycle.Iron is a constituent of many enzymes involved in the nutritional metabolism, energy transfer, nitrogen reduction and fixation, and lignin formation of plant (Marschner 1995 and Kabata&Pendias, 1999).

Mehasen and Saeed 2006; Rego*et al*., 2007; Kanwal*et al*., 2010; Attia, *et al*., 2011; El-Gharieb*et* al., 2011; Sadek and Attia 2011; Shafea and Saffari 2011; Siam, *et al*., 2012; Salem & El-Gizawy 2012; Balbaa and Awad 2013 and Raskar, *et al*., 2013 reported an significantly increases in plant height, leaf area index, No. of ears/fed., No. of kernels/ear, kernels weight/ear, weight of 100-kernel, biological yield, grain yield, stover yield, harvest index, nitrogen uptake/plant, Zn, Mn and Fe contents in leaves as well as Zn and Fe content in maize kernels by Zn application.Ashoub*et al.*, 1998; El-Gizawy 2000; Attia*et al*., 2011;Sadek and Attia 2011; Siam*et al*., 2012; Salem and El-Gizawy 2012 and Balbaa&Awad 2013 showed that using of Mn significantly increased plant height, No. of green leaves /plant, leaf area index, No. of ears/fed., No. of kernels/ear, kernels weight/ear, weight of100-kernel, biological yield, grain yield, stover yield, harvest index, Mn uptake, protein content in kernels, nitrogen uptake/plant, Zn, Mn and Fe contents in leaves.Al-Kanh and Abdullal 2008;El-Gharieb*et* al., 2011; Siam*et al*., 2012; Salem and El-Gizawy 2012 and Balbaa&Awad 2013 reported that application of iron significantly rising plant height, No. of ears/fed., No. of kernels/ear, kernels weight/ear, weight of 100-kernel, grain yield, nitrogen uptake/plant, Zn, Mn and Fe contents in leaves.

The aim of this investigation was designed to study the effect of nitrogen and micronutrients fertilization on growth, yield, its components and chemical composition of corn.

MATERIALS AND METHODS

Two field experiments were carried out at the Farm of Faculty of Agriculture at Moshtohor, Benha University(Toukh Directorate, Kalubia Governorate, Egypt), during the two summersgrowing seasons 2014 and 2015. The aim of this study was to investigate the effect of nitrogen fertilizationrates and some microelements, i.e.zinc, manganese and iron on growth, yield and its components of maize (white single cross hybrid 2031 for Misr hytech Seed Int.,) as well as some chemical composition of leaves and kernels of maize.Soil texture of the experimental site was clay of pH nearly of 8.00. The physical and chemical properties of the experimental soil were determined according to the standard procedures described by Black, 1965) andrepresented in Table, 1 in each of the two growing seasons.

Table1: Physical and chemical properties of the experimental soil units of the two growing seasons (2014 and 2015).

Properties	Seasons	
	2014	2015
Chemical analysis		
E.C.	2.26	2.32
pH (1 :2.5)	7.97	7.95
$CaCo_3$ %	2.96	2.90
O.M %	2.41	2.38
N % (total)	0.210	0.223
N(ppm) (available)	70.31	73.15
Soluble cations and anions (ppm)		
Mn^{++}	7.9	9.3
Fe^{++}	10.5	8.8
Zn^{++}	2.3	2.4
Particle size distribution (mechanical analysis)		
Course sand %	7.26	6.59
Find sand %	26.91	27.64
Silt %	13.85	12.60
Clay %	51.98	53.17
Texture grade	Clay	Clay

Each experiment included 20 treatments which were the combination of four nitrogen fertilizer treatments and five treatments of microelements.

Factors under study were as follows:

Four nitrogen fertilizationtreatments, i.e. 40, 70, 100 and 130 kg N/fed.,nitrogen fertilizer was applied in form of urea (46 % N), and divided into two equal parts and applied before the first and second irrigation in each season.Five microelements treatments, i.e. control (without microelements), Zn 0.6 %, Mn 0.6 %, Fe 0.6 % and Zn0.2 % +Mn0.2% +Fe 0.2 %. Microelements were applied once as foliar spray after 35 days from planting in form of Zinc Sulphate ($Zn So_4$. $7H_2o$), Manganese Sulphate ($Mn So_4$. H_2o) and Iron Sulphate ($Fe So_4$. $7H_2o$) for microelements under study using Gelatine Powder as a wetting agent to be sure that the solution mostly covered the green parts, the spray solution volume was 600 L/ fed. (1.5 L/plot)

The experimental design was split plot design (Gomez and Gomez, 1984) in four replications. Nitrogen fertilizer treatments were distributed in the main plots, whereas the microelements treatments were arranged at random in sub plots. The preceding winter crop in the two seasons was Egyptian clover.The sub plot area was 10.5 m^2 and contained five ridges of 3 m long and 70 cm apart. Experiments were planted on 24^{th} of May in the twoseasons. The distance between hills was 25 cm apart. Phosphorous fertilizer was applied in form of Calcium super phosphate (15 % P_2O_5) at a rate of 100 kg /fed.during soil preparation in each season. Maize plants were thinned before the first irrigation to one plant/hill. Other recommended cultural practices for growing maize in the region were practiced.

Data recorded:

A- Growth traits:

Ten plants were chosen at random from each sub plots to determine some growth traits:plant height (cm) at harvest, No. of green leaves/plant and leaf area index at 100 days after planting was estimated as described by Stickler (1964).Whereas, No. of days to 50 %tasseling and silking as well asNo. of ears/fed.were estimated from the whole plants of plot.

B- Yield and its components traits:

Ten ears were chosen at random from each sub plot at harvest to determine, the yield components: ear length (cm), No. of kernels/ear, ear weight (g), weight of kernels/ear (g), 100–kernel weight (g) and kernels shelling %.Meanwhile, biological yield (kg/fed.), grain yield (kg/fed.),stoveryield(kg/fed.)and harvest index % were estimated from the whole yield of plot.

C- Chemical analysis:

Maize leaves samples were taken from ear leaf at 70 days from planting and washed with water then dried on an air forced drying oven at 70ºC for 48 hours as well as, kernels samples were taken after harvest at random fromeach kernels of ten ears to determine:nitrogen content in leaves and kernels according to the modified micro Kjeldahl method (A. O. A. C., 1990), Kernels nitrogen uptake/fed., Kernels protein yield/fed., as well as Zinc, Manganese and iron (ppm) in leaves and kernels were determined according to Chapman and Pratt (1961) using atomic absorption spectrophotometer.

Statistical analysis:

The analysis of variance was carried out according to the procedure described by Gomez and Gomez (1984).Data were statistically analyzed according to using the MSTAT-C Statistical Software Package (Michigan State University, 1983). Where the F-test showed significant differences among means L. S. D. test at 0.05level was used to compare between means.

RESULTS AND DISCUSSION

Growth traits:

Effect of nitrogen fertilization:

Results in Table 2 showed that maize growth characters, i.e. plant height, No. of green leaves/plant, leaf area index and No. of ears /fed were significantly increased by increasing nitrogen fertilizer rates up to 130 kg N/fed in 2014 and 2015 seasons. On the other hand, increasing nitrogen fertilizer rates induced earlier mid tasseling and silking in the two seasons.Increases in maize growth traits with increasing nitrogen fertilizer may be attributed to the role of nitrogen in promoting the cell division, vegetative growth and encouraging the juvenility and active persistence of meristimatic tissues during maize growth. Many investigators came out with similar results asEl-Gizawy 2000; El-Gizawy 2005;Mehasen and Saeed 2006; El-Gedwy 2007; Attia*et al*., 2011; Siam *et al*., 2012; Verma*et al*., 2012 and Azeem*et al*., 2015.

Effect of foliar spray by microelements treatments:

Data presented in Table 2 showed that microelementsfoliar spray using Zn + Mn +Fe treatment was the most effective treatment of all maize growth traits, i.e. plant height, No. of green leaves/plantand leaf area index in the both seasons,also, adding of Zn + Mn + Fe induced earlier tasseling and silking % of in 2014 and 2015seasons.Treatments involving application of one of the microelements singly showed slight and significant superiority over than without microelementsapplication. The increase in maize growth traits with the application of microelements especially Zn + Mn + Fe treatment may be due to the synergetic role of microelements in improvingdirectly or indirectly photosynthesis, vital processes in plant such as respiration, protein synthesis, reproduction phase, biochemical and physiological activities. Many investigators came out with similar results asMarschner 1995; Ashoub *et al.*, 1998; Kabata and Pendias 1999; El-Gizawy 2000; El-Akabawy*et al.*, 2001; El–Gizawy 2005; Mehasen and Saeed 2006; Rego*et al*., 2007; Kanwal*et al*., 2010; Attia*et al*., 2011; Salem and El-Gizawy 2012; Siam *et al*., 2012 and Balbaa and Awad 2013.

Interaction effect:

Table 2 shows summary of the interaction effect of the two experimental factors on 50 % tasseling, 50 % silking, plant height, No. of green leaves/plant, leaf area index and No. of ears /fed. The results showed that this interaction significantly affected on plant height, No. of green leaves/plant and leaf area index on 2014 and 2015 seasons.The highest values of plant height, No. of green leaves/plant and leaf area index were recorded from maize plants which fertilized by 130 kg N/fed with foliar spray by Zn + Mn + Fe treatment. Such results are in accordance with those obtained byAttia*et al*., 2011; Mehasen&Saeed 2006and Siam *et al*., 2012.

Table 2: Effect of nitrogen fertilization and foliar spray by some microelements as well as their interaction on number of days to 50 % tasseling and silking, plant height (cm), No. of green leaves/plant, leaf area index and number of ears/feddan (1000 ears) of maize in 2014 and 2015 seasons.

Treatment	Trait	No. of days to 50 % tasseling		No. of days to 50 % silking		Plant height (cm)		No. of green leaves/plant		Leaf area index		No. of ears/fed (1000 ears)	
	Season	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015
Nitrogen fertilization													
40 kg N/fed		67.55	66.90	70.05	69.00	271.55	278.80	13.23	13.58	4.489	4.703	24.80	25.00
70 kg N/fed		66.55	65.75	69.20	68.15	290.40	298.25	14.21	14.47	5.232	5.427	25.60	25.90
100 kg N/fed		65.80	65.00	68.45	67.45	302.95	311.55	14.97	15.29	5.838	6.100	25.78	25.96
130 kg N/fed		64.80	64.05	66.80	65.80	313.10	321.10	15.52	15.85	6.296	6.556	25.90	26.22
L.S.D at 5%		0.96	1.01	1.42	1.32	9.26	10.55	0.44	052	0.271	0.322	0.36	0.39
Microelementsfertilization													
Zero		67.19	66.38	70.00	68.88	289.38	296.44	13.71	14.05	5.039	5.264	24.88	25.18
Zn		66.06	65.38	68.50	67.50	296.31	304.81	14.61	14.93	5.522	5.751	25.63	25.83
Mn		66.50	65.75	68.94	67.81	292.94	300.19	14.48	14.78	5.437	5.651	25.35	25.65
Fe		65.94	65.13	68.25	67.25	294.00	302.19	14.73	15.03	5.603	5.842	25.80	26.03
Zn+Mn+Fe		65.19	64.50	67.44	66.56	299.88	308.50	14.88	15.21	5.717	5.974	25.95	26.18
L.S.D at 5%		0.62	0.73	0.82	0.76	2.94	3.61	0.18	0.23	0.073	0.092	N.S	N.S
Nitrogen X Microelements fertilization interaction													
	Zero	68.75	68.25	71.75	70.75	263.50	269.00	12.45	13.00	4.000	4.253	24.00	24.10
	Zn	67.50	67.00	70.00	69.00	274.25	284.50	13.35	13.68	4.570	4.778	25.00	25.20
40 kg N/fed	Mn	68.00	67.50	70.25	69.25	269.75	274.25	13.23	13.50	4.473	4.663	24.50	24.80
	Fe	67.25	66.25	69.75	68.50	270.25	278.50	13.48	13.78	4.638	4.845	25.20	25.40
	Zn+Mn+Fe	66.25	65.50	68.50	67.50	280.00	287.75	13.65	13.95	4.763	4.978	25.30	25.50
	Zero	67.75	66.75	70.75	69.50	285.00	290.50	13.28	13.63	4.738	4.940	25.00	25.40
	Zn	66.50	65.75	69.00	68.00	292.50	300.25	14.38	14.63	5.305	5.495	25.70	25.90
70 kg N/fed	Mn	66.75	66.00	69.50	68.50	288.25	296.25	14.18	14.40	5.193	5.358	25.40	25.70
	Fe	66.25	65.50	68.75	67.75	289.00	298.50	14.53	14.75	5.395	5.598	25.90	26.20
	Zn+Mn+Fe	65.50	64.75	68.00	67.00	297.25	305.75	14.70	14.95	5.528	5.745	26.00	26.30
	Zero	66.75	65.75	69.50	68.50	299.25	307.75	14.20	14.45	5.440	5.680	25.10	25.40
	Zn	65.75	65.00	68.50	67.50	304.25	312.50	15.08	15.45	5.878	6.143	25.90	26.00
100 kgN/fed	Mn	66.25	65.25	68.75	67.50	301.25	310.00	15.03	15.33	5.823	6.053	25.70	25.90
	Fe	65.50	64.75	68.00	67.00	303.00	310.75	15.20	15.53	5.968	6.243	26.00	26.20
	Zn+Mn+Fe	64.75	64.25	67.50	66.75	307.00	316.75	15.35	15.70	6.083	6.380	26.20	26.30
	Zero	65.50	64.75	68.00	66.75	309.75	318.50	14.93	15.13	5.978	6.183	25.40	25.80
	Zn	64.50	63.75	66.50	65.50	314.25	322.00	15.63	15.95	6.335	6.590	25.90	26.20
130 kgN/fed	Mn	65.00	64.25	67.25	66.00	312.50	320.25	15.50	15.88	6.260	6.530	25.80	26.20
	Fe	64.75	64.00	66.50	65.75	313.75	321.00	15.73	16.05	6.410	6.683	26.10	26.30
	Zn+Mn+Fe	64.25	63.50	65.75	65.00	315.25	323.75	15.83	16.23	6.495	6.793	26.30	26.60
L.S.D at 5%		N.S	N.S	N.S	N.S	5.88	7.22	0.36	0.46	0.146	0.184	N.S	N.S

Yield and its componentstraits:

Effect of nitrogen fertilization:

Data presents in Tables 3 and 4 indicated that increasing nitrogen fertilization rates from 40, 70 and 100 to 130 kg N/fed caused significantly increased in all yieldand its componentstraits of maize in 2014 and 2015 seasons, i.e.ear length, No. of kernels/ear, ear weight, weight of kernels/ear, 100-kernel weight, kernels shelling %, biological yield, grain yield, stover yield, harvest index %, kernels nitrogen uptake and kernels protein yield.The higher nitrogen rate (130 kg N/fed) was more effective in increasing values of all studied traits,also, produced the maximum grain yield/fed and proved significantly superior to other nitrogen rates.The treatments of70, 100 and 130 kg N/fed significantly increased grain yield/fedof maize by 26.48, 56.16 and 74.37 % in the first season, respectively, and by 29.64, 53.35 and 71.89 %in the second season, respectively when compared with applying 40 kg N/fed. The present results clearly indicate that nitrogen application induced increases in yield and yield components traits of maize showing the major role of this vital nutritive element. The increase in nitrogen application encourages photosynthesis activities and the metabolic efficiency which contributes in enhancing the accumulation of the produced metabolites of maize. Many investigators obtained similar results asEl-Gizawy 2000; El-Gizawy 2005;Mehasen and Saeed 2006; El-Gedwy 2007; Attia*et al*., 2011; El-Ghariebe*t* al., 2011; Siam *et al*., 2012; Verma*et al*., 2012; Raskar*et al*., 2013; and Azeem*et al*., 2015.

Effect of foliar spray by microelements treatments:

Data recorded in Tables 3 and 4 indicated that the yield and its components traits studied of maize, i.e. ear length, No. of kernels/ear, ear weight, weight of kernels/ear, 100-kernel weight, kernels shelling %, biological yield, grain yield, stover yield, harvest index %, kernels nitrogen uptake and kernels protein yield significantly increased by application Zn, Mn and Fe singly or combinedin the firstand second seasons. Such increases were particularly significantly by theZn +Mn + Fe treatment with regard to ear and yield traits of maize under study.In 2014 season, the grain yield/fedincreased by 20.99, 15.76, 19.92 and 30.15 % when microelements application of Zn, Mn, Fe and Zn + Mn + Fe respectively over the control treatment (no microelements applied).Similar results were noticed in 2015 season, the grain yield/fed increased with by about 18.28, 13.96, 18.10 and 28.17 %, respectively.The increase in maize yield and its components traits with the applying of microelements foliar spray especially Zn + Mn + Fe treatment may be due to the synergetic role of microelements in improving directly or indirectly photosynthesis, vital processes in plant such as respiration, protein synthesis, reproduction phase, biochemical and physiological activities. Many investigators came out with similar results asMarschner 1995; Ashoub *et al.*, 1998; Kabata and Pendias 1999; El-Gizawy 2000; El-Akabawy*et al.*, 2001; El–Gizawy 2005; Mehasen and Saeed 2006; Rego*et al.*, 2007; Al-Kanh and Abdullal 2008;Kanwal*et al*., 2010; Attia*et al*., 2011; El-Ghariеb*et* al., 2011; Sadek and Attia 2011; Salem & El-Gizawy 2012; Balbaa and Awad 2013and Raskar*et al*., 2013.

Interaction effect:

Significant effect of interaction between nitrogen fertilization and foliar spray of microelements obtained for some yield and its components traits of maize namely, No. of kernels/ear, ear weight, weight of kernels/ear, biological yield/fed., grain yield/fed., kernels nitrogen uptake/fed. and kernels protein yield/fed. in the both seasons (Tables 3 and 4). The greatest values of previous traits were recorded from maize plants which fertilized by 130 kg N/fed with foliar spray by Zn + Mn + Fe treatment. Such results are in accordance with those obtained byEl-Ghariеb*et* al., 2011; Mehasen and Saeed 2006; Attia *et al*., 2011 andRaskar*et al*., 2013.

Table 3: Effect of nitrogen fertilization and foliar spray by some microelements as well as their interaction on ear length (cm), number of kernels/ear, ear weight (g), weight of kernels/ear (g), 100-kernel weight (g) and kernels shelling % of maize in 2014 and 2015 seasons.

Treatment	Trait	Ear length (cm)		No. of kernels/ear		Ear weight (g)		Weight of kernels/ear (g)		100-kernel weight (g)		Kernels shelling %	
	Season	**2014**	**2015**	**2014**	**2015**	**2014**	**2015**	**2014**	**2015**	**2014**	**2015**	**2014**	**2015**
Nitrogen fertilization													
40 kg N/fed		17.37	17.99	355.99	377.44	129.01	139.29	99.52	108.19	31.01	31.81	77.04	77.57
70 kg N/fed		19.39	20.15	417.36	444.76	153.80	168.54	123.27	136.46	32.80	34.06	80.09	80.90
100 kg N/fed		21.21	21.97	488.93	505.76	185.57	196.83	151.74	162.32	34.46	35.65	81.73	82.43
130 kg N/fed		22.35	23.38	531.42	549.31	205.65	217.26	170.44	181.75	35.63	36.81	82.86	83.64
L.S.D at 5%		1.14	1.21	31.21	30.29	12.24	13.25	7.53	6.95	1.22	1.16	1.92	2.01
Microelementsfertilization													
Zero		18.59	19.40	412.04	436.00	152.74	164.66	121.07	131.99	32.26	33.26	78.71	79.63
Zn		20.26	21.05	461.54	479.68	171.44	182.69	139.74	150.19	33.40	34.56	81.19	81.88
Mn		20.08	20.71	440.24	459.53	168.74	180.20	135.44	145.86	33.94	35.02	79.88	80.56
Fe		20.56	21.39	451.80	471.40	170.17	182.64	137.60	148.75	33.61	34.83	80.53	81.09
Zn+Mn+Fe		20.91	21.79	476.50	499.97	179.43	192.20	147.35	159.12	34.16	35.23	81.86	82.53
L.S.D at 5%		0.57	0.62	9.22	10.45	4.61	5.23	2.31	2.25	0.28	0.24	0.62	0.69
Nitrogen X Microelements fertilization interaction													
	Zero	14.78	15.43	318.08	344.00	111.23	123.13	82.73	92.50	28.90	29.88	74.40	75.14
	Zn	17.83	18.50	373.17	390.06	133.30	142.65	104.15	111.90	31.03	31.88	78.14	78.45
40 kg N/fed	Mn	17.68	18.25	346.69	362.53	130.55	137.70	99.23	105.78	31.80	32.43	76.03	76.83
	Fe	18.10	18.75	358.42	378.25	130.65	141.15	101.10	109.60	31.35	32.20	77.40	77.65
	Zn+Mn+Fe	18.48	19.00	383.61	412.37	139.33	151.83	110.38	121.18	31.98	32.65	79.24	79.81
	Zero	17.85	18.73	377.23	406.53	137.35	148.98	107.50	118.18	31.68	32.30	78.28	79.32
	Zn	19.58	20.23	432.03	458.15	156.20	172.28	126.33	140.68	32.50	34.13	80.88	81.66
70 kg N/fed	Mn	19.38	19.95	402.54	434.35	151.15	168.30	120.50	135.33	33.28	34.63	79.74	80.41
	Fe	19.90	20.70	418.35	446.75	155.00	171.60	124.13	138.63	32.98	34.48	80.10	80.77
	Zn+Mn+Fe	20.25	21.13	456.66	478.04	169.28	181.55	137.88	149.50	33.55	34.75	81.45	82.35
	Zero	19.93	20.93	445.30	466.15	166.98	179.10	133.98	145.48	33.43	34.68	80.24	81.23
	Zn	21.33	22.10	500.99	517.25	188.40	199.55	155.10	165.83	34.40	35.63	82.34	83.10
100 kg N/fed	Mn	21.05	21.63	485.35	499.41	187.05	197.18	152.23	161.68	34.85	35.98	81.39	82.00
	Fe	21.68	22.43	499.41	510.01	190.28	199.48	155.63	164.30	34.63	35.80	81.79	82.37
	Zn+Mn+Fe	22.05	22.75	513.59	535.99	195.15	208.85	161.78	174.33	35.00	36.15	82.91	83.47
	Zero	21.83	22.53	507.55	527.31	195.40	207.43	160.08	171.80	35.05	36.20	81.93	82.83
	Zn	22.33	23.38	539.99	553.27	207.88	216.30	173.38	182.35	35.68	36.63	83.40	84.30
130 kg N/fed	Mn	22.20	23.03	526.40	541.85	206.23	217.63	169.83	180.65	35.85	37.05	82.35	83.01
	Fe	22.55	23.68	531.04	550.61	204.75	218.35	169.55	182.48	35.48	36.83	82.81	83.57
	Zn+Mn+Fe	22.85	24.30	552.14	573.51	213.98	226.58	179.38	191.48	36.10	37.35	83.83	84.51
L.S.D at 5%		N.S	N.S	18.44	20.90	9.22	10.46	4.62	4.50	N.S	N.S	N.S	N.S

Table 4: Effect of nitrogen fertilization and foliar spray by some microelements as well as their interaction on biological yield (kg/fed), grain yield (kg/fed),stover yield (kg/fed), harvest index (%), kernels nitrogen uptake (kg/fed) and kernels protein yield (kg/fed) of maize in 2014 and 2015 seasons.

Treatment	Trait	biological yield (kg/fed)		Grain yield (kg/fed)		stover yield (kg/fed)		Harvest index (%)		kernels nitrogen uptake (kg/fed)		kernels protein yield (kg/fed)	
	Season	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015
Nitrogen fertilization													
40 kg N/fed		6119.0	6518.5	1994.4	2206.0	3535.0	3680.0	32.47	33.73	35.432	40.025	221.448	250.155
70 kg N/fed		7346.5	7876.5	2522.6	2859.9	4200.0	4345.0	34.26	36.23	48.752	56.146	304.701	350.911
100 kg N/fed		8513.0	8971.5	3114.5	3382.9	4705.0	4870.0	36.53	37.65	63.919	70.293	399.496	439.335
130 kg N/fed		9205.5	9657.0	3477.7	3791.8	5010.0	5125.0	37.75	39.24	73.939	81.821	462.121	511.382
L.S.D at 5%		398.1	425.6	210.4	231.5	133.7	153.5	1.28	1.46	4.862	5.264	30.381	35.614
Microelementsfertilization													
Zero		7121.3	7566.3	2366.4	2644.9	4137.5	4268.8	32.77	34.52	45.323	51.527	283.268	322.042
Zn		7968.8	8405.0	2863.1	3128.3	4456.3	4600.0	35.68	36.98	58.042	64.211	362.761	401.319
Mn		7711.9	8178.8	2739.3	3014.1	4300.0	4456.3	35.19	36.53	54.413	60.772	340.078	379.824
Fe		7878.1	8347.5	2837.8	3123.5	4368.8	4512.5	35.75	37.15	57.019	63.609	356.369	397.557
Zn+Mn+Fe		8300.0	8781.9	3079.8	3390.0	4550.0	4687.5	36.88	38.38	62.757	70.238	392.231	438.986
L.S.D at 5%		120.4	135.2	70.8	76.9	81.1	90.8	0.71	0.83	1.513	1.762	9.364	10.653
Nitrogen X Microelements fertilization interaction													
	Zero	5452.5	5847.5	1563.8	1782.8	3350.0	3475.0	28.69	30.49	25.330	29.510	158.311	184.435
	Zn	6300.0	6685.0	2109.5	2302.3	3600.0	3750.0	33.48	34.44	38.338	42.651	239.611	266.567
40 kg N/fed	Mn	6055.0	6397.5	1960.5	2129.8	3475.0	3625.0	32.36	33.29	34.713	38.652	216.952	241.576
	Fe	6190.0	6602.5	2062.0	2273.3	3525.0	3675.0	33.31	34.43	37.065	41.773	231.655	261.077
	Zn+Mn+Fe	6597.5	7060.0	2276.0	2542.0	3725.0	3875.0	34.50	36.00	41.714	47.539	260.712	297.118
	Zero	6492.5	6932.5	2107.5	2385.8	3800.0	3925.0	32.46	34.41	38.354	44.151	239.710	275.943
	Zn	7562.5	8115.0	2598.0	2951.8	4350.0	4500.0	34.37	36.38	51.058	58.819	319.109	367.620
70 kg N/fed	Mn	7177.5	7792.5	2433.5	2808.3	4125.0	4300.0	33.91	36.04	46.784	54.965	292.398	343.531
	Fe	7462.5	8020.0	2572.3	2944.5	4250.0	4375.0	34.47	36.70	50.042	58.291	312.761	364.318
	Zn+Mn+Fe	8037.5	8522.5	2901.5	3209.3	4475.0	4625.0	36.11	37.66	57.524	64.503	359.525	403.145
	Zero	7797.5	8295.0	2626.0	2920.3	4525.0	4700.0	33.68	35.21	51.862	58.625	324.139	366.407
	Zn	8690.0	9120.0	3202.3	3465.3	4800.0	4950.0	36.86	37.99	66.608	72.761	416.301	454.759
100 kg N/fed	Mn	8452.5	8897.5	3114.8	3359.8	4625.0	4800.0	36.85	37.76	63.383	69.125	396.145	432.032
	Fe	8650.0	9077.5	3230.5	3461.3	4700.0	4875.0	37.36	38.13	66.707	72.166	416.917	451.037
	Zn+Mn+Fe	8975.0	9467.5	3398.8	3708.0	4875.0	5025.0	37.89	39.17	71.037	78.790	443.980	492.439
	Zero	8742.5	9190.0	3168.3	3490.8	4875.0	4975.0	36.24	37.99	65.746	73.822	410.914	461.383
	Zn	9322.5	9700.0	3542.5	3793.8	5075.0	5200.0	38.00	39.11	76.164	82.613	476.024	516.330
130 kg N/fed	Mn	9162.5	9627.5	3448.5	3758.5	4975.0	5100.0	37.63	39.04	72.771	80.345	454.818	502.158
	Fe	9210.0	9690.0	3486.3	3815.0	5000.0	5125.0	37.85	39.37	74.263	82.208	464.143	513.797
	Zn+Mn+Fe	9590.0	10077.5	3743.0	4100.8	5125.0	5225.0	39.03	40.69	80.753	90.119	504.706	563.241
L.S.D at 5%		240.8	270.4	141.6	153.8	N.S	N.S	N.S	N.S	3.026	3.524	18.728	21.306

Chemical properties

Effect of nitrogen fertilization:

Results presented in Table 5 clearly show that the increase in nitrogen rate from 40, 70 and 100 to 130 kg N/fed caused significantly increases in kernel nitrogen content as well as nitrogen, Zinc, manganese and iron contents of maize leaves during 2014 and 2015 seasons. The higher nitrogen rate (130 kg N/fed) was more effective in increasing values of above studied traits, but, there is no significant difference among application of 100 kg N/fed and 130 kg N/fed in chemical properties under study.It could be concluded that the increase in N supply improved the leaves and kernels quality. These results are in agreement with that obtained byEl-Gizawy 2000; El-Gedwy 2007; Alizadeh 2010; El-Ghariebet al., 2011; Shafea and Saffari 2011; Siam *et al*., 2012 andManasek*et al*., 2013.

Effect of foliar spray by microelements treatments:

Results presented in Table 5 revealed that the differences between the studied five microelements, i.e. no-microelements, Zn, Mn, Zn and Zn + Mn + Fe treatments in chemical properties of leaves and kernels of maize in 2014 and 2015 seasons were significant except, nitrogen content in leaves and kernels of maize were not significant. These results revealed that application of combined of Zn + Mn + Fe treatment gave significantly the greatest values of zinc, manganese and iron contents of maize kernels in the both seasons. Meanwhile, maize plants which foliar spray by singly Zn, Mn and Fe treatments significantly recorded the highest values of leaf zinc content, leaf manganese content and leaf iron content respectively, in the 2014 and 2015 seasons. The increase in chemical properties of leaves and kernels of maize with the application of microelements especially Zn + Mn + Fe treatment may be due to the synergetic role of microelements in improving directly or indirectly photosynthesis, vital processes in plant such as respiration, protein synthesis, reproduction phase, biochemical and physiological activities. Many investigators came out with similar results asEl-Gizawy 2000; Al-Kanh and Abdullal 2008; El-Ghariebet al., 2011; Sadek and Attia 2011; Shafea and Saffari 2011; Salem and El-Gizawy 2012; Siam *et al*., 2012 and Balbaa and Awad 2013.

Table 5: Effect of nitrogen fertilization and foliar spray by some microelements as well as their interaction on leaf and kernels nitrogen content %, Leaf and kernels zinc content (ppm), leaf and kernels manganese content (ppm) as well as leaf and kernels iron content (ppm) of maize in 2014 and 2015 seasons.

Treatment	Trait	Nitrogen content %				Zinc content (ppm)				Manganese content (ppm)				Iron content (ppm)			
		in leaf		in kernel		in leaf		in kernel		in leaf		in kernel		in leaf		in kernel	
	Season	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015
Nitrogen fertilization																	
40 kg N/fed		2.319	2.372	1.768	1.806	48.250	52.400	31.150	32.700	55.400	58.000	35.200	37.350	108.95	113.05	55.80	58.90
70 kg N/fed		2.526	2.566	1.927	1.958	54.100	56.850	33.200	35.250	60.400	63.550	39.100	41.900	112.80	116.85	59.85	62.40
100 kg N/fed		2.638	2.692	2.049	2.075	57.200	59.250	35.700	37.850	63.250	65.900	43.050	45.250	115.65	119.65	63.50	65.95
130 kg N/fed		2.738	2.789	2.125	2.157	58.900	60.950	37.100	39.200	66.150	69.250	45.700	48.000	119.80	123.90	65.05	68.45
L.S.D at 5%		0.092	0.089	0.079	0.081	3.621	3.457	N.S	N.S	4.628	5.123	N.S	N.S	5.43	4.97	N.S	N.S
Microelementsfertilization																	
Zero		2.486	2.536	1.873	1.907	45.375	48.875	28.188	30.250	53.438	56.563	36.250	38.063	94.13	102.19	54.750	57.813
Zn		2.589	2.639	2.003	2.031	62.375	64.750	38.125	39.813	60.250	62.875	40.688	43.125	111.81	115.06	61.313	63.813
Mn		2.532	2.580	1.959	1.992	51.063	53.750	31.063	33.063	69.125	71.938	43.313	45.938	108.19	111.31	58.250	60.813
Fe		2.559	2.599	1.984	2.014	55.125	57.188	34.375	36.500	57.313	60.063	38.750	41.125	130.75	133.75	64.563	67.063
Zn+Mn+Fe		2.610	2.669	2.016	2.051	59.125	62.250	39.688	41.625	66.375	69.438	44.813	47.375	126.63	129.50	66.375	70.125
L.S.D at 5%		N.S	N.S	N.S	N.S	1.213	1.324	1.256	1.272	2.103	2.350	2.134	1.996	2.24	2.85	2.101	2.223
Nitrogen X Microelements fertilization interaction																	
40 kg N/fed	Zero	2.225	2.295	1.620	1.655	41.75	45.00	25.25	27.00	47.25	50.25	32.00	34.50	90.00	97.00	50.50	53.50
	Zn	2.363	2.420	1.818	1.853	55.25	61.00	35.00	36.25	55.25	56.75	34.75	36.25	106.75	109.50	55.75	59.00
	Mn	2.288	2.333	1.770	1.815	44.50	48.00	27.25	28.50	63.25	66.50	37.00	39.25	103.00	106.50	53.50	55.50
	Fe	2.323	2.355	1.798	1.838	46.75	50.50	31.75	33.50	51.50	54.00	33.75	35.50	124.25	128.50	59.00	62.25
	Zn+Mn+Fe	2.395	2.458	1.833	1.870	53.00	57.50	36.50	38.25	59.75	62.50	38.50	41.25	120.75	123.75	60.25	64.25
70 kg N/fed	Zero	2.440	2.473	1.820	1.850	45.50	49.00	27.50	29.25	53.50	56.75	34.75	36.50	92.75	101.50	54.50	56.75
	Zn	2.565	2.605	1.965	1.993	63.25	65.25	37.25	38.75	59.75	62.50	39.00	42.25	110.00	113.25	59.50	61.75
	Mn	2.500	2.540	1.923	1.958	49.25	51.50	29.50	32.25	66.50	70.25	41.50	45.25	107.00	110.50	57.00	58.50
	Fe	2.533	2.565	1.945	1.980	53.75	56.00	32.75	35.00	58.00	60.50	37.25	39.75	129.25	131.00	63.00	65.50
	Zn+Mn+Fe	2.593	2.645	1.983	2.010	58.75	62.50	39.00	41.00	64.25	67.75	43.00	45.75	125.00	128.00	65.25	69.50
100 kg N/fed	Zero	2.590	2.638	1.975	2.008	46.50	50.25	29.25	31.75	56.00	59.00	37.75	39.25	96.50	104.75	56.25	58.75
	Zn	2.665	2.718	2.080	2.100	65.00	66.00	39.50	41.50	61.50	64.50	43.00	45.75	113.00	117.00	64.25	66.25
	Mn	2.620	2.673	2.035	2.058	53.75	56.00	33.00	35.00	71.00	73.00	46.00	48.00	109.50	112.50	60.50	63.75
	Fe	2.638	2.690	2.065	2.085	59.00	60.25	35.75	38.00	58.75	61.75	40.75	43.50	131.00	133.25	67.50	69.00
	Zn+Mn+Fe	2.678	2.740	2.090	2.125	61.75	63.75	41.00	43.00	69.00	71.25	47.75	49.75	128.25	130.75	69.00	72.00
130 kg N/fed	Zero	2.690	2.740	2.075	2.115	47.75	51.25	30.75	33.00	57.00	60.25	40.50	42.00	97.25	105.50	57.75	62.25
	Zn	2.763	2.813	2.150	2.178	66.00	66.75	40.75	42.75	64.50	67.75	46.00	48.25	117.50	120.50	65.75	68.25
	Mn	2.720	2.775	2.110	2.138	56.75	59.50	34.50	36.50	75.75	78.00	48.75	51.25	113.25	115.75	62.00	65.50
	Fe	2.743	2.785	2.130	2.155	61.00	62.00	37.25	39.50	61.00	64.00	43.25	45.75	138.50	142.25	68.75	71.50
	Zn+Mn+Fe	2.775	2.833	2.158	2.198	63.00	65.25	42.25	44.25	72.50	76.25	50.00	52.75	132.50	135.50	71.00	74.75
L.S.D at 5%		N.S	N.S	N.S	N.S	2.43	2.65	N.S	N.S	4.21	4.70	N.S	N.S	4.48	5.70	N.S	N.S

Interaction effects:

The mean values of zinc, manganese and iron contents of maize leaveswere significantly affected by the interaction between nitrogen fertilization and foliar spray of microelements in 2014 and 2015 seasons, as shown in Table 5.It is clear that planting maize under soil fertilized by 130 kg N/fed with foliar spray by singly Zn, Mn Fe treatments significantly gave the maximum values of leaf zinc content, leaf manganese contentand leaf iron content, respectively, in the first and second seasons.Similar results were also reported byEl-Ghariebet al., 2011; Shafea&Saffari 2011 and Siam *et al*., 2012.

CONCLUSION

From the obtained results of this study it could be concluded that planting maize (white single cross hybrid 2031) under soil fertilized by 130 kg nitrogen/fed with foliar spray by mixed of some microelements especially Zn + Mn + Fe in order to maximizing its productivity under environmental of the experiments.

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استجابة محصول الذرة الشامية للتسميد النيتروجيني والرش الخضري ببعض العناصر الصغرى

الهادي إمبارك سالم غريبي , جابر يحيى محمد همام , محمد إسماعيل محمد سلوع , صلاح عباس حسن علام و السعيد محمد محمود الجدوي
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أجريت تجربتان حقليتان في أرض طينية لمركز البحوث والتجارب الزراعية بكلية الزراعة بمشتهر جامعة بنها (مركز طوخ ـ محافظة القليوبية ـ مصر) خلال الموسمين الصيفيين ٢٠١٤ و ٢٠١٥ لدراسة تأثير أربع معدلات من التسميد النيتروجيني (٣٠ ـ ٧٠ ـ ١٠٠ و ١٣٠ كجم نيتروجين/فدان) والرش بخمس معاملات من العناصر الصغري (بدون إضافة ـ الزنك ـ المنجنيز ـ الحديد والزنك + المنجنيز + الحديد) على صفات النمو الخضري والمحصول ومكوناته وبعض الصفات الكيميائية للذرة الشامية (هجين فردي أبيض ٢٠٣١). وكان التصميم التجريبي المستخدم هو قطع منشقة مرة واحدة في أربع مكررات. ويمكن تلخيص أهم النتائج فيما يلي:ـزادت صفات الذرة الشامية المدروسة (إرتفاع النبات ـ عدد الأوراق الخضراء/نبات عند ١٠٠ يوم من الزراعة ـ دليل مساحة الأوراق عند ١٠٠ يوم من الزراعة ـ عدد الكيزان/فدان ـ طول الكوز ـ عدد حبوب/الكوز ـ وزن الكوز ـ وزن حبوب الكوز ـ وزن ١٠٠ حبة ـ نسبة التفريط ـ المحصول البيولوجي/فدان ـ محصول الحبوب/فدان ـ محصول الحطب/فدان ـ دليل الحصاد ـ النيتروجين الممتص/فدان ـ محصول البروتين/فدان ـ محتوى الأوراق والحبوب من النيتروجين ـ ومحتوى الأوراق من الزنك والمنجنيز والحديد في كلا الموسمين) معنوياً بزيادة معدلات التسميد النيتروجيني بينما قل معنوياً عدد الأيام من الزراعة حتى ظهور ٥٠ % من النورات المذكرة والمؤنثة بزيادة التسميد النيتروجيني في كلا الموسمين. إضافة السماد النيتروجيني بمعدل ١٣٠ كجم نيتروجين/فدان أعطى معنوياً أعلى القيم في صفات. أوضحت النتائج أن الرش الخضري بالعناصر الصغرى بإستخدام المعاملة المختلطة (الزنك + المنجنيز + الحديد) كانت أفضل المعاملات حيث أعطت أعلى القيم في صفات النمو الخضري والمحصول ومكوناته في كلا الموسمين. بينما رش النباتات بالمعاملات الفردية الزنك أو المنجنيز أوالحديد أعطت معنوياً أعلى القيم في محتوى الأوراق من الزنك ـ المنجنيز والحديد على الترتيب في كلا الموسمين. أعطى التفاعل بالتسميد النيتروجيني بمعدل ١٣٠ كجم نيتروجين/فدان والرش الخضري بخليط العناصر الصغرى (الزنك + المنجنيز + الحديد) أفضل القيم معنوياً في صفات الذرة الشامية إرتفاع النبات ـ عدد الأوراق الخضراء/نبات عند ١٠٠ يوم من الزراعة ـ دليل مساحة الأوراق عند ١٠٠ يوم من الزراعة ـ عدد حبوب/الكوز ـ وزن الكوز ـ وزن حبوب الكوز ـ المحصول البيولوجي/فدان ـ محصول الحبوب/فدان ـ النيتروجين الممتص/فدان ـ محصول البروتين/فدان في كلا الموسمين. توصي النتائج بتسميد حقول الذرة الشامية هجين فردي أبيض ٢٠٣١ بمعدل ١٣٠ كجم نيتروجين/فدان ورش النباتات بخليط من العناصر الصغري (الزنك + المنجنيز + الحديد) حيث عظمت إنتاجية محصول الحبوب بوحدة المساحة.