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RESPONSE OF MAIZE CROP TO NITROGEN FERTILIZATION LEVELS AND FOLIAR APPLICATION WITH SOME MICRONUTRIENTS

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ABSTRACT

Two field experiments were carried out at al-Gemmiza ,Agricultural Research Station , Egypt El- Gharbia Governorate, during the two successive summer seasons of 2016 and 2017 to study the effect of four nitrogen fertilizer applications, *i.e*. 75, 90, 105 and 120 kg N/fed and foliar sprays of micronutrient treatments, *i.e*. Non - fertilized (control) , Zn 0.6 % , Mn 0.6 % , Fe 0.6 % and (Zn 0.2 % + Mn 0.2% + Fe 0.2 %) on the growth , yield and its component and some chemical properties of maize grains of the single cross (Sc 10). The experiments were laid out in a split plot design in a randomized complete block arrangement with four replications. The four nitrogen fertilizer applications, *i.e*. 75, 90, 105 and 120 kg N/fed were allocated in the main plots and foliar sprays of micronutrient treatments, *i.e*. Non - fertilized (control) , Zn 0.6 % , Mn 0.6 % , Fe 0.6 % and (Zn 0.2 % + Mn 0.2% + Fe 0.2 %), occupied the sub plots. The results 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 , 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 significant increase by increasing nitrogen fertilizer rate , except, mid tasseling and silking dates , while significantly decreased with increasing nitrogen rates and kernel zinc, manganese and iron contents in both seasons. Application of 120 kg N/fed significantly gave the maximum values of previous traits. Results revealed that mixed micronutrient foliar spray using (Zn 0.2 % + Mn 0.2% + Fe 0.2 %) treatment was the highest treatment for previous growth maize in both seasons. Meanwhile, maize plants which were foliar sprayed singly by Zn 0.6 % , Mn 0.6 % or Fe 0.6 % significantly gave the higher values of leaf zinc content , manganese and leaf iron contents , respectively, except leaf and kernel nitrogen contents, in both seasons . The interaction between nitrogen fertilizer of 120 kg N/fed. and foliar spray by the mixture (Zn 0.2 % + Mn 0.2 % + Fe 0.2 %) treatment gave the greatest values of maize 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 except 50 % tasseling and silking dates , ear length , 100-kernel weight , kernels shelling % , stover yield/fed., harvest index % , leaf and kernel nitrogen contents , zinc, manganese and iron contents of maize kernel in both seasons . It could be concluded that fertilization of maize plants by 120 kg N/fed. and foliar spray by (Zn 0.2 % + Mn 0.2% + Fe 0.2 %) maximized grain yield / feddan under Gharbia Location .

***Key words** : maize field , fertilizer rate , maximized grain yield.*

1. INTRODUCTION

Maize (*Zea mays* L.) ranks third of the most important cereal crops in the world, after wheat and rice. In Egypt, maize is essential for livestock and human consumptions as an available source of carbohydrate, oil, and slightly for protein. The growing area of maize in Egypt during 2013 is about 2,142,857 feddans with a total grain production of 6,500,000 ton and average grain yield per feddan about 3.033 ton (Egyptian Min. Agric. Statistic Year Book , 2013) . The total production supplies 50 % of the required consumption with a gap of 50 % which has to be filled via importation. Increasing maize production during the last decade became one of the most important goals of the Egyptian Government to meet human and animal demands. Determination of the required rate of nitrogen fertilization of maize is one of the important practices of great contribution for the highest production of better quality. 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 of maize. Shafea and Saffari (2011), Siam *et al.* (2012), Verma *et al.* (2012) , Raskar *et al.* (2013) , Manasek *et al.* (2013) and Azeem *et al.* (2015) reported that significant increases were observed in plant height, No. of green leaves/plant, leaf area index , 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 rate. On the other hand, No. of days to 50 % tasseling and silking were significantly decreased

Several investigators reported a positive response of maize plants to micronutrient foliar spaying El–Gizawy (2005), Attia *et al.* (2011), Shafea and Saffari (2011) , Salem and El-Gizawy, (2012) . Siam *et al* , (2012) and Raskar *et al.* (2013) . Micronutrients are required in small amounts and they affect directly or indirectly on photosynthesis and vital processes in plants such as respiration, protein synthesis and reproduction phase (Marschner, 1995). El-Akabawy *et al. (*2001) stated 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 plants (Sadek and Attia (2011) , Shafea and Saffari (2011), Siam *et al.* (2012),Salem and El-Gizawy (2012), Balbaa and Awad (2013) and Raskar *et al* (2013) reported significant increases in plant height, leaf area index, 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. Attia *et al.* (2011),Sadek and Attia (2011), Siam *et al.* (2012), Salem and El- Gizawy(2012) and Balbaa and Awad (2013) reported that using Mn significantly increased plant height, No. of green leaves /plant, leaf area index, No. of kernels/ear, kernels weight/ear, weight of 100-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 and Awad (2013) reported that the application of iron significantly increased plant height, 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 to study the effect of nitrogen levels and some micronutrients fertilization on growth,yield, its components and chemical composition of corn grain.

2. MATERIALS AND METHODS

Two field experiments were carried out at Al Gemmiza Experiment Agricultural Research Station , El-Gharbia Governorate , Egypt, during the two summers growing seasons 2016 and 2017. The aim of this study was to investigate the effect of nitrogen fertilization rates and some microelements, *i.e.* zinc , manganese , and iron on growth, yield and its components on a corn variety (single hybrid Sc10) .

Chemical composition of leaves and kernels of maize was carried out. Soil texture of the experimental site was clay and pH nearly (7.97 and 7.95 in both seasons). The physical and chemical properties of the experimental soil were determined according to the standard procedures described by Black (1965) and represented in Table (1) in each of the two growing seasons.

Table (1): Soil Physical and chemical properties of the experimental site in the two growing seasons (2016 and 2017).

Properties	Seasons	
	2016	2017
Mechanical analysis		
Course sand %	6.26	7.59
Find sand %	27.91	26.64
Silt %	14.85	14.85
Clay %	50.98	51.17
Texture grade	clay	clay
Chemical analysis		
E.C.	2.33	2.19
pH (1 :2.5)	7.84	7.95
$CaCo_3$ %	2.86	2.70
O.M %	2.51	2.48
N % (total)	0.220	0.233
N(ppm) (available)	71.31	74.15
Soluble cations and anions (ppm)		
Mn^{++}	8.1	8.9
Fe^{++}	11.5	8.6
Zn^{++}	1.9	2.2

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

The four nitrogen fertilization treatments were 75, 90, 105 and 120 kg N/fed. Nitrogen fertilizer was applied in form of urea (46 % N), and divided into two equal does and applied before the first and second irrigation in each season. Five microelement treatments, *i.e.* control (without microelements) , Zn 0.6 % , Mn 0.6 % , Fe 0.6 % and (Zn 0.2 % + Mn 0.2 % + Fe 0.2 %). Microelements were applied once as foliar spray after 35 and 45 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. $7H_2o$) 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 and l/plot)

The experimental design was split plot with randomized complete block arrangment with four replications. Nitrogen fertilizer treatments were distributed in the main plots, whereas the microelement treatments were arranged at random in sub plots. The sub plot area was 10.5 m^2 and contained five ridges of 3 m long and 70 cm apart. The preceding winter crop in the two seasons was Egyptian clover. Experiments were planted on the 15 *th* and the 19*th* of May in both seasons. The distance between hills was 30 cm apart. Phosphorous fertilizer was applied in form of Calcium super phosphate (15.5 % 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.

2.1. Data recorded

2.1.1. Growth traits

Five plants were taken at random from each sub plot to measure the growth traits: plant height (cm) at harvest, No. of green leaves /plant and leaf area at 90 days after planting according to Stickler (1964). Whereas, No. of days to 50 % tasseling and silking were estimated from the whole plants of the plot.

2.1.2. Yield and its component traits

Ten ears were taken at random from each sub plot at harvest to record,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) , stover yield (kg / fed) and harvest index % from the whole yield of plot.

2.1.3. Chemical analysis

Maize leaf samples were taken from ear leaf at 100 days from planting and washed with water then dried on an air forced drying oven at 70ºC for 48 hours . Kernel samples were taken after harvest at random from kernels of ten ears to determine : nitrogen content in the leaves and kernels according to the modified micro Kjeldahl method (A.O.A.C.,1990) , nitrogen content of grain and protein yield / fed , as well as Zinc, Manganese and iron (ppm) in the leaves and kernels were determined according to Chapman and Pratt (1961) using atomic absorption spectrophotometer.

2.2. Statistical analysis

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

3.RESULTS AND DISCUSSION

3.1. Growth traits

3.1.1. Effect of nitrogen fertilization

Results in Table (2) showed that maize growth characters, plant height, No. of green leaves/plant, leaf area index and No. of ears /fed. were significantly increased by increasing

Table (2): Effect of nitrogen fertilization rates and foliar spray by some micronutrients and their interaction on growth traits .

Treatment		No. of days to 50 %tasseling		No. of days to 50 % silking		Plant height (cm)		No. of green leaves/plant		Leaf area index (cm^2)	
		2016	2017	2016	2017	2016	2017	2016	2017	2016	2017
Nitrogen fertilization											
75 kg N/fed		60.80	64.89	64.45	65.55	285.1	287.2	13.63	14.39	3.73	3.57
90 kg N/fed		59.90	63.78	63.66	64.74	304.9	307.2	14.64	15.34	4.34	4.12
105 kg N/fed		59.22	63.05	62.97	64.08	318.1	320.9	15.42	16.21	4.84	4.64
120 kg N/fed		58.32	62.13	61.46	62.51	328.8	330.7	15.99	16.80	5.23	4.98
L.S.D at 5%		0.85	0.98	1.02	1.23	8.26	10.15	0.64	072	0.22	0.29
Microelements fertilization											
Zero		60.47	64.39	64.40	65.44	303.9	305.3	14.12	14.89	4.18	4.00
Zn		59.45	63.42	63.02	64.13	311.1	314.0	15.05	15.83	4.58	4.37
Mn		59.85	63.78	63.42	64.42	307.6	309.2	14.91	15.67	4.51	4.29
Fe		59.35	63.18	62.79	63.89	308.7	311.3	15.17	15.93	4.65	4.44
Zn+Mn+Fe		58.67	62.57	62.04	63.23	314.9	317.8	15.33	16.12	4.75	4.54
L.S.D at 5%		0.58	0.73	0.88	0.72	2.74	3.55	0.19	0.23	0.07	0.09
Nitrogen X Microelements fertilization interaction											
75 kg N/fed	Zero	61.88	66.20	66.01	67.21	276.7	277.1	12.82	13.78	3.32	3.23
	Zn	60.75	64.99	64.40	65.55	288.0	293.0	13.75	14.50	3.79	3.63
	Mn	61.20	65.48	64.63	65.79	283.2	282.5	13.63	14.31	3.71	3.54
	Fe	67.25	64.26	64.17	65.08	283.8	286.9	13.88	14.61	3.85	3.68
	Zn+Mn+Fe	60.53	63.54	63.02	64.13	294.0	296.4	14.06	14.79	3.95	3.78
90 kg N/fed	Zero	59.63	64.75	65.09	66.03	299.3	299.2	13.68	14.45	3.93	3.75
	Zn	60.98	63.78	63.48	64.60	307.1	309.3	14.81	15.51	4.40	4.18
	Mn	59.85	64.02	63.94	65.08	302.7	305.1	14.61	15.26	4.31	4.07
	Fe	60.08	63.54	63.25	64.36	303.5	307.5	14.97	15.64	4.48	4.25
	Zn+Mn+Fe	59.63	62.81	62.56	63.65	312.1	314.9	15.14	15.85	4.59	4.37
105 kgN/fed	Zero	58.95	63.78	63.94	65.08	314.2	317.0	14.63	15.32	4.52	4.32
	Zn	60.08	63.05	63.02	64.13	319.5	321.9	15.53	16.38	4.88	4.67
	Mn	59.18	63.29	63.25	64.13	316.3	319.3	15.48	16.25	4.63	4.60
	Fe	59.63	62.81	62.56	63.65	318.2	320.1	15.66	16.48	4.95	4.74
	Zn+Mn+Fe	58.95	62.32	62.10	63.41	322.4	326.3	15.81	16.64	5.05	4.85
120 kgN/fed	Zero	58.28	62.81	62.56	63.41	325.2	328.1	15.38	16.04	4.96	7.70
	Zn	58.95	61.84	61.18	62.23	330.0	331.7	16.10	16.91	5.26	5.01
	Mn	58.05	62.32	61.87	62.70	328.1	329.9	15.97	16.83	5.20	4.96
	Fe	58.28	62.08	61.18	62.46	329.4	330.6	16.20	17.01	5.32	5.08
	Zn+Mn+Fe	57.83	61.60	60.49	61.75	331.01	333.5	16.30	17.20	5.39	5.16
L.S.D at 5%		N.S	N.S	N.S	N.S	5.79	7.12	0.34	0.43	0.14	0.15

nitrogen fertilizer rate up to 120 kg N/fed. in 2016 and 2017 seasons. On the other hand, increasing nitrogen fertilizer rate induced earlier 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 reported similar results as El - Gedwy (2007) , Attia *et al.* (2011) , Siam *et al.* (2012) , Verma *et al.* (2012) and Azeem *et al.* (2015).

3.1.2. Effect of foliar spray by microelements

Data presented in Table (2) showed that micronutrents foliar spray using Zn 0.2 % + Mn 0.2 % +Fe0.2 % mixture was the most effective treatment for plant height, No. of green leaves/plant and leaf area index in the both seasons . Also, adding of Zn 0.2 % + Mn 0.2 % + Fe 0.2 % mixture induced earlier tasseling and silking % of in 2016 and 2017 seasons.

Treatments involving the application of single microelement showed a slight and significant superiority over the control without microelements application. The increase in maize growth traits with the application of microelements especially (Zn 0.2 % + Mn 0.2 % + Fe 0.2 %) mixture may be due to the synergetic role of microelements in directly or indirectly improving photosynthesis and vital processes in plant such as respiration, protein synthesis, reproduction phase, biochemical and physiological activities. Many investigators reported similar results as 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).

3.1.3. Interaction effect

Table (2) showed that the interaction had significant effect on plant height, No. of green leaves/plant and leaf area index in both of 2016 and 2017 seasons. The highest values of plant height, No. of green leaves/plant and leaf area index were recorded from maize plants were fertilized by 120 kg N/fed. with foliar spray by Zn 0.2 % + Mn 0.2 % + Fe 0.2 % treatment. Such results are in accordance with those obtained by Attia *et al.* (2011), Mehasen and Saeed (2006) and Siam *et al.* (2012) .

3.2. Yield and its component

3.2.1.Effect of nitrogen fertilization

Data present in Tables (3 and 4) indicated that increasing nitrogen fertilization rate from 75 to 90 , 105 and 120 kg N/fed caused significant increases in yield and its components of maize in both seasons .

The highest nitrogen rate (120 kg N/fed) was more effective in increasing values of all studied traits, also, produced the maximum grain yield/fed and proved significant superiority to other nitrogen rates . The treatments of 70, 95 , 105 and 120 kg N/fed significantly increased grain yield / fed of maize by 26.48, 56.16 and 74.37 % in the first season, and by 29.64, 53.35 and 71.89 % in the second season, respectively, when compared with applying 75 kg N/fed. The present results clearly indicate that nitrogen application induced increases in yield and yield components 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 to enhancing the accumulation of the produced metabolites of maize. Many investigators reported similar results Attia *et al.* (2011), El -Gharieb *et* al (2011), Siam *et al.*(2012), Verma *et al.* (2012), Raskar *et al.*, (2013) and Azeem *et al.* (2015).

3.2.2. Effect of foliar spray by microelements

Data recorded in Tables (3 and 4) indicated that the yield and its component 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 the application of Zn 0.6 % , Mn 0.6 and Fe 0.6,individually or in a mixture in the second seasons. Such increases were particularly significant by the mixture (Zn 0.2 + Mn 0.2 + Fe 0.2) with regard to ear and yield traits of maize under study. In 2016 season, the grain yield / fed increased by 20.99 , 15.76 , 19.92 and 30.15% whith microelements application of Zn 0.6 , Mn 0.6 , Fe 0.6 and (Zn 0.2 + Mn 0.2 + Fe 0.2) respectively over the control treatment (no microelements applied) . Similar results were noticed in 2017 season,where the grain yield / fed increased by about 18.28 , 13.96 , 18.10 and 28.17 %, respectively. Increases in maize yield and its components with the application of microelements as foliar spray , especially (Zn 0.2 % + Mn 0.2 % + Fe 0.2 %) 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 reported similar results Attia *et al.* (2011) , El - Gharieb *et al.*,(2011) , Sadek and Attia (2011) , Salem and El-Gizawy (2012), Balbaa and Awad (2013) and Raskar *et al.* (2013) .

3.2.3. Interaction effect

Significant effects of the interactions between nitrogen fertilization and foliar spray of microelements were obtained for some yield and its components 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 on maize plants when fertilized by 120 kg N/fed along with foliar spray of (Zn 0.2 % + Mn 0.2 % + Fe 0.2 %) mixture . Such results are in accordance with those reported by El-Gharieb *et al.* (2011) , Mehasen and Saeed (2006) , Attia *et al.* (2011) and Raskar *et al.* (2013) .

3.3. Chemical properties

3.3.1. Effect of nitrogen fertilization

Results presented in Table (5) clearly show that the increase in nitrogen rate from 75 to 90 , 105 and 120 kg N/fed. caused significantly increases in kernel nitrogen content as well as nitrogen, Zinc, manganese and iron contents of maize leaves during 2016 and 2017 seasons. The highest nitrogen rate (120 kg N/fed.) was more effective in increasing values of the above

Table (3): Effect of nitrogen fertilization rates and foliar spray by microenutrients and their interactions on ear length (cm), number of kernels/ear, ear weight (g), weight of kernels / ear (g), 100-kernel weight (g) and shelling % of maize in 2016 and 2017 seasons.

Treatment		Ear length (cm)		No. of kernels/ear		Ear weight (g)		Weight of kernels/ear (g)		100-kernel weight (g)		shelling %	
		2016	2017	2016	2017	2016	2017	2016	2017	2016	2017	2016	2017
Nitrogen fertilization													
75 kg N/fed		17.7	18.7	370.2	388.8	134.2	144.9	104.5	115.8	33.1	34.4	79.4	81.4
90 kg N/fed		19.8	21.0	434.1	458.1	160.0	175.3	129.4	146.0	35.1	36.8	82.5	84.9
105 kg N/fed		21.6	22.9	508.5	520.9	193.0	204.7	159.3	173.7	36.9	38.5	84.2	86.6
120 kg N/fed		22.8	24.3	553.7	565.8	213.9	226.0	179.0	194.5	38.1	39.8	85.3	87.8
L.S.D at 5%		1.3	1.2	32.2	29.3	11.2	14.3	6.9	6.8	1.4	1.1	1.8	1.9
Microelements fertilization													
Zero		19.0	20.2	428.5	449.1	158.9	171.3	127.1	141.2	34.5	35.9	81.1	83.6
Zn		20.7	21. 9	480.0	494.1	178.3	190.0	146.7	160.7	35.7	37.3	83.6	86.0
Mn		20.5	21.5	457.9	473.3	175.5	187.4	142.2	156.1	36.3	37.8	82.3	84.6
Fe		21.0	22.3	469.9	485.5	177.0	190.0	144.5	159.2	36.0	37.6	82.9	85.1
Zn+Mn+Fe		21.3	22.7	495.6	515.0	186.6	200.0	154.7	170.3	36.6	38.0	84.3	86.7
L.S.D at 5%		0.8	0.6	9.2	10.5	4.6	5.2	2.3	2.4	0.4	0.3	0.7	0.8
Nitrogen X Microelements fertilization interaction													
75 kg N/fed	Zero	15.1	16.0	330.8	354.3	115.7	128.1	86.9	99.0	30.9	32.3	76.6	78.9
	Zn	18.2	19.2	388.1	401.8	138.6	148.4	109.4	119.7	33.2	34.4	80.5	82.4
	Mn	18.0	19.0	360. 6	373.4	135.8	143.2	104.2	113.2	34.0	35.0	78.3	80.7
	Fe	18.5	19.5	372.8	389.6	135.9	146.8	106.2	117.3	33.5	34.8	79.7	81.5
	Zn+Mn+Fe	18.9	19.8	399.0	424.7	144.9	157.9	115.9	129.7	34.2	35.3	81.6	83.8
90 kg N/fed	Zero	18.2	19.5	392.3	418.7	142.8	154.9	112.9	126.5	33.9	34.9	80.6	83.3
	Zn	20.0	21.0	449.3	471. 9	162.5	179.2	132.6	150.5	34.8	36.9	83.3	85.7
	Mn	19.8	20.8	418.6	447.4	157.2	175.0	126.5	144.8	35.6	37.4	82.1	84.4
	Fe	20.3	21.5	435.1	460.2	161.2	178.5	130.3	148.3	35.3	37.2	82.5	84.8
	Zn+Mn+Fe	20.7	22.0	474.9	492.4	176.1	188.8	144.8	160.0	35.9	37.5	83.9	86.5
105 kg N/fed	Zero	20.3	21.8	463.1	480.1	173.7	186.3	140.7	155.7	35.8	37.5	82.6	85.3
	Zn	21.8	23.0	521.0	532.8	195.9	207.5	162.9	177.4	36.8	38.5	84.8	87.3
	Mn	21.5	22.5	504.8	514.4	194.5	205.1	159.8	173.0	37.3	38.9	83.8	86.1
	Fe	22.1	23.3	519.4	525.3	197.9	207.5	163.4	175.8	37.1	38.7	84.2	86.5
	Zn+Mn+Fe	22.5	23.7	534.1	552.1	203. 0	217.2	169.9	186.3	37.5	39.0	85.4	87.6
120 kg N/fed	Zero	22.3	23.4	527.9	543.1	203.2	215.7	168.1	183.8	37.5	39.1	84.4	87.0
	Zn	22.8	24.3	561.6	569.9	216.2	225.0	182.0	195.1	38.2	39.6	84.9	88.5
	Mn	22.6	24.0	547.5	558.1	214.5	226.3	178.3	193.3	38.4	40.0	84.8	87.2
	Fe	23.0	24.6	552.3	567.1	212.9	227.1	178.0	195.3	38.0	39.8	85.3	87.7
	Zn+Mn+Fe	23.3	25.3	574.2	590.7	222.5	235.6	188.3	204.9	38.6	40.3	86.3	88.7
L.S.D at 5%		N.S	N.S	18.4	18.9	8.2	11.5	5.6	4.5	N.S	N.S	N.S	N.S

traits, but, there was no significant difference between applications 105 kg N/fed. and 120 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 those obtained by El-Gizawy (2000) ,El - Gedwy (2007) , Alizadeh (2010), El - Gharieb *et al.* (2011) , Shafea and Saffari (2011) , Siam *et al.* (2012) and Manasek *et al.* (2013) .

3.3.2. 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 0.6 %, Mn 0.6 % , Fe 0.6 % and (Zn 0.2 % + Mn 0.2 % + Fe 0.2 %) treatments on the chemical properties of leaves and kernels of maize in 2016 and 2017 seasons were significant,except nitrogen content in the leaves and kernels of maize which were not significant .These results revealed that application of mixture of (Zn 0.2 % + Mn 0.2 %+ Fe 0.2 %) gave the significantly greatest values of zinc, manganese and iron contents of maize kernels in both seasons. Meanwhile, maize plants treated with foliar

Table (4): Effect of nitrogen fertilization rates and foliar spray by some microenutrients and interactions 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 2016 and 2017 seasons.

Treatment		biological yield (t/fed)		Grain yield (t/fed)		Stover yield (t/fed)		Harvest index (%)		Kernels nitrogen uptake (kg/fed)		Kernels protein yield (kg/fed)	
		2016	2017	2016	2017	2016	2017	2016	2017	2016	2017	2016	2017
Nitrogen fertilization													
75 kg N/fed		5.806	6.180	2.094	2.316	3.712	3.864	36.07	37.48	19.49	19.21	121.80	120.08
90 kg N/fed		7.058	7.565	2.648	3.003	4.410	4.562	37.52	39.70	26.81	26.95	167.59	168.44
105 kg N/fed		8.210	8.666	3.270	3.552	4.940	5.114	39.83	40.99	35.16	33.74	219.73	210.88
120 kg N/fed		8.913	9.362	3.652	3.981	5.261	5.381	41.97	42.52	40.67	39.27	254.17	245.46
L.S.D at 5%		3.98	4.26	2.10	2.32	1.34	1.54	1.28	1.46	4.86	5.26	30.38	35.61
Microelements fertilization													
Zero		6.830	7.259	2.486	2.777	4.344	4.482	36.40	38.26	24.93	24.73	155.80	154.58
Zn		7.685	8.115	3.006	3.285	4.679	4.830	39.12	40.48	31.92	30.82	199.52	192.63
Mn		7.391	7.844	2.876	3.165	4.515	4.679	38.91	40.35	29.93	29.17	187.04	182.31
Fe		7.567	8.018	2.980	3.280	4.587	4.738	39.38	40.91	31.36	30.53	196.00	190.83
Zn+Mn+Fe		8.012	8.482	3.234	3.560	4.778	4.922	40.36	41.97	34.52	33.72	215.73	210.72
L.S.D at 5%		1.20	1.35	7.08	7.69	8.11	9.08	0.71	0.83	1.51	1.76	9.36	10.65
Nitrogen X Microelements fertilization interaction													
75 kg N/fed	Zero	5.16	5.521	1.642	1.872	3.518	3.649	31.82	33.91	13.93	14.16	87.07	88.53
	Zn	5.995	6.355	2.215	2.417	3.780	3.938	36.95	38.03	21.09	20.47	131.79	127.95
	Mn	5.708	6.042	2.059	2.236	3.649	3.806	36.07	37.01	19.09	18.55	119.32	115.96
	Fe	5.866	6.246	2.165	2.387	3.701	3.859	36.91	38.22	20.39	20.05	127.41	125.32
	Zn+Mn+Fe	6.301	6.738	2.390	2.669	3.911	4.069	37.93	39.61	22.94	22.82	143.39	142.62
90 kg N/fed	Zero	6.203	6.626	2.213	2.505	3.990	4.121	35.68	37.81	21.09	21.19	131.84	132.45
	Zn	7.296	7.824	2.728	3.099	4.568	4.725	37.39	39.61	28.08	28.23	175.51	176.46
	Mn	6.886	7.464	2.555	2.949	4.331	4.515	37.10	39.51	25.73	26.39	160.82	164.89
	Fe	7.164	7.686	2.701	3.092	4.463	4.594	37.70	40.23	27.52	27.98	172.02	174.87
	Zn+Mn+Fe	7.746	8.226	3.047	3.370	4.699	4.856	39.34	40.97	31.64	30.96	197.74	193.51
105 kg N/fed	Zero	7.508	8.001	2.757	3.066	4.751	4.935	36.72	38.32	28.52	28.14	178.28	175.88
	Zn	8.402	8.837	3.362	3.639	5.040	5.198	40.01	41.18	36.64	34.92	228.97	218.28
	Mn	8.127	8.568	3.271	3.528	4.856	5.040	40.25	41.18	34.86	33.18	217.88	207.37
	Fe	8.327	8.753	3.392	3.634	4.935	5.119	40.73	41.52	36.69	34.64	229.31	216.50
	Zn+Mn+Fe	8.688	9.169	3.569	3.893	5.119	5.276	41.08	42.46	39.07	37.82	244.19	236.37
120 kg N/fed	Zero	8.446	8.889	3.327	3.665	5.119	5.224	39.39	41.23	36.16	35.43	226.00	221.46
	Zn	9.049	9.444	3.720	3.984	5.329	5.460	41.11	42.19	41.89	39.65	261.81	247.84
	Mn	8.845	9.301	3.621	3.946	5.224	5.355	40.94	42.43	40.02	38.57	250.15	241.04
	Fe	8.911	9.378	3.661	4.006	5.250	5.381	41.08	42.72	40.84	39.46	255.28	246.62
	Zn+Mn+Fe	9.311	9.792	3.930	4.306	5.381	5.486	42.21	43.97	44.41	43.26	277.59	277.36
L.S.D at 5%		2.41	2.70	1.42	1.54	N.S	N.S	N.S	N.S	3.03	3.52	18.73	21.31

spray by single Zn 0.6 % , Mn 0.6 % and Fe 0.6 % significantly recorded the highest values of maize leaf zinc content, leaf manganese content and leaf iron content, respectively, in the 2016 and 2017 seasons. The increase in chemical properties of leaves and kernels of maize with the application of microelements especially (Zn 0.2 % + Mn 0.2 % +Fe0.2%) may be due to the synergetic role of microelements in improving directly or indirectly photosynthesis, vital processes in plants such as respiration , protein synthesis , reproduction phase, biochemical and physiological activities. Many investigators reported similar conclusion El-Gharieb *et al.* (2011) , Sadek and Attia (2011), Shafea and Saffari (2011), Salem and El- Gizawy (2012), Siam *et al*. (2012) and Balbaa and Awad (2013).

3.3.3. Interaction effects

The mean values of zinc , manganese and iron contents of maize leaves were significantly affected by the interaction between nitrogen fertilization and foliar spray of microelements in 2016 and 2017 seasons, as shown in Table (5) .

Table (5): Effect of nitrogen fertilization rates and foliar microenutrients zinc , manganese and iron and their interaction on leaf and kernel content (ppm) of maize in 2016 and 2017 seasons.

Treatment		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	
		2016	2017	2016	2017	2016	2017	2016	2017	2016	2017	2016	2017	2016	2017	2016	2017
Nitrogen fertilization																	
75 kg N/fed		2.32	2.37	1.768	1.81	48.25	52.40	31.15	32.70	55.40	58.00	35.20	37.35	108.95	13.05	55.80	58.90
90 kg N/fed		2.53	2.57	1.927	1.96	54.10	56.85	33.20	35.25	60.40	63.55	39.10	41.90	112.80	16.85	59.85	62.40
105 kg N/fed		2.64	2.69	2.049	2.08	57.20	59.25	35.70	37.85	63.25	65.90	43.05	45.25	115.65	19.65	63.50	65.95
120 kg N/fed		2.74	2.79	2.125	2.16	58.90	60.95	37.10	39.20	66.15	69.25	45.70	48.00	119.80	23.90	65.05	68.45
L.S.D at 5%		0.09	0.08	0.079	0.08	3.62	3.46	N.S	N.S	4.63	5.12	N.S	N.S	5.43	4.97	N.S	N.S
Microelements fertilization																	
Zero		2.49	2.54	1.87	1.91	45.38	48.88	28.19	30.25	53.44	56.56	36.25	38.06	94.13	102.19	54.75	57.81
Zn		2.59	2.64	2.00	2.03	62.38	64.75	38.13	39.81	60.25	62.88	40.69	43.13	111.81	115.06	61.31	63.81
Mn		2.53	2.58	1.969	1.99	51.06	53.75	31.06	33.06	69.13	71.94	43.31	45.94	108.19	111.31	58.25	60.81
Fe		2.56	2.60	1.98	2.01	55.13	57.19	34.38	36.50	57.31	60.06	38.75	41.13	130.75	133.75	64.56	67.06
Zn+Mn+Fe		2.61	2.67	2.02	2.05	59.13	62.25	39.69	41.63	66.38	69.44	44.81	47.38	126.63	129.50	66.38	70.13
L.S.D at 5%		N.S	N.S	N.S	N.S	1.21	1.32	1.23	1.27	2.10	2.35	2.13	2.00	2.24	2.85	2.10	2.22
Nitrogen X Microelements fertilization interaction																	
75 kg N/fed	Zero	2.23	2.30	1.62	1.66	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	2.36	2.42	1.82	1.85	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	2.29	2.33	1.77	1.82	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	2.32	2.36	1.80	1.84	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	2.40	2.46	1.83	1.87	53.00	57.50	36.50	38.25	59.75	62.50	38.50	41.25	120.75	123.75	60.25	64.25
90 kg N/fed	Zero	2.44	2.47	1.82	1.85	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	2.57	2.61	1.97	1.99	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	2.50	2.54	1.92	1.96	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	2.53	2.57	1.95	1.98	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	2.59	2.65	1.98	2.01	58.75	62.50	39.00	41.00	64.25	67.75	43.00	45.75	125.00	128.00	65.25	69.50
105 kg N/fed	Zero	2.59	2.64	1.98	2.01	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	2.67	2.72	2.08	2.10	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	2.62	2.67	2.04	2.06	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	2.64	2.69	2.07	2.09	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	2.68	2.74	2.09	2.13	61.75	63.75	41.00	43.00	69.00	71.25	47.75	49.75	128.25	130.75	69.00	72.00
120 kg N/fed	Zero	2.69	2.74	2.08	2.12	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	2.76	2.81	2.15	2.18	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	2.72	2.78	2.11	2.14	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	2.74	2.79	2.13	2.16	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	2.78	2.83	2.16	2.20	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

It is clear that planting maize under soil fertilized by 120 kg N / fed along with foliar spray by Zn , Mn and Fe significantly gave the maximum values of leaf zinc content , leaf manganese content and leaf iron content, respectively, in the first and second seasons. Similar results were also reported by El-Gharieb *et al.*(2011), Shafea and 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 Sc 10) under soil fertilized by 120 kg nitrogen/fed with foliar spray by mixed microelements of (Zn 0.2% + Mn 0.2% + Fe 0.2%) maximizes productivity under EL-Garbia Governorate, Egypt.

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إستجابة محصول الذرة الشامية للتسميد النيتروجيني والرش الورقى ببعض العناصر الصغرى

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مركز البحوث الزراعية- الجيزة - مصر

ملخص

أجريت تجربتان حقليتان في مزرعة محطة البحوث الزراعية بالجميزة ،محافظة ا لغربيةن جمهورية مصر العربية خلال الموسمين الصيفيين 2016 و 2017 لدراسة تأثير أربع معدلات من التسميد النيتروجيني (75،90،105 و120 كجم نيتروجين/ فدان) والرش بخمس معاملات من العناصر الصغري هى : بدون إضافة ، 0.6 % زنك ، 0.6 % منجنيز ، 0.6 % حديد - مخلوط (0.2% زنك + 0.2% منجنيز + 0.2 % حديد) على صفات النمو الخضري والمحصول ومكوناته وبعض الصفات الكيميائية للذرة الشامية (هجين فردي أبيض 10) . وكان التصميم التجريبي المستخدم هو قطع منشقة مرة واحدة في أربع مكررات وضعت معدلات التسميد النيتروجيني فى القطع الرئيسية ، ووضعت معاملات الرش بالعناصر الصغري فى القطع الفرعية. يمكن تلخيص أهم النتائج فيما يلي :ـ زادت صفات الذرة الشامية المدروسة معنويا بزيادة معدلات التسميد النيتروجيني في كلا الموسمين (إرتفاع النبات - عدد الأوراق الخضراء / نبات عند 90 يوم من الزراعة - دليل مساحة الأوراق - طول الكوز - عدد حبوب / الكوز -وزن الكوز - وزن حبوب الكوز - وزن 100 حبة - نسبة التفريط - المحصول البيولوجي/فدان - محصول الحبوب/فدان - محصول الحطب / فدان - دليل الحصاد - النيتروجين الممتص/ فدان - محصول البروتين/فدان - محتوى الأوراق والحبوب من النيتروجين - ومحتوى الأوراق من الزنك والمنجنيز والحديد) بينما قل عدد الأيام معنوياً من الزراعة حتى ظهور 50 % من صفتى الطرد و الحريرة للنباتات بزيادة التسميد النيتروجيني 120 كجم نيتروجين/فدان في كلا الموسمين ما عدا محتوى الحبوب من من الزنك والمنجنيز والحديد . وأوضحت النتائج أن الرش الورقى بالعناصر الصغرى بإستخدام المعاملة المختلطة (0.2% زنك + 0.2% منجنيز +0.2% حديد) كانت أفضل المعاملات حيث أعطت أعلى القيم في صفات النمو الخضري والمحصول ومكوناته في كلا الموسمين. بينما أعطى رش النباتات بالمعاملات الفردية الزنك أو المنجنيز أوالحديد ً أعلى القيم معنويا في محتوى الأوراق من الزنك - المنجنيز والحديد على الترتيب في كلا الموسمين ما عدا محتوى الأوراق والحبوب من النيتروجين. أعطى التفاعل بالتسميد النيتروجيني بمعدل 120 كجم نيتروجين/فدان والرش الورقى بخليط العناصر الصغرى (0.2% زنك + 0.2% منجنيز +0.2% حديد) أفضل القيم معنوياً في صفات إرتفاع النبات - عدد الأوراق الخضراء/ نبات عند 100 يوم من الزراعة - دليل مساحة الأوراق عند 100 يوم من الزراعة - عدد حبوب/الكوز - وزن الكوز - وزن حبوب الكوز - المحصول البيولوجي / فدان - محصول الحبوب / فدان - النيتروجين الممتص / فدان - محصول البروتين / فدان ما عدا صفات (صفتى ظهور 50 % من الطرد و الحريرة للنباتات – طول الكوز – وزن 100 حبة - نسبة التفريط % - محصول الحطب / فدان - دليل الحصاد - محتوى الأوراق والحبوب من النيتروجين - محتوى الحبوب من الزنك والمنجنيز والحديد في كلا الموسمين. توصي النتائج بتسميد نباتات الذرة الشامية صنف هجين فردي 10 أبيض بمعدل 120 كجم نيتروجين / فدان بجانب رش النباتات بخليط من العناصر الصغري (0.2% زنك + 0.2% منجنيز +0.2% حديد) حيث عظمت إنتاجية محصول الحبوب من وحدة المساحة تحت ظروف المنطقة .

المجلة العلمية لكلية الزراعة – جامعة القاهرة – المجلد (69) العدد الأول (يناير2018):63-72 .