Effect of different levels of NPK and micronutrient on yield and distribution of nutrients in maize under irrigated agriculture

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Abstract: A field experiment was carried out in Kafer El Kadera village at El–Monofia Governorate, during 5 consecutive years, 2010–2014, to test the effects of NPK and balanced fertilization on the yield and its components, and distribution of nutrients in different parts of maize (var.30K8). There was a significant increase of the number of leaves/plant, the length of cob, the number of rows in the cob and the number of grains in the row as a result of treated plants with NPK according to soil testing plus foliar application of micronutrients by 34.18%, 27.94%, 32.182%, and 33.43%, respectively. There was also a significant increase in the chilling % rate, weight of 100 grains and yield of grain/plant, yield ton/ha by 16.52%, 35.39%, 68.40%, and 72.92%, respectively. There was an increase in the concentration of nitrogen in the grains, Envelope and leaves and increase in the concentration of phosphorus in the Envelope (husk leaves), Cob core and leaves, Also, increase in the concentration of potassium in the Envelope, stem and root, and increase in calcium concentration in grains and leaves also, increase in sodium in the envelope and roots. Values of iron and manganese concentrations were increased in grains, envelope and leaves, as well as increased concentration of zinc and copper in leaves. Significant positive correlation was found between concentrations of most leaf nutrients concentrations and nutrient concentrations of grain except significant negative correlation between P concentrations in leaves and K concentrations in grains and between Mg in leaves and Zn in grains and between Na in leaves and Fe concentrations in grains. As well as significant positive correlation were found between Ca, Zn and yield.

Keywords: maize, NPK fertilization, nutrients distribution, irrigated agriculture

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1 Introduction

Due to the increase in human population and consumption in Egypt, more grain maize is consumed. It is used as food and the cob and husk are used as animal feed. Fertilization is one of the most important factors affecting agricultural production.

At present, integrated and balanced fertilization has become a basis for modern agricultural production. The main purpose of agricultural production is to obtain high crop yields and good quality. Many studies revealed the significant roles of fertilizer on crop production over the past several decades. Optimal supplies of inorganic fer-

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tilizers can achieve higher crop yields depending on the cropping system and soil fertility. Zhang et al., (2007), pointed out that improving the nutrition of maize plants is important for obtaining high quality crop production.

Mobarak and Abdalla (1992) found that spraying micronutrients compounds increased the dry weight and the uptake of macro and micronutrients of maize plant over control treatment. Also, El-Fouly et al. (2012) found that the use of balanced fertilization between the macro and micro nutrients led to significant increases in maize grain yield.

Roberts (2007) and Bruulsema et al., (2009) pointed out that fertilization should be application of the right nutrient source, in the right place, at the right rate, and at the right time.

Recommendations of balanced fertilization with NPK and micronutrients, should take into account results of soil fertility test as a method for estimating the nutrient supplying power of the soil.

Measurement of the nutrients distribution in different crop parts contributes to increasing the knowledge of the nutritional value of the crop for both human and animal. Also, the knowledge of the nutrient distribution in plants is important in understanding and to establishing sound nutrient management programs for production.

Adeyeye (2005) mentioned that the levels of all the elements highly varied in the anatomical parts of each plant and between the various plants of Fadama crops.

Also, some authors such as Boekhcim et al. (1986), El-Fouly, et al. (2012) and Hamouda, et al. (2012) found that fertilization increase concentrations of nutrient in the aboveground tissues.

The correlation between nutrients in different parts of the maize contributes to improve the knowledge about the nutritional balance.

Some studies have dealt with the relationships of nutrients in maize plants such as Nair and Babu (1975), Safaya (1976), Elliott and Lauchli (1985), Mallarino and Webb (1995), Bansal et al. (1999), Awan and Abbasi (2000) and Nichols et al. (2012).

However, there have been relatively few studies on the concentration, distribution and correlation of nutrients in different parts of maize plants after fertilization.

This information is very important for farmers; because they can optimize soil management practices, mainly fertilization in productive crop. Excessive soil fertilization induces a nutrient imbalance in plants and environmental degradation due to the application of high doses of fertilizers to the soil.

The aim of this study was to determine (1) which levels of fertilization are better in improving maize yield and its components, (2) how fertilization influences the distribution of nutrients in maize plant, and (3) provide information on the correlation between nutrient concentrations in leaves, grain and yield of maize.

2 Material and methods

This study was conducted to clarify the effect of different levels of NPK and micronutrient on content and distribution of nutrients in plant parts (grain, envelope, cob core, leaves, stem, and root) for maize, grown in a soil with very high clay content during 5 consecutive years, 2010-2014.

The experiment was conducted in a farm located in Kafer El Kadera village at El–Monofia Governorate. All agronomic practices were done by the farm owner as being done by the farmers in the area. Before sowing representative soil sample were collected in all treatments from depth 0-30 cm every season. Maize grains were sowing in 6 June each season.

A complete randomized block design was used with four replicates.

Treatments were as follow:

T0 = control (without any fertilizers addition)

T1 = NPK added by the farmer i.e. 192 kg N + 120 kg P_2O_5 + 0 kg K_2O/ha.

T2 = The recommended NPK by MoA i.e. 288 kg N +144 kg P_2O_5 + 115 kg K_2O/ha.

T3 = The recommended NPK by MoA i.e. 288 kg N +144 kg P_2O_5 + 0 kg K_2O/ha.

T4 = The recommended NPK by MoA i.e. 288 kg N +0 kg P_2O_5 + 115 kg K_2O/ha.

T5 = NPK based on soil testing i.e. 300 kg N + 156 kg P_2O_5 + 192 kg K_2O/ha.

T6 = NPK based on soil testing + one time micronutrients foliar spray.

Soil was sampled before fertilization, NPK were applied to the soil at 30 days after sowing (N as ammonium nitrate 33.5% N, P as single superphosphate 15.5% P_2O_5, and K as potassium sulphate 48% K_2O). Microelements were used as a foliar application at 45 days after sowing using cheated micronutrient compound (3% Fe: 3% Zn: 3% Mn) at rate of 1.5 g/l. water. The volume used was 600 L/ha.

Leaf was sampled from each treatment at 75 days after sowing. After complete maturity, one-meter square was taken to determine yield and yield components. The plants were divided into the following parts: grain, envelope, cob core, leaves, stem, and root, and nutrient concentrations were analyzed in plant parts.

2.1 Data Recorded

At harvest, ten individual plants were harvested from each treatment to determine: Plant height, number of leaves /plant, ear length, number of row /ear, number of grains /ear, chilling %, grain yield /plant, 100-grain weight and grain yield (ton/ hectare).

Nutrient concentrations of grain, envelope, cob core, leaves, stem, and root were determined

2.2 Chemical analysis:

Soil testing: soil samples were analyzed for texture with a hydrometer (Bouyoucos, 1954), for pH and electric conductivity (EC) using water extract (1:2.5) method, (Jackson, 1973), total calcium carbonate ($CaCO_3$%): calcimeter method was used as described by Alison and Moodle (1965). Organic matter (O.M%) content was determined according to Walkley and Black (1934) using potassium dichromate (Chapman and Pratt, 1978). Phosphorus was extracted using sodium bicarbonate (Olsen et al., 1954).

Potassium, calcium, Magnesium and sodium were extracted using ammonium acetate (Jackson, 1973). Iron, manganese, zinc and copper were extracted using DTPA (Lindsay and Norvell, 1978).

Plant analysis: The plant material was digested using an acid mixture consisting of nitric, perchloric and sulfuric acids in the ratio of 8:1:1 (v/v), respectively (Chapman and Pratt, 1978). Nitrogen (N) was determined in the dry plant material using the boric acid modification described by Ma and Zuazage (1942), and distillation was done using a Buechi 320-N_2-distillation unit. Phosphorus was photo metrically determined using the molybdate vanadate method according to Jackson, (1973).

Potassium, calcium and sodium were determined using flame photometer. Mg, Fe, Mn, Zn and Cu were determined using the Atomic absorption spectrophotometer.

The soil data were evaluated using the criteria published by Ankerman and Large (1974) Lindsay and Norvell (1978) and Silvertooth (2001) whereas the leaf analysis data were evaluated according to the criteria reported by Jones et al. (1991) in Plant Analysis Handbook.

2.3 Statistical analysis:

The obtained data were subjected to the analysis of variance of Randomized complete block design according to Snedecor and Cochran (1990) where the means of different treatments were compared using the least significant difference (L.S.D) test at 5% level of significant.

3 Results and Discussion

Soil testing: the results in Table 1 summarizing the physical and chemical characteristics of the soil of the experimental location, the value of pH showed alkalinity and O.M and EC were medium. The total $CaCO_3$ content of the soil tended to be low. Data also, showed that the soil had moderate available of P, Mg, Fe and Cu nutrients, while K was in the beginning of the high level and Ca, Na, Mn and Zn were low.

Table 1 Average of soil test before sowing (0-30cm depth)

Character	Value	Evaluation	Nutrient content	Value	Evaluation
Sand %	31.00			(mg /100g)	
Silt %	28.00		Available – P	1.30	M
Clay %	41.00		Available –K	31.00	H
Soil Texture	S.C.L	Sandy clay loam	Available - Mg	140.00	M
pH	8.60	H	Available - Ca	225.00	L
E.C dS/m	0.25	M	Available - Na	24.00	L
$CaCO_3$ %	2.00	L		(mg/Kg)	
O.M %	2.50	M	Available - Fe	15	M
			Available - Mn	07	L
			Available - Zn	1.4	L
			Available - Cu	1.1	M

L = Low, M = Moderate, H = High

3.1 Effect of fertilization rates of NPK and of NPK + micro nutrients on yield and its components in maize plants

Data presented in Table (2) indicated that numbers of leaves /plant, ear length, number of row /ear, grains number/row, 100-grains weight, grains yield /plant and yield ton/ ha were significantly affected by the different treatments as compared with the control.

There was a significant increase compared to the control of the number of leaves/plant, the length of cob, the number of rows in the cob and the number of grains in the row as a result of treatment No. 6 by 34.18, 27.94, 32.182, and 33.43%, respectively.

There was also a significant increase in the chilling % rate, weight of 100 grains and yield of grain / plant, yield /ton/ha by 16.52, 35.39, 68.40, and 72.92%, respectively.

Maize treated with N 120, P 60, K 48, according to Ministry of Agric. surpassed the treatments of N 120, P 60 and N 120, K 48/feddan, (feddan = 4200m^2).

These results are in harmony with those obtained by Huang et al.(2004) who found that yield of applied N, P and K increased by 15.9%, 6.9% and 12.1 for high-oil corn by 20.3%, 8.6% and 12.7% for high-starch corn, and with Rastija et al. (2006) who found that by application of the ameliorative rates of NPK fertilizer, grain yields of maize significantly increased to level of 14% compared to standard fertilization (12.33 and 14.00 t ha^{-1}, for the control and the second rate of NPK fertilization, respectively.

The findings of Potarzycki and Grzebisz (2009) showed that the optimal rate of zinc foliar spray for achieving significant grain yield response was in the range from1.0 to 1.5 kg Zn/ha. Grain yield increase was circa 18% (mean of three years) as compared to the treatment fertilized only with NPK. Plants fertilized with 1.0 kg Zn/ha significantly increased both total N uptake and grain yield, and in accordance with Asghar et al. (2010) who concluded that grain yield of maize increased with application of NPK fertilizer.

Also these results corroborate the findings of El-Fouly et al. (2012) who found that NPK dose based on soil testing plus spraying of micronutrients, improved all growth parameters, ear characteristics and resulted in improving nutrient concentrations in maize leaves and also enhanced nutrients uptake which induced significant increase in maize grain yield as compared to other treatments.

Table 2 Mean ± SD of yield and its components of maize as affected by different levels of NPK and balanced fertilization (Average of 5 seasons)

Treatment	Number of leaves/plant	Ear length (cm)	Number of rows/ear	Grains number per/row	Chilling (%)	100 grains weight (g)	Grain yield/plant (g)	Yield/ton /ha
T0	12.23±2.26	19.61±2.58	10.44±0.76	40.59±3.80	70.88±9.90	25.46± 2.13	142.74±44.82	7.46±2.42
T1	13.68±2.25	20.89± 3.02	11.58±1.15	45.84±4.89	74.46±6.89	31.85±3.94	186.26±16.70	9.68±1.44
T2	14.83±2.69	23.00±2.45	12.89±0.96	49.54±4.34	81.16±4.78	33.16±2.66	218.14±22.74	11.58±0.85
T3	14.65±1.39	22.00±2.27	12.16±1.45	47.46± 3.53	75.97±5.89	31.94±1.50	222.21±45.75	10.77±0.75
T4	14.48±1.97	21.86±2.44	12.51±1.27	47.24±2.62	77.74±4.47	32.29±2.81	211.13±23.08	11.25±0.90
T5	15.84±1.58	24.05±2.22	13.34±0.92	52.93±3.96	81.09±3.97	34.76±2.30	225.89±21.12	11.97±0.59
T6	16.41± 0.99	25.09±1.82	13.80±1.16	54.16±5.08	82.59±5.16	34.47±2.34	240.38±25.22	12.90±0.31
LSD (5%)	1.46± 0.56	1.72±0.52	1.18±0.56	4.38±0.87	4.18±2.13	2.22± 1.38	16.00±10.25	0.95±0.49

3.2 Effect of fertilization rates of NPK and of NPK + micro nutrients on nutrient concentrations in different parts of maize plant:

For the nutrients, obtained results showed that all part of maize plant were characterized by an increasing of nutrients as a result of different treatments compared to control (Table 3, 4 and 5). The effects of NPK based on soil testing + one time micronutrients foliar spray on nutrient concentration of maize parts showed that there is a significant an increasing in the concentration of nitrogen in the grains, Envelope (husk leaves) and leaves, and a significant an increasing in the concentration of phosphorus in the Envelope (husk leaves), Cob core and leaves. There is a significant increase in the concentration of potassium in the Envelope (husk leaves), stem and root.

Also, A significant increase in calcium concentration in grains and leaves and a significant increase in sodium in the envelope (husk leaves) and roots. These results corroborate the findings of Paramasivan et al. (2011), and Bak and Gaj (2016), and also Bak et al. (2016).

Regarding the micronutrients, the results of this study indicated that, the value of iron and manganese concentrations were increased in grains, envelope (husk leaves) and leaves. Also, zinc and copper concentration in leaves of maize plants were increased.

Consequently, parts of the maize plant are a good and important source of nutrients for humans and animals.

Table 3 Mean± SD of N, P and K concentrations of maize parts as affected by NPK and micronutrients (Average of 5 seasons)

Treatment	Grain	Envelope (husk leaves)	Cob core	Leaves	Stem	Root
			N %			
Control	1.35± 0.18	0.99± 0.24	0.56± 0.16	1.75± 0.30	1.14± 0.25	1.30± 0.46
Farmer Fertilizer	1.22± 0.22	0.96± 0.31	0.51± 0.19	1.85± 0.38	0.97± 0.51	1.22± 0.46
NPK, Ministry.Agric	1.31± 0.19	0.99± 0.52	0.49± 0.23	1.74+ 0.28	1.21 ± 0.37	1.25± 0.61
NP, Ministry.Agric.	1.36± 0.31	1.07± 0.52	0.54± 0.23	1.81 ± 0.48	1.11 ± 0.48	1.40± 0.51
NK, Ministry.Agric.	1.31± 0.36	1.06± 0.45	0.56± 0.09	1.81± 0.22	1.09 ± 0.43	1.22± 0.42
NPK soil test	1.28± 0.37	1.17± 0.67	0.56± 0.18	1.67± 0.38	1.12 ± 0.48	1.29± 0.20
NPK soil testing+mic	1.41± 0.21	1.13± 0.49	0.52± 0.14	1.87± 0.18	1.09 ± 0.48	1.25± 0.28
LSD 5%	0.17	0.19	N.S	0.19	0.17	N.S
			P %			
Control	0.20 + 0.09	0.09 + 0.02	0.13+ 0.02	0.16 + 0.06	0.16 + 0.05	0.21+ 0.06
Farmer Fertilizer	0.24 + 0.04	0.09 + 0.02	0.15 + 0.06	0.15 + 0.06	0.16 + 0.04	0.20 + 0.07
NPK, Ministry.Agric	0.20 + 0.03	0.11 + 0.05	0.13+ 0.03	0.17+ 0.06	0.15 + 0.05	0.20 + 0.06

NP, Ministry.Agric.	0.22 + 0.01	0.12+ 0.06	0.12 + 0.02	0.18+ 0.05	0.15 + 0.07	0.17+ 0.04
NK, Ministry.Agric.	0.20 + 0.03	0.12+ 0.06	0.11 + 0.02	0.19+ 0.06	0.14 + 0.05	0.17 + 0.06
NPK soil testing	0.19+ 0.02	0.11 + 0.04	0.12 + 0.02	0.16+ 0.04	0.19 + 0.09	0.16 + 0.04
NPK soil testing+mic	0.20+ 0.02	0.11+ 0.05	0.15 + 0.03	0.18+ 0.07	0.15 + 0.06	0.16 + 0.04
LSD 5%	0.02	0.02	0.02	0.02	0.02	N.S
			K %			
Control	0.50±0.10	0.70± 0.29	0.91± 0.17	1.72± 0.31	1.98 ± 0.25	2.09± 0.40
Farmer Fertilizer	0.48±0.10	0.80± 0.35	0.90± 0.19	1.51± 0.27	1.50 ± 0.26	2.31± 0.70
NPK, Ministry.Agric	0.47± 0.07	0.79± 0.33	0.85± 0.25	1.60± 0.42	1.92 ± 0.43	1.96± 0.72
NP, Ministry.Agric.	0.45± 0.11	0.90± 0.47	0.90± 0.20	1.31± 0.21	1.67 ± 0.35	2.15±0.95
NK, Ministry.Agric.	0.52± 0.12	0.84± 0.35	0.91± 0.31	1.39± 0.26	1.95 ± 0.52	1.81± 0.41
NPK soil testing	0.49± 0.09	0.93± 0.36	0.88± 0.25	1.74± 0.24	1.73 ± 0.50	1.99±0.92
NPK soil testing+mic	0.50± 0.11	0.99± 0.28	0.89± 0.26	1.43± 0.29	2.15 + 0.46	2.22± 0.89
LSD 5%	0.03	0.10	N.S	0.14	0.20	0.24

Table 4 Mean± SD of Ca, Mg and Na concentrations of maize parts as affected by NPK and micronutrients (Average of 5 seasons)

Treatment	Grain	Envelope (husk leaves)	Cob core	Leaves	Stem	Root
			Ca %			
Control	0.21± 0.08	0.27± 0.05	0.18± 0.07	0.51± 0.15	0.47 ± 0.29	0.50± 0.23
Farmer Fertilizer	0.20 ± 0.08	0.23± 0.04	0.18± 0.09	0.54± 0.12	0.44± 0.28	0.42± 0.23
NPK, Ministry. Agric	0.18± 0.06	0.29± 0.06	0.18± 0.08	0.66± 0.11	0.37 ± 0.19	0.40± 0.24
NP, Ministry. Agric.	0.19± 0.06	0.25± 0.06	0.17± 0.07	0.71± 0.16	0.36 + 0.13	0.38± 0.13
NK, Ministry. Agric.	0.18± 0.07	0.25 ± 0.03	0.18± 0.06	0.73± 0.24	0.38 ± 0.18	0.47± 0.28
NPK soil testing	0.22± 0.07	0.21± 0.08	0.18± 0.08	0.70 ± 0.12	0.33 ± 0.18	0.41 ± 0.10
NPK soil testing+mic	0.25± 0.15	0.25± 0.04	0.20± 0.09	0.76± 0.25	0.39 ± 0.18	0.52± 0.25
LSD 5%	0.05	0.04	N.S	0.08	0.03	0.08
			Mg%			
Control	0.33± 0.09	0.39± 0.09	0.11± 0.06	0.27± 0.13	0.71± 0.21	0.51± 0.07
Farmer Fertilizer	0.33± 0.09	0.41± 0.06	0.12± 0.04	0.29± 0.06	0.56± 0.12	0.47± 0.11
NPK, Ministry. Agric	0.32± 0.09	0.42± 0.12	0.15± 0.08	0.32± 0.09	0.63± 0.19	0.44± 0.12
NP, Ministry. Agric.	0.29± 0.09	0.36± 0.11	0.16 ± 0.05	0.31± 0.09	0.61± 0.26	0.47± 0.13
NK, Ministry. Agric.	0.29± 0.09	0.37± 0.10	0.14± 0.06	0.29± 0.07	0.67± 0.22	0.34 ± 0.08
NPK soil testing	0.35± 0.08	0.40± 0.08	0.15± 0.05	0.30± 0.06	0.68 ± 0.20	0.55± 0.21
NPK soil testing+mi	0.32± 0.09	0.35± 0.10	0.16± 0.07	0.30± 0.06	0.69± 0.32	0.49± 0.23
LSD 5%	0.03	0.02	0.02	0.03	0.04	0.04
			Na %			
Control	0.07± 0.04	0.07± 0.05	0.07 ± 0.04	0.06± 0.01	0.06± 0.02	0.32± 0.16
Farmer Fertilizer	0.08± 0.06	0.08± 0.05	0.07 ± 0.05	0.06± 0.02	0.05± 0.02	0.32± 0.16
NPK, Ministry. Agric	0.08± 0.04	0.08± 0.04	0.07 ± 0.05	0.06± 0.02	0.06± 0.02	0.39± 0.07
NP, Ministry. Agric.	0.07± 0.05	0.08± 0.04	0.07 ± 0.06	0.06± 0.02	0.06± 0.02	0.44± 0.28
NK, Ministry. Agric.	0.08± 0.05	0.09± 0.05	0.08 ± 0.05	0.05 ± 0.02	0.05± 0.02	0.43± 0.20
NPK soil testing	0.09± 0.05	0.09± 0.05	0.09 ± 0.07	0.06 ± 0.01	0.05± 0.02	0.27± 0.14
NPK soil testing+mi	0.07± 0.05	0.10± 0.07	0.09±0.06	0.06 ± 0.02	0.06± 0.03	0.40± 0.26
LSD 5%	N.S	0.02	N.S	N.S	N.S	0.03

Table 5 Mean ± SD of micronutrient concentrations of maize parts as affected by different levels of NPK and micronutrients (Average of 5 seasons)

Treatment	Grain	Envelope (husk leaves)	Cob core	Leaves	Stem	Root
			Fe mg/Kg			
Control	182± 16	191± 15	178±22	168±57	198 ± 41	569± 062
Farmer Fertilizer	186±17	208± 34	162±36	172±67	223 ± 51	481±120
NPK, Ministry. Agric	167± 32	210± 18	133 ± 21	205± 51	186 ±18	514±158
NP, Ministry. Agric.	178±32	206± 45	138± 25	215±38	190 ± 22	474±143
NK, Ministry. Agric.	186±52	211± 49	138±39	188± 24	189 ± 14	463±111
NPK soil testing	186±63	250 ± 31	141±36	194± 40	192 ±48	489±171

NPK soil testing+ micro	199±68	272 ± 23	135± 25	210±66	179 ± 34	484±172
LSD 5%	25	21	13	14	22	94
			Mn mg/Kg			
Control	32+ 6	32± 12	34± 11	48± 17	26±8	36± 15
Farmer Fertilizer	38 + 11	38± 11	31± 11	48 ±17	21± 11	46 ± 12
NPK, Ministry. Agric	40± 16	34 ±8	29 ± 11	47± 13	20± 11	48± 13
NP, Ministry. Agric.	42± 13	31±9	24± 11	55± 20	21± 11	49± 16
NK, Ministry. Agric.	37+ 10	32±8	25± 9	47± 10	21±9	36 ± 13
NPK soil testing	32±9	41±19	27± 7	57± 29	22± 10	38±9
NPK soil testing+ micro	36+ 16	48±30	28± 7	57± 23	22± 11	39± 9
LSD 5%	5	4	4	9	2	8
			Zn mg/Kg			
Control	30±15	31± 17	25± 12	27 ±8	27± 11	36±14
Farmer Fertilizer	32±11	29± 12	25±9	28±9	24± 14	33±10
NPK, Ministry. Agric	30±12	28±10	23 ±10	29± 10	21± 7	30±13
NP, Ministry. Agric.	29±14	27± 14	23± 13	33±18	22± 11	27±13
NK, Ministry. Agric.	28±20	26±10	24± 13	29± 14	23± 13	30±12
NPK soil testing	28±13	33± 16	22 ± 11	29± 15	20±8	33±11
NPK soil testing+ micro	27±12	33± 18	20± 10	47± 30	20± 11	38±21
LSD 5%	3	2	2	5	4	3
			Cu mg/Kg			
Control	7 ± 3	7±2	9±6	9±5	11±6	13± 4
Farmer Fertilizer	6 ±3	6± 2	8±4	12±4	8±3	13± 5
NPK, Ministry. Agric	6 ± 3	6 ± 2	7 ± 4	10±5	9± 4	11±4
NP, Ministry. Agric.	6 ± 3	7± 2	6 ± 4	13±5	8±3	12± 3
NK, Ministry. Agric.	6 ± 3	6 ± 3	7± 4	12±5	8±2	14± 6
NPK soil testing	6 ± 2	8± 2	7±3	13±5	7±3	12 ±3
NPK soil testing+ micro	6 ± 3	8± 2	6 ± 4	13± 6	8±4	12± 4
LSD 5%	1	1.4	N.S	2	1	1.5

3.3 Correlation between nutrient concentrations in leaves, grain and yield of maize plants:

3.3.1 Correlation between leave nutrient concentrations and grain nutrient concentrations

Data of Table 6 showed that there are positive correlations between the following nutrients: (N leaves and P, K, Ca, Fe grains), (Ca leaves and Mg grains), (Mg leaves and Mg, Na grains), (Na leaves and Zn grains).

On the other hand, Negative correlations were found between the following nutrients: (P leaves and K grains), (Mg leaves and Zn grains), (Na leaves and Fe grains).

This means that attention should be paid to fertilization with nitrogen and calcium where nitrogen and calcium has a positive effect on the concentrations of phosphorus, potassium, calcium, magnesium and iron in maize grains, where the soil is low in the calcium. Also, calcium fertilization can reduce the concentration of sodium in the leaves where this can lead to improve the concentrations of iron in maize grain with an interest in fertilization with zinc as the soil is also low in its content, beside that maize grown on alkaline soils can show severe micronutrients deficiency.

Table 6. Correlation coefficient between leave and grain nutrient concentrations of the maize

Grain / Leave	N %	P %	K %	Ca %	Mg %	Na %	Fe mg/Kg	Mn mg/Kg	Zn mg/Kg	Cu mg/Kg
N%	-.091	0.344*	0.417*	0.461*	0.072	0.123	0.374*	-.136	0.120	-.119
P%		-.187	-.351*	-.146	0.154	0.154	0.108	-.108	-.032	0.175
K%			0.239	-.088	-.510*	0.266	-.152	0.211	-.285	0.311
Ca%				0.085	0.400*	0.222	-.142	-.323	0.294	0.319
Mg%					0.767**	0.545**	0.027	-.288	-.518**	-.126
Na%						-.050	-.513**	-.299	0.517**	0.210
Fe mg/Kg							-.038	0.218	-.087	0.036
Mn mg/Kg								0.324	-.302	0.057
Zn mg/Kg									-.248	-.112
Cu mg/Kg										0.252

r* 0.05 = 0.325, r** 0.01 = 0. 418

3.3.2. Correlation between leaf nutrient concentrations of the maize and yield

Data of Table 7 showed that there is positive correlations between the following nutrient were found: (N and Fe, Mn), (Fe and Cu), (Ca and Cu), (P and Mn), (Fe and Mn).

In this regard Kovacs and Vyn (2017) mentioned that N, P, S, Cu and Fe were positively correlated with each other.

Also, Negative correlations were found between the following nutrients: (Mn and Zn), (Mg and Mn), (N and Mg, Zn),(P and Mg), (K and Fe, Cu).

As well as highly significant positive correlation were found between Ca in leaves and yield and significant positive correlation were found between Zn in leaves and yield, r =0.450 and r = 0.333 respectively.

In this respect, Borges et al. (2009) mentioned that zinc is the most accumulated micronutrient in the aboveground matter of the maize hybrids, also, Potarzycki and Grzebisz (2009) found that maize crop responded significantly to zinc foliar application in two of three years of study.

This means that the interest of nitrogen fertilization can activate iron and manganese nutrients, iron and calcium can activate copper nutrient. Also, the interest of phosphorus fertilizer activates manganese and the interest of iron activates manganese nutrient. The negative correlations between the increased of some nutrients on the decreased of other nutrients in the leaves can be overcome by integrated balanced fertilization.

The study also showed a very strong and positive correlation between calcium leaf and yield as well as the strong and positive correlation between zinc leaf and yield.

Table 7 Correlation coefficient betwen leaf nutrient concentrations and yield of the maize

Nutrient	P %	K %	Ca %	Mg %	Na %	Fe mg/Kg	Mn mg/Kg	Zn mg/Kg	Cu mg/Kg	Yield
N%	0.285	-0.083	-0.118	-.496**	-.057	0.378*	0.365*	-.468**	-.111	302
P%		0.153	0.042	-.561**	-.232	0.231	0.470**	-.239	-.043	-.004
K%			-.285	-.486**	-.178	-.472**	-.005	-.249	0.205	-.004
Ca%				0.053	0.232	0.282	-.168	0.296	0.331*	0.450**
Mg%					0.0205	-.045	-.340*	0.470**	-.137	0.200
Na%						-.117	-.276	0.078	0.403*	0.185
Fe mg/Kg							0.441**	-.316	-.454**	-.124
Mn mg/Kg								-.344*	-.487**	-.133
Zn mg/Kg									0.355*	0.333*

r* 0.05 = 0.325 (significant at 5% level) , r** 0.01 = 0. 418 (significant at 1% level)

3.3.3 Correlation between grain nutrient concentrations of the maize and yield

Positive correlations were found between the following nutrients: (P and Cu), (Ca and Mg, Na), (Fe and Mn), (K and Zn, Cu), (Ca and Cu), (Mg and Na).

On the other hand, Negative correlations were found between the following nutrients :(N and K, Na, Cu),(Ca and Fe), (Mg and Zn , Fe, Cu), (K and Mg), (Ca and Mn), (Mg and Mn), (Na and Mn, Zn),(Fe and Zn), (Mn and Cu).

There was also, a significant negative correlation between Cu and grain yield, r = -0. 349 (Table 8)

This means that the relationships between the concentrations of maize grain components affect each other by activating and inhibition so as to reach the balance between them.

Also, the spraying of copper compounds at high concentrations leads to an increase in the concentrations of copper in grain and thus reduce grain yield.

Table 8 Correlation coefficient between grain nutrient concentrations and yield of the maize

Nutrient	P %	K %	Ca %	Mg %	Na %	Fe mg/Kg	Mn mg/Kg	Zn mg/Kg	Cu mg/Kg	Yield

N%	-.002	-.380*	-.177	0.220	-.344*	0.022	0.206	0.216	-.405*	0.103
P%		0.155	0.299	-.113	-.001	-.216	0.027	0.105	0.404*	-.255
K%			-.001	-.478**	-.255	-.240	-.0269	0.469**	0.444**	-.048
Ca%				0.367*	0.372*	-.369*	-.657**	-.242	0.614**	-.014
Mg%					0.588**	.006	-.444**	-.339*	-.172	0.149
Na%						0.104	-.422**	-.537**	0.137	0.222
Fe mg/Kg							0.328*	-.475**	-.416*	-.005
Mn/mg/Kg								0.205	-.519**	0.094
Zn mg/Kg									-0532	0.092
Cu mg/Kg										-.349*

r* 0.05 = 0.325, r** 0.01 = 0. 418

4 Conclusions

Based on soil testing, plants fertilized with 300 kg N + 156 kg P_2O_5 + 192 kg K_2O/ha., plus foliar application of micronutrients developed than other treatments. This resulted in

(1) Improved maize yield and its components significantly

(2) Significant increase in the concentration of most nutrients in different maize plant parts.

(3) Significant positive correlation between concentrations in most nutrients in leaves and nutrient concentrations in grains.

A significant positive correlation was also found between Ca, Zn in the leaves and yield.

The findings are helpful to make a nutrient regime recommendation for maize production.

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