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EFFECT OF HUMIC ACID AND MICRONUTRIENTS FOLIAR FERTILIZATION ON YIELD, YIELD COMPONENTS AND NUTRIENTS UPTAKE OF MAIZE IN CALCAREOUS SOILS

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ABSTRACT

Two field trials were conducted in calcareous soils at Nubaria Agriculture Research Station in 2011 and 2012 summer seasons. The objectives of this investigation was aimed to study the response of maize plants to humic acid and micronutrient foliar fertilization. This study was implemented in newly reclaimed lands at Nubaria region representing calcareous soils under surface irrigation system. Treatments were two humic acid levels (0 and 1000 ppm) and five micronutrient elements (Fe, Zn, Mn and mixture of Fe+Zn+Mn and control). Experimental design was split-plot with four replications. Humic acid was randomly assigned to the main plots, while micronutrients were arranged at random in sub-plots. Results showed that humic acid application resulted in significant decrease in days to 50% tasseling and silking but did not affect plant height and ear height. Spraying of FZM significantly increased weight of 100-kernel and grain yield. Macro- and micro-nutrients concentration in maize leaves and grains and also grain nutrients uptake were affected significantly by spraying humic acid and/or micronutrients comparing with control treatments. Spraying FZM recorded the highest nutrients concentrations and uptake in leaves. Interaction effects between humic acid and MN indicated that treatments of humic acid and micronutrients were superior to excluding humic acid. Nearly all prominent increases were obtained when a mixture of micronutrients and humic acid was used followed by humic acid, Fe, and Zn in the both growing seasons.

Regression relation between grain yield (GY) and 18 independnt varibles showed that there is a highly significant relation between grain yield and twelve of the independnt varibles. The regressing between GY and the most effective parameters indicated that there were a statistical model contains all the eighteen independnt varibles explain 78% of grain yield differences at the same time there were four varibles explained 72% of yield variations including (Puptake leaf fe content Nuptake and grain Mn concentration) under the experiment conditions.

Keywords: Maize, calcareous soils, humic acid, micronutrients, nutrient uptake,fertilizers.

INTRODUCTION

Maize (*Zea mays* L.) is one of the most important cereal crops in Egypt. It is mainly used to overcome the increasing requirements for animal and poultry rations as well as many industrial purposes. Cultivation of improved varieties, nutrient depletion, and little attention to balanced nutrient management are limiting factors of maize production. In this concern, FAO Fertilizer Yearbook (2003) concluded that the NPK fertilization in Egypt is characterized by the heavy use of N, high P and low K rates. Firgany *et al.* (1983) confirmed the role of micronutrients in intensive cropping, and that maize is susceptible to zinc deficiency. It is recommended that supplying these nutrients should be considered to prevent successive depletion.

Plant height, stalk diameter, and leaf area index of maize were significantly increased by application of nitrogen and phosphorus fertilizer 8 weeks after sowing (Onasanya *et al.*, 2009).

Improvement of soil conditions and establishing equilibrium among plant nutrients are important for soil productivity and plant production. On the other hand, excessive usage of chemical fertilizers in agriculture has caused environmental problems such as physical destruction of the soil and nutritional substances imbalance in the soil (Sebahat and Necdet, 2005). Majidian *et al.* (2006) stated that using organic and chemical fertilizers simultaneously can result in higher corn quality with a better yield in addition to reducing the use of chemical fertilizer and improving soil condition.

Humic acid is one of the major components of humic substances. Humic matter is formed through the chemical and biological humification of plant and animal matter and through the biological activities of microorganisms (Anonymous, 2010). Humic substances constituting 60 to 70% of the total organic matter (Schnitzer and Khan, 1972). Effects of humic acid on plant development have generally been ascribed to the chemical effects of associated mineral nutrients or growth regulatory molecules. However, the concentrations and precise identities of any humic acid derived chemicals in the rhizosphere that may affect whole plant growth, have yet to be established (Schmidt *et al.*, 2007). It seems that humic substances may influence both respiration and photosynthesis (Nardi *et al.*, 2002). Humic substances have a very profound influence on the growth of plant roots. When humic acids are applied to the soil, enhancement of root initiation and increased root growth may be observed (Pettit, 2004). The stimulatory effects of humic substances have been directly correlated with enhanced uptake of macronutrients (Chen and Aviad, 1990), and micronutrients, that as Fe, Zn, Cu and Mn (Chen *et al.*, 1999). Humic substances have been reported to influence plant growth both directly and indirectly. The indirect effects of humic compounds on soil fertility include. (i) Increase in the soil microbial population including beneficial microorganisms. (ii) Improved soil structure. (iii) Increase in cation exchange capacity and the pH buffering capacity of soil. Directly, humic acid compounds may have various biochemical effects either at cell wall, membrane level or in the cytoplasm, including increased photosynthesis and respiration rates in plants, enhanced protein synthesis and/or stimulating hormonal activities (Nardi *et al.*, 2000), enhancing mineral nutrition (Clapp *et al.*, 2001). Khristeva *et al.* (1980) showed an increase in ATP production due to humic substances.
Therefore the present work was carried out to investigate the effect of humic acid and micronutrients and the interaction on yield, yield components and nutrient uptake of maize plants.

MATERIALS AND METHODS

A field experiment was carried out in calcareous soils at Nubaria Res. Station, Field crops Res. Inst., Agric. Res. Center during 2011 and 2012 summer seasons to study the effect of humic acid (HA) and micronutrients (MN) treatments on growth, grain yield, NPK, and micronutrients use efficiency of single cross 166. Soils have low concentrations of micronutrients (Fe, Zn, and Mn) in addition to low availability due to increasing pH values, which related to high $CaCO_3$ content in both seasons, respectively. Soil samples were taking before planting from two depths surface (0-25 cm) and subsurface (25-50 cm). Some chemical, physical, and nutritional characteristics of the soils were determined. Analysis of soil samples was made according to the standard methods (Page, 1982 and Klute, 1986). Main soil characteristics are presented in Table (1). Treatments were two humic acid (HA) levels (0 and 1000 ppm) and five Treatments (MN) elements (Fe, Zn, Mn, a mixture of Fe+Zn+Mn (FZM), and control) with concentration of (0.02 %). Experimental design was split-plot with four replications. Humic acid was randomly assigned to the main plots, while MN was arranged at random in sub-plots. Foliar applications with HA and MN were made at 25 and 40 days after planting just before irrigation.

Table (1): Some physical and chemical characteristics of the experimental soils location at North Tahrir.

Characteristics	Growing Season			
	2011		2012	
	0-25, Cm	25-50, cm	0-25, cm	25-50, Cm
Sand, %	85.70	79.5	85.70	79.5
Silt +Clay, %	14.3	20.5	14.3	20.5
Soil texture class	LS	LS	LS	LS
FC; %	15.50	14.00	15.50	14.00
PWP; %	7.70	6.50	7.70	6.50
EC; dS m^{-1} (Soil paste)	3.72	3.65	2.68	2.52
pH (1:2.5)	8.32	8.45	8.30	8.39
$CaCO_3$, %	23.50	21.30	24.70	26.90
O.M, %	0.52	0.28	0.41	0.32
NO_3+NH_4;mg kg^{-1}	25.65	20.56	24.56	22.35
$NaHCO_3$-P;mgkg^{-1}	17.56	11.45	16.58	10.25
Exch.-K; mg kg^{-1}	225.36	220.25	221.54	209.5
DTPA Fe, mg kg^{-1}	5.30	4.80	5.00	4.40
DTPA Zn, mg kg^{-1}	2.40	2.10	2.50	2.3
DTPA Mn, mg kg^{-1}	6.30	5.32	5.30	4.60

FC=field capacity, PWP= permanent wilting point, LS= loamy sand

Experimental plots were of 5 rows; 80 cm in width, 6 m in length, and 20 cm between hills. One blank row was left between plots. All cultural practices for maize production were applied as recommended. Thirty kg P_2O_5 and 24 kg K_2O/fed were added during soil preparation. Nitrogen fertilizer (120 kg fed^{-1}) was added in the form of ammonium nitrate (33.5% nitrogen). Nitrogen was split into two equal doses in both seasons. Recorded data were number of days from planting to 50% tasseling (DTT), number of days from planting to 50% silking (DTS), plant height (PHT), ear height (EHT), and grain yield (GY) in ardab/feddan (ard fed^{-1}). One ardab=140 kg grains. Grain yield data were collected from the second and third rows. Grain yield was adjusted to 15.5% moisture content. Weight of 100-kernels (100-kwt) was estimated

Table (5) represents the effect of HA application on N, P, K, Fe, Zn, and Mn uptake in maize kernels. Results of 2011 and 2012 indicated that there were significant increase in maize nutrients uptake including macro- and micronutrients due to application of HA in the two growing seasons of 2011 and 2012.

Table 5: Effect of humic acids (HA) application on some micronutrient elements concentrations uptake in maize kernels during 2011 and 2012 seasons.

HA (g L^{-1})	N	P	K	Fe	Zn	Mn
	Uptake (kg fed^{-1})					
	2011					
treated	48	14	23	0.80	0.19	0.50
Control	35	11	17	0.64	0.17	0.41
F.test	*	*	*	*	*	*
	2012					
treated	54	17	24	1.04	0.26	0.66
Control	48	14	22	0.87	0.22	0.55
F.test	*	*	NS	*	*	*

*** significant at 0.05 level.**

The positive effect of humic acid on the uptake of N, P, Ca, Mg, Fe and Zn was reported by Fortun and Lopez, (1982).

Effect of Micronutrients (MN):

The results showed in Table (6) the effect of micronutrients on DTT, DTS, PHT, EHT, 100-KW, and GY of maize when Fe, Zn, and Mn were sprayed either as solo or in a mixture compared with the control treatments. Results showed that spraying of single or mixture of Fe, Zn, and Mn significantly decreased DTT and DTS compared with the control treatment. Plant height significantly increased by MN application only in 2012, while no significant differences were detected for EHT in both seasons. Spraying of single or mixture of Fe, Zn, and Mn significantly increased 100-GW and GY in both seasons (Table 6). The highest increase was detected when a mixture of FZM was used. Results showed the synergetic role of micronutrients in improving plant growth and other physiological activities. These results are in harmony with those obtained by Potarzycki *et al.* (2009).

The result represented in Table 7 showed the effect of spraying micronutrients on micro and macronutrient concentrations in leaves during the two seasons. No significant differences were found between MN application and control treatment for N concentration in leaves in both seasons, while treated maize with spraying of single or mixture of Fe, Zn, and Mn caused significant increase in P and K content in leaves in both seasons compared with control treatment, except for P in 2012 season.

The results in Table (7) indicated that spraying application of micronutrients significantly increased micronutrient content in leave in both seasons. Application of micronutrients either separate or as mixture did not increase N content in maize leaves, while application of Zn or mixture of Fe, Zn, and Mn significantly increased P content in 2011 only. Regarding K content from a sample of five ears. Maize ear leaf samples were collected to determine nutrient contents. Samples were washed, dried at 70 °C for 48 h, ground. At harvesting time grain samples were taken, air dried and crushed. Leaves and grain samples were wet digested using concentrated sulfuric acid (H_2SO_4) and hydrogen peroxide according to FAO method (FAO, 1980). Macro-elements (N, P, K) and MN (Fe, Zn and Mn) were determined in maize leaves and grains. The N, P, and K concentrations were determined using semi-automatic nitrogen distillation unit, spectrophotometer 21D and Jenway flame photometer, respectively, whereas MN elements were determined using atomic absorption spectrophotometer (AAS) according to (Westerman, 1990). Macro elements (NPK) and microelements (Fe, Zn and Mn), uptake components calculations were made according to (Huggins and Pan, 1993):

Data were statistically analyzed according to Steel and Torrie (1980). Comparisons among means of the different treatments were carried out using Duncan's multiple range tests as illustrated by Gomez and Gomez (1983).

RESULTS AND DISCUSSION

Grain yield and agronomic traits:

Effect of Humic Acid (HA):

Results in Table 2 show the effect of HA on DTT, DTS, PHT, and EHT in 2011 and 2012. Humic acid application resulted in significant decrease in DTT and DTS, except for DTT in 2012, while, no significant differences were found for PHT and EHT in both seasons, except for PHT in 2012 season. On the other hand, 100-KW and GY were significantly increased due to HA application in both seasons.

Table 2: Effect of humic acid application on days to 50% tasseling (DTT), days to 50% silking (DTS), plant height (PHT), ear height (EHT), weight of 100 kernels (100-KW), and grain yield during 2011 and 2012 seasons.

HA (g L^{-1})	DTT (d)	DTS (d)	PHT (cm)	EHT (cm)	100-KW (g)	GY (ard fed^{-1})
				2011		
Treated	60.1	62.3	177	94	31.0	22.87
Control	61.3	63.9	165	91	28.4	18.39
F.test	*	*	*	NS	*	*
				2012		
Treated	59.8	61.8	191	105	37.1	28.7
Control	61.8	64.0	196	113	32.8	23.9
F.test	NS	*	NS	NS	*	*

* significant at 0.05 level.

In general applying foliar application of humic acid increased vegetative growth indicators over control treatment. Results indicated that the application of HA significantly increased grain yield and some agronomic traits related to it. Previous reports have shown the stimulatory effects of humic substances on physiological processes related to growth and productivity in maize (Varanini and Pinton, 2001; Clapp *et al.*, 2001). Humic acid increased yields of some field crops as reported in several studies (Khanghah *et al.*, 2012).

Table (3) shows the effect of humic acid applications on N, P, and K percentage and Fe, Zn and Mn content in maize leaves. Results of 2011 indicated that spraying HA caused significant increased in P, Fe, Zn and Mn content in maize leaves, while in 2012 the application of HA caused a significant increase only for Fe, Zn and Mn content.

Table 3: Effect of humic acids (HA) application on some micronutrient elements concentrations in maize leaves during of 2011 and 2012 seasons.

HA (g L^{-1})	N	P	K	Fe	Zn	Mn
	(%)			(µg/g)		
	2011					
treated	2.5	0.39	2.5	488	38.5	253
Control	2.4	0.35	2.3	453	31.3	236
F.test	NS	*	NS	*	*	*
	2012					
treated	2.5	0.38	2.5	560	91	325
Control	2.5	0.36	2.4	486	74	280
F.test	NS	NS	NS	*	*	*

* significant at 0.05 level.

Table (4) shows the effect of humic acid applications on N, P, and K percentage and Fe, Zn, Mn, and protein content in maize kernels. Results of 2011 indicated that spraying HA caused significant increased in N, P, Zn, and protein content in maize kernel, while in 2012 the application of HA caused a significant increase only for N content. Ayas and Gulser (2005) reported that humic acid caused increasing nitrogen content of the plant. It has been reported that application of humic acid in nutritional solution led to increased content of nitrogen within aerial parts and growth of shoots and root of maize (Tan, 2003). In another investigation, the application of humic acid led to increased phosphorus and nitrogen content of bent grass plant and increased the accumulation of dry materials (Mackowiak *et al.* 2001). Humic acid leads to increased plant yield through positive physiological effects such as impact on metabolism of plant cells and, increasing the concentration of leaf chlorophyll (Nardi *et al.* 2002).

Table 4: Effect of humic acids (HA) application on some micronutrient elements and protein concentrations in maize kernels during 2011 and 2012 seasons.

HA (g L^{-1})	N	P	K	Fe	Zn	Mn	Protein
	(%)			(µg/g)			
	2011						
Treated	1.50	0.44	0.70	252	58	157	9.4
Control	1.36	0.40	0.65	248	66	159	8.5
F.test	*	*	NS	NS	*	NS	*
	2012						
Treated	1.43	0.43	0.60	261	65	165	8.8
Control	1.35	0.40	0.65	261	65	165	8.4
F.test	*	NS	NS	NS	NS	NS	NS

* significant at 0.05 level.

Table (5) represents the effect of HA application on N, P, K, Fe, Zn, and Mn uptake in maize kernels. Results of 2011 and 2012 indicated that there were significant increase in maize nutrients uptake including macro- and micronutrients due to application of HA in the two growing seasons of 2011 and 2012.

Table 5: Effect of humic acids (HA) application on some micronutrient elements concentrations uptake in maize kernels during 2011 and 2012 seasons.

HA (g L^{-1})	N	P	K	Fe	Zn	Mn
	Uptake (kg fed^{-1})					
	2011					
treated	48	14	23	0.80	0.19	0.50
Control	35	11	17	0.64	0.17	0.41
F.test	*	*	*	*	*	*
	2012					
treated	54	17	24	1.04	0.26	0.66
Control	48	14	22	0.87	0.22	0.55
F.test	*	*	NS	*	*	*

*** significant at 0.05 level.**

The positive effect of humic acid on the uptake of N, P, Ca, Mg, Fe and Zn was reported by Fortun and Lopez, (1982).

Effect of Micronutrients (MN):

The results showed in Table (6) the effect of micronutrients on DTT, DTS, PHT, EHT, 100-KW, and GY of maize when Fe, Zn, and Mn were sprayed either as solo or in a mixture compared with the control treatments. Results showed that spraying of single or mixture of Fe, Zn, and Mn significantly decreased DTT and DTS compared with the control treatment. Plant height significantly increased by MN application only in 2012, while no significant differences were detected for EHT in both seasons. Spraying of single or mixture of Fe, Zn, and Mn significantly increased 100-GW and GY in both seasons (Table 6). The highest increase was detected when a mixture of FZM was used. Results showed the synergetic role of micronutrients in improving plant growth and other physiological activities. These results are in harmony with those obtained by Potarzycki *et al.* (2009).

The result represented in Table 7 showed the effect of spraying micronutrients on micro and macronutrient concentrations in leaves during the two seasons. No significant differences were found between MN application and control treatment for N concentration in leaves in both seasons, while treated maize with spraying of single or mixture of Fe, Zn, and Mn caused significant increase in P and K content in leaves in both seasons compared with control treatment, except for P in 2012 season.

The results in Table (7) indicated that spraying application of micronutrients significantly increased micronutrient content in leave in both seasons. Application of micronutrients either separate or as mixture did not increase N content in maize leaves, while application of Zn or mixture of Fe, Zn, and Mn significantly increased P content in 2011 only. Regarding K content in leaves, spraying of Fe and Zn in 2011 or the mixture of Fe, Zn, and Mn significantly increased K content in 2012. Results of spraying of MN application on maize plants as either as single or a mixture of Fe, Zn, and Mn resulted in a significant increased in leaves content of Mn and K in both seasons and P content in 2011 only.

Table 6: Effect of micronutrients application on days to 50% tasseling (DTT), days to 50% silking (DTS), plant height (PHT), ear height (EHT), weight of 100 kernels (100-KW), and grain yield (GY) during 2011 and 2012 seasons.

MN (0.02 %)	DTT	DTS	PHT (cm)	EHT (cm)	100-KW (g)	GY ard fed^{-1}
				2011		
Fe	60.8	63.0	174	93	30.9	19.81
Zn	60.5	63.3	169	92	30.7	21.12
Mn	60.3	62.4	166	91	27.4	20.8
FZM	60.6	62.9	174	98	34.2	23.93
Control	61.4	63.9	173	88	25.4	17.48
LSDat$_{(0.05)}$	0.7	0.8	NS	NS	1.5	1.87
				2012		
Fe	59.9	62.1	198	109	35.0	24.4
Zn	61.0	63.3	193	109	38.0	30.1
Mn	60.9	62.9	194	110	32.4	25.8
FZM	60.6	62.8	202	111	40.3	33.1
Control	61.3	63.4	181	105	28.9	19.9
LSDat$_{(0.05)}$	0.9	1.0	7.5	NS	1.0	2.8

Table 7: Effect of micronutrients (MN) application on some micronutrient elements concentrations in maize leaves during 2011 and 2012 seasons.

MN (0.02 %)	N	P	K	Fe	Zn	Mn
		(%)			(µg/g)	
				2011		
Fe	2.5	0.35	2.6	504	29	227
Zn	2.5	0.39	2.7	457	40	235
Mn	2.4	0.33	2.3	467	34	278
FZM	2.6	0.41	2.1	516	37	264
Control	2.4	0.35	2.2	410	35	220
LSD at$_{(0.05)}$	NS	0.04	0.38	17.6	2.2	16.3
				2012		
Fe	2.4	0.36	2.6	568	70	319
Zn	2.4	0.38	2.6	520	86	303
Mn	2.4	0.36	2.2	524	74	299
FZM	2.6	0.40	2.7	538	101	320
Control	2.4	0.35	2.4	465	81	273
LSDat$_{(0.05)}$	NS	NS	0.28	23.1	3.3	11.6

Results illustrated in Table (8) showed the effect of spraying micronutrients (MN) on micro and macronutrients concentration in maize grains during 2011 and 2012 seasons. The results showed that spraying micronutrients (MN) caused significant increase of micro and macro-nutrients concentration in maize grains during both seasons, except for N, K, and protein content in 2012. Hegazi *et al.* (2002) indicated that foliar application is particularly useful under conditions where nutrient uptake from the soil is restricted. This is often the case for micronutrients such as Fe, Zn, Mn and Cu. These nutrients are frequently fixed by soil particles in alkaline soils and for this reason are scarcely available to plant roots.

As shown in Table (8) results indicated that spraying MN significantly increased all macro and micronutrients content in maize kernels per feddan in both seasons of study.

Table 8: Effect of micronutrient (MN) application on some micronutrient elements and protein concentrations in maize kernels during 2011 and 2012 seasons.

MN (0.02 %)	N	P	K	Fe	Zn	Mn	Protein
	(%)			(µg/g)			
	2011						
Fe	1.44	0.40	0.65	264	71	176	9.0
Zn	1.43	0.44	0.71	259	67	165	8.9
Mn	1.39	0.34	0.64	242	50	147	8.7
FZM	1.55	0.47	0.75	230	65	148	9.7
Control	1.34	0.41	0.62	256	56	153	8.4
LSDat$_{(0.05)}$	0.09	0.03	0.10	13.7	3.4	4.8	0.56
	2012						
Fe	1.45	0.40	0.66	274	73	178	9.0
Zn	1.33	0.43	0.64	267	71	173	8.3
Mn	1.34	0.39	0.55	259	54	158	8.3
FZM	1.42	0.45	0.64	241	69	157	9.0
Control	1.39	0.41	0.61	264	60	160	8.7
LSDat$_{(0.05)}$	NS	0.04	NS	18.1	5.2	1.5	NS

The results in Table (9) indicated that micronutrients mixture (FZM) was significantly more effective in most cases than single element application on increasing nutrients uptake.

Table 9: Effect of foliar application of micronutrients (MN) on some micronutrient elements uptake in maize kernels during 2011 and 2012 seasons.

MN (0.02 %)	N	P	K	Fe	Zn	Mn
	Uptake (kg fed^{-1})					
	2011					
Fe	43	12	20	0.78	0.21	0.52
Zn	40	12	20	0.72	0.19	0.46
Mn	41	12	19	0.71	0.15	0.43
FZM	53	16	26	0.76	0.21	0.49
Control	33	10	15	0.63	0.14	0.38
LSD$_{at(0.05)}$	4.0	1.2	2.6	0.06	0.01	0.03
	2012					
Fe	49	13	23	0.93	0.25	0.60
Zn	55	18	27	1.12	0.29	0.72
Mn	46	13.3	19	0.89	0.18	0.54
FZM	66	21	30	1.10	0.31	0.72
Control	39	12	17	0.74	0.17	0.45
LSDat$_{(0.05)}$	5.4	1.8	4.1	0.10	0.03	0.06

Interaction effects between HA and MN:

The results presented in Table (10) show the interaction effects between HA and MN on DTT, DTS, EHT, 100-KW, and GY in 2011 and 2012 seasons. Significant interactions was observed for DTT, DTS, EHT, and 100-KW in 2011, while in 2012 the interaction was significant only for GY.

The improvement of maize yield and its components in the present study shows the synergetic effect between HA and MN and this agreement with many studies, which showed that humic acid caused the increase in the uptake of mineral elements (Maggioni *et al.* 1987; Mackowiak *et al.* 2001).

Hegazi *et al.* (2002) indicated that foliar application is particularly useful under conditions where nutrient uptake from the soil is restricted. This is often the case for micronutrients such as Fe, Zn, Mn and Cu. These nutrients are frequently fixed by soil particles in alkaline soils and for this reason are scarcely available to plant roots.

Table 10: Effect of humic acid (HA) × micronutrient (MN) interaction on DTT, DTS, EHT, 100-KW, and grain yield (GY) in 2011 and 2012 seasons.

HA	MN (0.02 %)	DTT (d)	DTS (d)	EHT (cm)	100-KW (g)	GY (ard fed^{-1})
		2011				
Treated	Fe	60	62	99	31	20.9
	Zn	61	63	87	33	23.1
	Mn	59	61	89	29	23.2
	FZM	60	62	102	35	27.9
	Control	61	63	92	27	19.2
Control	Fe	62	65	87	31	18.7
	Zn	61	63	96	28	19.1
	Mn	61	64	92	26	18.4
	FZM	61	64	94	33	20.0
	Control	61	65	85	24	15.7
	$LSD_{(0.05)}$	1.03	1.03	10.8	1.8	NS
		2012				
Treated	Fe	58	61	104	36	26.7
	Zn	61	62	104	40	32.2
	Mn	60	61	108	35	27.1
	FZM	60	62	107	43	36.9
	Control	61	63	100	31	22.5
Control	Fe	62	64	113	34	22.1
	Zn	62	64	114	36	28.1
	Mn	62	65	111	30	24.5
	FZM	62	64	116	38	29.3
	Control	62	65	111	27	17.4
	$LSD_{(0.05)}$	NS	NS	NS	1.3	3.9

Parameters affected grain yield

The regression relation between grain yield (GY) and the eighteen variables showed that there is a highly significant relation between grain yield and twelve of the independent variables including (Leaf P, Leaf K,Leaf Fe,Leaf Zn,Leaf Mn,Grain P,N Uptake,P uptake,K uptake,Fe uptake and,Mn uptake) and the rest of variables not effected the grain yield under the experiment condition.

Stepwise regression analysis was made to explain the regression relation between grain yield as dependent variable and the most effective parameters (Table 11). The analysis indicated that there was a statistical model contains all the eighteen independent variables explain 78% (R-square = 0.778) of grain yield differences, at the same time there were four variables explained 72% (R-square=0.715) of yield variations including (P uptake,leaf Fe content,N uptake and grain Mn concentration).

Table 11: Regreesion rlatation of grain yield , nutrrients levels , grains concenentration and grain uptake

Step	Variable entered	partial ^{**2}	Model R ^{**2}	Prob> f
1	p uptake	0.4759	0.4759	0.0001
2	Leaf Fe	0.2003	0.6762	0.0001
3	N uptake	0.0323	0.7086	0.0048
4	Leaf N	0.0072	0.07158	0.1711
5	Leaf K	0.0100	0.7258	0.1049
6	Grain Fe	0.0061	0.7319	0.2013
7	Zn uptake	0.0066	0.7358	0.1812
8	Mn uptake	0.0061	0.7446	0.1987
9	Leaf Zn	0.0071	0.7517	0.1603
10	Grain Zn	0.0019	0.7536	0.4667
11	Grain Mn	0.0160	0.7696	0.0333
12	Grain P	0.0022	0.7718	0.4285
13	Grain N	0.0052	0.7770	0.2178
14	Grain K	0.0018	0.7788	0.4749

Finally, it might be concluded that foliar application of humic acid and micronutrients could be caused significant increase of micro and macro-nutrients concentration in maize grains. Micronutrients mixture (FZM) was significantly more effective in most cases than single element application on increasing nutrients uptake. Increasing in grain yield and yield components showed the synergetic effect between HA and MN.

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تأثير التسميد الورقي بحمض الهيوميك والعناصر الصغري على محصول الذرة الشامية ومكوناته وامتصاص العناصر المغذية فى الأراضي الجيرية

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اجريت تجربتين حقليتين خلال الموسم الصيفي ٢٠١١ ، ٢٠١٢ بهدف دراسة استجابة نباتات الذرة الشامية للتسميد الورقي بكل من حمض الهيوميك والعناصر المغذية الصغري. اجريت الدراسة فى ظروف الأراضي حديثة الاستصلاح فى منطقة النوبارية بالمزرعة البحثية لمحطة البحوث الزراعية بالنوبارية (شمال التحرير) ممثلة للأراضي الجيرية وذلك تحت نظام الري السطحي . حيث طبقت عشرة معاملات لتقييم اثر الرش الورقي على محصول الذرة الشامية ومكوناته وامتصاص العناصر المغذية بالحبوب. وكانت المعاملات عبارة عن معاملتين لحامض الهيوميك (بدون ، ١٠٠٠ جزء فى المليون) ؛ خمسة معاملات من العناصر المغذية الصغري هى الرش بالحديد (Fe) ، الرش بالزنك (Zn) ، الرش بالمنجنيز (Mn) والرش بخليط العناصر (FZM) وأخيرا المعاملة بدون رش. وكان التصميم التجربة قطع منشقة مرة واحدة في أربع مكررات ، حيث وزعت معاملات حمض الهيوميك فى القطع الرئيسية بينما وزعت معاملات العناصر المغذية الصغري الخمسة فى القطع المنشقة.

١- أوضحت النتائج أن هناك تأثير معنوي لحمض الهيوميك فى خفض عدد الايام حتي ظهور ٥٠% من السنبلة والحريرة فى كلا موسمي النمو . بينما لم تكن هناك فروق معنوية على ارتفاع النبات والكوز بين معاملتي حمض الهيوميك.

٢- ادي رش العناصر الصغري منفردة اوفى خليط أدي الى زيادة معنوية فى وزن ١٠٠ حبة ومحصول الحبوب خصوصا معاملة رش خليط العناصر (FZM) بالمقارنة بمعاملة الكنترول .

٣- اظهرت النتائج ان لكل من تركيز العناصر المغذية الكبري والصغري تاثيرا معنويا وايجابيا فى أوراق وحبوب نباتات الذرة وكذلك امتصاصها فى الحبوب عند الرش بحمض الهيوميك و/أو بالعناصر المغذية الصغري بالمقارنة بمعاملة بدون رش . حيث سجلت معاملات الرش بمخلوط العناصر (FZM) أعلى نتائج لتركيز العناصر وامتصاصها فى أوراق وحبوب الذرة وتبعها الرش بعناصر الحديد (Fe) والزنك (Zn) . وايضا كان التفاعل بين حمض الهيوميك والعناصر الصغري معنويا حيث كانت معاملات الرش الورقي باستخدام حمض الهيوميك مع العناصر الصغري تعطي نتائج مرتفعة لتركيز العناصر وامتصاصها بالمقارنة لنفس المعاملات بدون حمض هيوميك أو بدون العناصر الصغري. وقد كانت أعلى نتائج للمعاملة خليط العناصر الصغري (FZM) مع حمض الهيوميك يتبعها معاملات الرش بالحديد أو الزنك فى كلا موسمي النمو بالمقارنة بنفس المعاملات ولكن بدون رش حمض هيوميك.

٤- أشارت النتائج الي أن معامل الانحدار بين محصول الحبوب (GY) و عدد ١٨ عامل مستقل (هي تركيز العناصر الكبري و الصغري في الأوراق و الحبوب و امتصاص العناصر في الحبوب) معنوي في حالة ١٢ عامل فقط بينما العوامل الأخري لم تكن معنوية. حيث كان معامل الارتداد للـ ١٨ عامل يساوي ٧٨% من التأثيرات المسئولة عن اختلافات محصول الحبوب.و قد كان لـ ٤ عوامل فقط تأثير مباشر علي انتاج الحبوب لها معامل انحدار يمثل ٧٢% من الاختلافات و هي الفوسفور الممتص و محتوي الحديد في الأوراق و النيتروجين الممتص و أخيرا تركيز المنجنيز في الحبوب.

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