RESPONSE OF WHEAT-MAIZE CROPPING SEQUENCE IN A CALCAREOUS SOIL TO SOME MINERAL OR CHELATED MICRONUTRIENT FORMS ADDED TO SOIL IN COMBINATION WITH SULPHUR AND ORGANIC MANURES

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ABSTRACT:

The current work aimed to evaluate the effect of some micronutrients (Fe, Mn, Zn and Cu) in mineral (sulphates) and chelated (-amino acids and -EDTA) forms added to soil in solely or in combined treatments with both organic composts (wheat residues and cattle wastes) and sulphur on grain and straw yields as well as their contents of such micronutrients for wheat-maize cropping sequence in a calcareous soil, with special reference to the effects of these treatments on available soil contents of these micronutrients. To achieve this target two field experiments were conducted on a calcareous soil located at the eastern edge of Tamia district, El Fayoum Governorate, and cultivated with winter wheat (Sakha 69) followed by summer maize (single cross 10 hybrid) to verify the results obtained during growing season of 2003/2004 under surface irrigation system.

The data obtained reveal that the experimental soil is characterized by secondary calcic formations in compacted phase, especially in the uppermost layer, and micronutrient deficient. The soil is classified at the family level as Typic Haplocalcids, clayey, mixed, hyperthermic. Also, its capability was evaluated as marginally suitable ($S3_{ws}$), with a moderate intensity degree (rating = 60-85) for all the identified soil limitations (wetness, soil texture, soil depth and $CaCO_3$ content). The results showed an improvement occurred in available micronutrient contents (Fe, Mn, Zn and Cu) in the studied soil as a result of the applied treatments, with different magnitudes depend on their effective roles, nature of chemical composition, as shown in the following descending order: mineral micronutrients + organic composts > micronutrients + sulphur > chelated micronutrients > organic composts + sulphur > mineral micronutrients > organic composts > sulphur.

The favourable conditions of the combined treatments with organic composts or sulphur are commonly achieved by lowering soil pH and forming organo-metalic compounds. The chelated micronutrients (-amino acids and –EDTA) represented the next superior form due to a higher portion of these compounds still in maintained active forms for uptake by plant roots.

The beneficial effects of the studied treatments were actually reflected on increasing the grain and straw yields of wheat and also extended to the next cultivated maize. In addition, the positive effects of the studied treatments are more attributed to improve the efficiency of micronutrients uptake according to their effective roles. Moreover, the micronutrients response of Fe, Mn, Zn and Cu to accumulate in the grain and straw tissues showed a closely relationship to their corresponding available contents in the treated soils.

Key words: Organic manure, Elemental sulfur, Calcareous soils, Mineral and chelated micronutrients.

INTRODUCTION:

In Egypt, the soil survey data pointed to a considerable decrease in soil productivity for the desertic calcareous soils. This is mainly due to low levels of organic matter content, which represents the main factors for widespread occurrence of some micronutrients deficiency in the different desert regions of the world (Takker and Walker, 1993). Also, low organic matter below the critical level causes exhaustion for micronutrients through removal by plants as well as negatively influence on the availability of these micronutrients for grown crops. In addition, micronutrients deficiency is commonly known in calcareous soil, due to high levels of soil pH and $CaCO_3$ content (Basyouny, 2005).

Soil management of calcareous soils is usually carried out through addition of natural or chemical soil amendments that have become one of the most important practices for improving physical and chemical properties of these soils, and in turn enhancing their productivity. Many studies were carried out to investigate the beneficial effects of these materials, such as organic manures or elemental sulphur. Adding organic manure to soil decreased its ECe, pH and SAR values (Abou El Defan, 1990 and Estefanous and Sawan, 2002) and increased its productivity (El Maghraby, 1997). Abdel Aziz *et al.* (2000) showed that the values of Fe, Mn, Zn and Cu were increased in the newly reclaimed soils as a result of addition different rates of sludge and town refuse. Negm *et al.* (2003) found that organic manure application increased slightly cation exchange capacity, as well as, reduced soil pH just after additions in a small range by advancing time.

Moreover, soil organic matter content was increased due to organic manure application. Abdel Aziz *et al.* (2002) reported that application of organic manures to calcareous soils markedly increased the dry weight and the plant contents of Fe, Mn, Zn and Cu at the vegetative and elongation stages of maize. Also, the statistical analysis confirmed that potential bio-availability of micronutrients in soils was strongly controlled by their chemical forms related to solubility. Also, sulphur application led to a significant reduction in soil ECe, pH and SAR values and increased the straw and grain yields of wheat plants grown on calcareous soils (Abdalla, 1990, Khafagi and Abdelhadi, 1990 and Wassif *et al*., 1995).

The essential roles of micronutrients in plant metabolism, as activators or co-factor in all vital processes of a plant, can not be ignored. This leads undoubtedly to an increase in crop production, which is considered as the main goal in this respect (El Kabbany *et al*., 1996). Moussa *et al*., (1998) reported that the micronutrients (Fe, Mn and Zn) enhanced the crop yield because of their beneficial effect on some bio-processes, and in turn on the vegetative of plants. Papastyliaous, (1990) in field trials, the effectiveness of different Fe chelates (Fe-DDHA, Fe-EDDHA, Fe-DTPA, Fe-EDTA) and $FeSO_4$ was necessary to correct its availability under the adversable soil conditions, due to retention for nutrient in mineral form. Among the tested chelates, Fe-EDDHA, Fe-DTPA and Fe-EDDHA were most effective in correcting Fe chlorosis. On the other hand, applied $FeSO_4$ was not particularly effective in correction Fe chlorosis. El-Basioni *et al,* (1995) showed that dry matter of different maize plant parts were significantly affected by $FeSO_4$ or Fe-DDHA. Also, Ghaly *et* *al.* (1992) found that application of Fe- and Zn-EDTA to calcareous soil increased the maize yield.

Ibrahim and Shalaby (1994) pointed out that application of micronutrients to soil led to an increase of the grain and straw yields of wheat plants. In addition, micronutrients application in combination with organic manures to soil is considered to be of significant importance if high yields are to be produced. Also, More (1994) found that the yield of wheat was markedly enhanced due to treating the soil with organic manures. El-Naggar, (2004) stated that the amino acids have used to chelate metals, such as cation chelated of calcium, copper, iron, magnesium, manganese, potassium and zinc which were occasionally as oxides. Szajdak *et al*., (2004) stated that the application of amino acids as metal chelates is based on their requirement by plants in general and at critical stage of growth in particular plant absorb amino acids through stomas and is proportionate to environment temperature. They added that amino acids are also supplied to plant by incorporating them into the soil for improving the soil microflora and thereby facilitating the assimilation of nutrients.

The current work aimed to evaluate the effect of some micronutrients in two forms, i.e., mineral (Fe, Mn & Zn sulphates) and organo-micronutrient compounds (Fe, Mn, Zn & Cu-amino acids and -EDTA), added to soil in combination with organic composts of wheat residues or cattle wastes and sulphur, on yield and its components for wheat-maize cropping sequence in a calcareous soil. Also, the grain contents of these micronutrients, with special reference to the residual effects of these treatments on available micronutrients status were discussed.

MATERIALS AND METHODS:

a) Organic compost preparation:

Two tons of wheat residues mixed with chemical activator mixture (50 kg ammonium sulphate + 50 kg superphosphate), then a portion of these mixtures was scattered over an area of 2x5 m^2 and moistened with water. The moisture was considered satesfactory when a handful of the composting materials would wet the hand but not drip, (about 70% of water holding capacity). The previous mixture represents a first layer of 20 cm height, nine layers were built over the first layer in the same manner. After the heap was built to reach 2.0 m height, it was lousily covered with plastic sheet and was moistened with tap water from above if needed. The heap was turned from inside to outside wards every three weeks for four months. The main characteristics of composted wheat straw as well as the other one of cattle wastes in the current work are given in Table (1). The different characteristics, which carried out on these farm organic wastes, were pH (Jodice *et al*., 1982), organic matter content (Black, 1965), nitrogen, phosphorus, potassium (Chapman and Pratt, 1961) and micronutrients of Fe, Mn, Zn and Cu (Hesse, 1971).

Table (1): Some characteristics of the studied organic composts (dry weight basis).

Character	Composted wheat residues	Composted cattle wastes
Weight of 1 m^3 (kg)	373.45	748.32
pH (1:10 water suspension)	7.09	7.23
EC (dS/m, 1:10 water extract)	1.58	2.39
Moisture %	10.07	9.15
Organic matter %	53.78	69.95
Organic carbon %	31.27	40.67
C/N ratio	25.42	16.20
Total macro and micronutrients %:		
N	1.23	2.51
P	0.21	0.45
K	2.17	2.24
Fe	0.0856	0.3972
Mn	0.0275	0.0503
Zn	0.0492	0.0714
Cu	0.0687	0.0996
Available micronutrients (mg/kg) :		
Fe	32.54	143.79
Mn	25.37	51.46
Zn	16.05	36.78
Cu	7.92	10.04

b) Field experimental work:

Two field experiments were conducted on a wheat-maize cropping sequence in a calcareous soil located at the eastern edge of Tamia district, El Fayoum Governorate, Egypt under surface irrigation system during the growing season of 2003/2004. In split split plot design, with 3 replicates, twelve treatments of the mineral micronutrients as sulphates (19% Fe, 24% Mn, 22% Zn & 25% Cu), chelated micronutrients (amino acids and EDTA, 6.0 % Fe, 13.0 % Mn, 15.0 % Zn & 14.0 % Cu), elemental sulphur and organic manures (composted wheat residues and cattle wastes) as individual or combined treatments, in addition to the control treatment were applied in plots of an area 10.5 m^2 (3.0 m width x 3.5 m length) for each field experiment. The treatments were as follows:

a. Control treatment (Co, untreated soil).
b. Mineral micronutrients as sulphates (Ms).
c. Chelated micronutrients of amino acids (Cha).
d. Chelated micronutrients of EDTA (Che).
e. Elemental sulphur (Su).
f. Composted wheat straw (Cw).
g. Composted cattle wastes (Cc).
h. Ms + Su.
i. Ms + Cw.
j. Ms + Cc.
k. S + Cw.
l. S + Cc.

The applied rates were 20 kg/fed for each of the studied micronutrients in the forms of sulphates, 5 kg/fed for each of the chelated micronutrients of amino acids and EDTA, 500 kg/fed elemental sulpher, 30 m^3/fed of composted wheat residues and 20 m^3/fed of composted cattle wastes. The plots were ploughed twice in two ways and received elemental sulpher, composted wheat residues, composted cattle wastes and supersulphate (15% P_2O_5) at rates of 100 kg/fed before the second ploughing. Mineral fertilizers of N and P were also added at a rate of 120 kg N/fed as ammonium sulphate (20.6% N) and 48 kg K_2O/fed as potassium sulphate (48% K_2O), in two equal doses (after 15 and 40 days from planting) for both wheat and maize. The micronutrients of Fe, Mn, Zn and Cu either in sulphates or chelated forms were added to soil in two equal doses (after 15 and 40 days from planting) for both the studied two crops.

Wheat-maize cropping sequence was grown on the chosen soil during the growing seasons (winter-wheat and summer-maize) of 2003/2004. The second experiment of summer season was conducted on an adjacent area in the same experimental field to verify the trends obtained for the effective roles of the applied treatments on yield and its components of the next crop of maize. In the winter season, wheat grains (Sakha 69) were sown (mid November, 2003), and the grains or straw yields were recorded at harvest. Whereas, maize grains (single cross 10 hybrid) were sown at mid April 2004, and the grains or straw yields were also recorded at harvest.

c) Plant and soil analysis:

Samples of grains and straw were dried at 70 C^o, ground in a Willy mill and digested with H_2SO_4 and H_2O_2 according to Parkinson and Allen (1975) to determine Fe, Mn, Zn and Cu (Hesse, 1971). In addition, soil samples were taken from all profile layers before soil preparing to cultivation and described morphologically according to FAO (1990), then air dried, crushed to pass a 2 mm sieve and analyzed for the main soil physical and chemical properties as well as soil fertility status. Also, soil samples were taken at a depth of 0-30 cm from each plot at tillering and elongation (pre-flowering) stages of wheat and maize, respectively, to be chemically analyzed for available Fe, Mn, Zn and Cu. Particle size distribution (Piper, 1950), bulk density (Black and Hartge, 1986), hydraulic conductivity, soil strength (Richards, 1954), organic matter content (Walkely and Black method as described by Hesse (1971), $CaCO_3$ content (Wright, 1939), cation exchange capacity, exchangeable sodium per cent, pH, soil paste extract (Jackson, 1973) and available contents of Fe, Mn, Zn and Cu (Sultanpour and Schwab, 1977) were determined for the collected soil samples. The data obtained were subjected to statistical analysis according to Snedecor and Cochran (1980).

RESULTS AND DISCUSSION:

I. General view on the characteristics of the experimental soil:

Data in Tables (2 and 3) show that the representative soil profile in which the two experiments were carried out is characterized by clay in texture, slightly affected by salinity and non-alkaline, moderately drainage, inadequate drainage system, calcareous in nature and different forms of secondary calcic formations in compacted phase at the uppermost layer. The studied soils are mainly encompassing the Eocene limestone as a parent material, developed on alluvial terraces and their climatic conditions characterized by a long hot rainless summer and short mild winter, with scare amounts of rainfall.

Table (2): The main morphological aspects of the representative soil profiles.

Horizon	Depth (cm)	Soil colour			Texture grade	Soil structure			Calcic formations				
		Hue	Dry	Moist		Grade	Size	Type	Effer.	Feat.	Quan.	Size	Distr.
AP	0-25	10YR	6/2	5/2	C	2	m	sbk	+++	ln	c	m	r
C_1	25-45	2.5 Y	6/4	6/6	C	1	f	mas	+++	lc	c	m	r
C_2	45-95	2.5 Y	7/4	7/2	C	2	f	abk	+++	cg	c	s	h

Texture: c=Clay
Structure: ***Grade:*** 1=Weak 2=Moderate ***Size:*** f=Fine m=Medium
Type: sbk= Subangular blocky abk=Angular blocky mas=Massive
Calcic formations: ***Effervescene:*** +++ = Strong
Feature: ln=Lime nodules lc = Lime concretions cg=Crystals of gypsum
Lime quantity: c=Common ***Size:*** s=Small m=Medium
Distribution: r=Random h=Horizontal

The aforementioned features are evident that the secondary accumulations of $CaCO_3$ in uppermost layer of soil profile as a result of the upward movement of the saline ground water table (lime carbonation) by capillary rise under the hot and aridic conditions. Also, these results are confirmed by the occurrence of a relatively high soil strength value (2.97 kg/cm^2) in the uppermost layer, which occurred as a surface lime crust. These features are stood in harmony with the fact that $CaCO_3$ was subjected to intensive goechemical weathering as a result of shallow ground water table (95 cm depth) due to the un-permanent seepage from the upper level irrigation canal.

Soil taxonomic unit in the current experiments is identified and named at the family level according to Soil Survey Staff (USDA, 1999) as Typic Haplocalcids, clayey, mixed, hyperthermic. Also, according to parametric system undertaken by Sys and Verheye (1978), the intensity degrees of soil limitations and suitability categories for the studied soil were calculated and presented in Table (4).

It is cleared from data obtained that wetness (w), soil texture, (s_1), soil depth (s_2) and $CaCO_3$ content are the most effective limitations for soil productivity. Thus the experimental soil could be evaluated as marginally suitable ($S3_{ws}$), with an intensity degree for all the identified soil limitations lies in the range of moderate (rating = 60-85).

Table (3): Some physical, chemical and fertility characteristics of the representative soils.

Soil characteristics	Profile layers (cm)		
	0-25	25-45	45-95
Particle size distribution %:			
Coarse sand	5.40	9.30	6.80
Fine sand	20.60	27.20	32.70
Silt	24.80	21.90	19.60
Clay	49.20	41.60	40.90
Texture class	Clay	Clay	Clay
Total $CaCO_3$ %	37.45	28.91	42.74
$CaCO_3$ distribution %:			
Coarse sand	5.58	4.98	15.30
Fine sand	6.98	5.79	10.15
Silt	9.64	10.40	9.75
Clay	15.35	7.74	7.54
Soil strength (kg/cm^2)	2.97	1.86	1.42
Bulk density (g/cm^3)	1.17	1.34	1.39
Hydraulic cond. (cm/h)	1.43	1.57	1.53
ECe (dS/m)	5.72	4.94	4.05
Soluble ions (me/L):			
Ca^{++}	13.98	11.54	12.15
Mg^{++}	8.67	7.03	6.72
Na^{+}	34.25	30.63	21.46
K^{+}	0.55	0.42	0.30
CO_3^{--}	--	--	--
HCO_3^{-}	2.85	2.95	3.02
Cl^{-}	35.61	33.43	20.96
SO_4^{--}	18.99	13.24	16.65
pH (soil paste)	8.29	8.32	8.37
Organic matter %	0.67	0.46	0.35
Gypsum content %	1.57	2.04	2.73
CEC (meq / 100 g soil)	19.35	17.25	16.43
ESP	11.05	9.65	8.97
Available nutrients (mg/kg):			
N	32.69	19.75	11.35
P	4.32	3.04	2.68
K	138.51	127.95	119.74
Fe	3.27	2.78	1.95
Mn	1.13	0.95	0.89
Zn	0.76	0.54	0.43
Cu	0.49	0.43	0.38

Critical levels of available nutrients in soil (mg/kg), undertaken by Lindsay and Norvell (1978) and Page et al. (1982).

Nutrient level	N	P	K	Fe	Mn	Zn	Cu
Low	< 40.0	< 5.0	< 85.0	< 4.0	< 2.0	< 1.0	< 0.5
Medium	40.0-80.0	5.0-10.0	85.0-170.0	4.0-6.0	2.0-5.0	1.0-2.0	0.5-1.0
High	> 80.0	> 10.0	> 170	> 6.0	> 5.0	> 2.0	> 1.0

Table (4): Soil limitations and rating indices for evaluating the studied soil profile at the current experiments.

Topography (t)	Wetness (w)	s				Soil salinity/ alkalinity (n)	Rating (Ci)	Suitability class	Suitability subclass
		Soil texture (s1)	Soil depth (s2)	$CaCO_3$ (s3)	Gypsum (s4)				
100	70	80	60	85	90	100	25.70	S3	S3ws

The obtained results show that soil potentiality or supplying for the essential plant nutrients was low, and closed parallel to relatively moderate CEC values, low contents of charged silicate clay minerals and organic matter vs relatively high values of soil pH and $CaCO_3$ content, mostly their particles were found in the size of clay fraction particularly in the uppermost layer. The latter factors show a negative effect on the restriction of phosphorus and micronutrients availability. Thus, the studied soil is suffering from plant nutrients deficiency and supplying essential elements. This is undoubtedly of great importance, especially for micronutrient deficient in such calcareous soil, as shown in Table (3).

II. Effect of treatments on available micronutrient contents in soil:

The magnitudes of available micronutrient contents in the studied calcareous soil as affected by the different treatments under investigation during the studied two seasons, Table (5), showed a progressive increase in the available contents of Fe, Mn, Zn and Cu at the applied combined treatment (Ms+Cc followed by Ms+Cw and Ms+Su) as compared to the other ones or the untreated soil. In general, the treatment magnitudes could be arranged in the following descending order according their beneficial effects: mineral micronutrients + organic composts > micronutrients + sulphur > chelated micronutrients > organic composts + sulphur > mineral micronutrients > organic composts > sulphur.

The superiority of (Ms+Cc or Cw) treatments may be due to the released organic acids that exhibited a positive effect on lowering soil pH value. These findings can be interpreted as follows:

a) organic compost decomposition produces organic and inorganic acids that led to decrease soil pH as well as they have used to chelate metals (Fe, Mn, Zn and Cu), these chelated metal cations are not sensitive to the restriction or the adverseable effects of $CaCO_3$, consequently they are found as strategic storehouse in organo-metalic compounds which are more suitable for uptake by plant roots.

b) Elemental sulphur can be oxidized by many soil micro-organisms and forming sulphuric acid, consequently it reacts with soil $CaCO_3$ resulting in $CaSO_4$. The latter can be ionized to Ca^{2+} and SO_4^{2-}, then Ca^{2+} can be improved soil aggregation and permeability and SO_4^{2-} reduced soil pH. These results are in agreement with those obtained by Awadalla *et al.* (2003).

Table (5): Effect of applied treatments on available micronutrient contents in the experimental soil.

Treatments	Micronutrient contents in mg/kg soil			
	Fe	Mn	Zn	Cu
Co	3.42	1.15	0.78	0.54
Ms	8.15	3.21	1.97	1.34
Cc	7.98	3.08	1.85	1.31
Cw	7.13	2.93	1.76	1.27
Su	6.75	2.46	1.62	1.22
Cha	12.10	5.34	3.85	2.13
Che	10.97	4.95	3.24	1.99
Ms+Cw	14.02	6.01	4.32	3.04
Ms+ Cc	15.94	6.42	4.85	3.62
Ms+Su	12.85	5.70	3.91	2.57
Cw+Su	9.55	4.01	2.74	1.71
Cc+Su	8.67	3.72	2.05	1.35
L.S.D. at 0.05	2.84	0.99	0.79	0.64

Critical levels of available nutrients in soil (mg/kg), undertaken by Lindsay and Norvell (1978) and Page et al. (1982).

Nutrient level	N	P	K	Fe	Mn	Zn	Cu
Low	< 40.0	< 5.0	< 85.0	< 4.0	< 2.0	< 1.0	< 0.5
Medium	40.0-80.0	5.0-10.0	85.0-170.0	4.0-6.0	2.0-5.0	1.0-2.0	0.5-1.0
High	> 80.0	> 10.0	> 170	> 6.0	> 5.0	> 2.0	> 1.0

C0=control, Ms=mineral micronutrients, Cw=wheat residues compost, Cc=cattle wastes compost, Su=sulphur, Cha=cheated metallic-amino acids and Che=cheated metallic-EDTA

Data reveal also that the application of composted cattle wastes to calcareous soil was more effective in increasing the studied available micronutrients than composted wheat residues and sulphur. Such superior was expected due to the differences in their chemical compositions and micronutrient contents as well as the benefits of their residual effects on soil characteristics (Salem, 1996). In general, application of micronutrients to calcareous soil in the chelated form occupied the third category from the beneficial view. In this concern, Biswapati *et al.* (1993) reported that micronutrients in the chelated form found to be beneficial due to a higher portion of their application still in maintained active forms for uptake by plant roots as well as amino acids micronutrient compounds are found in smaller molecules that are more suitable for cell membrane permeability. On the other hand, a higher portion of applied mineral micronutrients was transformed to unactive forms due to the unfavourable soil media of relatively high values of pH and $CaCO_3$ content.

III- Effect of treatments on grain and straw yields of the studied crops:

Concerning the influence of applied treatments on soil productivity of wheat and maize, data in Table (6) show a markedly positive and significant effect on their grain and straw yields, with a superior effect was achieved upon treating the soil with the combined treatments of (Ms+Cc, Ms+Cw or Ms+Su), where the significance was confirmed by the values of L.S.D. at 0.05. The beneficial effects of these treatments are mainly attributed with the highly humified organic materials and elemental sulphur, where organic acids can chelate the micronutrients forming organo-metalic forms as a storehouse as well as increasing their availability and mobility for uptake by plant roots. In addition, the effect of sulphur added solely or combined treatments on decreasing soil pH.

Table (6): Effect of applied treatments on grain and straw of wheat and maize.

Treatments	Wheat				Maize			
	Grain		Straw		Grain		Straw	
	Kg/fed	R.I.	Ton/fed	R.I.	Kg/fed	R.I.	Ton/fed	R.I.
Co	1516.72	--	2.32	--	2189.65	--	3.85	--
Ms	1798.87	18.60	2.91	17.67	2842.57	25.25	4.87	21.30
Cc	1742.11	14.86	2.87	15.09	2817.93	19.56	4.71	17.14
Cw	1705.25	9.79	2.82	10.34	2768.04	14.54	4.63	9.87
Su	1697.45	6.84	2.78	7.76	2694.95	10.38	4.49	6.23
Cha	2017.83	33.04	3.27	28.02	3085.36	40.91	5.29	37.40
Che	1967.60	29.73	3.13	26.29	2997.25	34.14	5.21	33.25
Ms+Cw	2167.36	42.90	3.46	36.21	3282.65	49.92	5.42	40.78
Ms+ Cc	2256.75	48.79	3.57	40.95	3309.82	51.16	5.57	44.67
Ms+Su	2089.54	37.76	3.40	33.62	3125.75	42.75	5.33	38.44
Cw+Su	1886.05	24.35	3.09	24.57	2954.58	32.19	5.15	31.17
Cc+Su	1830.37	20.67	2.94	20.69	2903.07	28.01	4.96	26.23
L.S.D. at 0.05	178.53	--	0.45	--	411.74	--	0.62	--

C0=control, Ms=mineral micronutrients, Cw=wheat residues compost, Cc=cattle wastes compost, Su=sulphur, Cha=cheated metallic-amino acids Che=cheated metallic-EDTA and R.I.=relative increase

These beneficial effects can be explained on the basis that the studied micronutrients are involved directly or indirectly in formation of starch, protein and other biological components through their roles in the respiratory and photosynthesis mechanisms as well as in the activity of various enzymes (Nassar *et al*., 2002).

The aforementioned results concluded that applied organic composts led to improve soil physical, hydrological, chemical and biological characteristics as well as its fertility status, which are positively reflected on soil productivity and returned on increasing the wheat and maize yields (grain and straw yields). Also, such materials are enrichments in both organic and mineral substances essential to plant growth and activating the bio-chemical processes in plants, i.e., respiration, photosynthesis and chlorophyll content, which increased the crop quality and quantity (Hegazi, 2004).

Moreover, addition of chelated micronutrients to the studied calcareous soil increased the yields of grain and straw for both wheat and maize crops. It is worthy to mention that these increases were attributed to a higher portion of the applied chelated micronutrients still in maintained active forms for uptake by plant roots. Such results are in agreement with those obtained by Soliman (1980) for Zn, Baza *et al.* (1989) for Fe and Basyouny (2005) for Mn and Cu. The optimum yields of grain and straw for both wheat and maize were extending parallel close to the corresponding contents of available nutrient in soils, as shown in Tables (5 and 6). Thus, the positive roles of Cc, Cw and Su are more attributed to improve the efficiency of nutrients released or uptake and enhancing dry matter yield, and in turn the grain quality of both wheat and maize.

IV. Effect of applied treatments on grain and straw contents of micronutrients:

The uptake content of micronutrients (Fe, Mn, Zn and Cu) by both grain and straw for wheat and maize crops, Table (7), exhibited progressive increases as compared to the control treatment. Such surpassed effect being dependent on the nature of concerned material types, especially its chemical composition and applied method (solely or combined). So, the combined treatments of (Ms+Cc or Ms+Cw) caused the superior effect due to their more adhesion for chelating micronutrients, and enhancing their absorption and transportation inside the plant in easier status.

Therefore, the beneficial effects of the treatments under investigation were extended to the plant content of micronutrients. It could be noticed that the combined treatments of (Ms+Cc, Ms+Cw or Ms+Su) resulted in a markedly positive effect on the wheat-maize cropping sequence of Fe, Mn, Zn and Cu contents in both grain and straw as compared to the other ones. Also, the micronutrient contents were extending parallel close to the corresponding available micronutrient contents in soil, as shown in Tables (5 and 7). This means that micronutrients response of Fe, Mn, Zn and Cu to accumulate in the grain and straw tissues showed a closely relationship to their corresponding available contents in the treated soils.

Table (7): Effect of applied treatments on micronutrient contents in grain and straw of both wheat and maize.

Treatments	Grain				Straw			
	Fe	Mn	Zn	Cu	Fe	Mn	Zn	Cu
Wheat								
Co	91.76	53.45	29.05	9.23	86.79	45.12	20.85	7.86
Ms	200.75	109.90	101.08	15.11	193.05	109.69	97.45	13.45
Cc	196.43	104.85	100.52	14.42	178.46	107.25	93.36	13.30
Cw	194.03	101.57	97.15	13.76	169.58	104.70	90.98	12.82
Su	191.28	100.89	96.87	13.50	158.21	99.89	86.75	12.39
Cha	227.95	129.97	118.50	19.25	223.09	126.35	111.27	16.57
Che	212.76	123.36	113.82	17.94	219.00	120.26	106.05	15.92
Ms+Cw	277.82	147.84	129.95	23.61	245.05	137.58	123.94	18.64
Ms+ Cc	293.19	152.15	136.25	24.85	259.80	145.02	127.55	19.95
Ms+Su	256.34	138.70	123.14	21.73	238.27	131.74	118.75	16.32
Cw+Su	205.57	117.59	107.67	16.32	213.56	117.00	103.09	14.25
Cc+Su	201.06	112.60	103.53	15.87	205.11	112.55	99.65	13.94
L.S.D. at 0.05	98.88	45.92	66.62	3.98	66.39	52.91	64.62	4.44
Maize								
Co	208.96	59.26	42.74	8.03	179.25	54.12	37.65	7.46
Ms	283.05	72.89	55.67	11.02	271.05	69.01	46.36	10.05
Cc	275.09	72.37	55.31	10.65	245.98	66.90	43.91	9.56
Cw	268.36	71.25	54.50	9.98	213.57	64.63	42.56	8.84
Su	262.87	69.97	53.86	9.15	201.60	61.85	40.91	8.23
Cha	334.52	79.92	59.25	12.85	378.45	76.08	55.87	12.00
Che	317.37	76.12	57.14	12.32	356.26	74.30	53.75	11.94
Ms+Cw	427.85	85.68	61.58	14.03	410.25	77.97	57.96	13.10
Ms+ Cc	452.60	87.54	63.23	14.78	439.01	79.85	59.63	13.85
Ms+Su	398.46	81.45	60.94	13.90	395.74	76.06	56.17	12.63
Cw+Su	308.04	75.02	56.75	12.00	342.08	71.47	51.29	11.45
Cc+Su	295.21	73.96	55.98	11.57	298.56	70.52	48.45	10.92
L.S.D. at 0.05	46.44	9.98	10.87	1.03	17.22	7.33	2.42	0.68

C0=control, Ms=mineral micronutrients, Cw=wheat residues compost, Cc=cattle wastes compost, Su=sulphur, Cha=cheated metallic-amino acids and Che=cheated metallic-EDTA

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إستجابة القمح - أذرة كمحصولين متعاقبين فى أرض جيرية لبعض المغذيات الصغرى المضافة للتربة فى صورة معدنية أو مخلبية بالإشتراك مع الكبريت والمخصبات العضوية

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تهدف هذه الدراسة إلى تقييم تأثير بعض المغذيات الصغرى (Fe, Mn, Zn and Cu) فى صورتيها المعدنية (Sulphates) والمخلبية (-amino acids and -EDTA) المضافة للتربة - إما فى صورة معاملات منفردة أو مشتركة مع مكمور عضوى من مخلفات نباتية أو حيوانية (Wheat residues or cattle wastes) وكبريت معدنى – على محصولى الحبوب والقش وكذا محتواهما من تلك المغذيات لكل من القمح -الأذرة كمحصولين متعاقبين فى أرض جيرية، مع إعطاء أهمية خاصة لتأثير هذه المعاملات على الجزء الميسر من تلك المغذيات فى التربة . ولتحقيق هذا الهدف أجريت تجربتين حقليتين على أرض جيرية تقع غلى الحافة الشرقية لمركز طامية – محافظة الفيوم حيث زرعت بمحصول القمح الشتوى (صنف سخا ٦٩) أتبعه محصول الأذرة الصيفى (صنف هجين فردى ١٠)، وذلك للتحقق من النتائج المتحصل عليها من محصول القمح – تحت نظام الرى السطحى خلال الموسم الزراعى ٢٠٠٣/٢٠٠٤.

وتشير النتائج المتحصل عليها إلى أن تربة التجربة تتميز بتواجد تكوينات من كربونات الكالسيوم الثانوية نتج عنها حدوث ظاهرة الإندماج خاصة فى الطبقة السطحية من التربة، وكذلك نقص فى المغذيات الصغرى. وقد تم تحديد الوحدة التقسيمية تبعا لنظام التقسيم الحديث Soil Survey Staff (USDA, 1999) حتى مستوى العائلة Typic Haplocalcids, : Family clayey, mixed, hyperthermic وكذا قدرتها الإنتاجية – تبعا لنظام Sys and Verheye (1978)- بدرجة صلاحية "هامشية" (S3ws)، وبدرجة كثافة متوسطة (٦٠- ٨٥) بالنسبة لكل من محددات إنتاجية التربة (الترطيب، قوام التربة، عمق النربة، المحتوى من كربونات الكالسيوم). كما توضح النتائج أن هناك تحسن قد حدث فى محتوى التربة من المغذيات الصغرى (Fe, Mn, Zn and

Cu) كنتيجة لإضافة تلك المعاملات تحت الدراسة، ولكنه بدرجات متفاوتة تبعا لدورها المؤثر وطبيعة تركيبها الكيميائى، كما هو موضح فى الترتيب التنازلى التالى:

Mineral micronutrients + organic composts > micronutrients + sulphur > chelated micronutrients > organic composts + sulphur > mineral micronutrients > organic composts > sulphur.

وقد تحققت الظروف المحسنة الناجمة عن إستخدام المعاملات المشتركة مع المكمور العضوى أو الكبريت المعدنى كنتيجة لإنخفاض فى قيم Soil pH وتكوين معقدات معدنية-عضوية Organo-metalic compounds – ناتجة من خلب الأحماض العضوية لتلك المغذيات وحفظها فى صورة مركبات غير حساسة للتأثير المعوق أو المعاكس لمكون كربونات الكالسيوم، ومن ثم تعتبر مخزونا إستيراتيجيا لتلك المغذيات فى التربة، بالإضافة إلى أن الأحماض العضوية المنفردة لها القدرة على تحسين السلوك الرطوبى للتربة مما يشجع من ميكانيكية إمتصاص المغذيات بواسطة جذور النباتات، ومن ثم تزيد من المادة الجافة وكذا جودة الحبوب لكل من القمح والأذرة . وتأتى مخلبيات المغذيت الصغرى فى المرتبة التالية من حيث الأفضلية نتيجة لأن جزء كبير منها يظل محتفظا بحالته النشطة مما يسهل من إمتصاصه بواسطة جذور النباتات.

وقد إنعكست تلك التأثيرات المفيدة للمعاملات تحت الدراسة على زيادة محصولى الحبوب والقش للقمح، كما إمتدت إلى محصول الأذرة الذى يليه فى الزراعة. بالإضافة إلى أن التأثيرات الإيجابية للمعاملات تحت الدراسة قد ارتبطت بتحسين كفاءة إمتصاص المغذيات الصغرى تبعا لدورها الفعال. علاوة على أن إستجابة مغذيات الحديد والمنجنيز والزنك والنحاس للتراكم فى الأنسجة النباتية للحبوب والقش تدل على أن هناك علاقة وثيقة مع ما يقابلها من محتوى ميسر لتلك المغذيات فى التربة المعاملة.