INTERACTION EFFECTS AMONG Fe, Mn AND Zn IN AN ALLUVIAL NONCALCAREOUS CLAYEY SOIL AND A CALCAREOUS SANDY ONE DURING AND AFTER CULTIVATION WITH BEAN AND WHEAT PLANTS

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ABSTRACT

To throw some light on mutual effects among nutritive elements Fe, Mn and Zn in an alluvial clayey non calcareous soil and a calcareous sandy one under wheat (monocotyledonous plant) and bean (dicotyledonous plant), different combinations of Fe, Mn and Zn were added at a rate of 20 mg kg^{-1} eac. Moisture content was maintained at 70% of the F.C. and all the fertilization and agricultural practice were conducted as usual.

The obtained results revealed that application of an element whether solely or combined with the other ones caused its AB-DTPA extractable amount to increase whereas application of each of the other ones or both of them caused its AB-DTBA extractable amount to decrease. Such an observation occurred in both the clayey and and the calcareous soils. However, amounts of AB-DTAPA extractable Fe, Mn and Zn from clayey soil seemed a higher than the corresponding extractable ones from the calcareous soil. The high $CaCO_3$ content of the calcareous soil although decreased amount of the AB-DTPA extractable micronutrients, yet it seemed of no or very minute effect on their mutual re relationships.

INTRODUCTION

Calcareous soils are defined as soil containing amounts of calcium carbonate affect distinctly the soil properties related to plant growth. The most problem of these soils is decreasing availability of some macronutrients (Balba, 1995). However, fertilization with micronutrients has a great importance due to the high pH not only of the calcareous soils but also of the alluvial Egyptian ones. Therefore, the main issues with micronutrients are to ensure sufficient but not excessive supply of micronutrients to crops i.e. proper nutrient balance (Pendias and Pendias, 2004).

Interaction may be defined as i) a mutual or reciprocal action of one element upon another in relation to plant growth. ii)the differential response to one element in combination with varying levels of a second element applied simultaneously; that is the two elements combine to produce an added effect not due to one of them alone (Olsen, 1972). Dahdoh (1997b) noticed that there is an antagonistic relationship between every two micronutrients in plant and soil. Therefore, the aim of this study is to identify the mutual effect among Fe, Mn and Zn in an alluvial non calcareous soil and a calcareous sandy one.

MATERIALS AND METHODS

A greenhouse experiment was conducted in agric. Resh. Center, to evaluate the mutual effect among some micronutrients i. e., Fe, Zn and Mn on their AB-DTBA extractable amounts from an alluvia clayey non calcareous soil collected from Moshtohor and a calcareous sandy soil collected from El-Nobaria. Both the investigated soils were previously cultivated with wheat (*Triticum aestivum* L. cultivar Giza 168) as a monocotyledonous plant and bean (*Vicia faba* L. cultivar Nubaria 1) as a dicotyledonous plant. Physical chemical properties of the investigated soils were determined according to Page et al. (1982) and Klute (1986). Results of analyses are presented in table 1.
The experiment had eight fertilization treatments as follows:

1- (T1) without micronutrient addition(control)
2- (T2) 20 mg Zn/kg soil
3- (T3)20 mg Mn/kg soil
4- (T4) 20 mg Mn + 20mg Zn/kg soil
5- (T5) 20 mg Fe/kg soil
6- (T6) 20 mg Fe +20 mg Zn/kg soil
7- (T7) 20 mg Fe +20 mg Mn/kg soil
8- (T8) 20 mg Fe +20 mg Mn +20 mg Zn/kg soil

Table (1): Some physical and chemical properties of the studied soils.

Soil characteristics	Soil types	
	Alluvial soil	Calcareous soil
Soil chemical analysis		
pH (1 : 2.5 soil : water ratio)	7.80	8.00
EC (Soil paste extraction) dSm^{-1}	1.82	4.20
$CaCO_3$ (%)	3.17	22.70
O.M. (%)	2.63	0.30
CEC ($cmol_c$ kg^{-1})	49.70	16.60
ESP	3.59	7.15
Soluble cations (mmol/L):		
Calcium (Ca^{2+})	6.00	18.10
Magnesium (Mg^{2+})	7.70	12.50
Sodium (Na^{+})	2.00	15.60
Potassium (K^{+})	0.30	1.89
Soluble anions (mmol/L):		
Carbonate (CO_3^{-2})	0.00	0.00
Bicarbonate (HCO_3^{-})	8.00	4.30
Chloride (CL^{-})	7.70	18.59
Sulphate (SO_4^{2-})	0.30	25.20
NH4 - DTPA - extractable micronutrients (mg/Kg):		
Iron (Fe^{2+})	27.2	4.10
Manganese (Mn^{2+})	18.62	6.25
Zinc (Zn^{2+})	2.88	0.62
Physical properties (%)		
Field capacity	55.04	13.40
Wilting point	22.58	7.60
Available water	32.46	5.80
Coarse sand	2.29	34.20
Fine sand	18.84	30.10
Silt	22.22	11.70
Clay	52.62	24.00
Textural class	Clay	Sandy clay loam

Plastic pots of 20cm diameter and 15cm height were packed uniformly with samples of each soil (4kg soil per pot). Basal doses of N, P and K fertilizers, equivalent to 150kg N, 65.5kg P and 41.5kg K per fed were added as ammonium sulphate(20.5%N), superphosphate (6.77%P) and potassium sulphate (39.8%K), respectively, and mixed thoroughly with the soils before sowing. Soil moisture content was adjusted gravimetrically to 70% of field capacity during the experimental period using tap water for irrigation. After germination, plants were thinned to foure plants per pot. Micronutrient fertilizers added as $FeSO_4.7H_2O$, $MnSO4.H_2O$ and $ZnSO_4.7H_2O$ at rates of 20mg/kg soil solely or in combinations as mentioned before. Soil of all treatments were, sampled twice the first one after 60 days from sowing and the second one 60 days later i.e. after harvesting. The soil samples were air dried, crushed, sieved through a 2 mm sieve and extrated with AB-DTPA according to Soltanpour (1985).

The extractable amounts of Fe, Mn and Zn were determined using Atomic Absorption Spectrophotometer apparatus, Perkin Elmer, M 969AA.

All data obtained from this study were statistically analyzed through analysis of variance (ANOVA) according to Gomez and Gomez (1984).

RESULTS AND DISCUSSION

1-Extractable amounts of micronutrients at 60 day age of the beginning of the experiment

Values of AB-DTPA-extractable Fe, Mn and Zn from the non calcareous clay soil or the calcareous sandy soil cultivated with bean plant for 60 days are shown in table 2 and illustrated in fig.1. Data show that the extractable amounts of Fe increased due to its application to the soil solely or combined with Mn, Zn or both together. On the other hand, AB-DTPA extractable Fe decreased owing to the addition of the other micronutrients. The relative increase in AB-DTPA-extractable Fe from clay soil treated with Fe, Zn and Fe+ Mn, compared to the control treatment were 31.4, 18.6, 7.8 and 4%. The relative decreases in AB-DTPA extractable Fe found when Zn, Mn and Zn +Mn were added which it recorded 20.0, 17.5 and 29.4%, respectively.

Also, AB-DTPA- extractable Zn show highest values (7.9mg /kg) owing to added Zn, however, this content trended to decrease owing to application of Mn or Fe. Moreover, the lowest value of extractable Zn (1.7mg/kg) was attained owing to application of Fe +Mn treatment.

In brief, AB-DTPA-extractable Mn was increased owing to application of the Mn whether alone which resulted in the highest amount of AB-DTPA extractable Mn (22.6 mg/kg). Slightly lower values of Mn were reported due to application of Fe + Mn (20.4 mg/kg) and Mn + Zn (18.2 mg/kg), the lowest AB-DTPA- extractable Zn(18.2 mg/kg) was obtained owing to application of Fe + Zn.

Value of AB-DTPA extractable Fe from the calcareous soil reveal that the relative increases for Fe recorded 222.7, 181.8, 95.4 and 54% for Fe, Fe + Zn, Fe + Mn and Fe + Mn +Zn i.e. T_5, T_6, T_7 and T_8, respectively as compared with the control treatment. Relative decrease in Fe occurred owing to application of Zn, Mn and Mn + Zn i.e. T_2, T_3 and T_4 treatments. Theses decreased recorded 29.4, 10.0 and 46.7%, respectively as compared with T_1.

Values of AB-DTPA-extractable Zn fluctuated irregularly between 4.0 – 0.4 mg/kg. the highest increase in AB-DTPA extractable Zn(925.0%) was obtained due to T_2 treatment, while the lowest decrease (33.3%) in AB-DTPA-extractable Zn occurred owing to application of T_3, T_5 and T_7 treatments. With regard to AB-DTPA-extractable Mn, data reveal that there are remarkable increase in AB-DTPA-extractable Mn due to the addition of Mn, Mn + Zn, Fe + Mn, and Fe+Mn+Zn i.e. T_3, T_4, T_7, and T_8 treatments. On the other hand remarkable decrease in AB-DTPA-extractable Zn occurred due to addition of Zn, Fe and Fe+Zn i.e. T_2, T_5 and T_6 treatments.

Interactions among several factors are responsible for patterns attained within different studied treatments, manuring and fertility status in the concerned soil microorganisms were being of importance. In fact, chemical behavior of micronutrients related to soil texture, clay minerals and presence of $CaCO_3$. McLaren and Crawford (1973) stated that low mobility most metals added to soil is due to specific adsorption with effects of soil components being in the order of manganese oxides> organic matter> iron oxide> clay minerals. Doner (1978) reported that the mobility of metals in soil is determined by the properties of metal and type of soil adsorption sites along with concentration and type of completing anions (organic and inorganic as well as competing cations (especially H^+) in soil solution, Tyler and McBride (1982) added that soil chemical properties generally have a large effect on the mobility of metals than the properties of metals themselves.

With respect to AB-DTPA-extractable Fe, Mn and Zn from the clay and calcareous soil cultivated with wheat plants as affected by their addition individually or in combinations, data in table 3 and fig.2 revealed that there are gradual decreases in AB-DTPA-extractable Fe, Mn and Zn from the clayey and calcareous soils owing to mutual effects among them. AAB-DTPA-extractable Fe increased owing to the treatments T_5, T_6, T_7 and T_8. This means that application of Fe solely caused its extractable amount to be higher whereas its application combined with Mn, Zn or both together although decreased its extractable amount but this amount was still higher that extracted from the control treatment.

Table (2): Effect of Fe, Zn and Mn addition individually or in combination on AB-DTPA-extractable amounts (mg/kg) of bean plants growing on clay and calcareous soils (60 days after sowing).

Treatments (T)	Fe		Mean	Zn		Mean	Mn		Mean
	Clay	Calcareous		Clay	Calcareous		Clay	Calcareous	
T_1	24.2	2.2	13.2	1.8	0.4	1.1	14.7	3.4	9.1
T_2	20.0	1.7	10.9	7.9	4.1	6.0	12.8	3.3	8.1
T_3	20.6	2.0	11.3	2.0	0.3	1.2	22.6	6.2	14.4
T_4	18.7	1.5	10.1	4.0	3.2	3.6	18.2	4.7	11.5
T_5	30.8	7.1	19.0	2.7	0.3	1.5	12.3	3.1	7.7
T_6	28.7	6.2	17.5	6.1	3.7	4.9	10.8	2.8	6.8
T_7	27.1	4.6	15.9	1.7	0.3	1.0	20.4	5.1	12.8
T_8	25.3	3.4	14.4	2.9	2.0	2.5	16.1	4.0	10.1
Mean	24.4	3.6		3.6	1.8		16.0	4.1	
L.S.D$_{5\%}$	S=0.40 T=0.80 S*T=1.13			S=0.21 T=0.42 S*T=0.60			S=0.43 T=0.87 S*T=1.22		

T_1: Out with micronutrients addition. T_2: 20 mg Zn/Kg soil as $ZnSO_4 .7H_2O$.
T_3: 20 mg Mn/Kg soil as $MnSO_4. H_2O$ T_4: 20 mg Mn/Kg soil+20 mg Zn/Kg soil as $MnSO_4 .H_2O + ZnSO_4 .7H_2O$.
T_5: 20 mg Fe/Kg soil as $FeSO_4 .7H_2O$.
T_6: 20 mg Fe/Kg soil + 20 mg Zn/Kg soil as $FeSO_4.7H_2O + ZnSO_4.7H_2O$.
T_7: 20 mg Fe/Kg soil+ 20 mg Mn/Kg soil as $FeSO_4.7H_2O + MnSO_4.H_2O$.
T_8: 20 mg Fe/Kg soil + 20 mg Mn/Kg soil + 20 mg Zn/Kg soil as $FeSO_4.7H_2O + MnSO_4.H_2O + ZnSO_4.7H_2O$

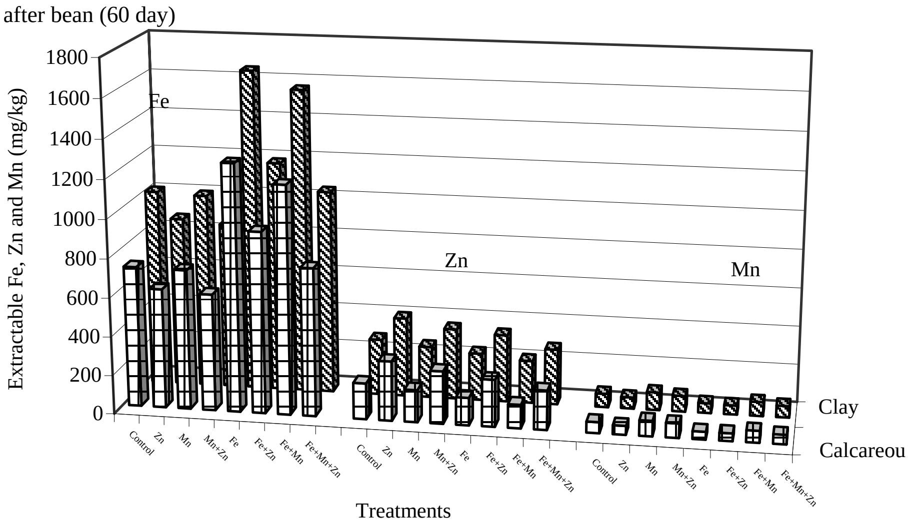

Fig. (1): Effect of Fe, Zn and Mn addition individually or in combination on values of AB-DTPA-extractable (mg/kg) of bean plants growing on clay and calcareous soils (60 days after sowing).

It is worthy to mention that the application of Zn, Zn +Fe, Zn + Mn and Fe + Mn + Zn i. e. T_2, T_6, T_4 and T_7 caused relative increases in AB-DTPA-extractable Zn by about 322.2, 222, 122 and 61% compared to the control treatment(T_1).

With regard to AB-DTPA-extractable Mn in soil treated with different micronutrients, data reveal that there are remarkable increases in AB-DTPA- extractable Mn due Mn, Mn+Zn, Mn + Fe and Fe +Mn +Zn i.e. T_3, T_4, T_7 and T_8 treatments. Such increase being about 64.2, 29.8, 33.6 and 11.2%, respectively as compared with that of the control.

Table (3): Effect of Fe, Zn and Mn addition individually or in combination on values of AB-DTPA-extractable (mg/kg) of wheat plants growing on clay and calcareous soils (60 days after sowing).

Treatments (T)	Fe		Mean	Zn		Mean	Mn		Mean
	Clay	Calcareous		Clay	Calcareous		Clay	Calcareous	
T_1	22.6	2.2	12.4	1.8	0.4	1.1	13.3	3.3	8.3
T_2	18.3	1.6	10.0	7.6	4.0	5.8	11.6	3.3	7.5
T_3	18.0	2.1	10.1	1.9	0.4	1.2	22.0	6.0	14.0
T_4	17.6	1.6	9.6	4.0	3.0	3.5	17.4	5.0	11.2
T_5	27.4	6.2	16.8	2.4	0.3	1.4	10.8	3.2	7.0
T_6	26.2	5.8	16.0	5.8	2.9	4.4	9.1	2.7	5.9
T_7	24.9	4.2	14.6	1.8	0.4	1.1	17.9	5.0	11.5
T_8	23.9	3.0	13.5	2.9	1.8	2.4	14.9	3.8	9.4
Mean	22.4	3.3		3.5	1.7		14.6	4.0	
L.S.D5%	S=0.33 T=0.66 S*T=0.93			S=0.25 T=0.49 S*T=0.69			S=0.27 T=0.54 S*T=0.76		

See footnote of table 1

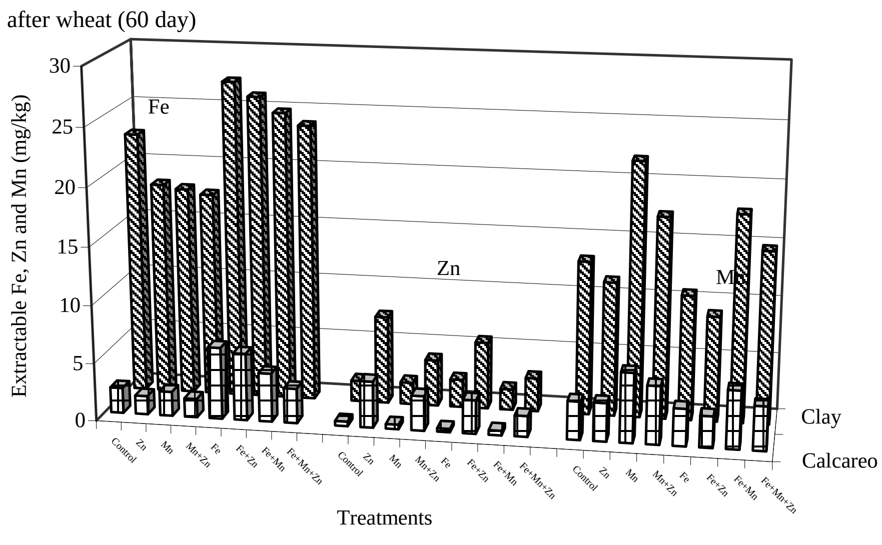

Fig. (2): Effect of Fe, Zn and Mn addition individually or in combination on values of AB-DTPA-extractable(mg/kg) of wheat plants growing on clay and calcareous soils (60 days after sowing).

Data show that the extractable amounts of Fe from the calcareous soil increased with its application solely or combined with the other micronutrients to soil, but decreased with the addition of the micronutrients other than Fe. The relative increases were 181.8, 163.7, 90.9 and 36.4% owing to application of Fe, Fe+ Zn, Fe +Mn and Fe + Mn+ Zn i.e. T_5, T_6, T_7 and T_8, respectively.

Also, AB-DTPA-extractable Zn showed the highest AB-DTPA extractable value (4.0 mg/kg) owing to application of T_2 treatment, while applied Fe (T_5) and Mn (T_3) or Fe + Mn (T_7) together recorded lower values of AB-DTPA-extractable Zn. Troeh and Thompson (1993). Reported that Mn can serve as an oxidizing agent and convert ferrous iron to the more insoluble ferric form. This finding illustrate the depressive effect of applied Mn on the available content of Fe.

2- Extractable amounts of micronutrients from the soil at the end of the experiment,

Values of AB-DTPA-extractable Fe, Mn and Zn from clay and calcareous soil cultivated with bean plants are shown in table 4and fig 3. Data show that the extractable amounts of each of Fe, Zn and Mn from clayey soil increased owing to application to the soil solely or in combination with wither of the two nutrients or both of them together. However, application of another nutrient other than the concerned one caused its AB-DTPA-extractable amount to decrease. Therefore, the lowest values of the AB-DTPA-extractable Fe were achieved owing to the combined application of Mn + Zn i.e. T_4 which scored 18.0 mg/kg . Also, the soil application of either Zn (T_2) or Mn (T_3) caused AB-DTPA-extractable Fe to be lower concentrations than the corresponding one of the control treatment (T_1). On the other hand, application of Fe solely (T_5) or in combination with either Zn(T_6) or Mn (T_7) or both of them (T_8) resulted in higher AB-DTPA-extractable Fe than the control treatment (T_1). The soil application of Mn (T_3), Fe (T_5) as well as their combination (T_7) resulted in concentration of AB-DTPA-extractable Zn lower than that of the control (T_1). Also, AB-DTPA- extractable Mn showed values lower than the control treatment due to the sole application of Fe (T_5), Zn (T_2) or both together (T_6).

Our results also showed that the addition of one or two elements other than the concerned one decreased its AB-DTPA-extractable amounts. This indicates an antagonistic relationship between Fe-Mn, Fe-Zn and Zn-Mn in the soil. Theses data are confirmed by the results of Moussa et al. (1993); Dahdoh et al.(1992) and Dahdoh (1993 and 1994) who declared that the antagonistic relationships among these combined elements may be attributed to the ionic composition at the adsorption sites of a soil with special emphasis on ionic radius and valence.

Data show that adding Fe (T_5) to the calcareous soil increased the chemical extractable Fe in soil by about 4.4mg/kg but at the same time decreased the AB-DTPA-extractable Mn by about 0.2 mg/kg with no effect on AB-DTPA-extractable Zn. Also, the soil application of Zn (T_2) increased the chemically extractable Zn by 1.2 mg/kg but decreased the AB-DTPA-extractable Fe and Mn by 0.6 and 0.1 mg/kg, respectively compared with the corresponding values of the control treatment (T_1). AB-DTPA-extractable Fe, Zn and Mn were increased owing to the combined application of Fe + Mn+Zn i.e. T_8 treatment.

Data presented in table 5 show the values of AB-DTPA-extractable Fe, Mn and Zn from both the clayey and calcareous soils after wheat plants. Extractable amounts of the micronutrients from the clayey soil at the end of experiment show that the AB-DTPA-extractable Fe, Mn and Zn increased owing to their sole application to soil. AB-DTPA-extractable amount of each studied micronutrient decreased upon adding one or two of other micronutrients. For example, application of Fe (T_5) increased its extractable amounts by about 4.7 mg/kg compared to the control treatment while it was decreased under Zn (T_2) and Mn (T_3) or both of them together (T_4). This indicates to the possible antagonistic relationship between these micronutrients in the soil. This might be attributed to the ionic competition at adsorption sites due to their almost identical ionic radii and their absorption by plant as divalent cations. Theses data are agree with those of Dahdoh et al.(1992) who found that the addition of Fe to the soil decreased the extractable amount of Zn and vice versa. Also, Moussa et al. (1993) found that addition of Mn to the soil decreased the extractable amounts of Zn or Fe and vice versa.

As for, the micronutrients extractable from calcareous soil, data in table 5 show that the extractable amounts of Fe increased owing to its application to the soil alone or combined with Mn and/or Zn. On the other hand, addition of Zn or Mn solely or together (T_2, T_3 and T_4 caused AB-DTPA –extractable Fe decrease.

Table (4): Effect of Fe, Mn and Zn addition individually or in combination values of AB-DTPA- extractable (mg/kg) from clay and calcareous soils after bean plants (at the end of the experiment).

Treatments (T)	Fe		Mean	Zn		Mean	Mn		Mean
	Clay	Calcareous		Clay	Calcareous		Clay	Calcareous	
T_1	23.9	2.1	13.0	1.7	0.4	1.1	13.4	3.0	8.2
T_2	19.6	1.5	10.6	3.8	2.0	2.9	12.9	2.9	7.9
T_3	19.9	1.7	10.8	1.6	0.4	1.0	17.3	5.1	11.2
T_4	18.0	1.5	9.8	2.9	1.9	2.4	15.4	4.3	9.9
T_5	28.3	6.5	17.4	1.6	0.4	1.0	12.9	2.8	7.9
T_6	27.9	5.1	16.5	3.2	1.9	2.6	11.0	2.8	6.9
T_7	25.0	4.3	14.7	1.7	0.3	1.0	16.1	4.6	10.3
T_8	24.3	3.0	13.7	2.6	1.6	2.1	14.3	4.0	9.2
Mean	23.4	3.2		2.4	1.1		14.2	3.7	
L.S.D$_{5\%}$	S=0.39 T=0.58 S*T=0.82			S=0.07 T=0.14 S*T=0.20			S=0.07 T=0.14 S*T=0.20		

See footnote of table 1

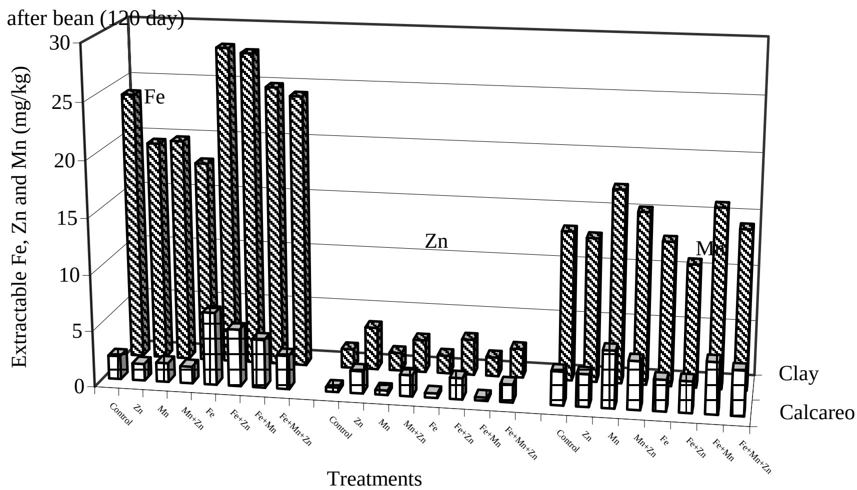

Fig. (3): Effect of Fe, Mn and Zn addition individually or in combination values of AB-DTPA- extractable (mg/Kg) of bean plants grown on clay and calcareous soils (120 days after sowing).

Table (5): Effect of Fe, Mn and Zn addition individually or in combination values of AB-DTPA- extractable (mg/kg) from clay and calcareous soils after wheat plants (at the end of the experiment).

Treatments (T)	Fe		Mean	Zn		Mean	Mn		Mean
	Clay	Calcareous		Clay	Calcareous		Clay	Calcareous	
T_1	20.9	2.0	11.5	1.8	0.4	1.1	12.8	3.1	8.0
T_2	19.3	1.7	10.5	3.4	3.8	3.6	11.0	3.0	7.0
T_3	19.8	1.8	10.8	1.6	0.5	1.1	16.9	4.6	10.8
T_4	16.8	1.5	9.2	3.0	2.8	2.9	14.5	4.0	9.3
T_5	25.6	4.6	15.1	1.6	0.3	1.0	10.0	2.9	6.5
T_6	24.1	4.2	14.1	3.1	2.7	2.9	9.0	2.7	5.9
T_7	23.4	3.2	13.3	1.5	0.3	0.9	14.8	4.0	9.4
T_8	21.8	2.9	12.4	2.7	1.5	2.1	13.9	3.2	8.6
Mean	21.5	2.7		2.3	1.5		12.9	3.4	
$L.S.D_{5\%}$	S=0.11 T=0.22 S*T=0.33			S=0.08 T=0.16 S*T=0.22			S=0.20 T=0.39 S*T=0.56		

See footnote of table 1

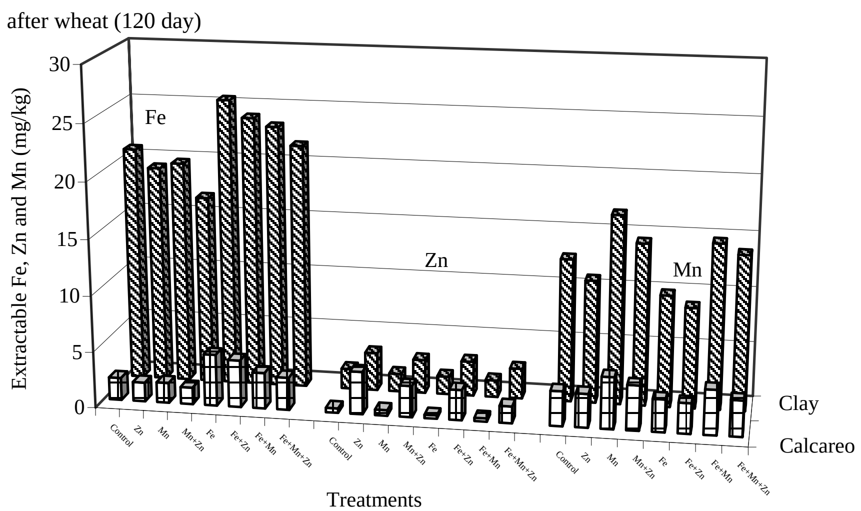

Fig. (4): Effect of Fe , Mn and Zn addition individually or in combination on values of AB-DTPA- extractable (mg/Kg) clay and calcareous of wheat plants on clay and calcareous soils (120 days after sowing).

A pattern similar to that Fe was noticed for the other applied micronutrients i.e. and Mn. Application of an element anther solely or combined with the other ones caused its AB-DTPA-extractable amount to increase whereas application of each of the other ones or both of them caused its extractable amount to decrease.

From the previous discussion, the study of nutrient interrelationships in the plant and soil is still a very difficult task due to the multivariate characters of both systems which are further affected by the characteristics of the element and their combinations with each other. Therefore further studies are needed to cover all the factors affecting such interrelationships between elements in different soils and/or plants species.

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التأثيرات المتبادلة بين الحديد والمنجنيز والزنك المضافة الى ارض رسوبية واخرى رملية جيرية أثناء وبعد زراعتها بنباتات الفول والقمح

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القاء بعض الضوء على التأثيرات المتبادلة بين العناصر المغذية حديد ومنجنيز وزنك فى أرض رسوبية طينية غير جيرية وأخرى جيرية رملية تم زراعتهما بالقمح (نبات احادى الفلقة) والفول كنبات ثنائى الفلقة ، تم اضافة توليفات مختلفة من الحديد والمنجنيز والزنك بمعدل 20 مجم كجم تربة فى ظل المحافظة على مستوى رطوبى ثابت مقدارة 70% من السعة الحقلية واجراء جميع المعاملات الزراعية كما هو معتاد بالنسبة لكل محصول وكل ارض.

وقد اوضحت النتائج أن اضافة احد العناصر سواء منفردا أو متصاحبا مع غيره من العناصر موضع الدراسة قد أدى الى زيادة المستخلص من بمحلول AB-DTPA فى حين أن اضافة أى من العنصر الآخرين منفردا أو معا قد أدى الى نقص الكمية المستخلصة من العنصر الثالث. وقد لوحظت هذه الظاهره فى كلا نوعى الارض الطينية والجيرية، ومع ذلك فقد كانت الكميات المستخلصة من كل من الحديد والمنجنيز والزنك من الارض الطينية أعلى بكثير من مثيلاتها المستخلصة من الارض الجيرية.

وبرغم أن ارتفاع محتوى الارض الجيرية من كربونات الكالسيوم فقد أدى الى نقص المستخلص من المغذيات الصغرى بواسطةAB-DTPA الا ان فيما يبدو لم يكن ذو أثر أو ذو أثر قليل جدا على العلاقات التبادلية بين هذه العناصر.